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Please Post through January 17, 2020

Illinois Environmental Protection Agency (IEPA)
Notice of Water Discharge Permit Public Hearing
NPDES Permit No. IL0077666

Exhibit 1

Williamson Energy, L.L.C.
Pond Creek Mine No. 1
Williamson and Franklin Counties

Public Hearing
Wednesday, December 18, 2019 6:00pm

Diamond Club, Rent One Park
1000 Miners Drive
Marion, Illinois 62959

The Illinois EPA Bureau of Water has prepared a draft renewed National Pollutant Discharge Elimination System (NPDES) permit with modifications for Williamson Energy, L.L.C., whose mailing address is P.O. Box 300, Johnston City, IL 62951. The Pond Creek Mine facility is located approximately four miles east of Johnston City in Williamson and Franklin Counties and proposes to discharge into Pond Creek, unnamed tributaries of Pond Creek, and into the Big Muddy River. Additional information is available online at https://www2.illinois.gov/epa/public-notices/npdes-notices/Pages/default.aspx (please enter IL0077666 in the search box above "Posting Data").

The Illinois EPA is holding a hearing to accept comments from the public on the proposed reissuance of a permit with modifications for this project, prior to making a final decision on the permit application. Issues relevant to this proceeding include the antidegradation analysis and the applicant's compliance with requirements of the federal Clean Water Act and Subtitles C and D, 35 Ill. Adm. Code. Issues related to the mining operations are not relevant in this proceeding and should be directed to the Illinois Department of Natural Resources, Office of Mines and Minerals.

The applicant operates surface facilities for an underground coal mine (SIC 1222). Mine operations result in the discharge of alkaline and acid mine drainage.

Comments are invited on the draft reissued permit which incorporates the following modifications:

1. Addition of three new outfalls designated as Outfall Numbers 009, 009ES, and 011;
2. Incorporation of various mining operation and drainage control plan revisions;
3. Incorporation of 229.78 acres for new Disposal Area Number 3;
4. Incorporation of 70.7 acres for a pipeline to the Big Muddy River;
5. Incorporation of 145.32 acres for Incidental Boundary Revisions (IBR's).
6. Addition of bi-annual metals monitoring for Outfall Numbers 006, 007, 008, 009, 009ES, and 011; and,
7. Incorporation of previously-issued State Construction and Operating Permits.

The Illinois EPA has made a tentative determination to reissue this NPDES permit with modifications for discharge into waters of the state in accordance with 35 Ill. Adm. Code Subtitle C (Water Pollution),

Subtitle D (Mine Related Water Pollution), the Illinois Environmental Protection Act and the federal Clean Water Act. The draft NPDES permit and the public notice/fact sheet were public noticed on July 12, 2019. The antidegradation assessment, which is part of the public notice, and other documents for this proceeding can be viewed on the IEPA website: https://www2.illinois.gov/epa/public-notices/npdes-notices/Pages/default.aspx (please enter IL0077666 in the search box above "Posting Data").

The draft permit, public notice/fact sheet, the regulations governing the conduct of the hearing and other documents can be reviewed and copied at the Illinois EPA, 1021 N. Grand Avenue East, Springfield, Illinois; 217-782-0610. Please call ahead for an appointment.

For information or requests about the draft permit, please contact: Barb Lieberoff, Office of Community Relations, Illinois EPA, 1021 N. Grand Ave. East, P.O. Box 19276, Springfield, IL 62794-9276, 217/524-3038 or by email at barb.lieberoff@illinois.gov

The hearing will be conducted under 35 Ill. Adm. Code 166 in accordance with provisions of 35 Ill. Adm. Code 309.115 through 309.119. Requests for special needs interpreters must be made to the Illinois EPA hearing officer by November 22, 2019. The hearing record is a file containing the hearing transcript and written comments. **Written comments must be physically received by January 17, 2020; mailed comments must be postmarked in sufficient time to arrive at Illinois EPA by January 17, 2020 when the hearing record closes.**

E-mails with written comments must be sent to epa.publichearingcom@illinois.gov and should specify **Pond Creek Mine or IL0077666 in the subject line**. Email comments originating on third party systems or servers intended for submittal of multiple emails of the same or nearly the same content will not be accepted without prior written approval from the hearing officer, Christine Zeivel, Christine.Zeivel@illinois.gov. Comments need not be notarized and should be sent to:

Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P. O. Box 19276
Springfield, IL 62794-9276 email comments: epa.publichearingcom@illinois.gov
Phone 217-524-3038 TDD (hearing impaired) 866/273-5488

Exhibit 1A

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Illinois Environmental Protection Agency (IEPA)
Notice of Water Discharge Permit Public Hearing
NPDES Permit No. IL0077666

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The Illinois EPA is holding a hearing to accept comments from the public on the proposed reissuance of a permit with modifications for this project, prior to making a final decision on the permit application. Issues relevant to this proceeding include the antidegradation analysis and the applicant's compliance with requirements of the federal Clean Water Act and Subtitles C and D, 35 Ill. Adm. Code. Issues related to the mining operations are not relevant in this proceeding and should be directed to the Illinois Department of Natural Resources, Office of Mines and Minerals.

The applicant operates surface facilities for an underground coal mine (SIC 1222). Mine operations result in the discharge of alkaline and acid mine drainage.

Comments are invited on the draft reissued permit which incorporates the following modifications:

1. Addition of three new outfalls designated as Outfall Numbers 009, 009ES, and 011;
2. Incorporation of various mining operation and drainage control plan revisions;
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4. Incorporation of 70.7 acres for a pipeline to the Big Muddy River;
5. Incorporation of 145.32 acres for Incidental Boundary Revisions (IBR's).
6. Addition of bi-annual metals monitoring for Outfall Numbers 006, 007, 008, 009, 009ES, and 011; and,
7. Incorporation of previously-issued State Construction and Operating Permits.

The Illinois EPA has made a tentative determination to reissue this NPDES permit with modifications for discharge into waters of the state in accordance with 35 Ill. Adm. Code Subtitle C (Water Pollution),

Subtitle D (Mine Related Water Pollution), the Illinois Environmental Protection Act and the federal Clean Water Act. The draft NPDES permit and the public notice/fact sheet were public noticed on July 12, 2019. The antidegradation assessment, which is part of the public notice, and other documents for this proceeding can be viewed on the IEPA website: https://www2.illinois.gov/epa/public-notices/Pages/npdes-individual-notices.aspx (please enter IL0077666 in the search box above "Posting Data").

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For information or requests about the draft permit, please contact: Barb Lieberoff, Office of Community Relations, Illinois EPA, 1021 N. Grand Ave. East, P.O. Box 19276, Springfield, IL 62794-9276, 217/524-3038 or by email at barb.lieberoff@illinois.gov

The hearing will be conducted under 35 Ill. Adm. Code 166 in accordance with provisions of 35 Ill. Adm. Code 309.115 through 309.119. Requests for special needs interpreters must be made to the Illinois EPA hearing officer by November 22, 2019. The hearing record is a file containing the hearing transcript and written comments. **Written comments must be physically received by January 17, 2020; mailed comments must be postmarked in sufficient time to arrive at Illinois EPA by January 17, 2020 when the hearing record closes.**

E-mails with written comments must be sent to epa.publichearingcom@illinois.gov and should specify **Pond Creek Mine or IL0077666 in the subject line**. Email comments originating on third party systems or servers intended for submittal of multiple emails of the same or nearly the same content will not be accepted without prior written approval from the hearing officer, Christine Zeivel, Christine.Zeivel@illinois.gov. Comments need not be notarized and should be sent to:

Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P. O. Box 19276
Springfield, IL 62794-9276 — email comments: epa.publichearingcom@illinois.gov
Phone 217-524-3038 — TDD (hearing impaired) 866/273-5488

Exhibit 2

NPDES Permit No. IL0077666
Notice No. 7516c

Public Notice Beginning Date: **July 12, 2019**

Public Notice Ending Date: **August 12, 2019**

National Pollutant Discharge Elimination System (NPDES)
Permit Program

Draft Renewed NPDES Permit to Discharge into Waters of the State

Public Notice/Fact Sheet Issued By:

Illinois Environmental Protection Agency
Bureau of Water, Division of Water Pollution Control
Permit Section
1021 North Grand Avenue East
Post Office Box 19276
Springfield, Illinois 62794-9276
217/782-0610

Name and Address of Discharger:

Williamson Energy, LLC
P.O. Box 300
Johnston City, Illinois 62951

Name and Address of Facility:

Williamson Energy, LLC
Pond Creek Mine
4 miles east of Johnston City, Illinois
(Williamson and Franklin Counties)

The Illinois Environmental Protection Agency (IEPA or Agency) has made a tentative determination to issue an NPDES permit to discharge into waters of the state and has prepared a draft permit and associated fact sheet for the above named discharger. The Public Notice period will begin and end on the dates indicated in the heading of this Public Notice/Fact Sheet. Comments will be accepted until midnight of the Public Notice period ending date indicated above, unless a request for an extension of the original comment period is granted by the Agency. Interested persons are invited to submit written comments on the draft permit to the IEPA at the above address. Commenters shall provide his or her name, address and the nature of the issues raised and the evidence supporting those issues. Commenters may include a request for public hearing. The NPDES permit and notice number(s) must appear on each comment page.

The application, engineer's review notes, Public Notice/Fact Sheet, draft permit, comments received, and other documents are available for inspection and may be copied at the IEPA between 9:30 a.m. and 3:30 p.m. Monday through Friday when scheduled by the interested person.

As provided in 35 Ill. Adm. Code 309.115(a) any person may submit a request for a public hearing and if such written comments or requests indicate a significant degree of public interest in the draft permit, the permitting authority may, at its discretion, hold a public hearing. The Agency shall issue public notice of such hearing no less than thirty (30) days prior to the date of such hearing in the manner described by 35 Ill. Adm. Code 309.109 through 309.112 for public notice. The Agency's responses to written and/or oral comments will be provided in the Responsiveness Summary provided when the final permit is issued.

The applicant proposes additional surface facilities area to an existing underground coal mine (SIC 1222). Mine operations result in the discharge of alkaline and acid mine drainage.

Public comments are invited on the entire draft permit. The following proposed modifications were incorporated into this Permit renewal:

Incorporated three (3) new outfalls designated as Outfall Nos. 009, 009ES and 011.

Various mining operation and drainage control plan revisions.

229.78 acres incorporated for new Refuse Disposal Area No. 3.

70.7 acres incorporated for the pipeline to the Big Muddy River.

145.32 acres for various IBR's for additional permit area.

Addition of bi-annual metals monitoring of discharges from Outfall Nos. 006, 007, 008,009, 009ES and 011.

Incorporated previously issued State Construction and Operating Permits (Subtitle D Permits).

This facility has eight (8) existing discharges which are located in Williamson County, Illinois. The following information identifies the discharge points and receiving streams:

Outfall	Receiving Stream	Latitude (North)	Longitude (West)
001	Unnamed tributary of Pond Creek	37° 50' 59.2"	88° 49' 37.5"
002	Unnamed tributary of Pond Creek	37° 50' 26.0"	88° 49' 51.5"
003	Unnamed tributary of Pond Creek	37° 50' 26.0"	88° 49' 58.0"
004	Unnamed tributary of Pond Creek	37° 50' 25.0"	88° 49' 56.6"
005	Unnamed tributary of Pond Creek	37° 50' 9.1"	88° 50' 00.0"
006	Unnamed tributary of Pond Creek	37° 50' 28.4"	88° 50' 40.6"
007	Unnamed tributary of Pond Creek	37° 50' 29.5"	88° 49' 34.0"
008	Unnamed tributary of Pond Creek	37° 50' 31.4"	88° 49' 33.9"

The stream segment NG-02 of Pond Creek receiving the flow from the unnamed tributary into which Outfall 001, 002, 003, 004, 005, 006, 007 and 008 discharges is not on the 2016 303(d) list of impaired waters.

Application is made for three (3) new discharges which are located in Williamson and Franklin Counties, Illinois. The following information identifies the discharge points and receiving streams:

Outfall	Receiving Stream	Latitude (North)	Longitude (West)
009	Pond Creek	37° 51' 16.1"	88° 49' 25.5"
009ES	Unnamed tributary to Pond Creek	37° 50' 52.3"	88° 48' 43.7"
011	Big Muddy River	37° 52' 37"	89° 01' 49"

The stream segment NG-02 of Pond Creek receiving the discharge from Outfalls 009 and 009ES is on the 2016 303(d) list of impaired waters.
The following parameters have been identified as the pollutants causing impairment.

Outfall	Pollutant
009, 009ES	Alteration in stream-side or littoral vegetative cover Changes in stream depth and velocity patterns Chlorides Loss of instream cover, dissolved oxygen, Sedimentation/siltation

The stream segment N-11 of Big Muddy River receiving the discharge from Outfall 011 is on the draft 2016 303(d) list of impaired waters. The following parameters have been identified as the pollutants causing impairment.

Outfall	Pollutant
011	Iron, Oxygen, dissolved; Sedimentation/Siltation Total Suspended Solids (TSS) Mercury, Polychlorinated biphenyls Fecal Coliform

The alkaline mine discharge from this facility shall be monitored and limited at all times as follows:

Outfalls: 001, 002, 003, 004, 005

Discharge Condition	Parameters											
	Total Suspended Solids (3) (mg/l)		Iron (total) (3) (4) (mg/l)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/l)	Chloride (mg/l)	Cadmium (Cd) (mg/l) (6)	Hardness (5)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum								
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 5.21 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for alkaline mine discharges are contained in 35 Ill. Adm. Code 406.110.
(3) Effluent standards for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 001, 002, 003, 004 and 005 are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average.
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limit.
(6) The Cadmium water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).

The acid mine discharge from this facility shall be monitored and limited at all times as follows:

Outfalls: 006, 007

Discharge Condition	Parameters												
	Total Suspended Solids (3) (mg/L)		Iron (total) (3) (4) (mg/L)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/L)	Chloride (mg/L)	Cadmium (Cd) (mg/l) (6)	Mn (total) (mg/L)	Hardness (5)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum									
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	1.0	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	1.0	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(b), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 1-year, 24-hours precipitation event, but less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 1-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hours precipitation event for this area is considered to be 5.21 inches.

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for acid mine drainage discharges are contained in 35 Ill. Adm. Code 406.110(b), (c), and (d).
(3) Effluent limitations for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 006 and 007 are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average.
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.
(6) The Cadmium water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).

The acid mine discharge from this facility shall be monitored and limited at all times as follows:

Outfall: 008

Discharge Condition	Parameters											
	Total Suspended Solids (3) (mg/L)		Iron (total) (3) (4) (mg/L)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/L)	Chloride (mg/L)	Mn (total) (mg/L)	Hardness (5)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum								
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	1.0	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	1.0	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(b), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 1-year, 24-hours precipitation event, but less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 1-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hours precipitation event for this area is considered to be 5.21 inches.

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for acid mine drainage discharges are contained in 35 Ill. Adm. Code 406.110(b), (c), and (d).
(3) Effluent limitations for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 008 are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average.
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.

The alkaline mine discharge from this facility shall be monitored and limited at all times as follows:

Outfall: 009

Discharge Condition	Parameters												
	Total Suspended Solids (3) (mg/L)		Iron (total) (3) (4) (mg/L)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/L)	Chloride (mg/L)	Mn (total) (mg/L)		Hardness (5)	Copper (CU) (mg/L)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum				
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	See Special Condition No. 14	-	-	Monitor only	-	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	See Special Condition No. 14	-	-	Monitor only	-	Measure When Sampling	-
IV	35	70	3.0	6.0	6.0-9.0	Alk.>Acid	1250	See Special Condition No. 14	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall at times of "low flow" or "no flow" conditions in the receiving stream as defined in Special Condition No. 14.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. At such time that receiving stream flow subsides to the degree that the mixing ratio specified in Special Condition No. 14 is not available, monitoring requirements and permit limitations shall revert to Discharge Condition I.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for alkaline mine discharges are contained in 35 Ill. Adm. Code 406.110.
(3) Effluent standards for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 009 are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.

The alkaline mine discharge from this facility shall be monitored and limited at all times as follows:

Outfall: 009ES

Discharge Condition	Parameters													
	Total Suspended Solids (3) (mg/L)		Iron (total) (3) (4) (mg/L)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/L)	Chloride (mg/L)	Mn (total) (mg/L)		Hardness (5)	Copper (CU) (mg/L)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum				
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	-	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	-	Measure When Sampling	-
IV	35	70	3.0	6.0	6.0-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for alkaline mine discharges are contained in 35 Ill. Adm. Code 406.110.
(3) Effluent standards for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 009ES are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.

The alkaline mine discharge from this facility shall be monitored and limited at all times as follows:

Outfall: 011

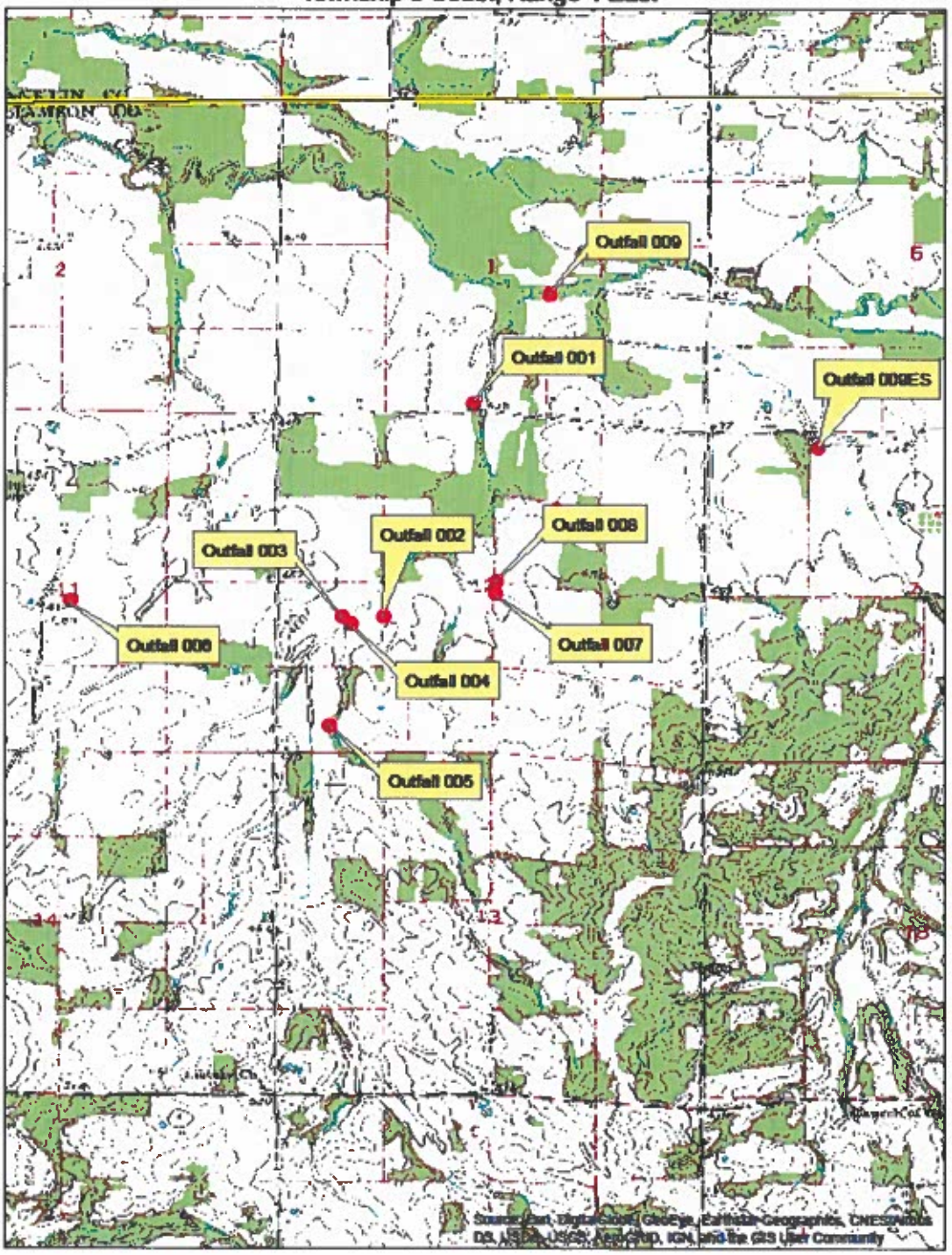
Parameters														
Total Suspended Solids (1) (mg/l)		Iron (total) (2) (mg/l)		pH (3) (S.U.)	Alkalinity/ Acidity (4)	Sulfate (5) (mg/l)	Chloride (mg/l)	Mn (total) (mg/l) (2)		Hardness (6)	Nickel (mg/L)	Copper (mg/L)	Flow (MGD)	Iron (Dissolved)
30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum					
35	70	3.0	6.0	6.0-9.0	Alk.>Acid	See Special Condition No. 16	See Special Condition No. 16	2.0	4.0	Monitor only	See Special Condition No. 16	See Special Condition No. 16	Measure When Sampling	See Special Condition No. 16

For any discharge not meeting the water quality standard for any of the above parameters, such discharge shall be subject to the limitations and monitoring requirements of Special Condition No. 16.

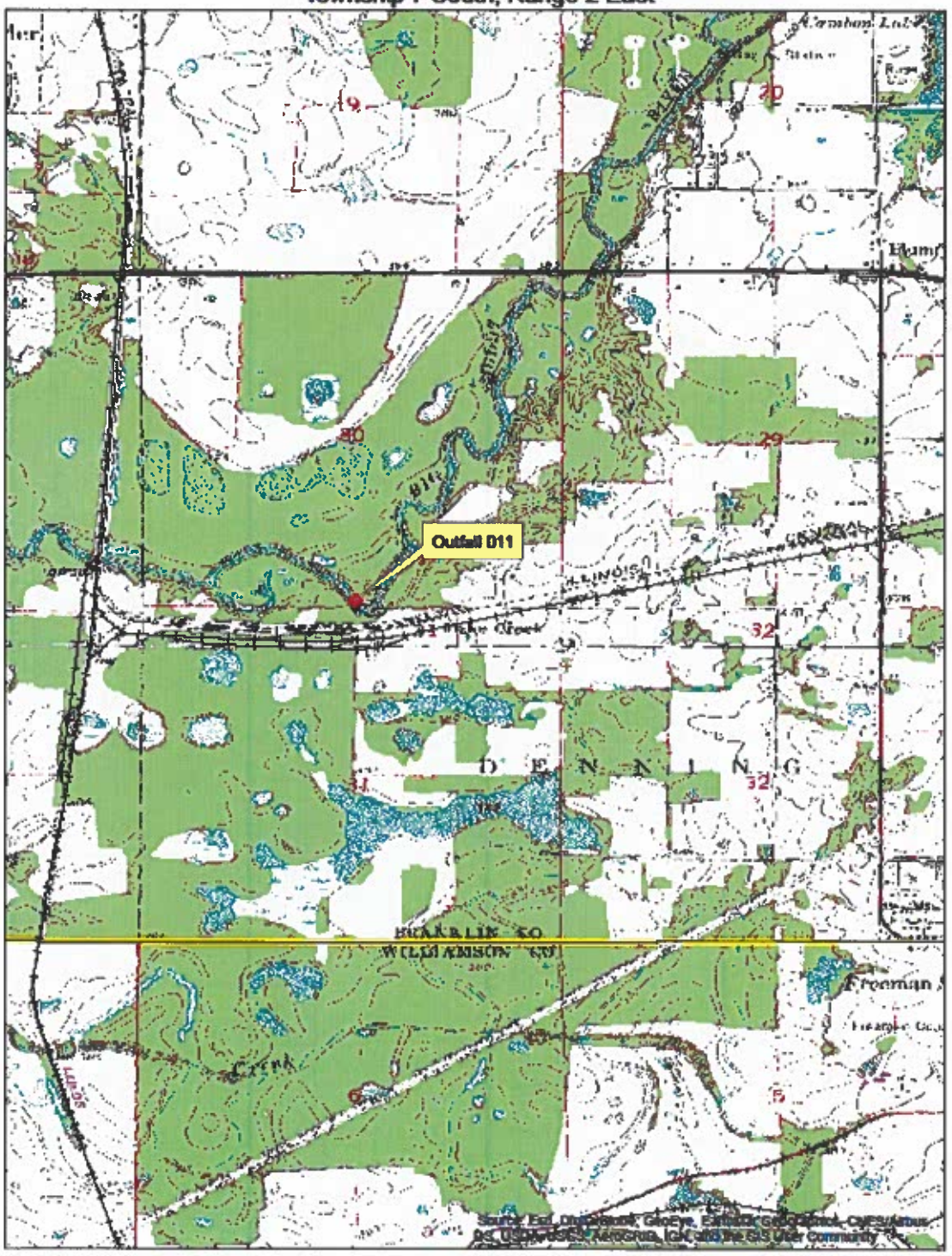
(1) Effluent standards for Total Suspended Solids in mine discharges are established pursuant to 35 Ill. Adm. Code 406.106.
(2) Effluent standards for Iron and Manganese are established pursuant to 35 Ill. Adm. Code 304.124.
(3) Pursuant to 35 Ill. Adm. Code 406.106, pH shall not be less than 6.0 or greater than 9.0 S.U.
(4) Pursuant to 35 Ill. Adm. Code 406.106, total acidity shall not exceed total alkalinity.
(5) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(6) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.

To assist you in identifying the location of the discharges, please refer to the attached map. The permit area for this facility is located in Sections 2, 3, 4, 7, 8, 9, 10, 12, 14, 15, 16, 17, 18 and 29, Township 8 South, Range 4 East, and Sections 11, 12, 13, 35, 36, Township 8 South, Range 3 East, Williamson County, 3rd P.M., Illinois, and Sections 1, 2 and 12, Township 8 South, Range 2 East, and Sections 7, 8, 9, 11, 14, 15, 16, and 17, Township 8 South, Range 3 East, and Sections 27, 28, 29, 30, 31, 32, 34 and 35, Township 7 South, Range 2 East, Franklin County , 3rd P.M., Illinois.

Williamson Energy, L.L.C. - Pond Creek Mine No. 1
NPDES No. IL0077666
Williamson County
Township 8 South, Range 3 East
Township 8 South, Range 4 East



Williamson Energy, L.L.C. - Pond Creek Mine No. 1
NPDES No. IL0077666
Franklin County
Township 7 South, Range 2 East



Antidegradation Assessment for RDA #3
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Williamson Energy, LLC –Pond Creek Mine No. 1 is creating a new Refuse Disposal Area No. 3. This proposed disposal area will tie into the existing Refuse Disposal Area No. 1 & 2. Associated with the new Refuse Disposal Area No. 3, a new sediment basin will be installed to control the rainfall that falls on the out-slopes of the sediment basin and will discharge through new Outfalls 009 and 009ES.

The facility is also requesting a modification to Outfall 005. The facility is proposing to stop using the geotextile tubes, which were operated in a no discharge configuration. The facility was using the geotextile tubes to remove fine refuse and collecting the water and pumping it to the existing refuse disposal area. Williamson Energy, LLC is requesting to modify the drainage control plan to allow stormwater runoff from the area to discharge through sediment ditches and spillway, into Ditch D-5C and through Pond 005. This drainage pattern is not a deviation from the originally approved drainage plan. Due to the nature of the geotextile tubes, surface water quality is not anticipated to be affected once the geotextile tubes are out of service and no longer being utilized.

To not increase chlorides and sulfates due to the construction of RDA No. 3, the mine is eliminating or reclaiming the outslopes of RDA No. 1 and RDA No. 2 that previously discharged through Outfalls 007 and 008. Therefore, there will not be an increase in loading due to the construction of RDA No. 3.

The information in this antidegradation assessment came from the December 2014 NPDES Renewal #2 for Permit #IL0077666 report by Alliance Consulting, Inc. titled "Pond Creek Mine No. 1 & Refuse Disposal Area No. 3" and the anti-degradation assessment provided on November 18, 2016.

Identification and Characterization of the Affected Water Body.

The subject facility proposed to discharge to Pond Creek through Outfall 009 at a point where 0 cfs of flow exists upstream of the outfalls during critical 7Q10 low-flow conditions. Pond Creek is classified as a General Use Water. Pond Creek is not listed as a biologically significant stream in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor is it given an integrity rating in that document. Pond Creek, Waterbody Segment, NG-02, is listed on the draft 2016 Illinois Integrated Water Quality Report and Section 303(d) List as impaired for aquatic life use with potential causes given as alteration in stream-side or littoral vegetative cover (non-pollutant), changes in stream depth and velocity patterns (non-pollutant), chlorides, loss of instream cover (non-pollutant), dissolved oxygen (non-pollutant), and sedimentation/siltation. Primary contact recreation and secondary contact uses are fully supported. Pond Creek is not subject to enhanced dissolved oxygen standards.

Identification of Proposed Pollutant Load Increases or Potential Impacts on Uses.

The mine outfalls will be classified as acid mine drainage. Suspended solids will be treated in the sedimentation ponds. Effluent discharged from these ponds will contain suspended solids loadings that are similar to those occurring from the land in its present use. Sulfates and chlorides will undergo an increase in loading to the receiving streams as a result of the mining activities. Based on estimated effluent concentrations for this mine, chloride and sulfate will meet water quality standards in the receiving stream based on the mixing provided by my December 13, 2016 water quality memo.

Fate and Effect of Parameters Proposed for Increased Loading.

Suspended solids discharged will eventually be incorporated into bed sediments and will continue to move downstream. Sulfate and chloride will remain dissolved in the water and will move through the downstream continuum. Small amounts of these substances will be removed by organisms as these substances are necessary for life. No adverse impacts to the receiving streams will occur as all water quality standards will be met.

Purpose and Social & Economic Benefits of the Proposed Activity.

The disposal of excess water, including the water infiltrating the mine, will allow the mine to continue to operate. The Pond Creek Mine is expected to generate 5 - 6 million tons of useable coal annually. According to information given in a document dated November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit IL0077666, continued operation of the existing mine will continue to provide jobs for 203 employees with an annual payroll of approximately $18 million. In addition to these 203 direct employees, it is estimated that another 100 persons are employed in daily work associated with the Mine's production. This includes truck drivers, supply and support personnel, train crews, and technical personnel. In addition, other local businesses would also benefit from the wealth created by the mine. The operation of the mine provides tax revenues through payroll, coal severance, and mineral resource taxes for the surrounding counties and the State of Illinois. The total local, state, and federal revenues generated by the continuation of this Mine are approximately $78 million annually. Current employment statistics indicate that the unemployment rate for Williamson County was 7.5%.

Antidegradation Assessment for RDA #3
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Assessments of Alternatives for Less Increase in Loading or Minimal Environmental Degradation.

Alternatives to discharge through Outfall 009 have been evaluated by the mine company in a document dated November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit and are summarized as follows:

Chloride and Sulfate

Membrane Processes. Standard reverse osmosis (RO) treatment results in a waste stream of water with a high concentration of contaminants that is typically 25% of the flow being sent to the RO treatment system. The reject stream must still be disposed of in a responsible manner. Due to the disposal issue, the Membrane Process is not viable.

Deep Well Injection of the Entire Groundwater Stream. The untreated groundwater infiltrate could be discharged directly to a deep well. Considering the cost and operational difficulties experienced to date for the two wells that have been installed at the nearby Sugar Camp Coal facility to accept 0.45 MGD each, deep well injection of the untreated groundwater infiltrate is not considered either applicable or feasible for the operation of the Mine.

Discharge to POTW or Other Sources. POTWs are not designed to treat wastewaters containing dissolved substances such as chloride or sulfate. This option is not feasible.

No discharge. Given the climate of Williamson County, the mine company concludes that evaporation is not a viable option for disposal of the stormwater runoff mine effluent.

Mechanical Evaporation. Mechanical evaporation uses high temperatures and pressure to remove the water. The equipment is expensive to construct/install, operate, and maintain. Also, there would be materials to dispose of either in a landfill or in the Injection Wells that have been found to be unreliable for nearby mines. Therefore, this option is not considered either applicable or feasible for the operation of the mine.

Crystallizaton. Crystallization equipment is expensive to construct/install, operate and maintain. The cost is estimated at $0.25/gallon, the mine company concludes that crystallization is not a viable option for disposal of the stormwater runoff mine effluent.

Cost Effective Sulfate Removal (CESR) process. This is a proprietary technology that uses hydrated lime and proprietary chemicals to precipitate gypsum, metals and ettringite. Sludge would be produced that would require landfill disposal. The proprietary technology is still being developed. Additionally, this method is not proven to remove chlorides. These drawbacks make the CESR process infeasible for use at the coal mine.

Chemical Precipitation. Alkaline chemicals may be added to acid mine effluent to precipitate metals. The sludge produced must be disposed of and in some cases will contain hazardous materials added to the wastewater to attain precipitation. The additives used require mining in their own right. The water discharged may contain these additives, such as aluminum, in elevated concentrations. Additionally, this method is not proven to remove chlorides. These drawbacks make chemical precipitation infeasible.

Sedimentation/Siltation

Sedimentation. The facility is proposing to pump the groundwater infiltration to a Water Staging Cell where the water will have an opportunity for solids to settle out. The water will then be discharged to the Big Muddy River though the diffuser.

Use alternate sediment control and treatment devices. Alternatives to the use of sediment control ponds exist for control of discharge of settleable solids. Such alternatives include chemical soil stabilizers, erosion control blankets, geotextile filter bags, fiber rolls, silt fencing, straw mulch, straw bale dikes, and temporary seeding. These measures are aimed at minimization of the generation of settable solids. Most of these measures have been used previously during the construction and operations and in accordance with the current permit, as supplemental treatment and prevention of generation of settable solids. The use of alternative sediment control measures is considered practical and cost effective for the treatment and control of surface runoff in conjunction with sediment control ponds. However, the use of these practices to eliminate the proposed sediment control ponds is not feasible. Instead, it is being proposed that these BMPs be incorporated into the proposed alternative as needed.

No discharge. Given the climate of Williamson County, the mine company concludes that evaporation is not a viable option for disposal of the stormwater runoff mine effluent.

Filtration. Filtration is a technology that is not feasible for the proposed facility because: filtration is much more expensive than sediment ponds, filtration processes require a steady stream of water for treatment which is not the case in treating stormwater runoff, a large area of land would be required for such a facility, and maintenance and supervision of the filtration and sludge disposal operation would be burdensome and would increase production costs.

Antidegradation Assessment for RDA #3
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Constructed Wetlands. Constructed wetlands have proven to be effective for treatment of suspended solids with several limitations. These limitations include; low and consistent rates of inflow, eventual sludge accumulation requiring dredging and wetland reconstruction, and release of hydrogen sulfide and other digestive gases into the atmosphere from sulfate digestion processes. Use of wetlands in mine stormwater runoff treatment would be limited by the enormous amount of land required to construct a wetland of sufficient size for the flow rates to be expected from such an operation.

Chemical Precipitation. Alkaline chemicals may be added to acid mine effluent to precipitate metals. The sludge produced must be disposed of and in some cases will contain hazardous materials added to the wastewater to attain precipitation. The additives used require mining in their own right. The water discharged may contain these additives, such as aluminum, in elevated concentrations. Concerns with the use of chemical precipitation at the proposed coal mine include; worker safety regarding the chemicals to be used, treatment costs, process operation and maintenance, disposal of precipitate sludge in a landfill, necessity of treatment considering that acid water is not considered a factor for the proposed operation, susceptibility to system malfunction due to high volume flows from storm events, and improbability of actual improvement in overall water quality when compared to the use of sediment ponds. These drawbacks make chemical precipitation infeasible.

Summary Comments of the Illinois Department of Natural Resources, Regional Planning Commissions, Zoning Boards or Other Entities

On November 2, 2016, the IDNR EcoCAT web-based tool was used and indicated that there were no aquatic endangered/threatened species present in the vicinity of the discharge. While the IDNR EcoCAT web-based tool did not terminate the consultation because of the nearby presence of Chuck-Will's-Willow (*Caprimulgus carolinensis*), future termination is likely.

Agency Conclusion.

This preliminary assessment was conducted pursuant to the Illinois Pollution Control Board regulation for Antidegradation found at 35 Ill. Adm. Code 302.105 (antidegradation standard) and was based on the information available to the Agency at the time the draft permit was written. We tentatively find that the proposed activity will result in the attainment of water quality standards; that all existing uses of the receiving stream will be maintained; that all technically and economically reasonable measures to avoid or minimize the extent of the proposed increase in pollutant loading have been incorporated into the proposed activity; and that this activity will benefit the community at large by allowing the continuation of coal mining with all of its economic benefits to the local economy. Comments received during the NPDES permit public notice period will be evaluated before a final decision is made by the Agency.

Antidegradation Assessment for Big Muddy River Mixing
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Williamson Energy, LLC operates the Pond Creek No. 1 Mine which is located in Williamson County. The mining complex contains an estimated 383.3 million tons of clean, recoverable coal reserves. Williamson Energy commenced construction of the Mine in 2005. The Mine has a life expectancy of more than 20 years. The mine has one operating longwall system. The Preparation Plant facilities are capable of processing 2,000 tons of coal per hour. The productive capacity of the mine is 5-6 million tons per year. Coal is shipped by rail, truck and barge (via railroad).

Williamson currently operates the mine under the existing Permit 375 and Permit 417 from the Illinois Department of Natural Resources, Office of Mines and Minerals (IDNR-OMM). The Mine currently discharges under NPDES Permits IL0077666.

The Pond Creek Mine has submitted an antidegradation report as part of the following NPDES permit activities:

- To respond to the over capacity of water on-site, a new outfall to the Big Muddy River is proposed. The outfall structure will be a multi-port diffuser and a mixing zone is being requested for the discharge; and
- The mine permit modification request includes the discharge of stormwater from stormwater ponds associated with the proposed Refuse Disposal Area No. 3 to Pond Creek. (Discussed under another antidegradation assessment.) A mixing zone is being requested for Pond Creek.

The mine uses water in two areas of operation; dust suppression during coal extraction and wash water in the preparation plant. The water used in the coal extraction process is fresh, untreated water purchased from the City of Johnston City and it not recoverable. The water used to wash the coal in the preparation plant comes from the fresh water lake. Over time, the fine solid particles present in the thickener underflow that is pumped to the Slurry Impoundment/RDA No. 3 settle to the bottom of the impoundment leaving clarified water on the surface. There is some loss of water during the washing process. Additionally, since the fines do not all settle immediately in the slurry impoundment, the quality of the clarified water results in a need for additional water for the preparation plant. Therefore, preparation plant water is supplemented with mine infiltration water and/or stormwater.

An aquifer above the coal seam causes an influx in water into the Mine. The infiltrating groundwater is from a saline aquifer, with a chloride content of approximately 1,099 to 2,799 mg/L. The sulfate ranges between 1,720 and 2,120 mg/L. Presently, the mine is removing 2.7 MGD of this high-chloride groundwater from the active mine. During normal coal processing operations, the preparation plant requires approximately 2.3 MGD. It is necessary to remove the water from the mine to protect the health and safety of the workforce, as well as, the overall mining operation.

Water will be stored in the Water Staging Cell and will be pumped to the Big Muddy River diffuser for mixing. An evaluation of the mixing zone will be reported in a separate memo.

The information in this antidegradation assessment came from the December 2014 NPDES Renewal #2 for Permit #IL0077666 report by Alliance Consulting, Inc. titled "Pond Creek Mine No. 1 & Refuse Disposal Area No. 3" and the anti-degradation assessment provided on November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit IL0077666

Identification and Characterization of the Affected Water Body.

The subject facility proposes to discharge to the Big Muddy River through Outfall 011 at a point where 37.0 cfs of flow exists upstream of the outfall during critical 7Q10 low-flow conditions. The Big Muddy River is classified as a General Use Water. The Big Muddy River is not listed as a biologically significant stream in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor is it given an integrity rating in that document. The Big Muddy River, Waterbody Segment, N-11, is listed on the draft 2016 Illinois Integrated Water Quality Report and Section 303(d) List as impaired for aquatic life use with potential causes given as iron (dissolved), dissolved oxygen (non-pollutant), sedimentation/siltation (non-pollutant), and total suspended solids; fish consumption use with potential causes given as mercury and polychlorinated biphenyls; and primary contact recreation use with potential cause given as fecal coliform. Aesthetic quality use is fully supported. This segment of the Big Muddy River is not subject to enhanced dissolved oxygen standards.

Identification of Proposed Pollutant Load Increases or Potential Impacts on Uses.

The constituents of concern are chloride, sulfates, manganese, iron, and total suspended solids. The chloride loading will range from 19,141 to 1,197,698 lbs/day at a concentration ranging from 1,699 to 12,000 mg/L. The sulfate loading will range from 9,720 to 476,031 lbs/day at a concentration ranging from 820 to 2,120 mg/L. The manganese loading will range from 33 to 336 lbs/day at a concentration ranging from 0.125 to 0.419 mg/L. The Iron (total) loading will range from 34 to 348 lbs/day at a concentration ranging from 0.216 to 1.835 mg/L. Iron (dissolved) is only a fraction of the Iron (total) and will meet the water quality standard at the end-of-pipe or at the edge of the mixing zone. The Nickel loading will range from 1 to 8 lbs/day at a concentration ranging from 0.004 to 0.014 mg/L. The Copper loading will range from 1 to 8 lbs/day at a concentration ranging from 0.011 to 0.32 mg/L. The TSS loading will range from 2,337 to 118,332 lbs/day at a concentration ranging from 7 to 70 mg/L.

Antidegradation Assessment for Big Muddy River Mixing
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Fate and Effect of Parameters Proposed for Increased Loading.

Chloride and sulfates would remain dissolved in the water and would move through the downstream continuum. Manganese, iron, Nickel, Copper, and total suspended solids will most likely settle and become part of the bed sediment load in the river. A mixing zone in the Big Muddy River will be utilized to dissipate chloride and sulfate to water quality standard levels. A zone of initial dilution will be utilized to dissipate Copper to water quality standard levels. Small amounts of chloride and sulfates would be removed by organisms as these substances are necessary for life. Because of the near real-time continuous monitoring of upstream and downstream conditions in the receiving stream, and the ability of the permittee's diffuser to adjust to flow and background concentration conditions, discharges will always be into a waterbody that is below water quality standards and in concentrations and flow combinations that will not cause or contribute to an exceedance downstream of the mixing zone. No adverse impacts to streams would occur as all water quality standards are expected to be met in the receiving water.

Purpose and Social & Economic Benefits of the Proposed Activity.

The disposal of excess water, including the water infiltrating the mine, will allow the mine to continue to operate. The Pond Creek Mine is expected to generate 5 - 6 million tons of useable coal. According to information given in a document dated November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit IL0077666, continued operation of the existing mine will continue to provide jobs for 203 employees with an annual payroll of approximately $18 million. In addition to these 203 direct employees, it is estimated that another 100 persons are employed in daily work associated with the Mine's production. This includes truck drivers, supply and support personnel, train crews, and technical personnel. In addition, other local businesses would also benefit from the wealth created by the mine. The operation of the mine provides tax revenues through payroll, coal severance, and mineral resource taxes for the surrounding counties and the State of Illinois. The total local, state, and federal revenues generated by the continuation of this Mine are approximately $78 million annually. Current employment statistics indicate that the unemployment rate for Williamson County was 7.5%.

Assessments of Alternatives for Less Increase in Loading or Minimal Environmental Degradation.

Excess water is proposed to be discharged to the Big Muddy River. Alternatives to this system have been evaluated by the mine company in a document dated November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit and are summarized as follows:

Chloride and Sulfate

Membrane Processes. Standard reverse osmosis (RO) treatment results in a waste stream of water with a high concentration of contaminants that is typically 25% of the flow being sent to the RO treatment system. The reject stream must still be disposed of in a responsible manner. Due to the disposal issue, the Membrane Process is not viable.

Deep Well Injection of the Entire Groundwater Stream. The untreated groundwater infiltrate could be discharged directly to a deep well. Considering the cost and operational difficulties experienced to date for the two wells that have been installed at the nearby Sugar Camp Coal facility to accept 0.45 MGD each, deep well injection of the untreated groundwater infiltrate is not considered either applicable or feasible for the operation of the Mine.

Discharge to POTW or Other Sources. POTWs are not designed to treat wastewaters containing dissolved substances such as chloride or sulfate. This option is not feasible.

No discharge. Given the climate of Williamson County, the mine company concludes that evaporation is not a viable option for disposal of the stormwater runoff mine effluent.

Mechanical Evaporation. Mechanical evaporation uses high temperatures and pressure to remove the water. The equipment is expensive to construct/install, operate, and maintain. Also, there would be materials to dispose of either in a landfill or in the Injection Wells that have been found to be unreliable for nearby mines. Therefore, this option is not considered either applicable or feasible for the operation of the mine.

Crystallizaton. Crystallization equipment is expensive to construct/install, operate and maintain. The cost is estimated at $0.25/gallon, the mine company concludes that crystallization is not a viable option for disposal of the stormwater runoff mine effluent.

Cost Effective Sulfate Removal (CESR) process. This is a proprietary technology that uses hydrated lime and proprietary chemicals to precipitate gypsum, metals and ettringite. Sludge would be produced that would require landfill disposal. The proprietary technology is still being developed. Additionally, this method is not proven to remove chlorides. These drawbacks make the CESR process infeasible for use at the coal mine.

Antidegradation Assessment for Big Muddy River Mixing
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Chemical Precipitation. Alkaline chemicals may be added to acid mine effluent to precipitate metals. The sludge produced must be disposed of and in some cases will contain hazardous materials added to the wastewater to attain precipitation. The additives used require mining in their own right. The water discharged may contain these additives, such as aluminum, in elevated concentrations. Additionally, this method is not proven to remove chlorides. These drawbacks make chemical precipitation infeasible.

Sedimentation/Siltation

Sedimentation. The facility is proposing to pump the groundwater infiltration to a Water Staging Cell where the water will have an opportunity for solids to settle out. The water will then be discharged to the Big Muddy River though the diffuser.

Use alternate sediment control and treatment devices. Alternatives to the use of sediment control ponds exist for control of discharge of settleable solids. Such alternatives include chemical soil stabilizers, erosion control blankets, geotextile filter bags, fiber rolls, silt fencing, straw mulch, straw bale dikes, and temporary seeding. These measures are aimed at minimization of the generation of settable solids. Most of these measures have been used previously during the construction and operations and in accordance with the current permit, as supplemental treatment and prevention of generation of settable solids. The use of alternative sediment control measures is considered practical and cost effective for the treatment and control of surface runoff in conjunction with sediment control ponds. However, the use of these practices to eliminate the proposed sediment control ponds is not feasible. Instead, it is being proposed that these BMPs be incorporated into the proposed alternative as needed.

No discharge. Given the climate of Williamson County, the mine company concludes that evaporation is not a viable option for disposal of the stormwater runoff mine effluent.

Filtration. Filtration is a technology that is not feasible for the proposed facility because: filtration is much more expensive than sediment ponds, filtration processes require a steady stream of water for treatment which is not the case in treating stormwater runoff, a large area of land would be required for such a facility, and maintenance and supervision of the filtration and sludge disposal operation would be burdensome and would increase production costs.

Constructed Wetlands. Constructed wetlands have proven to be effective for treatment of suspended solids with several limitations. These limitations include; low and consistent rates of inflow, eventual sludge accumulation requiring dredging and wetland reconstruction, and release of hydrogen sulfide and other digestive gases into the atmosphere from sulfate digestion processes. Use of wetlands in mine stormwater runoff treatment would be limited by the enormous amount of land required to construct a wetland of sufficient size for the flow rates to be expected from such an operation.

Chemical Precipitation. Alkaline chemicals may be added to acid mine effluent to precipitate metals. The sludge produced must be disposed of and in some cases will contain hazardous materials added to the wastewater to attain precipitation. The additives used require mining in their own right. The water discharged may contain these additives, such as aluminum, in elevated concentrations. Concerns with the use of chemical precipitation at the proposed coal mine include; worker safety regarding the chemicals to be used, treatment costs, process operation and maintenance, disposal of precipitate sludge in a landfill, necessity of treatment considering that acid water is not considered a factor for the proposed operation, susceptibility to system malfunction due to high volume flows from storm events, and improbability of actual improvement in overall water quality when compared to the use of sediment ponds. These drawbacks make chemical precipitation infeasible.

Summary Comments of the Illinois Department of Natural Resources, Regional Planning Commissions, Zoning Boards or Other Entities.

On November 2, 2016, the IDNR EcoCAT web-based tool was used and indicated that there were no aquatic endangered/threatened species present in the vicinity of the discharge. While the IDNR EcoCAT web-based tool did not terminate the consultation because of the nearby presence of Chuck-Will's-Willow (*Caprimulgus carolinensis*), future termination is likely.

Agency Conclusion.

This preliminary assessment was conducted pursuant to the Illinois Pollution Control Board regulation for Antidegradation found at 35 Ill. Adm. Code 302.105 (antidegradation standard) and was based on the information available to the Agency at the time the draft permit was written. We tentatively find that the proposed activity will result in the attainment of water quality standards; that all existing uses of the receiving stream will be maintained; that all technically and economically reasonable measures to avoid or minimize the extent of the proposed increase in pollutant loading have been incorporated into the proposed activity; and that this activity will benefit the community at large by allowing the continuation of coal mining with all of its economic benefits to the local economy. Comments received during the NPDES permit public notice period will be evaluated before a final decision is made by the Agency.

Antidegradation Assessment for RDA #3 (Supplemental Information)
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Pond 009 has an emergency discharge via Outfall 009ES. During normal operations, Pond 009 will discharge directly to Pond Creek via Outfall 009 and has provisions for allowed mixing. Outfall 009ES is not expected to have a discharge, except during an emergency.

Identification and Characterization of the Affected Water Body.

The subject facility discharges to an unnamed tributary of Pond Creek through Outfall 009ES at a point where 0 cfs of flow exists upstream of the outfalls during critical 7Q10 low-flow conditions. The unnamed tributary of Pond Creek is classified as a General Use Water. The unnamed tributary of Pond Creek is not listed as a biologically significant streams in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor is it given an integrity rating in that document. The unnamed tributary of Pond Creek, tributary to Waterbody Segment, NG-02, is not listed on the draft 2016 Illinois Integrated Water Quality Report and Section 303(d) List since it has not been assessed. The unnamed tributary of Pond Creek is not subject to enhanced dissolved oxygen standards.

Agency Conclusion.

Upon completing the assessment, it has been determined that the proposed activity will result in only short-term, temporary increases in pollutant loading and will not result in long term or permanent impacts to existing uses including aquatic life habitat; therefore, we find that it is subject to Subsection (d) "Activities Not Subject to a Further Antidegradation Assessment" of 35 Ill. Adm. Code 302.105.

NPDES Permit No. IL0077666

Illinois Environmental Protection Agency

Division of Water Pollution Control

1021 North Grand Avenue, East

P.O. Box 19276

Springfield, Illinois 62794-9276

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

Renewed NPDES Permit

Expiration Date:

Issue Date:
Effective Date:

Name and Address of Permittee:

Williamson Energy, LLC
P.O. Box 300
Johnston City, Illinois 62951

Facility Name and Address:

Williamson Energy, LLC
Pond Creek Mine
4 miles east of Johnston City, Illinois
(Williamson and Franklin Counties)

Discharge Number and Classification:		Receiving waters
001, 002, 003, 004, 005	Alkaline Mine Drainage	Unnamed tributary to Pond Creek
006, 007, 008	Acid Mine Drainage	Unnamed tributary to Pond Creek
009	Alkaline Mine Drainage	Pond Creek
009ES	Alkaline Mine Drainage	Unnamed tributary to Pond Creek
011	Alkaline Mine Drainage	Big Muddy River

In compliance with the provisions of the Illinois Environmental Protection Act, Subtitle C and/or Subtitle D Rules and Regulations of the Illinois Pollution Control Board, and the Clean Water Act, the above-named permittee is hereby authorized to discharge at the above location to the above-named receiving stream in accordance with the standard conditions and attachments herein.

Permittee is not authorized to discharge after the above expiration date. In order to receive authorization to discharge beyond the expiration date, the permittee shall submit the proper application as required by the Illinois Environmental Protection Agency (IEPA) not later than 180 days prior to the expiration date.

Darin E. LeCrone, P.E.
Manager, Industrial Unit, Permit Section
Division of Water Pollution Control

DEL:IKW:cs/7516c/06-19-19

NPDES Permit No. IL0077666

Effluent Limitations and Monitoring

From the effective date of this Permit until the expiration date, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfalls*: 001, 002, 003, 004, 005 (Alkaline Mine Drainage)

Discharge Condition	Parameters											
	Total Suspended Solids (mg/L) ***		Iron (total) (mg/L) ***		pH** (S.U.) ***	Alkalinity/ Acidity ***	Sulfate (mg/L) ***	Chloride (mg/L) ***	Cadmium (Cd) (mg/l)	Hardness ***	Flow (MGD)	Settleable Solids (ml/l)
	30 day average	daily maximum	30 day average	daily maximum								
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 5.21 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

Sampling during all Discharge Conditions shall be performed utilizing the grab sampling method.

*** There shall be a minimum of nine (9) samples collected during the quarter when the pond is discharging. Of these 9 samples, a minimum of one sample each month shall be taken during either Discharge Condition I or IV should such discharge condition occur. A "no flow" situation is not considered to be a sample of the discharge. In the event that Discharge Conditions II and/or III occur, grab sample of each discharge caused by the above precipitation events (Discharge Conditions II and/or III) shall be taken and analyzed for the parameters identified in the table above during at least 3 separate events each quarter. For quarters in which there are less than 3 such precipitation events resulting in discharges, a grab sample of the discharge shall be required whenever such precipitation event(s) occur(s). Should a sufficient number of discharge events occur during the quarter, the remaining three (3) quarterly samples may be taken during any of the Discharge Conditions described above.

The water quality standards for sulfate and chloride must be met in discharges from the above referenced outfall as well as in the receiving stream.

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* The Permittee is subject to the limitations, monitoring, and reporting requirements of Special Condition No. 13 for the discharges from Outfalls 001, 002, 003, 004 and 005 and unnamed tributary of Pond Creek receiving such discharges.

** No discharge is allowed from any above referenced permitted outfall during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

NPDES Permit No. IL0077666

Effluent Limitations and Monitoring

From the effective date of this Permit until the expiration date, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfalls*: 006, 007 (Acid Mine Drainage)

Discharge Condition	Parameters												
	Total Suspended Solids (mg/L) ***		Iron (total) (mg/L) ***		pH** (S.U.) ***	Alkalinity/ Acidity ***	Sulfate (mg/L) ***	Chloride (mg/L) ***	Cadmium (Cd) (mg/l) ***	Mn (total) (mg/L) ***	Hardness ***	Flow (MGD)	Settleable Solids (ml/l)
	30 day average	daily maximum	30 day average	daily maximum									
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	1.0	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	1.0	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(b), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 1-year, 24-hour precipitation event, but less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 1-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 5.21 inches.

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

Sampling during all Discharge Conditions shall be performed utilizing the grab sampling method.

*** There shall be a minimum of nine (9) samples collected during the quarter when the pond is discharging. Of these 9 samples, a minimum of one sample each month shall be taken during either Discharge Condition I or IV should such discharge condition occur. A "no flow" situation is not considered to be a sample of the discharge. In the event that Discharge Conditions II and/or III occur, grab sample of each discharge caused by the above precipitation events (Discharge Conditions II and/or III) shall be taken and analyzed for the parameters identified in the table above during at least 3 separate events each quarter. For quarters in which there are less than 3 such precipitation events resulting in discharges, a grab sample of the discharge shall be required whenever such precipitation event(s) occur(s). Should a sufficient number of discharge events occur during the quarter, the remaining three (3) quarterly samples may be taken during any of the Discharge Conditions described above.

The water quality standards for sulfate and chloride must be met in discharges from the above referenced outfall as well as in the receiving stream.

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* The Permittee is subject to the limitations, monitoring, and reporting requirements of Special Condition No. 13 for the discharges from Outfalls 006 and 007 and unnamed tributary of Pond Creek receiving such discharges. Also, discharges from Outfalls 006 and 007 shall be subject to the limitations, monitoring, and reporting requirements of Special Condition No. 18.

** No discharge is allowed from any above referenced permitted outfall during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

NPDES Permit No. IL0077666

Effluent Limitations and Monitoring

From the effective date of this Permit until the expiration date, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfall*: 008 (Acid Mine Drainage)

Discharge Condition	Parameters											
	Total Suspended Solids (mg/L) ***		Iron (total) (mg/L) ***		pH** (S.U.) ***	Alkalinity/ Acidity ***	Sulfate (mg/L) ***	Chloride (mg/L) ***	Mn (total) (mg/L) ***	Hardness ***	Flow (MGD)	Settleable Solids (ml/l)
	30 day average	daily maximum	30 day average	daily maximum								
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	1.0	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	1.0	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(b), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 1-year, 24-hour precipitation event, but less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 1-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 5.21 inches.

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

Sampling during all Discharge Conditions shall be performed utilizing the grab sampling method.

*** There shall be a minimum of nine (9) samples collected during the quarter when the pond is discharging. Of these 9 samples, a minimum of one sample each month shall be taken during either Discharge Condition I or IV should such discharge condition occur. A "no flow" situation is not considered to be a sample of the discharge. In the event that Discharge Conditions II and/or III occur, grab sample of each discharge caused by the above precipitation events (Discharge Conditions II and/or III) shall be taken and analyzed for the parameters identified in the table above during at least 3 separate events each quarter. For quarters in which there are less than 3 such precipitation events resulting in discharges, a grab sample of the discharge shall be required whenever such precipitation event(s) occur(s). Should a sufficient number of discharge events occur during the quarter, the remaining three (3) quarterly samples may be taken during any of the Discharge Conditions described above.

The water quality standards for sulfate and chloride must be met in discharges from the above referenced outfall as well as in the receiving stream.

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* The Permittee is subject to the limitations, monitoring, and reporting requirements of Special Condition No. 13 for the discharges from Outfalls 008 and unnamed tributary of Pond Creek receiving such discharges. Also, discharges from Outfalls 008 and 009ES shall be subject to the limitations, monitoring, and reporting requirements of Special Condition No. 18.

** No discharge is allowed from any above referenced permitted outfall during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

NPDES Permit No. IL000077666

Effluent Limitations and Monitoring

From the effective date of this Permit until the expiration date, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfall*: 009 (Alkaline Mine Drainage)

Discharge Condition	Parameters													
	Total Suspended Solids (mg/L) ***		Iron (total) (mg/L) ***		pH** (S.U.) ***	Alkalinity/ Acidity ***	Sulfate (mg/L) ***	Chloride (mg/L) ***	Mn (total) (mg/L) ***		Hardness ***	Copper (Cu) ***	Flow (MGD)	Settleable Solids (ml/l)
	30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum				
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	See Special Condition No. 14	-	-	Monitor only	-	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	See Special Condition No. 14	-	-	Monitor only	-	Measure When Sampling	-
IV	35	70	3.0	6.0	6.0-9.0	Alk.>Acid	1250	See Special Condition No. 14	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall at times of "low flow" or "no flow" conditions in the receiving stream are subject to Special Condition No. 14.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. At such time that receiving stream flow subsides to the degree that the mixing ratio specified in Special Condition No. 14 is not available, monitoring requirements and permit limitations shall revert to Discharge Condition I.

Sampling during all Discharge Conditions shall be performed utilizing the grab sampling method.

*** There shall be a minimum of nine (9) samples collected during the quarter when the pond is discharging. Of these 9 samples, a minimum of one sample each month shall be taken during either Discharge Condition I or IV should such discharge condition occur. A "no flow" situation is not considered to be a sample of the discharge. In the event that Discharge Conditions II and/or III occur, grab sample of each discharge caused by the above precipitation events (Discharge Conditions II and/or III) shall be taken and analyzed for the parameters identified in the table above during at least 3 separate events each quarter. For quarters in which there are less than 3 such precipitation events resulting in discharges, a grab sample of the discharge shall be required whenever such precipitation event(s) occur(s). Should a sufficient number of discharge events occur during the quarter, the remaining three (3) quarterly samples may be taken during any of the Discharge Conditions described above.

Discharges from the above referenced outfall that are subject to the requirements of Discharge Conditions II, III and/or IV must meet the water quality standards for sulfate and chloride in the receiving stream.

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* The Permittee is subject to the limitations, monitoring, and reporting requirements of Special Condition No. 14 for the discharges from Outfall 009 and Pond Creek receiving such discharges. Also, discharges from Outfall 009 shall be subject to the limitations, monitoring and reporting requirements of Special Condition No. 18.

** No discharge is allowed from any above referenced permitted outfall during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

NPDES Permit No. IL000077666

Effluent Limitations and Monitoring

From the effective date of this Permit until the expiration date, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfall*: 009ES (Alkaline Mine Drainage)

Discharge Condition	Parameters													
	Total Suspended Solids (mg/L) ***		Iron (total) (mg/L) ***		pH** (S.U.) ***	Alkalinity/ Acidity ***	Sulfate (mg/L) ***	Chloride (mg/L) ***	Mn (total) (mg/L) ***		Hardness ***	Copper (Cu) ***	Flow (MGD)	Settleable Solids (ml/l)
	30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum				
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	-	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	-	Measure When Sampling	-
IV	35	70	3.0	6.0	6.0-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

Sampling during all Discharge Conditions shall be performed utilizing the grab sampling method.

*** There shall be a minimum of nine (9) samples collected during the quarter when the pond is discharging. Of these 9 samples, a minimum of one sample each month shall be taken during either Discharge Condition I or IV should such discharge condition occur. A "no flow" situation is not considered to be a sample of the discharge. In the event that Discharge Conditions II and/or III occur, grab sample of each discharge caused by the above precipitation events (Discharge Conditions II and/or III) shall be taken and analyzed for the parameters identified in the table above during at least 3 separate events each quarter. For quarters in which there are less than 3 such precipitation events resulting in discharges, a grab sample of the discharge shall be required whenever such precipitation event(s) occur(s). Should a sufficient number of discharge events occur during the quarter, the remaining three (3) quarterly samples may be taken during any of the Discharge Conditions described above.

The water quality standards for sulfate and chloride must be met in discharges from the above referenced outfall as well as in the receiving stream.

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* The Permittee is subject to the limitations, monitoring, and reporting requirements of Special Condition No. 14 for the discharges from Outfall 009ES and Pond Creek receiving such discharges. Also, discharges from Outfall 009ES shall be subject to the limitations, monitoring and reporting requirements of Special Condition No. 18.

** No discharge is allowed from any above referenced permitted outfall during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

NPDES Permit No. IL0077666

Effluent Limitations and Monitoring

From the effective date of this Permit until the expiration date, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfall*: 011* (Alkaline Mine Drainage)

Parameters													
Total Suspended Solids (mg/l)		Iron (total) (mg/l)		pH** (S.U.)	Alkalinity/ Acidity	Sulfate (mg/l)	Chloride (mg/l)	Mn (total) (mg/l)		Hardness	Nickel (mg/L)	Copper (mg/L)	Flow (MGD)	Iron (Dissolved)
30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum					
35	70	3.0	6.0	6.5-9.0	Alk.>Acid	See Special Condition No. 16	See Special Condition No. 16	2.0	4.0	Monitor only	See Special Condition No. 16	See Special Condition No. 16	Measure When Sampling	See Special Condition No. 16

All sampling shall be performed utilizing the grab sampling method.

* Operation and management of pumpage to Outfall 011 is subject to the requirements of Special Condition No. 16. Also, discharges from Outfall 011 shall be subject to the limitations, monitoring, and reporting requirements of Special Condition No. 18.

NPDES Permit No. IL0077666

Effluent Limitations and Monitoring

Upon completion of Special Condition 10 and approval from the Agency, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfalls*: 001, 002, 003, 004, 005, 006, 007, 008, 009, 009ES (Reclamation Area Drainage)

Discharge Condition	Parameters					
	pH** (S.U.) ***	Sulfate (mg/L) ***	Chloride (mg/L) ***	Hardness ***	Flow (MGD)	Settleable Solids (ml/l) ***
I	6.5-9.0	1250	500	Monitor only	Measure When Sampling	0.5
II	6.0-9.0	1250	500	Monitor only	Measure When Sampling	0.5
III	6.0-9.0	1250	500	Monitor only	Measure When Sampling	-
IV	6.5-9.0	1250	500	Monitor only	Measure When Sampling	0.5

I Dry weather discharge (base flow, if present) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.109(b), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations. The 10-year, 24-hour precipitation event for this area is considered to be 5.21 inches.

III In accordance with 35 Ill. Adm. Code 406.109(c), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.109(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For reclamation area discharges, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

Sampling during all Discharge Conditions shall be performed utilizing the grab sampling method. A "no flow" situation is not considered to be a sample of the discharge.

*** One sample per month (1/month) shall be collected if and/or when a discharge occurs under either Discharge Condition I, II or IV and analyzed for the parameters identified in the table above. In addition, at least three (3) grab samples shall be taken each quarter from separate precipitation events under Discharge Condition III and analyzed for parameters indicated in the above table. For quarters in which there are less than 3 such precipitation events, a grab sample of the discharge shall be required whenever such precipitation event(s) occur(s).

The water quality standards for sulfate and chloride must be met in discharges from the above referenced outfall as well as in the receiving stream.

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* The Permittee is subject to the limitations, monitoring, and reporting requirements of Special Condition Nos. 13 and 15 for the discharges from Outfalls 001, 002, 003, 004, 005, 006, 007, 008 and 009ES and unnamed tributary to Pond Creek and Outfall 009 tributary to Pond Creek receiving such discharges.

** No discharge is allowed from any above referenced permitted outfall during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

NPDES Permit No. IL0077666

Effluent Limitations and Monitoring

Upon completion of Special Condition No. 11 and approval from the Agency, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfalls: 001, 002, 003, 004, 05, 006, 007, 008, 009, 009ES (Stormwater Discharge)

Parameters	
pH* (S.U.) **	Settleable Solids (ml/l) **
6.0-9.0	0.5

Stormwater discharge monitoring is subject to the following reporting requirements:

Analysis of samples must be submitted with second quarter Discharge Monitoring Reports.

If discharges can be shown to be similar, a plan may be submitted by November 1 of each year preceding sampling to propose grouping of similar discharges and/or updated previously submitted groupings. If updating of a previously submitted plan is not necessary, a written notification to the Agency, indicating such is required. Upon approval from the Agency, one representative sample for each group may be submitted.

Annual stormwater monitoring is required for all discharges until Final SMCRA Bond is released and approval to cease such monitoring is obtained from the Agency.

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* No discharge is allowed from any above referenced permitted outfalls during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

** One (1) sample per year shall be collected and analyzed for the indicated parameter; however, such sampling and analysis is required only if and/or when a discharge occurs from the individual Outfall(s) identified above.

NPDES Permit No. IL0077666

Construction Authorization No. 3117-15

Authorization is hereby granted to the above designee to construct and operate the mine and mine refuse area described as follows:

Surface facilities in support of an underground mine containing a total of 986.10 acres, also identified as IDNR/OMM Permit Nos. 375 417 and 456, located in Sections 2, 3, 4, 7, 8, 9, 10, 12, 14, 15, 16, 17, 18 and 29, Township 8 South, Range 4 East, and Sections 11, 12, 13, 35, 36, Township 8 South, Range 3 East, Williamson County, 3rd P.M., Illinois, and Sections 1, 2 and 12, Township 8 South, Range 2 East, and Sections 7, 8, 9, 11, 14, 15, 16, and 17, Township 8 South, Range 3 East, and Sections 27, 28, 29, 30, 31, 32, 34 and 35, Township 7 South, Range 2 East, Franklin County , 3rd P.M., Illinois.

The surface facilities at this site contain drainage control structures (ditches) and nine (9) sediment basins, incline slope, coal preparation plant, coal stockpiles, refuse disposal areas, coal conveyors, railroad loop, ventilation shafts, parking areas, access roads, and office and maintenance buildings. The following additional areas are being added to the original facilities approved for this operation.

An additional area of 4.05 acres, identified as IBR No. 4 to OMM Permit No. 375, located in Section 12, Township 8 South, Range 3 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log Nos. 2416-06 and 2416-06-A, installation of three (3) boreholes and associated pipeline to ensure mine ventilation is approved. Runoff from the area approved herein should be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 9.71 acres, identified as IBR No. 5 to OMM Permit No. 375, located in Section 13, Township 8 South, Range 3 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log Nos. 2380-06 and 2380-06-A, installation of the support facilities to ensure mine ventilation is approved. Runoff from the area approved herein should be controlled by two temporary catch basins, silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 3.20 acres, identified as IBR No. 10 to OMM Permit No. 375, located in Section 8, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log Nos. 1396-07 and 1396-07-A, installation of two (2) boreholes and a vertical pump to ensure mine ventilation is approved. Runoff from the area approved herein should be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 12.50 acres, identified as IBR No. 11 to OMM Permit No. 375, located in Sections 4, 7 and 8, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log Nos. 1525-07 and 1525-07-A, this area is incorporated for the installation of the water line from the Locust Grove Shaft area to Pond 006. Runoff from the area approved herein should be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 0.36 acres, identified as IBR to OMM Permit No. 375, located in Sections 11 and 12, Township 8 South, Range 3 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log Nos. 0190-08 and 0190-08-A, re-alignment of access road is approved. Runoff from the area approved herein should be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc

An additional area of 3.57 acres, identified as IBR No. 14 to OMM Permit No. 375, located in Section 9, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 0369-08, two (2) boreholes will be drilled and a vertical pump will be installed to ensure mine ventilation. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 8.1 acres, identified as IBR No. 25 to OMM Permit No. 375, located in Sections 9 and 10, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 8091-10, two (2) concrete transport boreholes and access road will be constructed and a turbine pump, buried waterline and power line will be installed. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 2.13 acres, identified as IBR No. 55 to OMM Permit No. 375, located in Section 9 and 16, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 5530-13 a buried pump discharge pipeline and electrical power line will be installed. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 4.18 acres, identified as IBR No. 52 to OMM Permit No. 375, located in Section 15, Township 8 South, Range 4 East, Williamson County, Illinois. As proposed and depicted in IEPA Log No. 5168-13, this area is being incorporated for the construction of an underground mine support facility including a borehole and installation of an electric vertical turbine pump. The area will also include a buried pipeline and electric power line. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 3.3 acres, identified as IBR No. 57 to OMM Permit No. 375, located in Section 18, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 4088-14, two (2) boreholes will be constructed and a pump and waterline will be installed to pump underground mine pumpage to an existing waterline along Jordan Fort Road. Topsoil stockpiles will also be located with the IBR area. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 3.3 acres, identified as IBR No. 58 to OMM Permit No. 375, located in Sections 8 and 17, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 5477-13, two (2) boreholes will be constructed and a pump and waterline will be installed to pump underground mine water and to ensure underground ventilation. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 9.89 acres, identified as IBR No. 60 to OMM Permit No. 375, located in Section 13, Township 8 South, Range 3 East, Williamson County, Illinois. As proposed and depicted in IEPA Log No. 4237-14, this area is for the development of topsoil and subsoil storage areas and construction of associated drainage ditches. Two (2) drainage ditches, identified as Collection Ditch Nos. D-5E-1 and D-5D-1, directs runoff from this area to existing Ditch D-5c and Pond 005.

An additional area of 1.0 acres, identified as IBR No. 78 to OMM Permit No. 375, located in Section 13, Township 8 South, Range 3 East, and Sections 7 and 18, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 9082-19, this area is incorporated into this permit for a buried four-inch waterline to be installed. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 19.9 acres, identified as IBR No. 79 to OMM Permit No. 375, located in Sections 35 and 36, Township 7 South, Range 3 East, in Franklin County, Illinois. As proposed and depicted in IEPA Log No. 9083-19, this area is incorporated into this permit for installation of a supply shaft to transport supplies underground as required for the continued effective operation of approved mine plan, belt air shaft and fan to supply required ventilation along with six (6) steel cased boreholes with a diameter less ten 10 5/8 inches for power and other supplies, power substation, dry storage barn and equipment yard. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 17.01 acres, identified as IBR No. 83 to OMM Permit No. 375, located in Sections 2, 3, 9 and 10, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 9109-19, this area is incorporated into this permit for a access roadway, one 16.5 foot bleeder shaft, utility boreholes, concrete pad for transformer, a compressor station and a portable crib plant. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

As described in IEPA Log No. 7395-11 and previously approved under Subtitle D Permit No. 2012-MA-7395-1, a permit area consisting of 9.82 acres located in Section 10, Township 8 South, Range 4 East, Williamson County, is incorporated into this permit for the construction of compressor bore hole, installation of a buried power line and an access road. All runoff from this area shall be monitored in accordance with stormwater monitoring requirements of Special Condition No. 11 of this NPDES Permit. This additional area is included in the total permit acreage cited above.

As described in IEPA Log No. 6141-12 and previously approved under Subtitle D Permit No. 2012-MA-6141-1, a permit area consisting of 0.64 acres located in Section 13, Township 8 South, Range 3 East, Williamson County, is incorporated into this permit for the construction of borehole for the batch material supply of crushed stone and concrete to the underground mine. All runoff from this area shall be monitored in accordance with stormwater monitoring requirements of Special Condition No. 11 of this NPDES Permit. This additional area is included in the total permit acreage cited above.

As described in IEPA Log No. 6562-12 and previously approved under Subtitle D Permit No. 2013-MA-6562, a permit area consisting of 3.81 acres located in Section 16, Township 8 South, Range 4 East, Williamson County, is incorporated into this permit for the construction of a steel-liner drill hole and temporary installation of a pumpable cement product mixing plant used for underground mine. All runoff from this area shall be monitored in accordance with stormwater monitoring requirements of Special Condition No. 11 of this NPDES Permit. This additional area is included in the total permit acreage cited above.

As described in IEPA Log No. 6039-12 and previously approved under Subtitle D Permit No. 2015-MA-6039, a permit area consisting of 4.65 acres located in Section 14, Township 8 South, Range 4 East, Williamson County, is incorporated into this permit for installation of ventilation shaft site. All runoff from this area shall be monitored in accordance with stormwater monitoring requirements of Special Condition No. 11 of this NPDES Permit. This additional area is included in the total permit acreage cited above.

As described in IEPA Log No. 2273-16 and previously approved under Subtitle D Permit No. 2016-MA-2273, a permit area consisting of 6.5 acres located in Section 29, Township 8 South, Range 4 East, Williamson County, is incorporated into this permit for the construction of a concrete lined South District Supply Shaft to provide supplies to underground workings, three (3) boreholes, a pole barn and an access road. All runoff from this area shall be monitored in accordance with stormwater monitoring requirements of Special Condition No. 11 of this NPDES Permit. This additional area is included in the total permit acreage cited above.

As previously approved under Subtitle D Permit No. 2014-MW-4275, a fine coal refuse (slurry) disposal area incorporating the use of geotextile tubes was developed at Pond Creek Mine site. As described and depicted in IEPA Log Nos. 4275-14, 4275-14-A, 4275-14-B, 1475-14-C development of this area included construction of a low permeability liner consisting of four (4) foot compacted clay with a hydraulic conductivity of 1 x 10^{-7} cm/sec, or less. Surface runoff and dewatering of the geotextile tubes is collected in a "no-discharge" perimeter containment basin and pumped to existing refuse disposal area or coal preparation plant. Hereby incorporated into this permit is a modification of the drainage control plan to allow stormwater runoff from the area to discharge through sediment ditches and spillway into existing Ditch D-5C and through Pond No. 005, as described and depicted in IEPA Log No. 3117-15. Reclamation of the geotextile tube refuse disposal area shell consists of construction of a low permeability cap consisting of four (4) foot compacted clay with hydraulic conductivity of 1x10^{-7}cm/sec, or less. Rooting medium and topsoil required for establishment of vegetative cover shall be in addition to the four (4) foot compacted clay low permeability cap. Four (4) monitoring wells identified as Well Nos. GW-29, GW-30, GW-31 and GW-32 shall be installed at each corner of the geotextile tube placement area. Groundwater monitoring shall be performed in accordance with Special Condition No. 12.

As described in IEPA Log Nos.1186-17, 1186-17-Band 1385-17, and previously approved under Subtitle D Permit No. 2017-MA-1186-1, a permit area consisting of 17.7 acres located in Section 12, Township 8 South, Range 3 East, Williamson County, is incorporated into this permit for construction of a Water Management Facility consisting of three (3) water holding cells. Construction and development of the water Management facility includes topsoil removal, grading, foundation preparation and installation of a low permeability liner consisting of four (4) foot compacted clay liner with a hydraulic conductivity of 1 x 10^{-7} cm/sec within the water holding cells. Compacted clay liner shall also be subject to and in accordance with the specifications and testing requirements of Condition No. 12. All runoff from this area shall be monitored in accordance with stormwater monitoring requirements of Special Condition No. 11 of this NPDES Permit. This additional area is included in the total permit acreage cited above. Four (4) monitoring wells identified as Well Nos. GW-33, GW-34, GW-35 and GW-36 shall be installed as depicted in IEPA Log Nos. 1186-17, 1186-17-B and 1385-17 Groundwater monitoring shall be performed in accordance with Special Condition No.13. This additional area is included in the total permit acreage cited above.

The following mining operations plan changes are incorporated into this permit:

Log No. 2413-06	The Mining Operations Plan has been revised to include the construction of an access tunnel under the railroad loop and administration building.
Log No. 2414-06	The Mine Operations Map has been revised to depict the revised various structures within the support facility.
Log No. 0371-08	Installation of a concrete sump at the existing road tunnel and a pipeline which will discharge to Sediment Pond No. 003, identified as IPR No. 13 to OMM Permit No. 375.

Surface drainage control is provided by eleven (11) sedimentation ponds with discharges designated as 001, 002, 003, 004, 005, 009, 09ES and 011 classified as alkaline mine drainage, and Outfalls 006, 007, 008 classified as acid mine discharge. The sanitary wastewater water treatment system will be approved by the Illinois Department of Public Health.

The location and receiving stream of the Outfalls at this facility is as follows:

Outfall No.	Latitude			Longitude			Receiving Water
	DEG	MIN	SEC	DEG	MIN	SEC	
001	37°	50'	59.2"	88°	49'	37.5"	Unnamed tributary to Pond Creek
002	37°	50'	26.0"	88°	49'	51.5"	Unnamed tributary to Pond Creek
003	37°	50'	26.0"	88°	49'	58.0"	Unnamed tributary to Pond Creek
004	37°	50'	25.0"	88°	49'	56.6"	Unnamed tributary to Pond Creek
005	37°	50'	9.1"	88°	50'	00.0"	Unnamed tributary to Pond Creek
006	37°	50'	28.4"	88°	50'	40.6"	Unnamed tributary to Pond Creek
007	37°	50'	29.5"	88°	49'	34.0"	Unnamed tributary to Pond Creek
008	37°	50'	31.4"	88°	49'	33.9"	Unnamed tributary to Pond Creek
009	37°	51'	16.1"	88°	49'	25.5"	Pond Creek
009ES	37°	50'	52.3"	88°	48'	43.7"	Unnamed tributary to Pond Creek
011	37°	52'	37"	89°	01'	49"	Big Muddy River

Original Sedimentation Ponds with discharges designated as Outfall Nos. 007 and 008 have been re-designed as described and depicted in IEPA Log No. 8554-10.

Refuse disposal
Refuse Disposal Area as previously approved in IEPA Log No. 3054-05, was constructed in phases as depicted and described in IEPA Log No. 2377-06 (RDA No. 1), Refuse Disposal Area No. 2 was constructed at Pond Creek Mine facilities as proposed and described in IEPA Log Nos. 1465-07, 1465-07-B, 1465-07-D, 1465-07-E, 1465-07-G, 1520-07, 0346-08, 9005-09, 9198-09, 9198-09-A, 8114-10, 8114-10-A, 7185-11, 7225-11, 6431-12, 6431-12-A and 5378-13.

As previously approved under Subtitle D Permit No. 2015-MA-3432, construction and development of Refuse Disposal Area No. 3 includes topsoil removal, grading, foundation preparation for refuse area, also construction of the water holding cell and installation of four (4) foot compacted clay liner was performed in accordance with the procedures discussed and outlined in IEPA Log No. 3432-15. As described in IEPA Log No. 3432-15, all stormwater runoff from the deposited coarse refuse within the RDA No. 3 is collected and maintained within the RDA No. 3 and/or is pumped into the slurry impounding structure of the existing RDA, which is an integral part of the Pond Creek Mine No. 1 coal preparation plant closed circuit wastewater handling system.

As described and depicted in IEPA Log Nos. 3001-15 and 3001-15-C Refuse Disposal Area No. 3 (RDA 3) is approved for construction. RDA 3 is located immediately east of the RDA 1 and RDA 2 areas, contains 229.78 acres, and is included in the above cited total Permit acreage. The area for RDA 3 is located in Section 12, Township 8 South, Range 3 East and Section 7, Township 8 South, Range 4 East, Williamson County, Illinois. To not increase chloride and sulfates due to construction of RDA 3, the mine is reclaiming the outslopes of the RDA 1 and RDA 2 that previously discharged through Outfalls 007 and 008. There will be no increase in loading due to the construction of RDA 3. Runoff from this area will be tributary to previously constructed water holding cell with the designated NPDES Outfalls 009 and 009ES, as depicted in IEPA Log No. 3117-15-A. Construction of four (4) foot compacted clay liners for the Refuse Disposal Area No. 3, Sediment Pond 009 and associated drainage control structures shall be subject to and in accordance with the specifications and testing requirements of Condition No. 12. With prior approval as to thickness and installation procedures, an HDPE synthetic liner may be utilized in lieu of the compacted clay liners proposed.

Mixing Zone (Big Muddy River)
Excess water will be transported from the Pond Creek Mine to Outfall No. 011 on the Big Muddy River through a high-density polyethylene (HDPE) pipeline. Water will be pumped from the Water Holding Cell by pumps through approximately 12.5 miles of pipe to the diffuser located at the mixing zone location. The pipeline ROW will be approximately 50 feet in width with a total permitted area of approximately 70.7 acres. The amount of water that could be discharged through the Pipeline depends upon the chloride concentration in the discharge stream, the background chloride content and the flow in the Big Muddy River. The upper limit to the discharge will be based on the pumping capacity of the facility. Maximum pumping rate of 5,000 gallons per minute or 11.1 cfs. from the facility. The volume of water discharged to Big Muddy River will be dependent upon the flow in the Big Muddy River and the chloride concentration of the water in the Water Holding Cell and the chloride concentration coming downstream in the River.

During operations of the pipeline, continuous flow monitors will be installed to provide protection against leakage. Flow will be monitored near the pump discharge while the pipeline is within the sediment control structure of Pond Creek Mine. Flow will also be monitored at the mixing zone location. This instrumentation will be connected to an alarm monitoring system and flow data will be transmitted to a central location for tracking and assessing system operations. The flow monitoring system operation and maintenance is subject to the requirements of Special Condition No. 16.

Groundwater monitoring for the facility will consist of Monitoring Well Nos.GW-1, GW-2, GW-3, GW-4, GW-5GW-9, GW-30, GW-33, GW-34, GW-35 and GW-36. Monitoring Well Nos. MW-8R, MW-10, MW-11, MW-12, MW-13, MW-14 and MW-28, as depicted in IEPA Log No. 3001-15, will monitor effects of the initial refuse disposal area. Groundwater monitoring requirements are outlined in Condition No. 13.

This Construction Authorization replaces Construction Authorization No. 3054-05.

The abandonment plan shall be executed and completed in accordance with 35 Ill. Adm. Code 405.109.

All water remaining upon abandonment must meet the requirements of 35 Ill. Adm. Code 406.202. For the constituents not covered by 35 Ill. Adm. Code Parts 302 or 303, all water remaining upon abandonment must meet the requirements of 35 Ill. Adm. Code 406.106.

NPDES Permit No. IL0077666

Construction Authorization No. 3117-15

This Authorization is issued subject to the following Condition(s). If such Condition(s) require(s) additional or revised facilities, satisfactory engineering plan documents must be submitted to this Agency for review and approval to secure issuance of a Supplemental Authorization to Construct.

1. If any statement or representation is found to be incorrect, this permit may be revoked and the permittee thereupon waives all rights thereunder.

2. The issuance of this permit (a) shall not be considered as in any manner affecting the title of the premises upon which the mine or mine refuse area is to be located; (b) does not release the permittee from any liability for damage to person or property caused by or resulting from the installation, maintenance or operation of the proposed facilities; (c) does not take into consideration the structural stability of any units or parts of the project; and (d) does not release the permittee from compliance with other applicable statutes of the State of Illinois, or with applicable local laws, regulations or ordinances.

3. Final plans, specifications, application and supporting documents as submitted by the permittee and approved by the Agency shall constitute part of this permit in the records of the Agency.

4. There shall be no deviations from the approved plans and specifications unless revised plans, specifications and application shall first have been submitted to the Agency and a supplemental permit issued.

5. The permit holder shall notify the Agency (217/782-3637) immediately of an emergency at the mine or mine refuse area which causes or threatens to cause a sudden discharge of contaminants into the waters of Illinois and shall immediately undertake necessary corrective measures as required by 35 Ill. Adm. Code 405.111. (217/782-3637 for calls between the hours of 5:00 p.m. to 8:30 a.m. and on weekends.)

6. The termination of an NPDES discharge monitoring point or cessation of monitoring of an NPDES discharge is not authorized by this Agency until the permittee submits adequate justification to show what alternate treatment is provided or that untreated drainage will meet applicable effluent and water quality standards.

7. Initial construction activities in areas to be disturbed shall be for collection and treatment facilities only. Prior to the start of other activities, surface drainage controls shall be constructed and operated to avoid violations of the Act or Subtitle D. At such time as runoff water is collected in the sedimentation pond, a sample shall be collected and analyzed, for the parameters designated as 1M through 15M under Part 5-C of Form 2C and the effluent parameters designated herein with the results sent to this Agency. Should additional treatment be necessary to meet the standards of 35 Ill. Adm. Code 406.106 or applicable water quality standards, a Supplemental Permit must be obtained. Discharge from ponds is not allowed unless applicable effluent and water quality standards are met in the basin discharge(s).

8. This Agency must be informed in writing and an application submitted if drainage, which was previously classified as alkaline (pH greater than 6.0), becomes acid (pH less than 6.0) or ferruginous (base flow with an iron concentration greater than 10 mg/L). The type of drainage discharging to the basin should be reclassified in a manner consistent with the applicable provisions of 35 Ill. Adm. Code Part 406. The application should discuss the treatment method and demonstrate how the discharge will meet the applicable standards.

9. A permittee has the obligation to add a settling aid if necessary to meet the suspended solids or settleable solids effluent standards. The selection of a settling aid and the application practice shall be in accordance with a. or b. below

    a. Alum ($Al_2(SO_4)_3$), hydrated lime ($Ca(OH)_2$), soda ash (Na_2CO_3), alkaline pit pumpage, acetylene production by-product (tested for impurities), and ground limestone are acceptable settling aids and are hereby permitted for alkaline mine drainage sedimentation ponds.

    b. Any other settling aids such as commercial flocculents and coagulants are permitted only on prior approval from the Agency. To obtain approval a permittee must demonstrate in writing to the Agency that such use will not cause a violation of the toxic substances standard of 35 Ill. Adm. Code 302.210 or of the appropriate effluent and water quality standards of 35 Ill. Adm. Code parts 302, 304, and 406.

10. A general plan for the nature and disposition of all liquids used to drill boreholes shall be filed with this Agency prior to any such operation. This plan should be filed at such time that the operator becomes aware of the need to drill unless the plan of operation was contained in a previously approved application.

11. Any of the following shall be a violation of the provisions required under 35 Ill. Adm. Code 406.202:

    a. It is demonstrated that an adverse effect on the environment in and around the receiving stream has occurred or is likely to occur.

b. It is demonstrated that the discharge has adversely affected or is likely to adversely affect any public water supply.

c. The Agency determines that the permittee is not utilizing Good Mining Practices in accordance with 35 Ill. Adm. Code 406.204 which are fully described in detail in Sections 406.205, 406.206, 406.207 and 406.208 in order to minimize the discharge of total dissolved solids, chloride, sulfate, iron and manganese. To the extent practical, such Good Mining Practices shall be implemented to:

i. Stop or minimize water from coming into contact with disturbed areas through the use of diversions and/or runoff controls (Section 406.205).

ii. Retention and control within the site of waters exposed to disturbed materials utilizing erosion controls, sedimentation controls, water reuse or recirculation, minimization of exposure to disturbed materials, etc. (Section 406.206).

iii. Control and treatment of waters discharged from the site by regulation of flow of discharges and/or routing of discharges to more suitable discharge locations (Section 406.207).

iv. Utilized unconventional practices to prevent the production or discharge of waters containing elevated contaminant concentrations such as diversion of groundwater prior to entry into a surface or underground mine, dewatering practices to remove clean water prior to contacting disturbed materials and/or any additional practices demonstrated to be effective in reducing contaminant levels in discharges (Section 406.208).

12. The four (4) foot compacted clay liner to be constructed course refuse disposal area, fine coal refuse area (RDA No. 3) and Sedimentation Basin 009 shall be subject to the specifications and procedures presented in IEPA Log No. 3001-15-C.

Construction Specifications

a. All soils to be used for the compacted clay liner shall be free of grass, vines, vegetation and rock or stones greater than four (4) inches in diameter.

b. Samples collected from the borrow area shall be evaluated in accordance with ASTM D422, D4318 and D2487 to ensure classification criteria are met.

c. Each successive soil lift shall be placed to a 6 to 8 inch loose thickness; however, in no instance shall the loose lift thickness exceed the length of the pads or feet on the compactor or roller.

d. Each soil lift shall be compacted to the minimum Standard Prototor (ASTM D698) density identified in item no. 12(q) below, at a moisture content of 0% to 5% above the optimum moisture content of the soil.

e. Inter-lift surfaces shall be adequately scarified to ensure inter-lifting bonding.

f. Liner construction shall be performed to consistent achievement of density, moisture content, and hydraulic conductivity for each successive lift.

g. The placement of frozen material or the placement material on frozen ground is prohibited.

h. Contemporaneous placement or protective covering shall be provided to prevent drying, desiccation and/or freezing where necessary.

i. Liner construction shall be completed in a manner which reduces void spaces within the soil and liner.

j. All construction stakes shall be removed during construction, and all test holes (Shelby tube samples) are to be backfilled with bentonite.

k. The compacted clay liner shall be constructed in a manner to achieve a uniform barrier with a hydraulic conductivity of 1×10^{-7} cm/sec.

l. In the event that acceptable compaction results are not achieved, the soil lift shall be reprocessed or removed and replaced. If moisture content is less than optimum, or greater than 5% above optimum, the falling material shall be wetted or dried to a moisture content within specification and re-compacted. If the dry density is below specification, the failing material shall be re-compacted until a passing test is achieved.

m. In the event of a failing conductivity test, the soil may be removed or re-compacted and retested until a passing result is obtained; or the soil immediately above and below the test specimen from the same Shelby tube may be tested. If both tests pass, the original test shall be nullified. If either test fails, that portion of the liner shall be rejected and shall be reconstructed and retested until passing results are obtained. The limits of necessary reconstruction shall be determined by additional sampling and testing within the failed region, thereby isolating the failing area of work.

Testing Specifications

n. Prior to initiating soil liner construction, borrow soils shall be identified, qualified, and verified. At minimum, a representative sample of each soil type identified within the borrow area is to be collected and analyzed for gradation, compaction, and hydraulic conductivity characteristics.

o. Samples collected from borrow area shall be evaluated in accordance with ASTM D422, D4318 and D2487 to ensure classification criteria are met.

p. Samples collected from the borrow area shall be tested in accordance with ASTM D 698 to determine maximum dry density and optimum moisture content of the soil.

q. Samples collect from the borrow area shall be compacted to 90% and 95% standard Proctor density at or near optimum moisture content. The hydraulic conductivity of the re-compacted samples shall be determined in accordance with ASTM D5084 procedures. The results of this testing shall be used to establish the minimum dry density for soil liner compaction necessary to achieve a hydraulic conductivity of 1×10^{-7} cm/sec or less.

r. Moisture and density testing by nuclear methods (ASTM D2922 and D3017) shall be conducted at a rate of at least one test per 1,000 cubic yards placed. Testing locations shall be random and shall not be known to the earthwork contractor prior to lift placement.

s. To ensure the accuracy and reproducibility of the nuclear testing, all nuclear density gauges shall be certified to calibration. Soil compaction tests shall be double-checked with independent test methods. A drive cylinder test and laboratory moisture content determination shall be conducted and compared to gauge readings. These independent checks shall be made at the outset of construction and on a bi-weekly basis (e.g., every ten working days) thereafter.

t. Samples for hydraulic conductivity verification shall be retrieved from the compacted soil liner and tested in accordance with ASTM D5084 procedures. Samples shall be retrieved using three-inch Shelby tubes. Samples shall be completed at frequency of one sample/test per 20,000 cubic yards placed. The vertical location of the recovered samples shall be varied so that representative portions or lifts of the contractor prior to soil liner construction.

u. Survey checks shall be conducted at a minimum spacing of 100 ft. centers, and at 100 ft. intervals along each line where a break in slope occurs, to verify liner thickness. To verify liner thickness, the survey checks shall be taken before and after liner construction.

13. Groundwater monitoring requirements for Well Nos. MW-12, MW-13, MW-14, MW-8R and MW-28 are as follows:

a. Ambient background monitoring shall be performed for all referenced wells. Such ambient monitoring shall consist of six (6) samples collected during the first year (approximately bi-monthly) following well installation but no later than during the first year of operation or disturbance to determine ambient background concentrations. Background monitoring shall include the following list of constituents:

Aluminum	Fluoride	Sulfate
Antimony	Iron (dissolved)	Thallium
Arsenic	Iron (total)	Total Dissolved Solids
Barium	Lead	Vanadium
Beryllium	Manganese (dissolved)	Zinc
Boron	Manganese (total)	pH (field)
Cadmium	Mercury	Acidity
Chloride	Molybdenum	Alkalinity
Chromium	Nickel	Hardness
Cobalt	Phenols	Static Water Elevation
Copper	Selenium	
Cyanide	Silver	

b. Following the ambient monitoring as required under Condition No. 13(a) above, routine monitoring shall continue on a quarterly basis as follows:

i. Monitoring Well Nos. MW-12, MW-13, MW-14, MW-8R and MW-28 shall continue to be monitored quarterly for the contaminants identified in Condition No. 12(a) above.

ii. Monitoring Well Nos. MW-12, MW-13, MW-14, MW-8R and MW-28 shall be monitored quarterly as required by IDNR/OMM for the following list of constituents:

Chloride	Total Dissolved Solids
Iron (dissolved)	Hardness
Iron (total)	Acidity
Manganese (dissolved)	Alkalinity
Manganese (total)	pH
Sulfate	Static Water Elevation

c. Following completion of active mining and reclamation, post-mining monitoring of all above referenced wells shall consist of six (6) samples collected during a 12-month period (approximately bi-monthly) to determine post-mining concentrations. Post-mining monitoring shall include the list of constituents identified in Condition No. 13(a) above.

d. Groundwater monitoring reports shall be submitted to the Agency in accordance with Special Condition Nos. 3 and 5 of this NPDES permit.

e. A statistically valid representation of background and/or post mining water quality required under Condition No. 13(b) above shall be submitted utilizing the following method. This method shall be used to determine the upper 95 percent confidence limit for each parameter listed above.

Should the Permittee determine that an alternate statistical method would be more appropriate based on the data being evaluated, the Permittee may request utilization of such alternate methodology. Upon approval from the Agency, the alternate methodology may be utilized to determine a statistically valid representation of background and/or post mining water quality.

The following method should be used to predict the confidence limit when single groundwater samples are taken from each monitoring (test) well.

i. Determine the arithmetic mean $\left(\overline{X}_b\right)$ of each indicator parameter for the sampling period. If more than one well is used, an equal number of samples must be taken from each well.

$$\overline{X}_b = \frac{X_1 + X_2 + \ldots X_n}{n}$$

Where:

$\overline{X}_b$ = Average value for a given chemical parameter

X_n = Values for each sample

n = the number of samples taken

ii. Calculate the background and/or post mining variance (S_b^2) and standard deviation (S_b) for each parameter using the values (X_n) from each sample of the well(s) as follows:

$$S_b^2 = \frac{(X_1 - \overline{X}_b)^2 + (X_2 - \overline{X}_b)^2 + \ldots + (X_n - \overline{X}_b)^2}{n-1}$$

$$S_b = \sqrt{S_b^2}$$

iii. Calculate the upper confidence limit using the following formula:

$$CL = \overline{X}_b \pm t\sqrt{1 + 1/n}\ (S_b)$$

Where:

CL = upper confidence limit prediction
(upper and lower limits should be calculated for pH)
t = onetailed t value at the required significance
level and at n1 degrees of freedom from Table 1
(a twotailed t value should be used for pH)

iv. If the values of any routine parameter for any monitoring well exceed the upper confidence limit for that parameter, the permittee shall conclude that a statistically significant change has occurred at that well.

v. When some of the background and/or post mining values are less than the Method Detection Limit (MDL), a value of one-half (1/2) the MDL shall be substituted for each value that is reported as less than the MDL. All other computations shall be calculated as given above.

If all the background and/or post mining values are less than the MDL for a given parameter, the Practical Quantitation Limit (PQL), as given in 35 Ill. Adm. Code Part 724 Appendix I shall be used to evaluate data from monitoring wells. If the analytical results from any monitoring well exceed two (2) times the PQL for any single parameter, or if they exceed the PQLs for two or more parameters, the permittee shall conclude that a statistically significant change has occurred.

Table 1
Standard tTables Level of Significance

Degrees of freedom	tvalues (onetail)		tvalues (twotail)*	
	99%	95%	99%	95%
4	3.747	2.132	4.604	2.776
5	3.365	2.015	4.032	2.571
6	3.143	1.943	3.707	2.447
7	2.998	1.895	3.499	2.365
8	2.896	1.860	3.355	2.306
9	2.821	1.833	3.250	2.262
10	2.764	1.812	3.169	2.228
11	2.718	1.796	3.106	2.201
12	2.681	1.782	3.055	2.179
13	2.650	1.771	3.012	2.160
14	2.624	1.761	2.977	2.145
15	2.602	1.753	2.947	2.131
16	2.583	1.746	2.921	2.120
17	2.567	1.740	2.898	2.110
18	2.552	1.734	2.878	2.101
19	2.539	1.729	2.861	2.093
20	2.528	1.725	2.845	2.086
21	2.518	1.721	2.831	2.080
22	2.508	1.717	2.819	2.074
23	2.500	1.714	2.807	2.069
24	2.492	1.711	2.797	2.064
25	2.485	1.708	2.787	2.060
30	2.457	1.697	2.750	2.042
40	2.423	1.684	2.704	2.021

Adopted from Table III of "Statistical Tables for Biological Agricultural and Medical Research" (1947, R.A. Fisher and F. Yates).

* For pH only when required.

NPDES Permit No. IL0077666

Special Conditions

Special Condition No. 1: No effluent from any mine related facility area under this permit shall, alone or in combination with other sources, cause a violation of any applicable water quality standard as set out in the Illinois Pollution Control Board Rules and Regulations, Subtitle C: Water Pollution.

Special Condition No. 2: Samples taken in compliance with the effluent monitoring requirements shall be taken at a point representative of the discharge, but prior to entry into the receiving stream.

Special Condition No. 3: All periodic monitoring and reporting forms, including Discharge Monitoring Report (DMR) forms, shall be submitted to the Agency according to the schedule outlined in Special Condition No. 4 or 5 below with one (1) copy forwarded to each of the following addresses:

Illinois Environmental Protection Agency
Division of Water Pollution Control
1021 North Grand Ave., East
P.O. Box 19276
Springfield, IL 62794-9276

Attn: Compliance Assurance Section

Illinois Environmental Protection Agency
Mine Pollution Control Program
2309 West Main Street, Suite 116
Marion, Illinois 62959

The Permittee will be required to submit electronic DMRs (NetDMR) instead of mailing paper DMRs to the IEPA, unless a waiver is approved by the Agency. More information, including registration information for the NetDMR program, can be obtained on the IEPA website, https://www2.illinois.gov/epa/topics/water-quality/surface-water/netdmr/Pages/quick-answer-guide.aspx.

Special Condition No. 4: Completed Discharge Monitoring Report (DMR) forms and as well as upstream and downstream monitoring results, shall be retained by the Permittee for a period of three (3) months and shall be submitted electronically (or mailed if waiver is approved by the Agency) and received by the IEPA at the addresses indicated in Special Condition No. 3 above in accordance with the following schedule, unless otherwise specified by the permitting authority.

Period	Received by IEPA
January, February, March	April 15
April, May, June	July 15
July, August, September	October 15
October, November, December	January 15

The Permittee shall record discharge monitoring results on Discharge Monitoring Report (DMR) forms using one such form for each Outfall and Discharge Condition each month. In the event that an Outfall does not discharge during a monthly reporting period or under a given Discharge Condition, the DMR form shall be submitted with "No Discharge" indicated.

Any and all monitoring results, other than NPDES outfall discharge results reported through NetDMR, shall be submitted to the Agency at the addresses indicated in Special Condition No. 3 above.

Special Condition No. 5: Completed periodic monitoring and reporting, other than DMR's and stream monitoring (i.e., groundwater monitoring, coal combustion waste analysis reports, etc.), shall be retained by the Permittee for a period of three (3) months and shall be mailed and received by the IEPA at the addresses indicated in Special Condition No. 3 above in accordance with the following schedule, unless otherwise specified by the permitting authority.

Period	Received by IEPA
January, February, March	May 1
April, May, June	August 1
July, August, September	November 1
October, November, December	February 1

Special Condition No. 6: The Agency may revise or modify the permit consistent with applicable laws, regulations or judicial orders.

Special Condition No. 7: If an applicable effluent standard or limitation is promulgated under Sections 301(b)(2)(C) and (D), 304(b)(2), and 307(a)(2) of the Clean Water Act and that effluent standard or limitation is more stringent than any effluent limitation in the permit or controls a pollutant not limited in the NPDES Permit, the Agency shall revise or modify the permit in accordance with the more stringent standard or prohibition and shall so notify the permittee.

Special Condition No. 8: The permittee shall notify the Agency in writing by certified mail within thirty days of abandonment, cessation, or suspension of active mining for thirty days or more unless caused by a labor dispute. During cessation or suspension of active mining, whether caused by a labor dispute or not, the permittee shall provide whatever interim impoundment, drainage diversion, and wastewater treatment is necessary to avoid violations of the Act or Subtitle D Regulations.

Special Conditions

Special Condition No. 9: Plans must be submitted to and approved by this Agency prior to construction of any future sedimentation ponds. At such time as runoff water is collected in the sedimentation pond, a sample shall be collected and analyzed for the parameters designated as 1M-15M under Part 5-C of Form 2C and the effluent parameters designated herein with the results sent to this Agency. Should additional treatment be necessary to meet these standards, a Supplemental Permit must also be obtained. Discharge from a pond is not allowed unless applicable effluent and water quality standards are met.

Special Condition No. 10: The special reclamation area effluent standards of 35 Ill. Adm. Code 406.109 apply only on approval from the Agency. To obtain approval, a request form and supporting documentation shall be submitted to request the discharge be classified as a reclamation area discharge. The Agency will notify the permittee upon approval of the change.

Special Condition No. 11: The special stormwater effluent standards apply only on approval from the Agency. To obtain approval, a request with supporting documentation shall be submitted to request the discharge to be classified as a stormwater discharge. The documentation supporting the request shall include analysis results indicating the discharge will consistently comply with reclamation area discharge effluent standards. The Agency will notify the permittee upon approval of the change.

Special Condition No. 12: Annual stormwater monitoring is required for all discharges not tributary to a sediment basin until Final SMCRA Bond is released and approval to cease such monitoring is obtained from the Agency.

a. Each discharge must be monitored for pH and settleable solids annually.

b. Analysis of samples must be submitted with second quarter Discharge Monitoring Reports. A map with discharge locations must be included in this submittal.

c. If discharges can be shown to be similar, a plan may be submitted by November 1 of each year preceding sampling to propose grouping of similar discharges and/or update previously submitted groupings. If updating of a previously submitted plan is not necessary, a written notification to the Agency indicating such is required. Upon approval from the Agency, one representative sample for each group may be submitted.

Special Condition No. 13: Sediment Pond Operation and Maintenance (Outfalls 001, 002, 003, 004, 005, 006, 007, 008, 009ES):

a. For discharges resulting from precipitation events, in addition to the alternate effluent (Discharge Condition Nos. II and III) monitoring requirements, as indicated on the applicable effluent pages of this Permit, discharges from Outfalls 001, 002, 003, 004, 005, 006, 007, 008, 009ES shall be monitored and reported for Discharge Rate, Sulfate, Chloride and Hardness.

b. The following sampling and monitoring requirements are applicable to flow in the unnamed tributary to Pond Creek which receive discharges from Outfalls 001, 002, 003, 004, 005, 006, 007, 008, 009ES.

   i. All sampling and monitoring required under 13(b)(ii) and (iii) below shall be performed during a discharge and monitoring event from the associated outfall.

   ii. Unnamed tributary to Pond Creek shall be monitored and reported quarterly for Discharge Rate, Chloride, Sulfate and Hardness downstream of the associated outfall. This downstream monitoring shall be performed a sufficient distance downstream of the associated outfall to ensure that complete mixing has occurred. At such time that sufficient information has been collected regarding receiving stream flow characteristics and in-stream contaminant concentrations the permittee may request a re-evaluation of the monitoring frequency required herein for possible reduction or elimination. For the purpose of re-evaluating the downstream monitoring frequency of the receiving stream, "sufficient information" is defined as a minimum of ten (10) quarterly sampling events.

   In the event that downstream monitoring of the receiving waters is eliminated during the term of this permit based on an evaluation of the quarterly data, a minimum of three (3) additional samples analyzed for the parameters identified above must be submitted with the permit renewal application a minimum of 180 days prior to expiration of this permit.

   iii. Unnamed tributary to Pond Creek shall be monitored and reported annually for Discharge Rate, Chloride, Sulfate and Hardness upstream of the associated outfall.

Special Condition No. 14: Sediment Pond Operation and Maintenance (Outfall 009):

a. No discharge is allowed from Outfall No. 009 during "low flow" or "no flow" conditions in the receiving stream, unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.

Pursuant to 35 Ill. Adm. Code Part 302.102, discharges from the referenced outfalls that otherwise would not meet the water quality standards of 35 Ill. Adm. Code Part 302 may be permitted if sufficient flow exists in the receiving stream to ensure that applicable water quality standards are met. That is, discharges not meeting the water quality standards of 35 Ill. Adm. Code Part 302 may only be discharged in combination with stormwater discharges from the basin, and only at such times that sufficient flow exists in the receiving stream to ensure that water quality standards in the receiving stream beyond the area of allowed mixing will not be exceeded.

The permittee shall determine the effluent limitation for chloride and/or the maximum effluent flow rate allowable to maintain water quality in the receiving stream. The following equations shall be used to make such determinations:

$$C_{DS} = [C_E Q_E + 0.25 C_{US} Q_{US}]/ (0.25 Q_{US} + Q_E)$$

Where:

C_E = Effluent concentration (mg/L)

Q_E = Effluent flow rate (cfs) for Outfall 009

Q_{US} = Upstream flow rate (cfs)

C_{US} = Upstream concentration (mg/L)

C_{DS} = Downstream concentration

The "calculated" downstream concentration shall be less than 500 mg/L for chloride and reported on the discharge monitoring reports (DMRs).

The permittee shall install a gauging station and conductivity monitor upstream of the discharge to determine an upstream flow (Q_{US}) and a chloride concentration (C_{US}) correlated to the conductivity value. In addition, the permittee shall install a continuous conductivity monitor downstream to ensure that the chloride concentration (correlated to the conductivity value) stays within the chloride water quality standard. The daily maximum downstream chloride concentration controlled to conductivity shall be reported on the DMR"s.

If there is no upstream mixing available for Outfall 009, the NPDES permit shall be regulated at 500 mg/L for Chloride and 1250 mg/L for Sulfate.

The upstream and downstream conductivity monitoring locations need to be approved by the Agency.

b. The following sampling and monitoring requirements are applicable to flow in Pond Creek which receives the discharges from Outfall 009.

   i. All sampling and monitoring required under 14(b)(ii) and (iii) below shall be performed during a discharge and monitoring event from the associated outfall.

   ii. Pond Creek shall be monitored and reported quarterly for Discharge Rate, Sulfate, Chloride and Hardness downstream of the associated outfall. This downstream monitoring shall be performed a sufficient distance downstream of the associated outfall to ensure that complete mixing has occurred. At such time that sufficient information has been collected regarding stream flow characteristics and in-stream contaminant concentrations, the permittee may request a re-evaluation of the monitoring frequency required herein for possible reduction or elimination. For the purpose of re-evaluating the downstream monitoring frequency of the receiving stream, "sufficient information" is defined as a minimum of ten (10) quarterly sampling events.

   In the event that downstream monitoring of the receiving waters is eliminated during the term of this permit based on an evaluation of the quarterly data, a minimum of three (3) additional samples analyzed for the parameters identified above must be submitted with the permit renewal application a minimum of 180 days prior to expiration of this permit.

   iii. Pond Creek shall be monitored and reported annually for Discharge Rate, Sulfate, Chloride and Hardness upstream of the associated outfall.

Special Condition No. 15: Sediment Pond Operation and Maintenance (Outfall 009 – Reclamation Area Discharge Classification):

a. For discharges resulting from precipitation events, in addition to the alternate effluent (Discharge Condition Nos. II and III) monitoring requirements, as indicated on the applicable effluent pages of this Permit, discharges from Outfall 009 shall be monitored and reported for Discharge Rate, Sulfate, Chloride and Hardness.

b. The following sampling and monitoring requirements are applicable to flow in the Middle Fork Big Muddy River which receive discharges from Outfall 009.

Special Conditions

i. All sampling and monitoring required under 15(b)(ii) and (iii) below shall be performed during a discharge and monitoring event from the associated outfall.

ii. Middle Fork Big Muddy River shall be monitored and reported quarterly for Discharge Rate, Chloride, Sulfate and Hardness downstream of the associated outfall. This downstream monitoring shall be performed a sufficient distance downstream of the associated outfall to ensure that complete mixing has occurred. At such time that sufficient information has been collected regarding receiving stream flow characteristics and in-stream contaminant concentrations the permittee may request a re-evaluation of the monitoring frequency required herein for possible reduction or elimination. For the purpose of re-evaluating the downstream monitoring frequency of the receiving stream, "sufficient information" is defined as a minimum of ten (10) quarterly sampling events.

In the event that downstream monitoring of the receiving waters is eliminated during the term of this permit based on an evaluation of the quarterly data, a minimum of three (3) additional samples analyzed for the parameters identified above must be submitted with the permit renewal application a minimum of 180 days prior to expiration of this permit.

iii. Middle Fork Big Muddy River shall be monitored and reported annually for Discharge Rate, Chloride, Sulfate and Hardness upstream of the associated outfall.

Special Condition No. 16: Sediment Pond Operation and Maintenance (Outfall 011):

a. Pursuant to 35 Ill. Adm. Code Part 302.102, discharges from the referenced outfalls that otherwise would not meet the water quality standards of 35 Ill. Adm. Code Part 302 may be permitted if sufficient flow exists in the receiving stream to ensure that applicable water quality standards are met. That is, discharges not meeting the water quality standards of 35 Ill. Adm. Code Part 302 may only be discharged in combination with stormwater discharges from the basin, and only at such times that sufficient flow exists in the receiving stream to ensure that water quality standards in the receiving stream beyond the area of allowed mixing will not be exceeded.

The permittee shall determine the effluent limitation for chloride and/or the maximum effluent flow rate allowable to maintain water quality in the receiving stream. The following equations shall be used to make such determinations:

$$C_{DS} = [C_E Q_E + 0.25 C_{US} Q_{US}]/ (0.25 Q_{US} + Q_E)$$

Where:

C_E = Effluent concentration (mg/L)

Q_E = Effluent flow rate (cfs) for Outfall 011

Q_{US} = Upstream flow rate (cfs)

C_{US} = Upstream concentration (mg/L)

C_{DS} = Downstream concentration

The "calculated" downstream concentration (CDS) shall be less than 500 mg/L for chloride and reported on the discharge monitoring reports (DMRs).

Chloride is limited in the NPDES permit at the limits described below. The maximum flow from Outfall 011 is 5,000 gpm and the maximum chloride concentration is 12,000 mg/L.

Sulfate and Iron (dissolved) shall be monitored from the effluent monthly when discharging.

The permit only allows a discharge when the Big Muddy River is flowing above 30 cfs. The maximum dispersion required for all water quality parameters is 34:1. Model predictions have been made for a maximum effluent total flow rate of 11.1 cfs. At the maximum chloride concentration of 12,000 mg/L, this maximum discharge requires a river flow of 1,734 cfs to meet a dispersion of 34:1 in less than 25 % of the river volume. The maximum distance to meet the water quality standard for all scenarios is 251 feet downstream with a plume width of 25 feet. The maximum zone of initial dilution to meet the acute Copper water quality standard for all scenarios is 18.2 feet downstream with a plume width of 4 feet.

The upstream flow (Q_{US}) should be based on the full flow measurement upstream of the proposed Outfall 011 that shall be approved by the Agency.

The upstream and downstream conductivity monitoring locations need to be approved by the Agency.

Special Conditions

The permittee shall install a conductivity monitor upstream of the discharge to determine a chloride concentration (C_{US}) correlated to the conductivity value. In addition, the permittee shall install a continuous conductivity monitor downstream to ensure that the chloride concentration (correlated to the conductivity value) stays within the chloride water quality standard. The daily maximum downstream chloride concentration controlled to conductivity shall be reported on the DMR's.

b. The following sampling and monitoring requirements are applicable to flow in Big Muddy River which receives the discharges from Outfall 011.

i. All sampling and monitoring required under 16(b)(ii) and (iii) below shall be performed during a discharge and monitoring event from the associated outfall.

ii. The Big Muddy River shall be monitored and reported quarterly for Discharge Rate, Sulfate, Chloride and Hardness downstream of the associated outfall. This downstream monitoring shall be performed a sufficient distance downstream of the associated outfall to ensure that complete mixing has occurred. At such time that sufficient information has been collected regarding stream flow characteristics and in-stream contaminant concentrations, the permittee may request a re-evaluation of the monitoring frequency required herein for possible reduction or elimination. For the purpose of re-evaluating the downstream monitoring frequency of the receiving stream, "sufficient information" is defined as a minimum of ten (10) quarterly sampling events.

In the event that downstream monitoring of the receiving waters is eliminated during the term of this permit based on an evaluation of the quarterly data, a minimum of three (3) additional samples analyzed for the parameters identified above must be submitted with the permit renewal application a minimum of 180 days prior to expiration of this permit.

iii. The Big Muddy River shall be monitored and reported annually for Discharge Rate, Sulfate, Chloride and Hardness upstream of the associated outfall.

Special Condition No. 17: Data collected in accordance with Special Condition Nos. 13, 14, 15 and 16 above will be utilized to evaluate the appropriateness of the effluent limits established in this Permit. Should the Agency's evaluation of this data indicate revised effluent limits are warranted; this permit may be reopened and modified to incorporate more appropriate effluent limitations. This data will also be used for determination of effluent limitations at the time of permit renewal.

Special Condition No. 18: Discharges from Outfalls 006, 007, 008, 009, 009ES and 011 shall be monitored twice annually with such monitoring spaced at approximately 6-month intervals during the entire 5-year term of this NPDES Permit. Sampling of the discharges shall be performed utilizing the grab sampling method and analyzed for total (unfiltered) concentrations. The results of the sampling required under this Special Condition shall be submitted twice annually to the Agency in January and July of each calendar year to the addresses indicated in the Special Condition No. 3 above. The parameters to be sampled and the detection limits (minimum reported limits) are as follows:

Parameter	Detection Limit
Arsenic	0.05 mg/L
Barium	0.50 mg/L
Cadmium	0.001 mg/L
Chromium (hexavalent)	0.01 mg/L
Chromium	0.05 mg/L
Copper	0.005 mg/L
Lead	0.05 mg/L
Manganese	0.50 mg/L
Mercury*	1.00 ng/l**
Nickel	0.005 mg/L
Phenols	0.005 mg/L
Selenium	2.000 µg/l***
Silver	0.003 mg/L
Zinc	0.025 mg/L

* Utilize USEPA Method 1631E and the digestion procedure described in Section 11.1.1.2 of 1631E.
** 1.00 ng/l (nanogram/liter) = 1 part per trillion.
*** µg/l = micrograms/liter

Exchange 55
Inspection Log

Chicago Department of Public Health "CDPH"
Office of Safety and Health Administration "OSHA"
United States Army Corp of Engineers
Metropolitan Water Reclamation District "MWRD"
Illinois Department of Public Health "IDPH"
Illinois Environmental Protection Agency "IEPA"
Chicago Fire Department

	Date	Agency	Reason for Visit	Result
1	10/23/2018	CDPH	Complaint: Fugitive dust	No Violations Issued, Project in Compliance and Good Standing
2	11/27/2018	CDPH	Reviewed demolition wetting procedures.	No Violations Issued, Project in Compliance and Good Standing
3	12/6/2018	CDPH	Complaint: Fugitive dust	No Violations Issued, Project in Compliance and Good Standing
4	12/7/2018	CDPH	Observed demolition.	No Violations Issued, Project in Compliance and Good Standing
5	12/18/2018	CDPH	Complaint: Fugitive dust	No Violations Issued, Project in Compliance and Good Standing
6	1/16/2019	CDPH	CDPH served a citation for two counts of creating dust during demolition of Fly Ash structure on December 6, 2018.	Two (2) Citations (Downgraded to administrative penalties during April 25, 2019 Administrative Court hearing) received from CDPH.
7	2/28/2019	CDPH	Anonymous Complaint. Inspectors reviewed all recording keeping, interviewed seven (7) laborers and inspected asbestos containment area.	No Violations Issued, Project in Compliance and Good Standing
8	4/29/2019	CDPH	Complaint: Insufficient wetting of asbestos material during abatement	No Violations Issued, Project in Compliance and Good Standing
9	6/29/2019	CDPH	Complaint: Insufficient wetting of asbestos material and excessive asbestos fibers in the air	No Violations Issued, Project in Compliance and Good Standing
10	7/9/2019	CDPH	Complaint: Insufficient watering in containment and at direction of IDPH.	No Violations Issued, Project in Compliance and Good Standing
11	7/10/2019	CDPH	Followed up to complete inspection on 7/9/2019	No Violations Issued, Project in Compliance and Good Standing
12	7/12/2019	CDPH	Followed up to complete inspection on 7/9/2019	No Violations Issued, Project in Compliance and Good Standing
13	9/18/2018	OSHA	Reviewed safety protocols. OSHA representatives requested documents and materials to support performance on site.	No Violations Issued, Project in Compliance and Good Standing
14	7/5/2019	OSHA	Complaint: Fugitive dust	No Violations Issued, Project in Compliance and Good Standing
15	7/9/2019	OSHA	Evaluated asbestos program, evaluated lead protection program, and reviewed air sampling files.	No Violations Issued, Project in Compliance and Good Standing
16	6/17/2018	United States Army Corps of Engineers	Expressed concerns on the demolition of the Crib House and Waste Water Treatment Plant. Took photographs of both structures.	No Violations Issued, Project in Compliance and Good Standing
17	12/21/2018	MWRD	Expressed thoughts on the Chicago Sanitary and Ship Canal and concerns of residents in thea area.	No Violations Issued, Project in Compliance and Good Standing
18	6/20/2018	IDPH	Evaluated abatement process.	No Violations Issued, Project in Compliance and Good Standing
19	1/16/2018	IDPH	Accompanied CDPH in issuing Citation for the release of dust. Citation was issued by CDPH and not IDPH.	No Violations Issued, Project in Compliance and Good Standing
20	2/28/2018	IDPH	Reviewed record keeping for abatement personnel including repitor fit testing and IL DPH licenses.	No Violations Issued, Project in Compliance and Good Standing
21	8/21/2018	IEPA (Water Quality Division)	Reviewed demolition plans, potential impacts on waterway, and environmental planning. An electronic copy of the Environmental Remediation Plan was provided.	No Violations Issued, Project in Compliance and Good Standing
22	3/28/2019	Chicago Fire Department	Conducted an inspection to determine potential culpability from structure that caught on fire two days prior. A finding of "no fault" was generated.	No Violations Issued, Project in Compliance and Good Standing

Exhibit 3

I oppose the Pond Creek application to dump waste into the Big Muddy. For the sake of all our lives do something right for once!!!

Jerry L. Dudley
P.O. Box 245
Ashley, IL 62808

SAINT LOUIS MO 630
18 JUL 2019 PM 6 L

USA FOREVER

USPS
1021 North Grand Ave
P.O. Box 19276 East
Springfield, IL
62794-9276

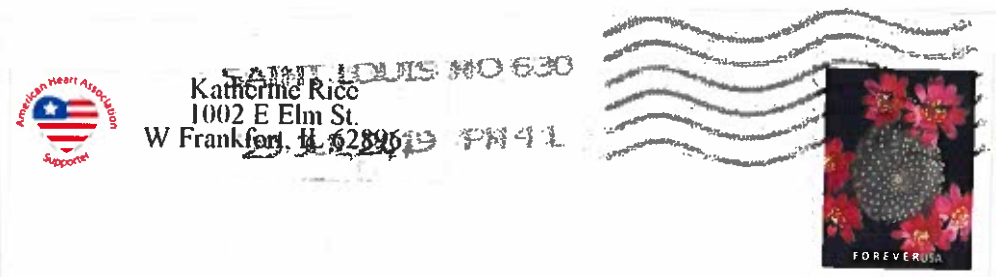
Exhibit 4

I oppose the dumping of toxic waste from Pond Creek Mining into the Big Muddy!

Please for our lives!

Don't poison all of us!!

R02846



USPS
1021 North Grand Ave East
P.O. Box 19276
Springfield, IL
62794-9276

WOLF KAHN
Fall Waters (Connecticut River), 1995
Oil on canvas, 43 x 72 in.
Courtesy of Beadleston Gallery, New York

SAINT LOUIS MO 630
29 JUL 2019 PM 4 L



Exhibit 5

Re: Pond Creek Mine
Approvals (Williamson Energy)
Permit #'s { IL0077666 and 7516C

The highly contaminated waste water (sulfates + chloride) cannot be pipelined to + dumped in the Big Muddy River below the gauging system. If it were gauged it would be deemed unsafe. Don't allow profits over people's health

I.D.N.R.
1021 N. Grand Ave. E.
P.O. Box 19276
Springfield, IL
62794-9276

Bonnie Burton
7040 Old Hwy 51 N.
Cobden, IL 62920

© 2000 Wolf Kahn

62794-9276

We all know the Big Muddy [illegible] thanks. This will be an environmental concern for decades to come.

July 29, 2019

To: the Illinois Environmental Protection Agency:

Re: IL0077666 and 7516C

Exhibit 6

From: Laraine Wright
194 Peachtree Lane
Carbondale IL 62902

I am calling for a public hearing on your proposal to discharge mine waste water into the Big Muddy River. This is a completely unnecessary action in our era of moving away from coal to promote, invest in, and build clean, sustainable energy sources.

I suspect you are being pressured by state and Congressional politicians and for short-term political gain — rather than environmental protection. A public hearing will let us get a clearer set of facts on this proposal. The Big Muddy is not a straight channel: look at a map!

R02849

Laraine Wright
194 Peachtree Lane
Carbondale IL 62902

SAINT LOUIS MO 630
29 JUL 2019 PM 5 L



Illinois Environmental Protection Agency
Post Office Box 19276
1021 North Grand Ave. East
Springfield IL 62794-9276

62702-407293

Name: Chris Burton Exhibit 7

Address: PO BOX 1161
DUQUOIN, ILLINOIS 62832

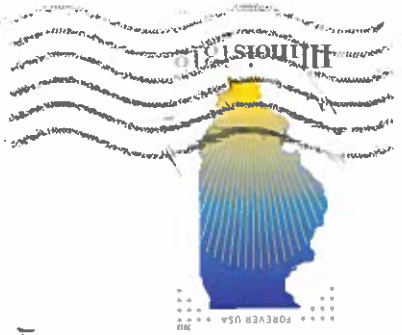
Nature of Issue: I DO NOT SUPPORT DUMPING WASTE WATER FROM POND CREEK MINE OR ANY MINE INTO THE BIG MUDDY RIVER.

Evidence Supporting: THE MINE ITSELF STATES THAT THE WASTEWATER POSES A DANGER TO MINERS AND ENVIRONMENT, IN THIER APPLICATION.

Burton
PO Box 1161
Duquoin, IL. 62832

SAINT LOUIS MO 630

30 JUL 2019 PM 5 L



CO: BIG MUDDY River Dumping
1021 North Grand Avenue East
Post office Box 19276
Springfield, IL. 62794

62794-927676

R02851

Exhibit 8

July 30, 2019

Illinois Environmental Protection Agency
PO Box 19276
Springfield, IL 62794-9276

RE: Williamson County Energy - Pond Creek Mine

TO WHOM IT MAY CONCERN:

Please consider this correspondence as a resounding NO to allowing the dumping of waste water from Pond Creek Mine into the Big Muddy River. We are just now recovering from a disastrous flood. The thought of contamination of the river, the fish and wildlife it serves, as well as farmland and recreational areas around the river is something that cannot be ignored.

It is my understanding from Pond Creek Mine's application and/or permit that we are looking at potentially 3.5 million gallons per day dumping into the Big Muddy River. THIS IS UNACCEPTABLE!!! This is a problem for Pond Creek Mind to resolve, not those who live on and use the Big Muddy River. The people of southern Illinois deserve better from the IEPA than to allow this to happen.

Sincerely,

Debra Mileur

Debra Mileur
8496 Old Hwy 13
Murphysboro, IL 62966

ST LOUIS 630
30 JUL 2019
PM 2L

FIRST-CLASS

PITNEY BOWES

US POSTAGE

02 1P $ 000.50⁰
0002105776 JUL 30 2019
MAILED FROM ZIP CODE 62959

IEPA
PO Box 19276
Springfield, IL 62794-9276

62794-927676

R02853

July 30, 2019

Exhibit 9

USPS
1021 N. Grand Ave. East
P.O. 19276
Springfield, IL 62794-9276

Dear Sir:

Please reconsider dumping millions of gallons of toxic water into the Big Muddy River from the Pond Creek Mine. This could cause flooding, damage to fish and wildlife, and environmental problems. We should be taking care of the environment, not causing problems.

Also please consider how this will affect people living along this river. Thank you for considering my opinion.

Yours truly,
Linda Craig
Herrin, IL

Ms. Linda Craig
811 Melody Ct.
Herrin, IL 62948-2472

SAINT LOUIS MO 630
30 JUL 2019 PM 10 L



USPS
1021 N. Grand Ave East
P.O. 19276
Springfield, IL 62794-9276

62794-927676

R02855

Exhibit 10

Dotty Mitchell
108 E Mitchell St
Macon, IL 62959

To Whom it may Concern,

This is in response to the request of Williamson Energy to dump mine waste water into the Big Muddy River.

This area is a rural, low income region. The river is a source of recreation as well as wild life watering. Most importantly, it is a food source to many. The Big Muddy provides fish for many low income families who try to supplement their food supply to ease their financial burdens. As a child I fished the river with my father many times for just such a reason.

This proposed dumping would make the fish inedible, that is, if they don't die first.

I site U.S. Dept of the Interior Water resources investigations Report 99-4288 2000 as supportive evidence.

Please don't do this to S. Illinois!

Dotty Mitchell

D. L Mitchell
103 E Mitchell St
Marion, IL 62959

SAINT LOUIS MO 630
31 JUL 2019 PM 7 L



Illinois EPA
1021 North Grand Ave East
PO Box 19276
Springfield, IL 62794-9276

62794-927676

R02857

Exhibit 11

Ladies & Gentlemen

I am writing to voice my complete opposition to dumping waste water from the Pond Creek Mine into the Big Muddy River.

I am opposed because it would be quite possible for the operators of the mine to dig a pit for their waste water and to treat it on their own property. This is just another example of a private corporation reaping profits while dispersing liabilities to the public.

Our environment faces plenty of challenges and is being degraded daily. It's time to actually try to protect it, rather than turn it over to corporations trying to evade their responsibilities.

Evelyn Stenger
336 County Line Rd
Grand Chain IL
62941

SAINT LOUIS MO 630

21 AUG 2009 PM 9 L



1021 N. Grand Ave. East
PO Box 19276
Springfield IL
62794-9276

62794-527676

R02859

Exhibit 12

Dear I.E.P.A.

Please do what you can to prevent Pond Creek Mine from poluting the water. It's our most precious commodity. People don't realize that conserving our water is the most important thing they can't replace if there comes a time when its scarce.

Doris Snider
53 Private Rd 1M
De Soto, Il
62924

RS.
I'm 92 yrs old
and thinking of my grandchildren

DORIS SNIDER
53 PRIVATE Rd 1M
DE SOTO, IL 62924

ST LOUIS MO 630
02 AUG 2019 PM 5 L



I.E.P.A.
1021 N GRAND AVE. EAST
PO Box 19276
SPRINGFIELD, IL 62794-9276

34-927676

To Whom This Concerns

Exhibit 13

Please stop all waste pollution and impact....

Ancient native american saying -

"We dont inherit the earth from our ancestors; we borrow it from our children."

I live in So. AZ. but want all in our country to do much better



BNP

VOICE OF THE READER

Big Muddy River crisis

.To the Editor:

Thanks to The Southern for keeping us informed about the Pond Creek Mine's application to dump millions of gallons of toxic water into the Big Muddy River.

I'm urging all of you to write to the IEPA opposing their "tentative" approval of this project and to request a public hearing.

No environmental impact studies have been done on the long term effects of this proposal: cumulative water quality, effects on fish and wildlife, bank erosion, flooding, the climate crisis, social and environmental costs to the people along the course of the river, many of whom are already impoverished. The public hearing held by IDNR last October was poorly publicized. This wealthy corporation is offering little bonding to offset any problems that might arise, and no plan for detoxifying the water beyond a series of sediment ponds, which of course can overflow during periods of heavy rain.

Also, to clear up some misinformation: There is NO Severance Tax on coal in Illinois. Legislation to create one has stalled in the legislature since March. So neither the state nor the local communities will benefit from that.

Most of this coal will be sold abroad, also no benefit to Southern Illinoisans.

The email address to comment is: darin.lecrone@illinois.gov. Include the NPDES IL0077666 & Notice No. 7516c in your subject line and on each page. You can also use USPS address 1021 North Grand Avenue East, Post Office Box 19276 Springfield, Illinois 62794-9276. The deadline is Aug. 12 – for receipt, not postmark, so act soonest!

Thank you.

Jan Thomas
Murphysboro

THE SOUTHERN ILLINOISAN

SAINT LOUIS MO 630

29 JUL 2019 PM 3 L



FOREVER / USA

"Big Muddy River Crisis"
IEPA
1021 North Grand Ave. East
Post Office Box 19276
Springfield, IL
62794-9276

Exhibit 14

EPA.PublicHearingCom

From: Kathleen Doherty <kathleendoh2010@hotmail.com>
Sent: Wednesday, July 31, 2019 8:46 PM
To: EPA.PublicHearingCom
Subject: [External] Pond Creek. NPDES Permit No. IL0077666 Notice No. 7516c

Dear Illinois Environmental Protection Agency:

Dumping toxic mine waste into the water source for drinking water is incredibly short sighted and stupid. Absolutely NO dumping into the Big Muddy and her tributaries. Water is life. It is the economic and environmental heart of Southern Illinois. And it is necessary for healthy children and adults.

Do not allow a mining company to poison our state for short term gain. We know that the tax payers of Illinois will clean up their mess. NO.

Listen to the people, not the money.

Kathleen Doherty
770 Dodge Ave
Evanston, IL 60202

Sent from my iPhone

Exhibit 15

EPA.PublicHearingCom

From: ED HEIERMAN <eheierman@yahoo.com>
Sent: Wednesday, July 31, 2019 9:06 PM
To: EPA.PublicHearingCom
Subject: [External] Big Muddy

Dear Illinois Environmental Protection Agency:

The dumping of toxic mine waste into the water source for drinking water is incredibly short sighted. Their shouldn't be any dumping into the Big Muddy and her tributaries. Our water sources must be protected from contamination.Water is the economic and environmental heart of Southern Illinois. And it is necessary for healthy children and adults.

Please do not allow a mining company to poison our water for short term gain.

Ed Heierman...

Exhibit 16

EPA.PublicHearingCom

From: Dawna Miller <dawnamiller76@yahoo.com>
Sent: Sunday, August 4, 2019 7:54 PM
To: EPA.PublicHearingCom
Subject: [External] NPDES IL0077666 & Notice No. 7516c

To Whom it may concern
From: Dawna Miller
Re: NPDES IL0077666 & Notice No. 7516c

I respectfully ask that the proposal to allow Williamson Energy to dump waste water into the Big Muddy River be denied. The thought of one more of this country's beautiful water ways being polluted by yet another energy corporation is mind boggling. How many more water sources do we have to poison to realize that we, as a human race, have no more drinkable water? We are not just poisoning ourselves but all of the plants and animals that depend upon these resources for survival. The crops that are grown next to these water ways will be toxic and guess who then will consume them? So, we will in fact be contributing to our own demise by lack of clean water and also by contaminated produce. I think the biggest question we need to ask ourselves is how do explain to our children, grandchildren, and perhaps our great grandchildren how we allowed THEIR water to be so contaminated and so scarce that they have to ration it and perhaps do without? We are water beings; our bodies depend on clean water to function properly. If we have to ration water or drink contaminated water our bodies will not be able to operate properly. The water we drink now already had so much chemicals in it that I filter my water and just look at around at all of the stories in the news regarding lead poisoning from the pipes, all of the fluoride in our water, arsenic, etc. At the rate in which the human race is destroying virtually every resource we have upon and within this planet I shutter to think what is in store for my descendants. I want to be able to look them in the eye and tell them I did everything I could to preserve the resources on this planet. We have much more at stake here than jobs or lining the pockets of the already uber rich. This is our very existence. The time has come to not just consider renewable energy it is time to put it in place. Then we create jobs and save our resources at the same time. Please reconsider the ramification of what is being proposed.

Dawna Miller
113 Holly Terrace
Anna IL. 62906

Sent from Mail for Windows 10

Exhibit 17

EPA.PublicHearingCom

From: Jay Bull <jaybull@gmail.com>
Sent: Monday, August 5, 2019 9:01 AM
To: EPA.PublicHearingCom
Subject: [External] NPDES Permit No. IL0077666 Notice No 751c

NPDES Permit No. IL0077666 Notice No 751c

I live in Murphysboro, IL, and I would like a hearing about the decisions to allow coal waste dumped into one of the main waterways in our area. The Big Muddy feeds into many lakes and rivers in the region - a region that has a healthy amount of tourism for fishing, swimming, and hunting bringing in money to the area - and destroying the animals that live there is unacceptable.

We do not need the business of a coal company that wants to pollute one of the main rivers in this area. We need to keep our rivers clean and our environment unpolluted.

I am against this 100% and I demand that a public hearing be held to discuss this disastrous and stupid idea.

Thank you,
Jennifer "Jay" Bull
2031 Gartside St, Murphysboro, Il 62966
618-201-1232

Author of
Hel's Belles, Kindle Edition
Hel's Belles, Paperback Edition
Hands Full of Shadow, Kindle Edition
Hands Full of Shadow, Paperback Edition

Exhibit 18

EPA.PublicHearingCom

From: Sandy Hoskins <sanleeott@gmail.com>
Sent: Monday, August 5, 2019 2:03 PM
To: EPA.PublicHearingCom
Cc: Senator Richard Durbin
Subject: [External] NPDES Permit No. IL0077666 Notice No. 7516c

Save the Big Muddy! Request a public hearing to STOP polluting under the permit referenced above!

Exhibit 19

EPA.PublicHearingCom

From: Sandy Hoskins <sanleeott@gmail.com>
Sent: Monday, August 5, 2019 2:09 PM
To: EPA.PublicHearingCom
Subject: [External] Save the Big Muddy River

I, Sandra Hoskins, 66 Conifer Lane, Murphysboro, IL 62966 request a public hearing on the damages to our environment posed by the following permit: Please HELP SAVE OUR RIVER and, MORE IMPORTANTLY, OUR PLANET.

NPDES Permit No. IL0077666 Notice No. 7516c

IEPA Conclusion: Upon completing the assessment, it has been determined that the proposed activity will result in only short term temporary increase in pollutant loading and will not result in long term or permanent impact to existing uses including aquatic life habitat; therefore we find that it is subject to Subsection (d) "Activities not subject to a further Antidegradation Assessment" of 35 ILL. Adm. Code 302.105

Exhibit 20

EPA.PublicHearingCom

From: lisa suits <lisasuits123@gmail.com>
Sent: Monday, August 5, 2019 8:30 PM
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine wastewater

I am against the Pond Creek Mine being granted a permit to dump its wastewater into the Big Muddy River (or any river at all).

I don't see how dumping 3 million gallons of wastewater A DAY from a coal mine could possibly be considered ENVIRONMENTAL PROTECTION. The IEPA isn't protecting a damn thing by dumping water containing chloride and sulfates into a PUBLIC WATERWAY.
There is also increased danger of flooding.
This is going to have negative impacts on everything that lives in and depends on the water, including people.

Lisa Suits
2210 E. Bearfield Subdivision
Columbia, MO 65201

Post Office Box 279
Hurst, IL 62949-0279
August 5, 2019

Dear Sirs & Madams;

In regards to NPDES IL 0077666 & Notice No. 7516c I strongly object to Williamsons' Energy request to dump millions of gallons of waste water into the Big Muddy River.

Having grown up and lived near this river all of my life, I view it as something to conserve. The wildlife which lives near the river and the aquatic life which the river sustains deserve protection. The greater good supercedes money and work force considerations.

I dare say that all who live along and use this river agree with me.

Yours truly,
Mae L. Harris

EXHIBIT 21

R02873



Mae Hanns
PO Box 279
Hurst, IL 62949



To Whom It May Concern
1021 North Grand Avenue East
Post Office Box 19276
Springfield, IL
62794-9276

R02874

Post Office Box 279
Hurst, IL 62949-0279
August 5, 2019

Dear Sirs + Madams;

In regards to NPDES IL 0077666 + Notice No. 7516c
I strongly object to Williamsons' Energy request to dump millions
of gallons of waste water into the Big Muddy River.

Having grown up and lived near this river all of my life,
I view it as something to conserve. The wildlife which lives
near the river and the aquatic life which the river sustains
deserve protection. The greater good supercedes money and
work force considerations.

I dare say that all who live along and use this river
agree with me.

Yours truly,
Mae L. Hanna

EXHIBIT 21

R02875



Mae Hanns
PO Box 279
Hurst, IL 62949



To Whom It May Concern
1021 North Grand Avenue East
Post Office Box 19276
Springfield, IL
62794-9276

R02876

Exhibit 22

Aug 3, 2019

IEPA:

Please do not allow Williamson Energy to dump their sewage into the Big Muddy River.

It is your job to protect these waterways and our frail eco-systems + not accomodate those who would destroy our world for the sake of the dollars involved.

Thanks - I ~~know~~ hope you will have faith do what is right for our environment.

Sincerely,

Judy Hawkins
Du Quoin, IL 62832

R02878

Ruth E. Hawkins
1037 N. Hickory St
Du Quoin, Ie 62832

SAINT LOUIS MO 630
05 AUG 2019 PM 10 L



I.E.P.A.
1021 N. Grand Ave. East
PO Box 19276
Springfield, Ie 62794-9276

62794-927676

Exhibit 23

8/4/19

Re: NPDES IL0077666
Notice No 7516C

I oppose the dumping of Waste Waster by the Coal Co into the Big Muddy River

Nelda Jent

NELDA JENT
1109 TROUT AVE
Johnston City IL
62951
618-983-5320

1109 (1) Front Ave
IL 62951

SAINT LOUIS MO 630
5 AUG 2019 PM 2L



1021 N Grand Ave East
P O Box 19276
Springfield IL 62794-9276

62794-927676

R02880

Exhibit 24

August 4, 2019

Dear I. E. P. A -

Please do not allow Williamson Energy to discharge their toxic waste waters into the Big Muddy River.

To allow such waste would be a travesty.

Judith A Becker

Bill & Judy Rea
7542 Park Street Road
Benton, Illinois 62812

SAINT LOUIS MO 630
06 AUG 2019 PM 7 L



I. E. P. A.
1021 No. Grand Ave East
P.O. Box 19276
Springfield, IL. 62794-9276

62794-927676

R02882

Exhibit 25

IEPA
NPDES IL0077666, NOTICE NO. 7516C

My family and I own 64 acres that the Big Muddy River flows through. We hunt and fish the river. We are against your allowing the Coal Creek Mine to pollute the water that flows onto our property.

Tim Moss
664 Little Wolf Rd.
Carbondale, IL.
62902

R02884



Tim Moss
6641 Little Wolf Rd.
Carbondale, IL 62902

SAINT LOUIS MO 630

05 AUG 2019 PM 5 L

IEPA
1021 North Grand Ave. East
P.O. Box 19276
Springfield, Illinois
62794-9276

62794-927676

Exhibit 26

8-7-19

USPS
1021 N. GRAND AVE E
PO Box 19276
SPRINGFIELD, IL 62794
RE: NPDES IL 0077666
NOTICE # 7516C

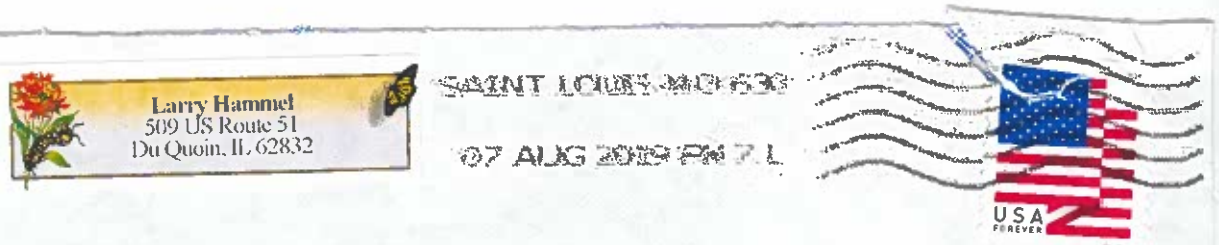
Running Pond Creek mine water into Big Muddy river is not a solution to their water problem. The mine should be required to filter and clean up their toxic water not dump it in the river.

Who knows what problems this might cause later for people. This is a disaster waiting to happen and needs to be stopped before the Big Muddy is ruined.

Larry Hammel

Larry Hammel
509 US Route 51
Du Quoin, IL 62832

R02886



USPS
1021 N. GRAND AVE E
PO BOX 19276
SPRINGFIELD, IL 62794

RE: NPDES IL 0077666

Exhibit 27

Wilma Hammel
509 US Route 51
Du Quoin, IL 62832

Aug. 7, 2019

USPS
1021 N. Grand Ave. E.
P.O. Box 19276
Springfield, IL 62794
RE: NPDES IL0077666
Notice # 7516C
To whom it may Concern:

I sincerely hope you will deny the application from Williamson Energy regarding their plan to run their poisonous chemical water into the Big Muddy River. There are too many unknowns about the massive discharge. Who will be in charge of monitoring and testing these chemicals? You sure can't rely on the mine company to monitor it.

When there is flooding, like we seem to have yearly, where will these toxic chemicals go — directly on peoples yards and farm fields!

You are supposed to be protecting the people of the State of IL, not lining the pockets of one Coal Company. Please consider us in your decision and deny this application.

Sincerely

Wilma Hammel

R02887

R02888

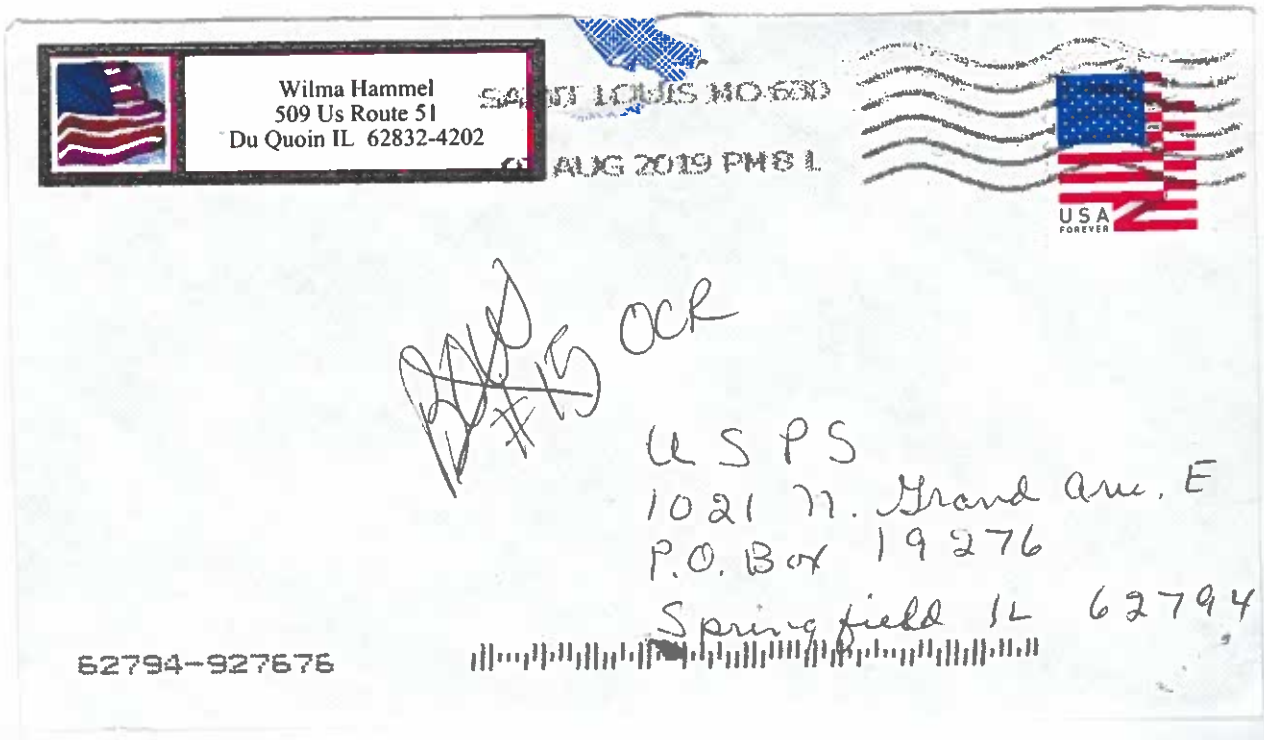

Wilma Hammel
509 Us Route 51
Du Quoin IL 62832-4202
ST LOUIS MO 630
AUG 2019 PM 8 L
USA
FOREVER
#15 OCR
USPS
1021 N. Grand Ave. E
P.O. Box 19276
Springfield IL 62794
62794-927676

Exhibit 28

August 5, 2019

1021 North Grand Avenue East
P. O. Box 19726
Springfield, IL 62794-9276

Linda L Wright
416 Gosnell Road
DeSoto, IL 62924

To Whom It May Concern:

I am very much against Pond Creek dumping wastewater into the Big Muddy River for or several reasons.

I live very close to the Big Muddy River in the North West corner of Williamson County. Because we have had so much rain this year the low area behind my house has been full of water since April or May and has just recently subsided. The Water also gets over the road south and up into my lower field. In 2011 it also flooded the road north of me so I could not get out either way. It also came over my pond dam.

Dumping 3.5 million gallons of water into the river each day will increase the flooding problem in this area. The water gets up almost to the road along 149, around the Pentecostal church and covers the road leading into Blairsville. This happens almost every spring. The extra 3.5 gallons will only increase the problem and flooding damage. Along with this water come mosquitos and the smell of rotten vegetation.

I also have concerns about the chemicals will be dumped into the river and the effect on the environment. Many people still fish in the Big Muddy and the wildlife in the area drink and live in and along the river. I see no way the chemicals that are going to be in this water will improve the river. We have eagles nesting along the river bank along with many land creatures that make their home in my wooded acreage. I don't want these animals and trees/foliage to be eliminated by the water that will be coming from this mine.

I hope you will keep the residents that live along this river in mind when you make a decision on this dumping. Please consider what is a stake if this river is damaged with chemicals and the amount of flooding that will affect so many along the river path.

Concerned citizen,

Linda L. Wright

Linda L. Wright

Linda Wright
416 Gosnell Road
DeSoto, IL 62924

SAINT LOUIS MO 630

16 AUG 2019 PM 9 L



OCR

1021 North Grand Avenue East
P. O. Box 19726
Springfield, IL 62794-9276

Re: Pond Creek Mine

62794-972626

R02890

Exhibit 29

NPDESIL 0077666
NOTICE No. 7516c

TO: IEPA

This short letter is to ask your organization to reject POND CREEK MINES request to dump coal mine water in THE BIG MUDDY RIVER.

The risk of polluting the river is to great to allow this project which could affect thousands of Southern Illinoisans

ROBERT B. PILAND

Lifetime Illinoisan
Born ROSICLARE, IL. 6-24-27

Mr Bob Piland
71 Pineview Rd
Carbondale, IL 62901

SAINT LOUIS MO 630
07 AUG 2019 PM 6 L



OCR

IEPA
1021 NORTH GRAND AVE. EAST
P.O. BOX 19276
SPRINGFIELD, ILL.62794-9276

62794-927676

R02892

IEPA,

Exhibit 30

My name is Carmen Burzynski I live in Franklin County, Illinois. I am much opposed to giving approval to Williamson Energy: NPDES IL0077 666 (take a look at the last 3 digits) + Notice NO. 7516C to dump their waste water into the Big Muddy River. The IEPA should not grant any industry the approval to dump toxic waste into any body of water, especially, a living, flowing river that runs through towns, farmlands and lakes that feed into the Mississippi River. Rivers were created to give life to people, vegetation, and creatures of all types, and not to poison and destory.

Carmen Burzynski (618-218-4023)
22173 Clark Rd., Macedonia, IL. 62860

R02894

Carmen Burzynski
22173 Clark Rd.
Macedonia, IL. 62860

SAINT LOUIS MO 630
30 AUG 2019 PM 6 L



IEPA
1021 North Grand Ave. East
P.O. Box 19276
Springfield, IL. 62794-9276

62794-927676

Exhibit 31

EPA.PublicHearingCom

From: Matt Battaglia <mmbattaglia@gmail.com>
Sent: Thursday, August 8, 2019 9:31 PM
To: EPA.PublicHearingCom
Subject: [External] NPDES IL0077666 Notice No. 7516c

To Whom It May Concern,

My name is Matt Battaglia I am a fourth generation farmer. I am writing this email regarding the permit application(NPDES IL0077666, Notice No. 7516c) for the Pond Creek mine to allow the disposal of waste water from its mine into the Big Muddy River. Allowing this will greatly impact the agricultural productivity of our ground and livelihood and I am asking that this permit be reconsidered and request more hearings on the matter.

Thank You, Matt Battaglia
714 Walnut Road
Royalton, IL 62983
Sent from my iPhone

Exhibit 32

EPA.PublicHearingCom

From: Kaitlin Battaglia <ktcoosh@hotmail.com>
Sent: Thursday, August 8, 2019 9:34 PM
To: EPA.PublicHearingCom
Subject: [External] NPDES Permit No. IL0077666 Notice No 7516c

To whom it may concern,

I would like to let you know that I am opposed to dumping of wastewater into the Big Muddy River (NPDES Permit No. IL0077666 Notice No 7516c). Please do not let this happen. Let's preserve Southern Illinois and do the right thing by not polluting our river. I know that coal mining is important for our area's economy, but surely there must be a better way for the mine to dispose of their waste. For the sake of our environment and the health of the people of Southern Illinois, please do not allow the polluting of the Big Muddy River by the Pond Creek Mine. I would like to request a public hearing. Thank you for your time.

Kaitlin Battaglia
714 Walnut Rd
Royalton, IL
62983

Exhibit 33

EPA.PublicHearingCom

From: Chuck Mitroka <chuckmitroka@gmail.com>
Sent: Friday, August 9, 2019 7:35 AM
To: EPA.PublicHearingCom
Subject: [External] NPDES Permit No. IL0077666, Notice No. 7516c

To Whom It May Concern,

My name is Charles Mitroka Jr. and I am a farmer in Franklin county Illinois. I am writing this email to say I am against allowing the dumping of waste water into the Big Muddy River by the Pond Creek Mine(NPDES IL0077666, Notice No. 7516c). I feel allowing this would not only be harmful to our areas important water way, but also to the farm ground that borders the river. I would also like to request more public hearings on the matter.

Thanks, Charles Mitroka Jr.
582 Walnut Road
Royalton,IL 62983

Exhibit 34

EPA.PublicHearingCom

From: Megan Flexter <meganflexter@gmail.com>
Sent: Friday, August 9, 2019 8:50 AM
To: LeCrone, Darin; EPA.PublicHearingCom
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Hello,

I along with many Southern Illinoisans oppose any dumping of waste water into our Big Muddy River. I request a public hearing on the matter. My name is Megan Flexter and I live on 12173 E Bunny Farm Rd in Mount Vernon, Il.

Thank you,

Megan Flexter & Family

Exhibit 35

EPA.PublicHearingCom

From: Ananimal 999 <starpeace999@gmail.com>
Sent: Friday, August 9, 2019 8:02 PM
To: EPA.PublicHearingCom; DNR.Mmlrd
Subject: [External] Save The Big Muddy River from Coal Dump

Hi please do what you can to stop the coal company from polluting the river. As aa kayaker I am very sad that this is happening and am asking you to do something about protecting the Big Muddy River!

Exhibit 36

EPA.PublicHearingCom

From: S Browne <soltys.browne@gmail.com>
Sent: Saturday, August 10, 2019 8:32 AM
To: EPA.PublicHearingCom; DNR.Mmlrd; LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c - Pond Creek Mine Big Muddy River

To: Darin Lecrone, et al
Subject: NPDES IL0077666 & Notice No. 7516c

Dear Mr. Lecrone and officials at IEPA and IDNR,

I oppose the use of the Big Muddy River for dumping of coal mining waste. The Big Muddy River basin includes many tributaries and drinking water sources in southern Illinois. There are too many public health and environmental risks.

Instead, Williamson Energy should utilize technology and science to process its waste without using public land and water.

Thank you for respecting public comments regarding this matter. We should do everything we can to ensure clean drinking water and biodiversity in our beautiful part of Illinois. Allowing this dumping permit could also someday cost the state which could be found liable for future health impacts.

As noted in the Southern Illinoisan newspaper, the Big Muddy River belongs to the people of Illinois. The state should not have the authority to sublet an entire river.

Sincerely,
Deb Browne
2029 Navajo Dr., Carbondale IL 62902
Williamson County, Illinois

Exhibit 37

EPA.PublicHearingCom

From: Kathy Livingston <kathyliving@midwest.net>
Sent: Sunday, August 11, 2019 3:32 PM
To: EPA.PublicHearingCom
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Greetings:

I am writing with regard to the proposed pipeline and dumping of coal mine waste water into the Big Muddy River.

According to the Shawnee Group of the Sierra Club:

•" No assessment is provided of the biological or other environmental impacts of the proposed mixing of this contaminated mine water on the ecosystem and current uses (fishing, livestock, recreation, etc.) of the Big Muddy River

• No assessment is provided of the cumulative water quality impacts on the Big Muddy River from this proposal over the many years of continued coal mining

• No assessment is given either of what such a large groundwater withdrawal quantity could be doing to the local area or what implications this might have for the future"

According to the Illinois Natural History Survey (2019), "LaRue Pine Hills Ecological Area, located within the Shawnee National Forest, contains one of the finest assemblages of diverse vegetation in the Midwest. The site represents species of northern, southern, eastern and western affinities, including 40 species rare in Illinois." This is only one of such areas that would be disastrously impacted by the proposed dumping.

According to an April 4, 2019 article in the Southern, the newspaper out of Carbondale:

"Recently, Murphysboro mayor Will Stephens spoke out against the request, noting that Williamson Energy had amended its request 24 times. Stephens said, correctly in our estimation, that the company lacks foresight, or at worst, isn't acting in good faith.

Which brings us to a vital point.

Who is going to make sure the discharge meets water quality standards and who is going to make sure the discharge doesn't exceed the allowable volume?

Is anyone willing to take the coal company at its word?

The Illinois Department of Natural Resources is woefully understaffed. And, even if a violation is detected, it could be too late to prevent an environmental disaster. The Big Muddy flows through agricultural lands downstream as well as some of the most unique and sensitive biological areas in the state."

As a citizen of southern Illinois, it strikes me that the fact that these plans are proceeding without environmental impact assessments and realistic plans for oversight demands immediate cessation.

Polluting our waterways is never a wise idea.

The Big Muddy River should not be a sewer for corporate profit.

The unique biological diversity of the region must be preserved for the enjoyment of all its creatures, big and small.

Sincerely,

Kathy Livingston

709 W. Cherry St.

Carbondale, IL 62901

Exhibit 38

EPA.PublicHearingCom

From: Kelley <kahessian@aol.com>
Sent: Monday, August 12, 2019 8:35 AM
To: EPA.PublicHearingCom
Subject: [External] Big Muddy River

To Whom It May Concern (And it concerns us all!)

Please, please do not allow the Big Muddy River to become polluted by fracking water. Water is a most precious and irreplaceable commodity. If the government does permit this water being released into our river we will guarantee that it will become heavily polluted and that pollution will continue downstream into the Mississippi River and then the oceans. A public hearing would greatly improve the ability of those of us who live along the Big Muddy and surrounding areas to voice our desire not to permit fracking water in our river.

Please consider our plea
Thank you
Kelley Hessian
243 E No Name Rd
Carbondale IL 62902

Exhibit 39

EPA.PublicHearingCom

From: M. A. Smith <christopherareanews@gmail.com>
Sent: Monday, August 12, 2019 7:31 AM
To: EPA.PublicHearingCom
Subject: [External] SAVE THE BIG MUDDY RIVER

I am exercising my right as an active registered voter of the State of Illinois to demand that a public hearing be held to discuss the matter of Pond Creek Mine #1 be allowed to dump 3.5 millions of gallons of wastewater in the Big Muddy.

We must stop this assault on our environment! Shame on the IEPA for not doing their job, not only in this matter, but in other issues as well.

Marian Smith Furlow
611 S. Thomas St
Christopher, Il. 62822

618-218-3452

Exhibit 40

EPA.PublicHearingCom

From: freemansoldier24@aol.com
Sent: Monday, August 12, 2019 1:38 PM
To: EPA.PublicHearingCom
Subject: [External] BIG MUDDY RIVER

I use the big muddy for net fishing, bank pole fishing, trot line fishing, swimming , kayaking, mud sliding, camping, hunting, and trapping.
It,s hard for me to believe the IEPA would allow the pollutant loading by the Williamson county Energy Co. into the BIG MUDDY RIVER.

These pollutants will poison waters from Zeigler Il. all the way to the Gulf of Mexico. If these actions cannot be stopped, PLEASE monitor the water closely.

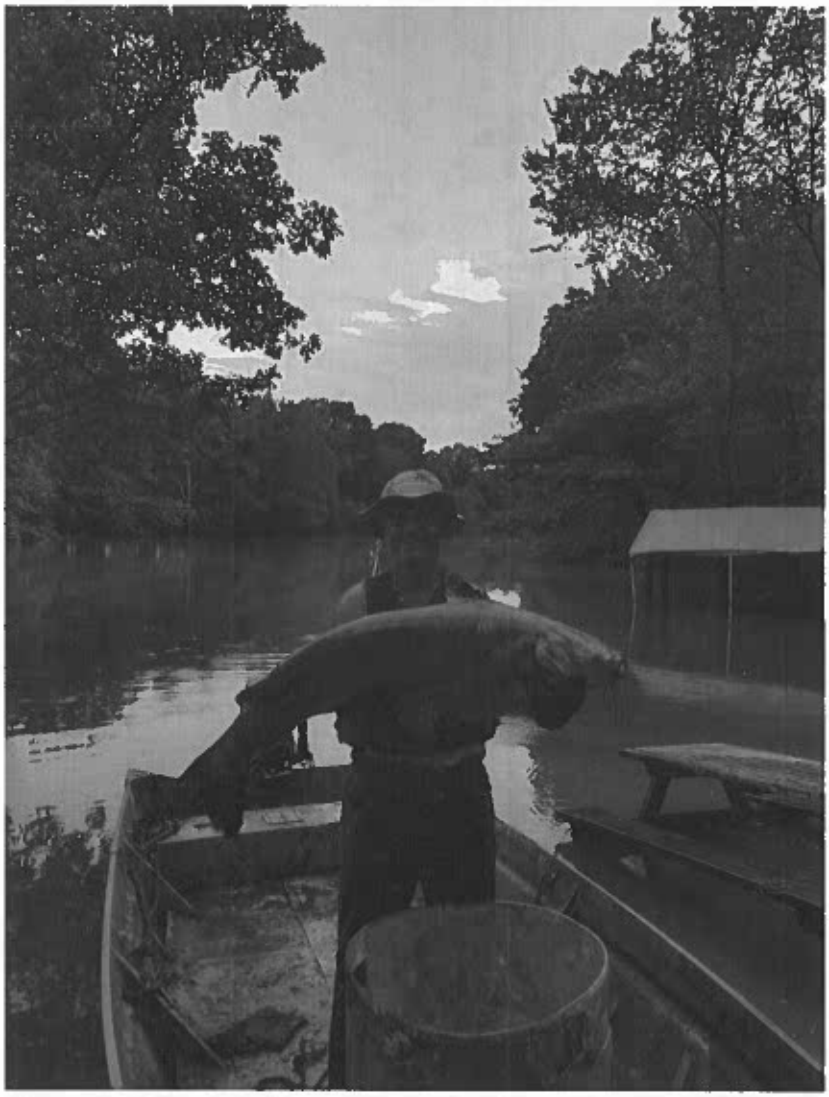
VERY CONCERNED CITIZEN ..... David L. Freeman
909 S. Pine St.
Zeigler, Il. 62999

NPDES Permit No.IL0077666 Notice NO. 7516C

EPA.PublicHearingCom

From: freemansoldier24 <freemansoldier24@aol.com>
Sent: Monday, August 12, 2019 2:26 PM
To: EPA.PublicHearingCom
Subject: [External] We use the big muddy...Protect it.The terms in the permit....activity will result in only short term temporary increase in pollutant loading
Attachments: 190628_064039_2.jpeg

Sent from my Verizon, Samsung Galaxy smartphone



EPA.PublicHearingCom

From: freemansoldier24 <freemansoldier24@aol.com>
Sent: Monday, August 12, 2019 2:27 PM
To: EPA.PublicHearingCom
Attachments: 20190604_085759.jpg

Sent from my Verizon, Samsung Galaxy smartphone



EPA.PublicHearingCom

From: freemansoldier24 <freemansoldier24@aol.com>
Sent: Monday, August 12, 2019 2:29 PM
To: EPA.PublicHearingCom
Subject: [External] The big muddy.. PROTECT IT
Attachments: 20180915_185236.jpg

Sent from my Verizon, Samsung Galaxy smartphone



EPA.PublicHearingCom

From: freemansoldier24 <freemansoldier24@aol.com>
Sent: Monday, August 12, 2019 2:30 PM
To: EPA.PublicHearingCom
Subject: [External] We love this country and BIG MUDDY
Attachments: 20180915_163405.jpg

Sent from my Verizon, Samsung Galaxy smartphone



EPA.PublicHearingCom

From: freemansoldier24 <freemansoldier24@aol.com>
Sent: Monday, August 12, 2019 2:31 PM
To: EPA.PublicHearingCom
Subject: [External] We party on the BIG MUDDY
Attachments: 20180915_184610.jpg

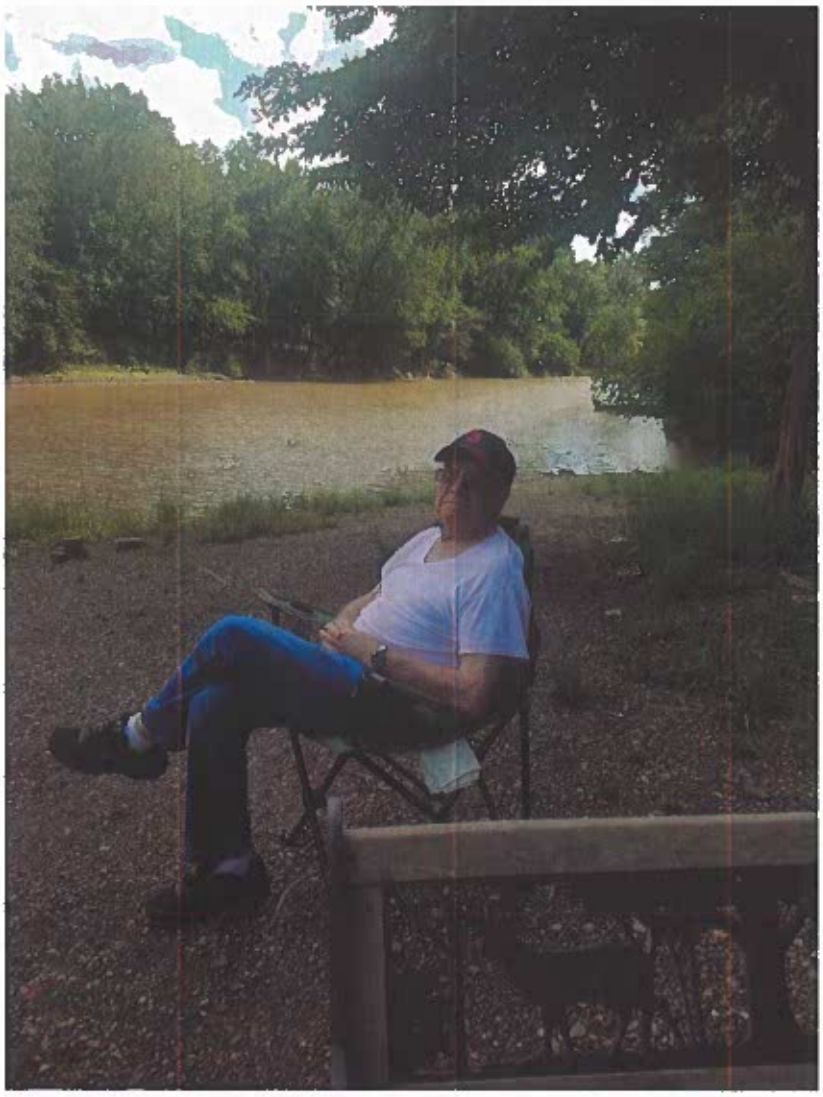
Sent from my Verizon, Samsung Galaxy smartphone



EPA.PublicHearingCom

From: freemansoldier24 <freemansoldier24@aol.com>
Sent: Monday, August 12, 2019 2:33 PM
To: EPA.PublicHearingCom
Subject: [External] The BIG MUDDY is relaxing
Attachments: 20180530_150312.jpg

Sent from my Verizon, Samsung Galaxy smartphone



EPA.PublicHearingCom

From: freemansoldier24 <freemansoldier24@aol.com>
Sent: Monday, August 12, 2019 2:36 PM
To: EPA.PublicHearingCom
Subject: [External] BIG MUDDY SQUIRRELS
Attachments: 20190105_173333.jpg

Sent from my Verizon, Samsung Galaxy smartphone



EPA.PublicHearingCom

From: freemansoldier24 <freemansoldier24@aol.com>
Sent: Monday, August 12, 2019 2:40 PM
To: EPA.PublicHearingCom
Subject: [External] Please don't let the mines poison our river. Our grandchildren will suffer
Attachments: 20160731_194815.jpg

Sent from my Verizon, Samsung Galaxy smartphone



EPA.PublicHearingCom

From: freemansoldier24 <freemansoldier24@aol.com>
Sent: Monday, August 12, 2019 2:44 PM
To: EPA.PublicHearingCom
Subject: [External] Our pictures are endless. If u let the Pond Creek mine dump 3.5 millions of water daily into the BIG MUDDY it will not be safe for our children. That's a fact, do the right thing
Attachments: 20151025_162145.jpg

Sent from my Verizon, Samsung Galaxy smartphone



Exhibit 41

EPA.PublicHearingCom

From: Sabrina Hardenbergh <sabrina@midwest.net>
Sent: Monday, August 12, 2019 2:31 PM
To: LeCrone, Darin; EPA.PublicHearingCom; Pressnall, Chris
Cc: info@dickdurbin.com; tammy@tammyduckworth.com
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Darin LeCrone
IEPA Bureau of Water, Water Pollution Control Permit Section,
1021 North Grand Ave. East,
Springfield, IL 62794-9276
darin.lecrone@illinois.gov

Dear Darin LeCrone, IEPA Bureau of Water staff, and other government officials:

I am writing in concern of NPDES IL0077666 & Notice No. 7516c, wherein Foresight Energy/Williamson Energy/Pond Creek Coal Mine wants a permit to dump coal waste water into our Pond Creek and Big Muddy River in southern Illinois, which then flows to the Mississippi River through Oakwood Bottoms below Little Grand Canyon. Please schedule a public hearing on this issue. Please do not permit this company to build their pipeline and continue dumping coal waste water into our waterways which already exceed TMDL limits.

The mathematical "dilution" of or change in TMDL calculation (to thus gerry-rig or enable consideration of the permit) is an inappropriate solution to poisoning our aquatic life and the ecological system that feeds off of the aquatic life. I previously wrote about this in an article last winter: https://www.sierraclub.org/sites/www.sierraclub.org/files/sce/shawnee-group/ShawneeTrailsDec2018forWeb.pdf.
Hence your conclusion copied below is highly suspect because of recent TMDL calculation maneuvers:
"IEPA Conclusion: Upon completing the assessment, it has been determined that the proposed activity will result in only short term temporary increase in pollutant loading and will not result in long term or permanent impact to existing uses including aquatic life habitat; therefore we find that it is subject to Subsection (d) "Activities not subject to a further Antidegradation Assessment" of 35 ILL. Adm. Code 302.105"
I do not accept this recent trick on the public to erase our polluted water problems via fancy mathematical averaging.

It doesn't seem that the mining company has improved their permit application since last year; instead they are simply attempting to legitimate their already happening violations of waste water pollution discharge into Pond Creek with their additional listing of discharge points (that flows to the Big Muddy River), in addition to the pipeline. All the pollution is being released into already TMDL impacted waters.

Given the recent death of Chris Cline, maybe the mine should just be decommissioned if they cannot treat and contain the waste water onsite, even though they allocate profit to other sectors. The mine pollution should not be left for the rest of southern Illinoisans to incur and clean up at expense to our health, local ecological health, and our pocket books. Coal mining costs our state (https://reinvestil.org/the-facts/), so it needs to be transitioned out.

I have canoed in the Big Muddy, and I wouldn't want it to be more polluted than it already has been for other southern Illinoisans to enjoy recreating on and around. We owe it to our children to leave them a safe place to play, learn and grow. The Will Scarlet debacle was bad enough to not repeat, or even approach.

I frequently hike in the Little Grand Canyon area near the Big Muddy, and enjoy seeing the wildlife that lives in this habitat, spring, summer, fall and winter. It's bothersome that our recent flooding upstream on the Mississippi River pushed water into and flooding the Big Muddy up into the creeks in the Little Grand Canyon area. Additional high volume water discharge coming from the pipeline is just going to add to the problematic flooding conditions brought on by climate change and other misuse of our waterways. I also hope to see the IEPA protect the wildlife like eagles and otters, and the other fish and mussels and such, on which they feed. Flooding also impacts municipalities like Murphysboro and other towns, roads and fields along the Big Muddy River. You're supposed to protect our national bird and other threatened and endangered species (see weblinks in article above), no matter what our misguided current federal administration tries to ignore (while they repeal Acts and Rules that were supposed to protect out water, air, land, health and wildlife) so they can grab all the fossil fuel they can scrounge up for their own profits. Don't argue "jobs" because people need to be

retrained into less harmful jobs, as some of us in the region are working toward (plus this particular mine's managers already has a problematic labor history). Please do not be an accomplice to the current corrupt federal administration. The state of Illinois should fight the current corruption in Washington.

Please help move southern Illinois toward use of alternate renewable energy resources and energy efficiency instead. Please preserve southern Illinois for its outdoor tourism, cultural history and recreation that we are known for; this area is not a sacrifice zone for the mining company profiteers.

Please schedule a public hearing on this issue. Please do not permit this company to build their pipeline and continue dumping coal waste water into our waterways, many of which already exceed TMDL limits that should be cleaned up.

Sincerely,

Sabrina Hardenbergh
1 Hardenbergh Road
Carbondale, IL 62902
618-549-2608 (landline)
sabrina@midwest.net

Exhibit 49

EPA.PublicHearingCom

From: Jennifer Reiman <jreiman618@gmail.com>
Sent: Monday, August 12, 2019 4:00 PM
To: EPA.PublicHearingCom
Subject: [External] NPDES IL0077666 & Notice No. 7516c

To whom it may concern,

Please schedule a public hearing for the Pond Creek Mine permit application. The Big Muddy River is a precious resource for Southern Illinois. It flows through some of the most scenic and unique landscapes of the Shawnee National Forest. Aquatic life in the Big Muddy and in the wetlands along it's banks should not be subjected to pollutants in the discharged water. The river should not be sacrificed for the benefit of a coal mining corporation. The people of Illinois deserve to have a public hearing to gather all evidence and comments before any action is taken on the permit application. Please schedule the hearing and let the voices of the people be heard.

Thank you,
Jennifer Reiman
215 Garden Blvd, Belleville, IL 62220
618-334-1371

Exhibit 43

EPA.PublicHearingCom

From: Paula Meinert <paulamein54@gmail.com>
Sent: Monday, August 12, 2019 4:31 PM
To: EPA.PublicHearingCom
Subject: [External] RE: Pond Creek Mine Permit to Dump Mine wastewater into the Big Muddy River NPDES Permit No. IL0077666 Notice No. 7516c

My name and address is:

Paula A Meinert
401 N Victor St
Christopher, IL 62822

Even if this mine does filter the water before it dumps it via direct pipeline into the Big Muddy River, the pollutants it will carry will kill aquatic life and vegetation. The mussels that are part of the ecosystem of the river survive by siphoning river water. Through the way they take in their nutrients in this manner, these pollutants will accumulate in their bodies and thereby killing them. Mussels are already an endangered species. I have friends who camp, fish and boat on the river. The pollutants will contaminate the fish and vegetation. I understand the Sugar Creek mine has already been approved and apparently dumping this crap into our river already. Allowing this mine to get rid of this problem in this way will double these horrendous results. How did this get approved when the results of this contamination are readily discernible and common sense? The fellow that owns this mine is notorious for not taking care of the problems he creates. I don't trust him nor should you. I descend from a long line of coal miners, 2 great grandpas, both grandpas, and my dad were all coal miners. The mines used to provide a good way to make a living here, but automation has taken away most the jobs, as I understand it today only about 2000 coal miners work here due to this automation. To enrich Mr Murray at the expense of all of the rest of us should not be allowed. If we no longer have fresh water to drink or fresh air to breathe, what good will corporate profits do? The incidence of cancer is so high in this area and I believe the coal mines are a big part of the blame. I do not trust Mr Murray to adhere or follow any law so how are you going to monitor the amount of sulfates and chlorides in this water? If it's his responsibility, I would not trust the results. Unfortunately, the victims of this malpractice will be us, the people that unfortunately live here. As I understand, Mr Murray does not live in Southern Illinois so why would he want to be a good caretaker of our area. To him it's the almighty dollar. I wish to request that this permit not be issued or at least let us have a public hearing to decide the matter.

Paula A Meinert

Exhibit 44

EPA.PublicHearingCom

From: Patty Mullen <patty_makanda@yahoo.com>
Sent: Monday, August 12, 2019 7:07 PM
To: EPA.PublicHearingCom
Subject: [External] Big Muddy River 7516c

As much as I am a supporter of coal. The idea of dumping coal waste in the big muddy river is a horrible idea. My family fishes, boats and walks through the water. People live very close to the river and its tributaries.
Patricia Mullen
313 Lee Ln
Murphysboro, IL 62966
618-559-0635
NPDES permit number IL0077666 notice number 7516c

Sent from Yahoo Mail for iPhone

Exhibit 45

EPA.PublicHearingCom

From: freemansoldier24@aol.com
Sent: Monday, August 12, 2019 7:32 PM
To: EPA.PublicHearingCom
Subject: [External] Proposal of dumping mine water into the Big Muddy

To Whom It May Concern:

This letter pertains to the proposal of Pond Creek Mine dumping waste water into the Big Muddy.
We have owned 23 acres of wooded land on the Big Muddy for the last 25 years. My family and I camp, picnic, kayak, boating, and fishing on this river. We grew up on this river. It is our recreational area now and has been for many years.

This letter hopes that the EPA will take a second look at how this will affect those that live on the Big Muddy. Please stand up for those of us that can't.

Also, it would be nice to have a public meeting about this issue. It is sad that we hear about this after part of the process went through for the permit. I would think that the EPA would want to hear both sides of the situation. So if at all possible, please have a public meeting to discuss the dumping of waste water in the Big Muddy.

NPDESPermit No. IL0077666 Notice No. 7516c

Thank you,
Betty Freeman
909 S. Pine Street
Zeigler, IL 62999

Exhibit 46

EPA.PublicHearingCom

From: Shirley Krienert <sjkrienert72@gmail.com>
Sent: Monday, August 12, 2019 10:31 PM
To: EPA.PublicHearingCom
Subject: [External] NPDES Permit No. IL0077666 Notice No. 751C

I am opposed to the Pond Creek Mine's plan to dump mine wastewater into the Big Muddy River. As a longtime resident of Illinois, and a taxpayer I am asking for a public hearing in Murphysboro, Illinois. I am shocked the IEPA approved the Permit. The Big Muddy River and Murphysboro will be effected by this dumping, as will everyone along the River. Wildlife populations will be effected as well as the general ecosystem. The almost seasonal flooding in Riverside Park will carry particles outside of the River's bank and into the park area. Recreational boating on the river will quite possibly be effected. Passing along waste to another area is not a viable solution. Pond Creek Mine needs to find another way to dispose of its waste. I look forward to a public hearing where residents can express their opinions directly to State officials.

Shirley Krienert
1905 Edith Street
Murphysboro, Illinois 62966

RECEIVED
AUG 09 2019
IEPA
BOW/WPC/PERMIT SECTION

306 S. Glover Dr.
Carbondale, IL 62901

August 7, 2019

Exhibit 47

Dear Mr. Lecrone,

I am writing to protest the request of Williamson Energy to dump millions of gallons of wastewater into the Big Muddy River. I refer to the following: NPDES IL0077666 Notice No. 7516C. I'm enclosing two letters from a recent edition of the Southern Illinoisan newspaper that point to many good reasons many of us have in opposing Williamson Energy's request to dump thousands of gallons of polluted chemical liquids into a river that means a great deal to those who care for what happens to our river.

I urge you not to allow this vast pollution to take place. I hope my letter and the two letters I'm enclosing will convince IEPA not to allow this permanent dumping to take place. Please put a permanent and clear end to this IEPA proposal.

Sincerely,

Isabel Madry Zimmerman

 from the Southern Illinoisan newspaper

The Big Muddy River

To the Editor:

This river is one of very few inland rivers within the boundary of the state of Illinois. It is 156 miles long, passes through Rend Lake and eventually joins the great Mississippi. It is called the Big Muddy for a reason: It has a mud bottom for the most most part, and drains a 2,344-square-mile watershed. Although it appears unfit for human consumption, the water quality was assessed as "fair to good" in 1995.

My property in Murphysboro overlooks the Big Muddy. Frequently, I observe fishermen, kayaks, canoes, jet skies, ski and pontoon boats, and occasional hikers and campers making their journey along this river enjoying the beautiful scenery and experiencing the abundance of wildlife and forest area that abounds. The deer, waterfowl, wildlife, etc., is very plentiful and allows so many to just marvel at their presence and behaviors. Very few things are more beautiful than observing the great bald eagles fish and bathe in the river and annually bear young and teach them survival skills that should ensure the species' existence for the future.

The actions of so few can affect so many. Decisions made concerning the Big Muddy to possibly be used as a dumping source of hundreds of thousands of gallons of polluted chemical liquids by a local coal mine will have an everlasting effect on the many humans, wildlife, adjoining forests and watersheds, and the Mississippi River which empties into the Gulf of Mexico.

This is a wake-up call for local folks to start protecting our God-given planet for the sake of all mankind. Please contact your local mayor, state representative, Department of Natural Resources, governor's office, or any organization that you can sound off to before it is too late.

Michael L. Duncan
Murphysboro

Our watershed

To the Editor:

The Big Muddy is our watershed. It runs through eastern Williamson County past De Soto, toward Carbondale and through Murphysboro (right through the town!) then south to skirt some of the most glorious land formations in the watershed, the sheer limestone cliffs and Chalk Bluff, Horseshoe Bluff and then the ecological area of La-Rue Pine Hills on its way to the Mississippi.

If we cannot halt this permanent despoiling, it will happen without environmental impact studies, even though the threat is real to poison the entire ecosystem. We, at least, need to learn what chemicals would be released and what effects they have on living organisms. Let's get some publicity about that. In our watershed, there are those who use wells for their drinking water, to irrigate crops, make wine. They all need to know what is being proposed and what our IEPA signed off on.

In a true market-based economy, this coal mine might have to concede that caring for its waste in environmentally sound ways costs more than the coal is worth out of the ground. That's an important lesson to publicize. What value is the IEPA giving to all the proposed damage and loss in the lower Big Muddy River watershed ecosystem?

Southernmost Illinois has glorious natural gifts. Much of our economy depends on them: clean lakes, agriculture, fishing, recreation and winery tourism. We want to attract people and businesses that depend on healthy land and waters. If we must choose between assisting one coal mine and all that comes with an environmentally sound watershed for generations to come, we must choose the future.

Kay Rippelmeyer
and David Tippy
Pomona

■ **Letter to the Editor and Guest View policy:** *Letters and guest opinion pieces must be submitted via email to letters@thesouthern.com. All submissions should address a current issue and include your name, hometown and telephone number for verification. The Southern does not publish telephone numbers. We reserve the right to edit letters for content or length. We do not print poetry, libelous material or submissions send en masse to numerous news organizations.*

■ **News Tips:** *To report news, call 618-351-5807, our toll-free line at 800-228-0429 or email us at news@thesouthern.com.*

Comment for NPDES Permit No. IL0077666/Notice No. 7516c

7/22/2019

Exhibit 48

RECEIVED
JUL 29 2019
IEPA
BOW/WPC/PERMIT SECTION

Lucia Amorelli
315 N. Westridge Dr. Apt. 12
Carbondale, IL 62901

IEPA Bureau of Water, Div. of Water Pollution Control Permit Section
1021 N. Grand Ave E
PO Box 19276
Springfield, IL 62794-9276

Comment for NPDES Permit No. IL0077666/Notice No. 7516c

First, I want to request to have a public hearing where the public can ask questions about and raise concerns with the current draft permit. After reading through the entirety of the permit, I see many deficiencies with regard to environment protections.

Big Muddy River

The draft permit states that the Big Muddy River is already compromised, although it does not mention that according to the EPA report (2004), abandoned coal mines are the "likely source" of sulfate and manganese pollution. Despite the fact that coal mines have already caused pollution to the Big Muddy River, the IEPA/IDNR wants to allow yet another coal mine to add coal mine discharge without properly filtering the water. Diffusing wastewater with the river water itself and having a sedimentation process is not going to adequately filter the water for contaminants such as lead, mercury, and arsenic that will most likely be present in the discharge waters. It already has a fish advisory warning for mercury and PCBs. And how can adding more sulfate to a river with already high levels of sulfate possible? How is this proposed process going to eliminate the toxins that will be present in the mine wastewater from entering the river?

The Big Muddy River was not mentioned in the draft permit as being a candidate for a National Wild and Scenic River. This gives it special federal protections. Have the agencies been contacted to determine whether the mine wastewater would be detrimental to this river for potentially becoming a listed wild and scenic river? I

read the proposal for the Army Corps of Engineer which did consult with the US Fish and Wildlife. I was dismayed that the US Fish and Wildlife signed-off on this project saying it would have no impact on threatened/endangered species even though it states that there are threatened/endangered species within the area of the river. Even on their own website it says that "because acid mine drainage can destroy a stream's aquatic community for miles, many of the old mining sites are being reclaimed." (US Fish and Wildlife 2019). It is already up to the "stakeholders" to deal with the pollution caused by the abandoned mines. Will the stakeholders also have to try to deal with even more pollution in the future? A water protection group has already formed with regard to the Big Muddy River. And it is seeking help in getting the Big Muddy River cleaned up. How does the EPA ensure that Pond Creek Mine will not become another company which we have to clean up after. The company is already in financial trouble. How is it going to deal with the already existing sediment ponds it has? How is the pollution from those going to be mitigated in the future?

The Big Muddy River runs through the Shawnee National Forest. Has it been consulted about this project since it is one of the four agencies which help oversee the Wild and River Scenic Act? It also flows adjacent to Little Grand Canyon and through La Rue Pine Hills both of which are National Natural Heritage Landmarks which are federally protected. La Rue Pine Hills has up to 40 listed endangered, threatened, and rare plant and animal species. Have all these species been considered? Specifically the ones which would be within the watershed of the Big Muddy River. La Rue Pine Hill/Otter Pond is also a federal natural research area with protections. Can these species live in long-term exposure levels of 500mg/L of chlorides? (See Appendix A)

Effects on Aquatic Life

The only mention of the effects on aquatic life is the statement that there would be no effects because water quality standards would be met. How does mixing 12,000mg/L of chloride into the river to be diluted down to 500mg/L occur, especially within 250 feet downstream as the permit states? How can the EPA say with a clear conscience that there will be no adverse effects on aquatic life? Has there been studies on a river the size of the Big Muddy that have had 3 million gallons a day injected into with elevated levels of chlorides and sulfates? According

with science-backed evidence

to a study by University of Rhode Island (2012) long-term exposure amounts as low as 230mg/L of chloride can be detrimental to aquatic life. Can mussels withstand 500mg/L of chloride on a continuous basis? 44% of the mussel species of Illinois are already endangered. What about the endangered Illinois chorus frog? And how can testing only quarterly assure that the water quality standards are being met? Could not the mine, just make sure on the day of testing they are not dumping as much wastewater as on other days? And why is the permit asking for the pipeline to be built just below the monitoring station?

Issues Not Addressed

There are several important issues I did not see addressed in the draft permit. The first one is soil erosion. I did not see information regarding the effects on erosion of riverbanks of an extremely winding river when there could be up to three million gallons a day discharged into it. Have the accumulative effects been determined of this kind of water entering a small river on a continual basis? The second issue pertains to the fact that I did not read anywhere in the draft permit mentioning the enormous amounts of mine discharge water that will be dumped into the river. It was discussed in the initial permit application, but I did not read it in the draft permit. Why has this extremely important information been left out? How is a river that fluctuates wildly between low flow and flooding be a good candidate for this huge amount of water to be discharged into it. And that brings me to the third issue not addressed. The actual size and geography of the river is not discussed. Compared to rivers such as the Ohio and the Mississippi, the Big Muddy is very small. Being continually infused with high levels of sulfates and chlorides and other contaminants will be detrimental to the already compromised composition of the river.

In closing, I want to add that in the draft permit there is a paragraph discussing the economic benefits of keeping this coal mine in operation. It does not discuss the environmental cost. Coal mines cause contamination and pollution.

> Mining operations can negatively impact water supplies, often with long-lasting effects. The fundamental issue involves contamination of nearby rivers, lakes, and aquifers by what comes *out* of a coal mine—usually highly acidic water containing heavy metals like arsenic, copper, and lead... Runoff can change the pH of nearby streams to the same level as *vinegar*. (Union of Concerned Scientists 2019)

There is a global movement to phase out the use of fossil fuels as quickly as we can. Allowing this permit will just allow a coal mine to keep operating for longer. We are in a planetary climate change crisis. Money made from coal is costing us exponentially more than the salaries being made. Illinois already has programs helping coal miners transition to safer jobs such as solar installation. Solar jobs already outnumber coal mining jobs. IEPA and IDNR are not supposed to be concerned about making jobs. These agencies are about protecting our environment and resources. Has the IEPA/IDNR analyzed the long-term environmental cost that allowing this mine to expand will have? And finally, does Foresight Energy have a clean record for adhering to water quality standards? How many violations does it have?

Appendix A

Endangered and Threatened Plants from the Larue-Pine Hills-Otter Pond Complex

The list of Endangered and Threatened Plants of Illinois was published by the Illinois Species Endangered Species Board of May 15, 2015

I have collected or seen specimens of each of the following:

ENDANGERED

Asplenium bradleyi	Bradley's Spleenwort
Asplenium resiliens	Black Spleenwort
Botrychium biternatum	Southern Grape Fern
Carex alata	Winged Sedge
Carex decomposita	Cypress Knee Sedge
Carex gigantea	Large Sedge
Carex intumescens	Swollen Sedge
Carex physorhynca	Chert Sedge
Carya pallida	Pale Hickory
Cypripedium parviflorum	Small Ladies'-slipper
Dichanthelium joori	Joor's Rosette Grass
Glyceria arkansana	Arkansas Manna Grass
Hydrolea uniflora	One-flowered Hydrolea
Malus angustifolia	Narrow-leaved Crab Apple
Penstemon tubaeflorus	Tube-flowered Beards-tongue
Pinus echinata	Shortleaf Pine
Ptilimnium nuttallii	Nuttall's False Bishop's-weed

Sparganium americanum	American Bur-reed
Spiranthes vernalis	Spring Ladies'-tresses
Torreyochloa pallida	Pale Manna Grass
Trichophyllum cespitosum	Tufted Bulrush
Trillium viride	Green Trillium
THREATENED	
Carex communis	Upland Sedge
Carex oxylepis	Sedge
Carex willdenowii	Willdenow's Sedge
Methoria pendula	Squirting Cucumber
Quercus montana	Mountain Chestnut Oak
Quercus phellos	Willow Oak
Styrax americana	American Snowbell Bush

DATE: August 1, 2019

Exhibit 49

RECEIVED
AUG 06 2019
IEPA
BOW/WPC/PERMIT SECTION

TO: IEPA Bureau of Water
Water Pollution Control Permit Section
1021 North Grand Ave. East
Springfield, IL. 62794-0276

FROM: Jerry and Carolyn Worthen
3974 Watt Hill Road
Murphysboro, IL. 62966

PERMIT: NPDES IL0077666 NOTICE NO. 7516C

We are responding to the Pond Creek Mine dumping waste in to The Big Muddy River.

The Worthen farm has been in the family since 1836. We raise grain and have cattle. It is registered with The state of Illinois as a "Centennial Farm". This farm is located 5 miles southwest of Murphysboro on The Big Muddy River. The farm is prime bottom ground and is susceptible to flooding. This year our whole farm was flooded and prevented us from planting. Our son does the planting as I am disabled. We have hopes of the farm being carried through for generations. This farm is our living. So is the mine going to compensate us for that?

We find the dumping of waste water, will contaminate our ground, kill fish, and wildlife, cause erosion, and high water. Not only is that our concern, but those who have farm wells will have contaminated drinking water. The Big Muddy runs into the Mississippi - more land and water contamination. No end to it!

There are many farms and towns up and down the river. What kind of an effect would that cause them?

Since when did the IEPA, not protect all ground and waterways, at our cost? If this goes through it will be a disaster and cause hardship for those of us just trying to make an honest living. The mine is taking advantage of a lot of people's lives. We request a meeting with the Illinois EPA in our area, Southern Illinois!

Concerned Citizens
Of Southern Illinois

Cc: Terri Bryant
Mike Bost

R02931

Jerry & Carolyn Worthen
3974 Watt Hill Road
Murphysboro, IL 62966

SAINT LOUIS MO 630
2 AUG 2019 PM 2L



IEPA Bureau of Water
Water Pollution Control Permit Section
1021 North Grand Ave. East
Springfield, IL.
62794-0276

62702-405921

R02932

TO: IEPA
BUREAU OF WATER

RECEIVED
AUG 05 2019
IEPA
BOW/WPC/PERMIT SECTION

Exhibit 50

FM: LYNN WINSTON
64 GRIFFITH DR
CARBONDALE IL 62903-8304

DT: 30 JULY, 2019

RE: POND CREEK MINE PERMIT APPLICATION TO DUMP WASTEWATER INTO BIG MUDDY RIVER
NPDES PERMIT #IL0077666 NOTICE#7516c

I strongly protest permitting Pond Creek Mine to dump TOXIC wastewater into the Big Muddy River. This proposed activity can cause more flooding and can poison a large portion of the surrounding area. This will negatively impact recreational opportunities, to say the least, and will be just one more fatal blow to our fragile planet.

I also request a public hearing to allow affected residents and all concerned citizens to express their views.

Thank you,
Lynn Winston

Christian Sasse
108 Gaylord Drive
Collinsville, IL 62234

Exhibit 51

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AUG 06 2019
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BOW/WPC/PERMIT SECTION

Concerns of detrimental environmental impacts upon aquatic life and water quality

It was found in previous situations where wastewater was allowed to be unloaded into local waterways that there was a large net negative impact to the local environment persisting a good distance downstream. In the 2014 Belmer et. al. paper "Impact of a coal mine waste discharge on water quality and aquatic ecosystems in the Blue Mountains World Heritage area" it was found that there was a loss of invertebrate richness of more than 66% and abundance of over 80%. While there was not a direct study upon other forms of life it can be inferred that there was a loss of life that is statistically significant of other forms as well. Besides the direct impact on aquatic life it was found that major changes occurred in the physical and chemical properties of the water in comparison to samples taken upstream of the dump site. Something to note is that the coal mined in this area is of higher quality than that found in Southern Illinois meaning it has lower sulfur, chlorine, nickel, and zinc content of which there were still major increases in the quantity found. So, my concern is this, if an area that has cleaner coal is found to have such major detrimental changes to aquatic life and water quality how can it not be assumed that even worse will occur here. Even if some of the pollutants are found to be compliant of regulations that ecologically hazardous conditions will occur and be persistent throughout the future. I believe that public hearing should occur in order to answer questions of what mitigation steps they have in place of conditions that break regulations, potential for other wastewater disposal methods that were mentioned but not specified, as well as other concerns that may not be addressed here.

Exhibit 52

RECEIVED
AUG 12 2019
IEPA
BOW/WPC/PERMIT SECTION

August 9, 2019

Darin Lecrone, et al

1021 North Grand Avenue East, Post Office Box 19276 Springfield, Illinois 62794-9276.

Subject: NPDES IL0077666 & Notice No. 7516c

Dear Mr. Lecrone et al,

I am writing with regard to the proposed pipeline and dumping of coal mine waste water into the Big Muddy River.

According to the Shawnee Group of the Sierra Club:

•" No assessment is provided of the biological or other environmental impacts of the proposed mixing of this contaminated mine water on the ecosystem and current uses (fishing, livestock, recreation, etc.) of the Big Muddy River

• No assessment is provided of the cumulative water quality impacts on the Big Muddy River from this proposal over the many years of continued coal mining

• No assessment is given either of what such a large groundwater withdrawal quantity could be doing to the local area or what implications this might have for the future"

According to the Illinois Natural History Survey (2019), "LaRue Pine Hills Ecological Area, located within the Shawnee National Forest, contains one of the finest assemblages of diverse vegetation in the Midwest. The site represents species of northern, southern, eastern and western affinities, including 40 species rare in Illinois." This is only one of such areas that would be disastrously impacted by the proposed dumping.

According to a April 4, 2019 article in the Southern, the newspaper out of Carbondale: "Recently, Murphysboro mayor Will Stephens spoke out against the request, noting that Williamson Energy had amended its request 24 times. Stephens said, correctly in our estimation, that the company lacks foresight, or at worst, isn't acting in good faith.

Which brings us to a vital point.

Who is going to make sure the discharge meets water quality standards and who is going to make sure the discharge doesn't exceed the allowable volume?

Is anyone willing to take the coal company at its word?

Subject: NPDES IL0077666 & Notice No. 7516c cont'd

The Illinois Department of Natural Resources is woefully understaffed. And, even if a violation is detected, it could be too late to prevent an environmental disaster. The Big Muddy flows

through agricultural lands downstream as well as some of the most unique and sensitive biological areas in the state."

The fact that these plans are proceeding without environmental impact assessments and realistic plans for oversight spark suspicions of corporate/state government corruption.

The Big Muddy River should not be a sewer for corporate greed.

The unique biological diversity of the region must be preserved for the enjoyment of all its people.

Sincerely,

Kathy Livingston

Kathy Livingston

709 W. Cherry St.

Carbondale, IL 62901

Karen Fiorino
45 Old US Hwy 51
Makanda, IL 62958
claylickcreek@gmail.com

Exhibit 53

RECEIVED
AUG 12 2019
IEPA
BOW/WPC/PERMIT SECTION

6th August, 2019

Darin LeCrone
IEPA Bureau of Water
Water Pollution Control Permit Section
1021 North Grand Ave East
Springfield, IL 62794-9276

Re: NPDES IL0077666 & NOTICE No. 7516C

Dear Mr. LeCrone,

After seeing the articles in the Southern Illinoisan about the Pond Creek Mine discharging pollutants into the Big Muddy along with other unnamed tributaries, I decided to take a look at the draft permit for such discharging.

It is a hard read, but a few points:

1.) on page 13, there is an error in the name of the bird Chuck's-Will-Widow, not Willow. I found at least 2 instances of this. I am told researchers and the papers they write go through at least 5 editors. Obviously, this got missed. I have a background in biology/zoology, and this error jumped out at me. It makes me wonder what other errors are included in this draft permit.

2.) I find it disrespectful to list the Big Muddy as a waterway that is not a biological significant stream. This attitude shows the utter disregard humans have for the land and water around them and monitizes everything. I did check the publication where this information came from, Integrating Multiple Taxa in a Biological Stream Rating System, which in their own words state, "One of the goals of the previous BSC initiatives was to update stream ratings on an annual basis and to publish the revised ratings every five years. However, the original BSC stream ratings were updated only once based on data that were collected through 1993. Similarly, the BSS project was based on data collected through 1991 and has not been updated since. Therefore, stream designations identified in these projects are based on data that is at least 14 years old. Given that these ratings are used by a diverse group of stakeholders, it was clear that an updated version was required. "

3.) The 303 jobs employed by the mine, coal mining is a dying industry, if anything it will become more and more mechanized. If this mine has produced so much wealth, where is it?

4.) Dilution is not the solution in this case. In your own words the chloride and sulfates would remain dissolved in the water and more through the downstream continuum. I am not really reassured that no adverse impacts to streams would occur as all water quality standards *are expected* to be met in the receiving water.

Finally, as companies, are now given "personhood" via Citizens United, they should have to pay a fee to the people impacted by them dumping pollutants into a public waterway, since everything always relates to the dollar. I know personal friends who would be impacted by this dumping as their business in Murphysboro, the Douglas School Glass Studio, is prone to flooding.

In conclusion, I urge that a public hearing is called in a central area where the people who are impacted most can attend and so that an individual with a second opinion can look at the numbers and give a plain and clear answer to the real amount of pollutant discharge.

Sincerely,



Karen Fiorino

R02937



Karen Fiorino
45 Old US Highway 51
Makanda, IL 62958

SAINT LOUIS MO 630

07 AUG 2020 PM 6 L



Darin LeCrone
IEPA Bureau of Water
Water Pollution Control Permit Section
1021 North Grand Ave East
Springfield, IL 62794-9276

62702-407299

R02938

NPDES IL 0077666
NOTICE NO. 7516C

RECEIVED
AUG 12 2019
IEPA
BOW/WPC/PERMIT SECTION

Exhibit 54

Good Morning:

Please keep protection in:

Environmental
Protection
Agency

Our water is our most precious resource - please protect our precious!

Russ Kramer
Jude Baker

VOICE OF THE SOUTHERN NPDES IL 0077666

NOTICE NO. 7516C

The state should not turn Big Muddy River into wastewater

EPA.

The "P" stands for protection. Not Pond Creek. And not permission.

That's our viewpoint concerning the Illinois Environmental Protection Agency making a tentative determination approving Williamson Energy's request to dump millions of gallons of wastewater into the Big Muddy River.

The proposal states that up to 3.5 million gallons of water per day could be dumped into the river. During the summer months, that figure would represent about one-tenth of the river's daily flow.

The IEPA's approval is apparently part one of a two-part process. The final ruling will come at the end of a public comment period that closes Aug. 12.

We're hoping this indicates that the "P" in EPA may stand for procedural and that the agency isn't actually considering giving the agency the green light to turn the Big Muddy River into its own private sewer.

The coal company has been required to amend its proposal more than a dozen times. At one point, it had asked to pump water with high concentrations of chlorides and sulfates, both of which are toxic to aquatic organisms, into the river.

The latest proposal apparently calls for water to be diluted through a system of tanks prior to being discharged. Frankly, this isn't any more palatable.

We understand jobs are critical to Southern Illinois. We understand much of Southern Illinois is impoverished, but what price are we willing to pay for the state to subsidize one employer?

Virtually every manufacturing operation generates waste material that needs to be disposed. This newspaper certainly does. However, it isn't the state's job to see that our waste is disposed of properly. We're not asking the people of Illinois to bury old newspapers at Giant City State Park or at Lake Murphysboro.

Nor, should we think it is acceptable for the state to grant permission to turn the Big Muddy into a Williamson Energy subsidiary. The Big Muddy River belongs to the people of Illinois. The state should not have the authority to sublet an entire river.

It's not just the newspaper opposing the project.

Recently, Murphysboro mayor Will Stephens spoke out against the request, noting that Williamson Energy had amended its request 24 times. Stephens said, correctly in our estimation, that the company lacks foresight, or at worst, isn't acting in good faith.

Which brings us to a vital point.

Who is going to make sure the discharge meets water quality standards and who is going to make sure the discharge doesn't exceed the allowable volume?

Is anyone willing to take the coal company at its word?

The Illinois Department of Natural Resources is woefully understaffed. And, even if a violation is detected, it could be too late to prevent an environmental disaster. The Big Muddy flows through agricultural lands downstream as well as some of the most unique and sensitive biological areas in the state.

The ecological importance of the lower Big Muddy River seems to be ample justification for denying the request.

In the name of environmental protection, the use of farm chemicals is regulated to keep harmful materials from flowing into ditches, which empty into creeks, which empty into rivers. Yet, it seems the IEPA may approve the discharge of 3.5 million gallons of polluted water into one of the state's major rivers.

Finally, public sentiment, at least what we've been able to gauge, is adamantly opposed to the mine's proposal. Granted, making decisions based on group think isn't necessarily the proper course of action, but in this case, it certainly merits consideration.

It is "We the people" who will have to live with the consequences of this decision.

Area residents have until Aug. 12 to make their voices heard.

 7 AUG '19 SOUTHERN ILLINOISAN

The Big Muddy River

To the Editor:

This river is one of very few inland rivers within the boundary of the state of Illinois. It is 156 miles long, passes through Rend Lake and eventually joins the great Mississippi. It is called the Big Muddy for a reason: It has a mud bottom for the most most part, and drains a 2,344-square-mile watershed. Although it appears unfit for human consumption, the water quality was assessed as "fair to good" in 1995.

My property in Murphysboro overlooks the Big Muddy. Frequently, I observe fishermen, kayaks, canoes, jet skies, ski and pontoon boats, and occasional hikers and campers making their journey along this river enjoying the beautiful scenery and experiencing the abundance of wildlife and forest area that abounds. The deer, waterfowl, wildlife, etc., is very plentiful and allows so many to just marvel at their presence and behaviors. Very few things are more beautiful than observing the great bald eagles fish and bathe in the river and annually bear young and teach them survival skills that should ensure the species' existence for the future.

The actions of so few can affect so many. Decisions made concerning the Big Muddy to possibly be used as a dumping source of hundreds of thousands of gallons of polluted chemical liquids by a local coal mine will have an everlasting effect on the many humans, wildlife, adjoining forests and watersheds, and the Mississippi River which empties into the Gulf of Mexico.

This is a wake-up call for local folks to start protecting our God-given planet for the sake of all mankind. Please contact your local mayor, state representative, Department of Natural Resources, governor's office, or any organization that you can sound off to before it is too late.

Michael L. Duncan
Murphysboro

Our watershed

To the Editor:

The Big Muddy is our watershed. It runs through eastern Williamson County past De Soto, toward Carbondale and through Murphysboro (right through the town!) then south to skirt some of the most glorious land formations in the watershed, the sheer limestone cliffs and Chalk Bluff, Horseshoe Bluff and then the ecological area of La-Rue Pine Hills on its way to the Mississippi.

If we cannot halt this permanent despoiling, it will happen without environmental impact studies, even though the threat is real to poison the entire ecosystem. We, at least, need to learn what chemicals would be released and what effects they have on living organisms. Let's get some publicity about that. In our watershed, there are those who use wells for their drinking water, to irrigate crops, make wine. They all need to know what is being proposed and what our IEPA signed off on.

In a true market-based economy, this coal mine might have to concede that caring for its waste in environmentally sound ways costs more than the coal is worth out of the ground. That's an important lesson to publicize. What value is the IEPA giving to all the proposed damage and loss in the lower Big Muddy River watershed ecosystem?

Southernmost Illinois has glorious natural gifts. Much of our economy depends on them: clean lakes, agriculture, fishing, recreation and winery tourism. We want to attract people and businesses that depend on healthy land and waters. If we must choose between assisting one coal mine and all that comes with an environmentally sound watershed for generations to come, we must choose the future.

Kay Rippelmeyer
and David Tippy
Pomona

■ **Letter to the Editor and Guest View policy:** *Letters and guest opinion pieces must be submitted via email to letters@thesouthern.com. All submissions should address a current issue and include your name, hometown and telephone number for verification. The Southern does not publish telephone numbers. We reserve the right to edit letters for content or length. We do not print poetry, libelous material or submissions send en masse to numerous news organizations.*

■ **News Tips:** *To report news, call 618-351-5807, our toll-free line at 800-228-0429 or email us at news@thesouthern.com.*

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NPDES IL 0077666
NOTICE NO. 7516C

Exhibit 55

CARBONDALE PARK DISTRICT

PO BOX 1326
CARBONDALE, IL 62903-1326
PH: 618/529/4147 OR 618/549/4222
FAX: 618/457/2580

RECEIVED
AUG 09 2019
IEPA
BOW/WPC/PERMIT SECTION

Mr. Darin LeCrone
IEPA Bureau of Water, Water Pollution Control Permit Section
1021 North Grand Avenue East
Springfield, Illinois 62794-9276

August 5, 2019

RE: NPDES IL 007666
NO:7516

Dear Sirs and Madams:

The Carbondale Park District located in Carbondale Illinois, has very serious concerns regarding the tentative determination to allow Williamson Energy request to release water into the Bid Muddy River. I respectfully request that a public hearing be held to discuss this issue with area residents.

The District owes and maintains property adjacent to the Big Muddy River and have experienced detrimental flooding from the Big Muddy on to said properties. High chloride and sulfate content in the water are of great concern for Hickory Ridge Golf Course, a 300-acre tract of land used for recreation, encompasses an 18-hole course and an 18-hole Frisbee golf course. The irrigation lakes that serve these properties have great potential to be contaminated by this wastewater, as even at its current flow rate, flood waters were on the golf course for over two months in 2019.

Based on concerns for the health of humans, plants and wildlife in addition to the concerns about flooding the Park District respectfully requests that no wastewater from Williamson energy be allowed to be introduced into the Big Muddy River.

Sincerely,

Kathy Renfro, Executive Director

Exhibit 56

RECEIVED
AUG 09 2019
IEPA
BOW/WPC/PERMIT SECTION

To Darin Lecrone, IEPA
Re: NPDES IL0077666 Notice No. 7516c

Are we not paying you and funding the IEPA to PROTECT the ENVIRONMENT? And paying a lot. What's going on here? No, we won't stand for you using our river like a sewer drain.

The Big Muddy is our watershed. It runs through eastern Williamson Co. past DeSoto, toward Carbondale and through Murphysboro, (right through the town!) then south to skirt some of the most glorious land formations in the watershed, the sheer limestone cliffs and Chalk Bluff, Horseshoe Bluff and then the ecological area of La-Rue Pine Hills on its way to the Mississippi.

If we cannot halt this permanent despoiling, it will happen without environmental impact studies, even though the threat is real to poison the entire ecosystem. We at least need to learn what chemicals would be released and what effects they have on living organisms. Let's get some publicity about that. In our watershed, where I live, there are those who use wells for their drinking water, to irrigate crops, make wine. They all need to know what is being proposed and what our IEPA signed off on.

In a true market based economy, this coal mine would have to concede that caring for its waste in environmentally sound ways costs more than the coal is worth out of the ground. That's an important lesson to publicize. What value is the IEPA giving to all the proposed damage and loss in the lower Big Muddy River watershed ecosystem?

Southernmost Illinois has glorious natural gifts. Much of our economy depends on them: clean lakes, agriculture, fishing, recreation, and winery tourism. We want to attract people and businesses that depend on healthy land and waters. If we must choose between assisting one coal mine and all that comes with an environmentally sound watershed for generations to come, we must choose the future.

Kay Rippelmeyer and David Tippy
1451 Macedonia Rd. (Just up the bluff from the Big Muddy)
Pomona, IL

Exhibit 57

RECEIVED
AUG 07 2019
IEPA
BOW/WPC/PERMIT SECTION

To Whom it may concern

From: Dawna Miller

Re: NPDES IL0077666 & Notice No. 7516c

I respectfully ask that the proposal to allow Williamson Energy to dump waste water into the Big Muddy River be denied. The thought of one more of this country's beautiful water ways being polluted by yet another energy corporation is mind boggling. How many more water sources do we have to poison to realize that we, as a human race, have no more drinkable water? We are not just poisoning ourselves but all of the plants and animals that depend upon these resources for survival. The crops that are grown next to these water ways will be toxic and guess who then will consume them? So, we will in fact be contributing to our own demise by lack of clean water and also by contaminated produce. I think the biggest question we need to ask ourselves is how do explain to our children, grandchildren, and perhaps our great grandchildren how we allowed THEIR water to be so contaminated and so scarce that they have to ration it and perhaps do without? We are water beings; our bodies depend on clean water to function properly. If we have to ration water or drink contaminated water our bodies will not be able to operate properly. The water we drink now already had so much chemicals in it that I filter my water and just look at around at all of the stories in the news regarding lead poisoning from the pipes, all of the fluoride in our water, arsenic, etc. At the rate in which the human race is destroying virtually every resource we have upon and within this planet I shutter to think what is in store for my descendants. I want to be able to look them in the eye and tell them I did everything I could to preserve the resources on this planet. We have much more at stake here than jobs or lining the pockets of the already uber rich. This is our very existence. The time has come to not just consider renewable energy it is time to put it in place. Then we create jobs and save our resources at the same time. Please reconsider the ramification of what is being proposed.

Dawna Miller
113 Holly Terrace
Anna, IL. 62906

NPDES IL 0077666 & NOTICE # 7516C

RECEIVED
AUG 07 2019
IEPA
BOW/WPC/PERMIT SECTION

August 5, 2019

R02945

Exhibit 58

Dear Mr. LeCrone,

I request a public hearing about the IEPA's permit that allows Pond Creek Mine to run a pipeline through southern Illinois and to dump mine wastewater into the Big Muddy River. My concerns include the mining company's poor track record and violations, incomplete considerations of the consequences of pipeline breaks or leaks, and disregard for the area that people, plants and creatures use as their home. Why is IEPA and IDNR and the legislators ignoring the Southern Illinoisan news-papers' call for NO permit? In a word, it is greed. The mining company can afford to make whole and good the outcomes of their dirty extraction business, or they

R02946

can take their mining elsewhere. If the mining company insists that their investment in southern Illinois is not worth providing appropriate clean-up and management of the toxic mess they are making, the public should not bear the consequences. IEPA is supposed to care for creation and hold private industry accountable for its deadly practices. Deny the permit; or if you will not do so, then let the people who live here be heard in a public hearing!

NPDES IL0077666
& Notice # 7516C

Beth Spezia
Herrin, IL resident
502 Legacy Drive

Exhibit 59

1021 North Grand Avenue East,
Post Office Box 19276
Springfield, Illinois 62794-9276

Dear IEPA,

I am writing this letter in response to Williamson Energy's application that will allow its Pond Creek Mine operation to pump millions of gallons of high chloride, high sulfate wastewater into the Big Muddy River. I understand that this wastewater will be diluted in a system of tanks, prior to emptying into the Big Muddy, but one of my major concerns is how will the public and your organization know if this dilution system is effective, especially if the proposed egress of the wastewater is downstream from the gauging station where water is measured and analyzed. This brings into question, has the wastewater been tested before and after diluted measures taken place on a normal day? and week of operation? And, what exactly does "diluted measures" mean? The only difference I see between concentrated and diluted wastewater is that former option will contaminate an ecosystem immediately and the latter option will do it more slowly.

This leads to my second issue about the presence of heavy metals within the chloride and sulfate wastewater. How effective and how much of the heavy metals are recovered in the process on a daily, weekly, and monthly period? I don't imagine the quality of water being dumped into the Big Muddy River will be like a natural spring, but how dangerous will this water be for the ecosystem? Is it safe for anyone or anything to consume, bath, and swim? If not, why not?

My third issue is the economic impact as it relates to the tourism and recreation industry. What are the financial numbers unique to the townships and businesses (restaurants, hotels, etc) located downstream from this proposed egress. Residents living near and afar tend to boat and to fish on the Big Muddy River. Southern Illinois has more to offer through its tourism industry than an energy industry that is on its last legs. No one is coming to this region because our waterways will be polluted with wastewater.

It's difficult enough to concede to an industry that contributes towards rising greenhouse effects and now climate crisis and climate apartheid, all because it's a cheap (heavily subsidized) way to keep the lights on. Given the existence of alternative modes of energy production, it's embarrassing as an evolved species, community, and government that the obvious harmful system continues to operate, while responsible Green alternatives continue to struggle. If only there was a system that would protect the environment by phasing out the old and phasing in the new. Sure, there is a point when the old and new will be coexisting together, but there is also a point when the old must concede, especially when it proves economically unsalvageable. What makes a system unsalvageable? When it willfully ignores its own faults (to the physical well-being of its workers and community) and tries to squeeze pennies into thin strands of copper wire or until the momentum of the lobbyists-politician life cycle ends.

This leads to my last point about Williamson Energy's concern for the health and well-being of its workers, since they brought it up, by saying that pumping this water will keep its workers safe. What is Williamson Energy's safety and health record for its miners? Does Williamson Energy care about

the health of the community and ecosystem near it's facilities? If so, to what degree, beyond words and future promises? How have other mines dealt with this similar situation? How are the waterways dealing with wastewater? How is the physical health of individuals living near and on the water in similar areas? What was the economic impact of other river town communities in allowing wastewater being dumped in the water system? Were similar river towns, located further downstream, elated with the waste water or did anyone or other municipal governments file lawsuits. Given that the Big Muddy River flows into the Mississippi River, how will this impact the nutrient loading into this waterway. Where is the evidence that this will not contribute to algal blooms and oxygen deficiency in the Big Muddy River? Given the recent and regularly increasing weather patterns of drought and floods, what impact will this have on the quality of soil near the banks of the river? What about house and land property values? Who would want to live or operate along the Big Muddy if it's well known that wastewater is emptied into the system?

Lastly, I understand, according to The Southern newspaper article, that "there were other alternatives to dumping the diluted wastewater into the river, but they were ultimately passed on for a variety of reasons, including financial and technological concerns." This is a clear and present warning that a system is unsalvageable, bankrupt, and ethically irresponsible. An energy company is unwilling to finance its own technological solution for the benefit of both miners and the ecosystem? Why are these mines allowed to operate without implementing such environmental safeguards. Have they tried to raise funds through other means (grants/loans) to keep their operation in business without this wastewater alternative? I think the public deserves to know what those other financial and technological concerns. Perhaps, the community can be of assistance. Instead, the quick and cheap solution is to dilute the harmful contaminants and let it be someone else's problem and claim that it will benefit everyone's bank account and payroll. If the mining company invests in the technology in doing it the safe and proper way, they too would be contributing to jobs and probably have a greater chance in doing business for the long run. What is the environmental safety record for similar transporting pipelines? Have any leaked? Who is liable if the pipeline does leak? Whose property does the pipeline extend? If so, is there a backup plan and who will be responsible? Do sulfate and chloride contribute to pipeline corrosion? Who is installing the pipes?

One more question, when will this wastewater valve be turned on and what is the projected amount of settled contaminants in the river bed over a period of 1 month, 6 months, 1 year, 5 years, and 10 years time? Based on the economic forecast of the coal industry, how long will Williamson Energy be around before alternative energy industries will replace old technologies? Is building the pipeline worth it for even one day, if the inevitable collapse of an industry is on the horizon.

In the Southern newspaper article, it mentioned an IEPA fact sheet that reads "Small amounts of these substances [Sulfate and Chloride] will be removed by organisms as these substances are necessary for life. No adverse impacts to the receiving streams will occur as all water quality standards will be met." Are there any guarantees that large colonies of sulfur-reducing bacteria will not result from short and long term wastewater dumping? What does independent-reviewed research show based on similar wastewater management systems?

Sincerely,

Antonio Jacob Martinez

R02949

Martinez
104 North Springer St
Carbondale, IL 62901

SAINT LOUIS MO 630
12 AUG 2019 PM 10 L



IEPA
1021 North Grand Ave East
PO Box 19276
Springfield, IL 62794-9276

62794-927575

R02950

Exhibit 60

RECEIVED
AUG 12 2019
ASSOCIATE DIRECTOR'S OFFICE

No. They should not let the mine dump their waste in the Big Muddy River. We don't have to much in Southern IL. any more, but the beauty Dale gave us. Please protect it for the future generations.

Please. Please.

Clara Jane Smith

Clara Smith
1041 N Hickory St
Du Quoin IL 62832-2722

USA FOREVER

USPS
1021 N. Grand Ave East.
PO Box 19276
Springfield, IL 62794-9276

Exhibit 41

From: Meghan Cole
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine
Date: Monday, November 11, 2019 1:54:34 PM
Importance: High

I very much object to the allowance of Williamson Energy being permitted to build, among other things, a 12-mile pipeline to discharge effluent from the mine eventually or directly into the Big Muddy.

As a resident of Murphysboro, Illinois, with small children, and of Southern Illinois, I ask you to not permit this company.

Sincerely,

M
Meghan Cole
Executive Director

Carbondale Main Street
121 S Illinois Avenue
Carbondale, IL 62901

carbondalemainstreet.com
618-529-8040 (office)
618-927-6878 (cell)

Exhibit 62

Studer, Dean

From: Michelle Knox <michelle@windsolarusa.com>
Sent: Monday, July 22, 2019 1:52 PM
To: Ward, Iwona; Stricklin, Gail
Subject: [External] Public Hearing Request NPDES IL0077666 Notice No. 7516c

Dear Ms. Ward and Ms. Stricklin,

I am writing today to object to the proposed 14 mile pipeline traveling from Pond Creek Mind to the Big Muddy River near Benton. As I understand it, this mine plans to pump an average of 3 million gallons of unfiltered mining discharge water, filled with chrorides and sulfates into the Big Muddy River on a daily basis. This will also increase the volume of water in the river by 10-20% per day. In addition to increasing flooding concerns (strategically positioned downstream of the Plumfield Gage Station where the Corps of Engineers could monitor water flow), the unprocessed water could have an impact on the balance of life in the river.

Please include my comments in your consideration of this permit and choose to decline. We have an obligation beyond financial benefits of certain entities to uphold. We must care for our water and the habitat that it provides if we plan to sustain ourselves and our planet for future generations. Thank you for your consideration of the information I've included herein.

--
Best Regards,

Michelle

Michelle Knox, Founder
WindSolarUSA, Inc.
ph. 217.825.4206
michelle@windsolarusa.com
www.windsolarusa.com

Exhibit 63

EPA.PublicHearingCom

From: Darla Judd <judd@mchsi.com>
Sent: Tuesday, August 13, 2019 6:29 AM
To: EPA.PublicHearingCom
Subject: [External] Big Muddy River

Please don't let them dump crap into the Big Muddy!
Darla Judd
200 1st Street
Bush, IL
62924

Sent from my iPad

Exhibit C4

Don't Dump Into Big Muddy
Mine WASTE - ARE You
TRYing to Kill All OF US!!!
Big Coal's Like to rule
the universe !!

WANGLER
607 W. ST. LOUIS ST
W. FRANKFORT,
IL

USPS
1021 North Grand Ave
East
P.O. 19276
Springfield, IL

DISTRICT OFFICES:
2929 BROADWAY, STE. 3
MT. VERNON, ILLINOIS 62864
618. 242. 8115
618. 242. 8118 FAX

1032 W. INDUSTRIAL PARK RD.
MURPHYSBORO, ILLINOIS 62966
618. 684. 1100
618. 529. 2788 FAX

CAPITOL OFFICE:
207-N STRATTON BUILDING
SPRINGFIELD, ILLINOIS 62706
217. 782. 0387
EMAIL: STATEREPTERRIBRYANT@GMAIL.COM

TERRI BRYANT
STATE REPRESENTATIVE · 115TH DISTRICT

08/06/2019

Exhibit 65

Director John Jim
1021 N Grand Ave E
Springfield, IL 62702

Dear Director,

I have received feedback from several of my constituents on Pond Creek Mine and water being dumped into the Big Muddy River.

As the public comment period is still open I am requesting a public hearing to be held in Murphysboro, Illinois prior to issuing any permits.

Sincerely,

Terri Bryant

State Representative
115th District

RECEIVED IN
AUG 12 2019
THE OFFICE OF THE DIRECTOR

Exhibit 66

EPA.PublicHearingCom

From: Lieberoff, Barb
Sent: Wednesday, July 24, 2019 10:30 AM
To: Ward, Iwona; Studer, Dean
Cc: LeCrone, Darin
Subject: FW: [External] Pond Creek Mine Permit-Williamson Enery

FYI comments regarding Pond Creek Mine-request for hearing

-----Original Message-----
From: Katie Foley <foleyk20@gmail.com>
Sent: Wednesday, July 24, 2019 10:28 AM
To: Lieberoff, Barb <Barb.Lieberoff@Illinois.gov>
Subject: [External] Pond Creek Mine Permit-Williamson Enery

Barb,

I am a resident of Murphysboro, IL and I wanted to express my opposition to the IEPA granting a permit to Williamson Energy for a pipeline that would allow Pond Creek Mine to pump millions of contaminated water into the Big Muddy River. I think the impact would be disastrous for the waterways and residents in southern Illinois. I request a public hearing and once again oppose the IEPA grating this permit.

Please consider the impact on my community. Southern Illinois should not a dumping ground for energy companies. We are already battling contaminants from the past and don't need new pollutants dumped into our rivers.

Thanks you for your time and consideration.

Katie Keller
1104 N 20th Street
Murphysboro, IL 62966
618-534-8809

Sent from my iPhone

State of Illinois - CONFIDENTIALITY NOTICE: The information contained in this communication is confidential, may be attorney-client privileged or attorney work product, may constitute inside information or internal deliberative staff communication, and is intended only for the use of the addressee. Unauthorized use, disclosure or copying of this communication or any part thereof is strictly prohibited and may be unlawful. If you have received this communication in error, please notify the sender immediately by return e-mail and destroy this communication and all copies thereof, including all attachments. Receipt by an unintended recipient does not waive attorney-client privilege, attorney work product privilege, or any other exemption from disclosure.

Exhibit 67

EPA.PublicHearingCom

From: Nel Battrell <nelbattrell@gmail.com>
Sent: Friday, July 26, 2019 10:04 AM
To: LeCrone, Darin
Subject: [External] NPDES #IL0077666 and Notice No. 7516C

Sir:

I am writing to request a public hearing on this matter. My name is Nelma Battrell, 1451 E Grand Ave, Carbondale, IL 62902. We are in a time that requires us to protect our natural resources AT ALL COST. The time for destruction of wildlife and our environmental treasures, because of jobs and money making ventures needs to come to an end. People can retrain for better jobs. The coal mines have not been beneficial to our area and population beyond making money anyway. I am not in favor of dumping additional waste into any of our rivers or water ways.

Thank you,

Nelma Battrell

Exhibit 68

EPA.PublicHearingCom

From: Katrina Renzaglia <krenzag@gmail.com>
Sent: Friday, July 26, 2019 1:42 PM
To: LeCrone, Darin
Subject: [External] Hearing

EMAIL & REQUEST A HEARING ON POND CREEK MINE PERMIT APPLICATION TO

I am requesting A PUBLIC HEARING BY AUG 12

- My name is Katrina Renzaglia. My address is87 Harris Lane Alto Pass Illinois. I am concerned that pollutants are going to be dumped into the water and create a health and environmental hazard.
- I Ask that IEPA hold a Public Hearing
- NPDES IL0077666 & Notice No. 7516C

Exhibit 69

EPA.PublicHearingCom

From: Joan Steele <hikerj76@gmail.com>
Sent: Friday, July 26, 2019 3:20 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice No.7516c

I am contacting you to express concern about plans for the Big Muddy River and to request a public hearing on the above. I live near the Big Muddy River and cross it every day on my way to work. It is flooding with increased regularity and the addition of millions of gallons of chemical water would impact all downstream as well as cause further erosion. There is already mine pollution from permitted sites being put in that river. I do not believe there has been an assessment of the cumulative water impacts of these and the proposed addition of sulfates and chlorides which usually exceed the water quality standard allowed to be discharged. In addition the pipeline input into the river would be just below a pumping station where water contents are measured.

I also do not believe there was an assessment of the long range impact of the large amount of groundwater being removed. The local mayor opposes this action despite having a parent and grandparent working in the mines. Towns downstream have to pay to treat their wastewater, so the company should have to also. I would like to see an assessment of the full social, health, environmental, and climate costs over the long term. I do not understand why the public will have to underwrite the long term bad effects of a mining company, Foresight Energy, who has made billions of dollars of profits on Illinois coal mining. Only looking at short term economics without consideration of the environment and subsequent impacts including financial of people is what got us in trouble with climate change. Please require the mine to build a water treatment plant on-site instead of using southern Illinois as its sewer to make more profits.

Joan Steele
191 Wides Road
Murphysboro IL 62966

Exhibit 70

EPA.PublicHearingCom

From: Patty W <pweyhrich711@hotmail.com>
Sent: Saturday, July 27, 2019 2:32 PM
To: LeCrone, Darin
Cc: Jane Cogie; Carla Womack; Patty W
Subject: [External] Hearing request for Pond Creek Mine NPDES IL0077666 & Notice No. 7516C

Darin Lecrone

As a resident of Jackson Co, IL and a citizen concerned about water quality I request a hearing on the Pond Creek Mine permit application to discharge waste water into the Big Muddy River. Rivers are a diverse habitat that support life, they are not sewers for discharging waste produced by industry.
Several concerns are:

- adverse short-term or long-term effects of elevated levels of chlorides and sulfates on aquatic plants and animals
- the amount of waste water being discharged
- how penalties for violations would be applied
- who is responsible for monitoring the chemicals in the discharge

Patty Weyhrich
28 Southmoor Street
Carbondale, IL

Exhibit 71

EPA.PublicHearingCom

From: Susan Livingston <twipottergames@yahoo.com>
Sent: Saturday, July 27, 2019 4:10 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice No. 7516C

Dear IEPA,

Hello, my name is Beatriz and I live in Southern IL. It has come to my attention that the IEPA is planning to discharge mine water into the Big Muddy River. I am e-mailing you in the hope that this harmful plan will be called off. I would like to urge the IEPA to hold a public hearing on this issue.

Sincerely,
Beatriz S.

Exhibit 72

EPA.PublicHearingCom

From: robinr702@gmail.com
Sent: Sunday, July 28, 2019 10:12 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Dear Mr. Lecrone:

I am dismayed that the IEPA is apparently in the process of making a decision that will allow the Pond Creek Mine to dump millions of gallons of toxic water into the Big Muddy River.

I had thought—obviously naively—that the IEPA is in place to protect the people of Illinois.

This decision would not only affect the people of Illinois, but because the Big Muddy flows into the Mississippi River, which flows into the Gulf of Mexico—it would impact all aquatic and human life along the way.

The owners of the Pond Creek Mine claim they can't afford the cost of properly filtering the wastewater generated by the mine. I am skeptical.

I request a public hearing regarding NPDES IL0077666—one that is adequately publicized.

Thank you.

Sincerely,

Robin Russell
565 Rowan Road
Makanda, IL 62958
robinr702@gmail.com

Exhibit 73

EPA.PublicHearingCom

From: Jack McKillip <jamckillip48@hotmail.com>
Sent: Sunday, July 28, 2019 2:17 PM
To: LeCrone, Darin
Subject: [External] NPDESIL0077666 & notice no. 7516c

Dear Mr. Lecrone,

I am told that the IEPA is contemplating " approval of Pond Creek Mine's application to discharge millions of gallons of waste into Big Muddy River." I'm sure this isn't true. Certainly the IEPA would deny such an application on its merits. If such an application has been made, I request a public hearing on the matter.

Sincerely,

John A. McKillip

Carbondale, Illinois 62901

Toradh na córa an tsíocháin

Exhibit 74

EPA.PublicHearingCom

From: Gayla Kain <gkain51@hotmail.com>
Sent: Monday, July 29, 2019 9:55 AM
To: LeCrone, Darin
Cc: Gayla Kain
Subject: [External] NPDESIL0077666. Notice No. 7516c

NPDESIL 0087666 notice no. 7516c

As per the letter to the editor from Jan Thomas of Murphysboro in the July 28th edition of the Southern Illinoisan, I feel there is a need for a public hearing on the Pond Creek Mine's application to dump millions of gallons of toxic water into the Big Muddy River.

Charles & Gayla Kain
West Frankfort Il
Sent from my iPhone

Exhibit 75

EPA.PublicHearingCom

From: Michael Duncan <vetrepdunk@yahoo.com>
Sent: Monday, July 29, 2019 1:34 PM
To: LeCrone, Darin
Subject: [External] Pond Creek Mine application to dump toxic water into the Big Muddy River

Re: NPDESIL0077666 & Notice No. 7516c

Fr: Michael L. Duncan
1619 Shomaker Drive
Murphysboro, IL. 62966
Ph. # 618-841-8731

My home/property is located along the North side of the Big Muddy River in Murphysboro, IL. I have approx. 3 acres that overlooks the river and an abundance of wildlife that utilizes it for drinking, bathing, feeding, & habitat.
Commonly are the Bald Eagles, Canadian Geese, Deer, Racoons, Coyotes, and an enormous amount of species of Egrets & Herons and common birds.

Every year the Big Muddy rises and covers approximately 1.5 - 2 acres of my back yard and stays for two or three months . With that comes an abundance of wildlife activity that any person would enjoy. Only a short distance downstream is the Murphysboro park where families and their children attend and enjoy nature, fishing, concerts,outdoor activities, etc.

I certainly oppose Pond Creek Mines project of dumping any amount of toxic contaminates into the Big Muddy River that very well impose danger to families, wildlife, and vegetation species along our Shawnee Forest area.

Respectfully submitted,

Michael L. Duncan
Murphysboro, Il 62966

Exhibit 76

EPA.PublicHearingCom

From: bluebird7@frontier.com
Sent: Monday, July 29, 2019 3:06 PM
To: LeCrone, Darin
Subject: [External] IEPA hold a Public Hearing • NPDES IL0077666 & Notice No. 7516C

Dear Mr. Lecrone,

I believe it is important to hold a Public Hearing on Pond Creek Mine Permit Application to pump toxic wastewater into the Big Muddy River. Our rivers should not be considered as "dumping grounds" for toxic wastewater. The public needs to hear from IEPA on all the reasons/proofs taken into consideration to prove this type of action is not harmful to humans or other species in the Big Muddy River.

Thank you,
Amber Hewette
1711 W. Walnut St.
Carbondale, IL 62901

Exhibit 77

EPA.PublicHearingCom

From: tessford@mediacombb.net
Sent: Monday, July 29, 2019 5:18 PM
To: LeCrone, Darin
Subject: [External] Re: NPDES IL0077666 Notice No. 7516c Pond Creek Mine

Dear Mr. LeCrone,

Re: NPDES IL0077666 Notice No. 7516c

I am writing to express deep concerns with the plan for Pond Creek Mine to release water into the Big Muddy River. I own property along the Big Muddy near De Soto and experience flooding every year. I am unable to access some of the land for several months due to flooding. This year was particularly difficult as the water remained high for many months. The additional water from the mine will no doubt make this problem considerably worse for me and many others who live along the river. I pay taxes on this land and cannot use during months of flooding. One of my neighbors has a building that becomes flooded when the water is high, and there are many farmers near me that cannot get their crops out or sometimes even leave their property without a boat. I am also concerned about the pollutants (sulfates and chlorides) added to the water for our fish, wildlife and our drinking water. We need to take action now to protect our environment.

While I support mining, I do not support mining that damages our environment by increasing flooding pollutants or the use of fracking measures to extract ore. The Pond Creek Mine should seek other avenues that do not negatively impact all residents along the Big Muddy and lower Mississippi Rivers.

Please share my concerns with others and for the good of southern Illinois, please do not approve this permit.

Thank you.

Sincerely,

Tess D. Ford
204 Pinewood Court
De Soto, Illinois 62924
618534-8245

tessford@mediacombb.net

Exhibit 18

EPA.PublicHearingCom

From: t g <tom.grant.1@hotmail.com>
Sent: Tuesday, July 30, 2019 10:48 AM
To: LeCrone, Darin
Subject: [External] Pond Creek Mine Proposal

Dear Mr. Lecrone,

I respectfully request that the IEPA hold a well publicized public meeting regarding the discharge proposal into the Big Muddy River.

Thank you.

Thomas Grant

Sent from Outlook

Exhibit 79

EPA.PublicHearingCom

From: Robert Swenson <robert.swenson41@gmail.com>
Sent: Tuesday, July 30, 2019 11:10 AM
To: LeCrone, Darin
Cc: les.winkeler@thesouthern.com
Subject: [External] Big Muddy River / Pond Creek Mine toxic water

As a resident of this planet and more specifically a resident of Jackson County, Illinois and one who has been a water-person since growing up on the Ohio at Metropolis, I am particularly dismayed/disgusted that anyone would propose to dump toxic mine waste into our public water system. I just can't imagine the arrogance to think that it is OK to do this to our environment - to poison the fish, reptiles, waterfowl, and people who depend on this natural resource flowing out of Rend Lake and through farmland, new public recreation and winery facilities, the City of Murphysboro, and the Pine Hills/Larue Swamp area !!!! . . . and then into the Mississippi River. It is the responsibility of the coal extraction company to make sure their holding/sediment ponds (as many as needed) protect our creeks and rivers from contamination.

Thank you for this opportunity to comment. Robert Swenson

--
Robert Swenson, Architect (retired)
Heritage Preservation Consultant
Associate Professor Emeritus - SIUC School of Architecture
211 S. Dixon Avenue
Carbondale, IL 62901
618-967-3016
robert.swenson41@gmail.com

Exhibit 80

EPA.PublicHearingCom

From: Neil Claussen <rnclaussen@gmail.com>
Sent: Tuesday, July 30, 2019 11:31 AM
To: LeCrone, Darin
Subject: [External] NPDESIL0077666 & Notice #7516c

I am writing to express my opposition to granting this proposal and to request a public hearing. I personally need more time to investigate the inpact on the Big Muddy River. Time may prove that it is safe, but we should not go forward without further investigation. Thanks for your consideration.

R Neil Claussen
2950 Westridge Place, Apt. 215
Carbondale, IL 62901

Sent from Mail for Windows 10

Virus-free. www.avast.com

Exhibit 81

EPA.PublicHearingCom

From: Kathryn Jenkel <katjenkel@hotmail.com>
Sent: Tuesday, July 30, 2019 12:50 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666, Notice #7516c, Pond Creek Mine Application

Kathryn Jenkel
98 Ox Tail Trail
Carbondale, IL 62902
katjenkel@hotmail.com

July 30, 2019

IEPA
1021 North Grand Avenue East
Post Office Box 19276
Springfield, IL 62794-9276

RE: NPDES IL0077666 - Notice #7516c

Dear IEPA,

I am requesting a Public Hearing.

I am opposed to tentative approval of Pond Creek Mine's application to dump millions of gallons of toxic water into Big Muddy River.

No environmental studies have been done on the long term effects of proposal: cumulative water quality, effects on fish and wildlife, bank erosion, flooding, climate crisis, social and environmental costs to people along course of river, many of whom are already impoverished.

The public hearing held by IDNR last October was poorly publicized.

This wealthy corporation is offering little bonding to offset any problems that might arise, and no plans for detoxifying the water beyond a series of sediment ponds, which of course can overflow during periods of heavy rain.

Also there is no severance tax on coal in Illinois. Legisation to create one has stalled in the legislature since March 2019.

Most of Pond Creek Mine's coal will be sold abroad, also no benefit to Southern Illinoisans.

Truly,
Kathryn Jenkel, Very Concerned Citizen

Exhibit 82

EPA.PublicHearingCom

From: Cheryl Couch <ccouch54@gmail.com>
Sent: Tuesday, July 30, 2019 3:23 PM
To: LeCrone, Darin
Subject: [External] IL0077666 & Notice No. 7516C

Mr. Lecrone ,

I am concerned that the Pond Creek Coal mine has applied to be able to discharge mine water into the Big Muddy River. I request that the IEPA hold a public hearing. We cannot pollute our rivers .

Cheryl Couch
11644 Hurricane Rd
Carterville, IL

Exhibit 83

EPA.PublicHearingCom

From: Henry Gelstor <henry.gelstor@gmail.com>
Sent: Wednesday, July 31, 2019 12:10 AM
To: LeCrone, Darin
Subject: [External] Public Hearing Request NPDES IL0077666 Notice No. 7516c

We the People request a public hearing for Public Hearing for NPDES IL0077666 Notice No. 7516c.

So somehow the mine is permitted to dump millions of pounds of toxic pollutants into our river... and for free? Why is this even being considered? Who does allowing this benefit? A few number of very rich people will get a little tiny bit richer. The people of the state of illinois lose an important waterway asset forever. You can't clean this stuff up at any cost. Once it's in there, it's there forever. If there was a safe, affordable way to clean it up, the company would be doing it.

I sure hope whatever personal gains you people are getting out of this is worth the literal death, cancer, organ failure, chronic sickness, pain, suffering and destruction to our families, our children, children's children and to our pets, livestock, wildlife, farms- our very economic future is at stake. Why trash the place for everyone, forever? We should fight to preserve what little clean drinkable water we have left - not go out of our way to encourage an unnecessary mass industrial shitting in it.

Do the right thing. Say "NO". Leave something left for your grand kids to exploit. Oh BTW, Can I drop everybody's garbage at your house? Just figured you wouldn't mind...you know, since there's nothing "wrong" with it- lets spread it on your neighborhood instead...

Henry-

Exhibit 84

EPA.PublicHearingCom

From: Jon Womack <womackdaddy55@gmail.com>
Sent: Thursday, August 1, 2019 12:10 PM
To: LeCrone, Darin
Subject: [External] Public Hearing Request NPDES IL0077666 Notice No. 7516c

We the People request a public hearing for Public Hearing for NPDES IL0077666 Notice No. 7516c.
Jon Womack
dulce55@yahoo.com

Exhibit 85

EPA.PublicHearingCom

From: Sheila Simon <sheilajsimon@gmail.com>
Sent: Thursday, August 1, 2019 4:35 PM
To: LeCrone, Darin
Subject: [External] Fwd: Big Muddy permit, NPDES IL0077666

Hello Darin, this is Sheila Simon, from Carbondale. I am very concerned about the proposed waste dumping into the Big Muddy.

My husband and I are regular bike riders and pass over a creek just off the river almost every day. When there are floods the river backs up into the creek, so the landscape changes regularly. We stop at the bridge on every ride to look for herons, turtles and gar (the gar look like sharks!).

We are far from the only folks who enjoy this spot. Just this morning on the bridge a driver stopped to tell us about a huge turtle that she and her young son saw when they stopped there the other day.

I am sure the mine owners portray Southern Illinois as coal territory. And there are a few people left who earn their living from coal. But the natural beauty of our area is an economic resource that will far outlast coal reserves if we are wise.

Please do what you can to protect our land. And let me know if there is anything else I can do.

Sheila Simon
404 North Springer St.
Carbondale, Illinois 62901

618 867-2062

EPA.PublicHearingCom

From: Sheila Simon <sheilajsimon@gmail.com>
Sent: Thursday, August 1, 2019 3:04 PM
To: LeCrone, Darin
Subject: [External] Fwd: Big Muddy permit, NPDES IL0077666

---------- Forwarded message ---------
From: **Sheila Simon** <sheilajsimon@gmail.com>
Date: Thu, Aug 1, 2019, 2:43 PM
Subject: Big Muddy permit, NPDES IL0077666
To: <darin.lecrone@illinos.gov>

Hello Darin, this is Sheila Simon, from Carbondale. I am very concerned about the proposed waste dumping into the Big Muddy.

My husband and I are regular bike riders and pass over a creek just off the river almost every day. When there are floods the river backs up into the creek, so the landscape changes regularly. We stop at the bridge on every ride to look for herons, turtles and gar (the gar look like sharks!).

We are far from the only folks who enjoy this spot. Just this morning on the bridge a driver stopped to tell us about a huge turtle that she and her young son saw when they stopped there the other day.

I am sure the mine owners portray Southern Illinois as coal territory. And there are a few people left who earn their living from coal. But the natural beauty of our area is an economic resource that will far outlast coal reserves if we are wise.

Please do what you can to protect our land. And let me know if there is anything else I can do.

Sheila Simon
404 North Springer St.
Carbondale, Illinois 62901

618 867-2062

Exhibit 86

EPA.PublicHearingCom

From: Christina Krost <christina@faithinplace.org>
Sent: Friday, August 2, 2019 9:49 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 and Notice No. 7516c

My name is Christina Krost and I am requesting a public hearing on NPDES IL0077666 Notice No. 7516c.

Address: 78 Ledford Rd., Harrisburg, IL 62946.

CONCERNS: The Big Muddy is already impacted by permitted and pre-regulations mine pollution from upstream and downstream sources. What is a full assessment of the biological or other environmental impacts of the proposed mixing of this contaminated mine water on the river ecosystem and current uses (fishing, private land and other recreational uses) of the Big Muddy River?

-No assessment of the cumulative water quality impacts on the Big Muddy River from this proposal over the many years of continued coal mining
-No assessment of potential to add to flooding, river bank erosion and downstream impacts
-No assessment of what such a large groundwater withdrawal quantity (millions of gallons a day infiltrating underground mine works) could be doing to the local area or what implications this might have for the future
-No assessment of the full social, health, environmental, and climate costs of this mine and whether those are greater than the claimed $78 million in local, state, and federal revenues that it claims to generate each year
-Proposed pipeline route from the IDNR mining permit materials
The Pond Creek mine should be required to build a water treatment plant on-site to ensure their water discharges meet all regulations instead of using the Big Muddy River as a "dilution solution." The Big Muddy River flows into the Mississippi River and is considered a water of the state. Public entities pay to treat their sewage and millions have been spent on efforts to clean up Mississippi River water quality. The mine should be required to manage their pollution without shifting the risks and potential problems and costs to the public.

As a person of faith, I believe I should speak up on behalf of our shared land, air, and water. Therefore, I am requesting a public hearing on NPDES IL0077666 Notice No. 7516c.

Christina Krost
Southern IL Outreach Coordinator
Faith in Place
The Illinois Affiliate of Interfaith Power & Light

UMW Be Just Be Green Jurisdiction Guide (NCJ)

217-343-4899

Pronouns: she/her/hers

Exhibit 87

EPA.PublicHearingCom

From: Ann Wheeler <ridge_girl1@yahoo.com>
Sent: Friday, August 2, 2019 4:20 PM
To: LeCrone, Darin
Subject: [External] NPDES IL OO77666, Notice #7516C

Dear Mr. Lecrone;

I am respectfully requesting that the IEPA hold an open hearing by August 12 on the item referenced. The proposed discharge of toxic mine waste into the Big Muddy River has been demonstrated to be hazardous for the environment, local wildlife, and those who depend on the river for their livelihood. If that weren't bad enough, should the discharge prove --- as is fully expected --- to be environmentally and fiscally disastrous, there is no way in which Pond Creek Mine can be held accountable for the damage.

Sincerely,

Ann E. Wheeler
2532 Dutch Ridge Road
Carbondale IL 62903

Exhibit 88

EPA.PublicHearingCom

From: toni kennedy <tcakes1@gmail.com>
Sent: Saturday, August 3, 2019 9:39 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Please do the right thing and stop this from moving forward. Thousands of people, fish and wildlife are counting on you.

Thank you
Toni L. Kennedy
Murphysboro, Il 62966

Exhibit 89

EPA.PublicHearingCom

From: Dona Reese <dona.reese@gmail.com>
Sent: Sunday, August 4, 2019 9:01 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

As a citizen of Southern Illinois, I am begging you to stop Williamson Energy from dumping wastewater into the Big Muddy River. We the People will be harmed by this pollution of our river. Please go by the will of the people, which is the foundation of our democracy.

--

Dona J. Reese, PhD, MSW, LCSW
Professor
School of Social Work
Southern Illinois University

Exhibit 90

EPA.PublicHearingCom

From: william grisley <wgrisley@gmail.com>
Sent: Sunday, August 4, 2019 9:36 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Greetings. I oppose the proposed use of the Big Muddy River as a dumping place for any and all wastes, including those from coal mining operations. The Big Muddy is owned by the people of Illinois and should NEVER be used as a dumping ground. The Illinois EPA has both a responsibility and duty to protect the natural integrity of this river. Nothing less is acceptable.

William Grisley
Pittsburg, Illinois

Exhibit 91

EPA.PublicHearingCom

From: Rippelmeyer-Tippy, Kay M <kayrip@siu.edu>
Sent: Sunday, August 4, 2019 10:35 AM
To: LeCrone, Darin
Subject: [External] Our watershed
Attachments: The Big Muddy is our watershed.docx

To Darin Lecrone, IEPA
Re: NPDES IL0077666 Notice No. 7516c

Are we not paying you and funding the IEPA to PROTECT the ENVIRONMENT? And paying a lot. What's going on here? No, we won't stand for you using our river like a sewer drain.

The Big Muddy is our watershed. It runs through eastern Williamson Co. past DeSoto, toward Carbondale and through Murphysboro, (right through the town!) then south to skirt some of the most glorious land formations in the watershed, the sheer limestone cliffs and Chalk Bluff, Horseshoe Bluff and then the ecological area of La-Rue Pine Hills on its way to the Mississippi.

If we cannot halt this permanent despoiling, it will happen without environmental impact studies, even though the threat is real to poison the entire ecosystem. We at least need to learn what chemicals would be released and what effects they have on living organisms. Let's get some publicity about that. In our watershed, where I live, there are those who use wells for their drinking water, to irrigate crops, make wine. They all need to know what is being proposed and what our IEPA signed off on.

In a true market based economy, this coal mine would have to concede that caring for its waste in environmentally sound ways costs more than the coal is worth out of the ground. That's an important lesson to publicize. What value is the IEPA giving to all the proposed damage and loss in the lower Big Muddy River watershed ecosystem?

Southernmost Illinois has glorious natural gifts. Much of our economy depends on them: clean lakes, agriculture, fishing, recreation, and winery tourism. We want to attract people and businesses that depend on healthy land and waters. If we must choose between assisting one coal mine and all that comes with an environmentally sound watershed for generations to come, we must choose the future.

Kay Rippelmeyer and David Tippy
1451 Macedonia Rd. (Just up the bluff from the Big Muddy)
Pomona, IL

Exhibit 92

EPA.PublicHearingCom

From: Schilling, Lawrence <lchillin@siu.edu>
Sent: Sunday, August 4, 2019 10:37 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

NPDES IL0077666 & Notice No. 7516c

I firmly oppose the dumping of coal mine waste into the Big Muddy river!!!

Exhibit 93

EPA.PublicHearingCom

From: James Kimmel <j.kimmel83@gmail.com>
Sent: Sunday, August 4, 2019 10:41 AM
To: LeCrone, Darin
Subject: [External]

Hello,
I am writing you in regards to the a Pond Creek project. I disagree with the proposal to let the mine run a pipeline directly to the big muddy river. There are countless reasons not to do so. I feel the most important reason though, is establishing past practice. Once pond creek has been allowed to do so, it has opened the doors for every other business in Illinois to ask for the same conditions. The Big Muddy River is a glorified creek that runs though some of southern illinois greatest nature escapes. Allowing any change to that ecosystem could have a domino effect on the plants and wildlife. Take for instance the red legged frog incident in California, who change and loss of habitat crushed it's population. Now a program is in place to restore the population costing taxpayers money.

Use pond creek for an example. If they don't follow the guidelines (which they will not, history has shown that non union coal mines feel its cheaper to pay the fines rather than be safe), then they dump contaminated water just below the measuring station. This is strategic to use our waterways way to help dilute their waste. What if they start killing a frog population, that leads to the decline of predator food, which leads to the decline in wildlife.

In closing, the big muddy river is a public waterway that belongs to the public. If you want to get the best numbers possible, then you should put it on the ballot it 2020 in all of the counties that border the big muddy river. My family stands strongly against the pond creek project. If they need to dump water, then they need to build a water treatment facility like every other business and community in southern illinois.
Thank you for your time,
The kimmel family

Exhibit 94

EPA.PublicHearingCom

From: Jamie Nash-Mayberry <jnashmayberry@shawneedistrict84.com>
Sent: Sunday, August 4, 2019 10:42 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

I read in the paper to direct comments to you regarding my opinion on allowing the Pond Creek Mine in southern IL to dump into the Big Muddy River. If this isn't correct, please let me know.
My name is Jamie Nash-Mayberry, and I'm a teacher in the Shawnee School District which includes floodplain land that the Big Muddy River flows through. For the past 10 years my students and I have raised awareness of the deteriorating levees both along the Muddy and the Mississippi River, and our fear that one day those levees will fail us, and leave my students without homes, farms, and a school. When I read about the mine's plan to dump waste into the Muddy, I was so upset. First of all, it will increase water levels along the muddy, and that is never needed. We now have seen where a flash flood, which is essentially what the New Year Flood of Dec 2015/Jan 2016 was, can result in catastrophic river flooding. Thus, we must do all we can to prevent adding extra water into the muddy at any time, whether it be during a flood or not. We never know when the next big week of rains might come and result in horrific results. Tied to that, if the river overflows, those contaminants will spread into areas where people reside. Second, I worry about what the pollutants will do to our natural beautiful area. I don't want to see places like the beautiful valleys around Grand Tower, IL become polluted. Third, many farmers grow crops in those valleys and it could hurt the health of those who consume those crops if they grow in polluted areas. Finally, I worry about the pollutants seeping into the water supply of people's wells and other areas. For all these reasons, and more, I ask that you NOT allow the dumping of wastes into the Big Muddy River.
Sincerely,
Jamie Nash-Mayberry
Shawnee High School

Exhibit 95

EPA.PublicHearingCom

From: jmrestivo53 <jmrestivo53@gmail.com>
Sent: Sunday, August 4, 2019 10:52 AM
To: LeCrone, Darin
Subject: [External] Npdes il0077666&notice no. 7516c

I oppose discharge of poluted wastewater into the big muddy river

Sent via the Samsung Galaxy S7 active, an AT&T 4G LTE smartphone

Exhibit 96

EPA.PublicHearingCom

From: Ruane & Debra Tanner <rdtanner85@gmail.com>
Sent: Sunday, August 4, 2019 11:29 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No.7516c

We are strongly against the IEPA allowing Williamson Energy to dump wastewater into the Big Muddy River. One would think that this matter would be a "no-brainer", due to the level of pollution being considered and the obvious potential ecological and health related problems this could create. I also refer you to the editorial in the 8/4/19 Southern Illinoisan. And honestly, I really thought this level of industrial pollution and betrayal of the public trust was outlawed thirty years ago.

Ruane Tanner
Debra Tanner
Anna

Exhibit 97

EPA.PublicHearingCom

From: leonard brantley <lcb54@hotmail.com>
Sent: Sunday, August 4, 2019 2:03 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666&NoticeNo7516c

I am against the dumping of coal mine waste in to any Illinois water way including the Big Muddy River my name is Leonard Brantley 2651 Town Creek Rd Murphysboro Illinois 62966. (618) 6872662

Sent from my iPhone

Exhibit 98

EPA.PublicHearingCom

From: Donna Brantley <donnajcbrantley@hotmail.com>
Sent: Sunday, August 4, 2019 2:18 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

I am against the dumping of coal mine waste into any Illinois water way including the Big Muddy River. My name is Donna Brantley, I am a resident of Illinois in Jackson County and a registered, tax paying voter. My address is 2651 Town Creek Road, Murphysboro, Illinois 62966. Thank you for your time in reading my email.

Exhibit 99

EPA.PublicHearingCom

From: Monika Plumb <flockie99@gmail.com>
Sent: Sunday, August 4, 2019 4:21 PM
To: LeCrone, Darin
Subject: [External] NPDES IL 0077666 Notice Ino. 7516c

I am urging you to reconsider the tentative approval for letting millions of toxic waste water flow into the Bid Muddy River. There needs to be another public hearing (well advertised), and an environmental impact study. The corporation is not bonded to take care of adverse effects. And what will happen to the toxic waste when we have flooding like in the past!!
This sounds like a public health hazard to me.

Monika Plumb
708 Emerald Lane
Carbondale, Il 62901
618-559-7441

Exhibit 100

EPA.PublicHearingCom

From: Terry Gillespie <terrywhizgee@me.com>
Sent: Sunday, August 4, 2019 5:51 PM
To: LeCrone, Darin
Subject: [External] Big Muddy Environmental

I am only one voter and land operator. I don't believe that the Big Muddy basin ought to be trashed with chemicals by anyone.

Sent from my PiePad

Exhibit 101

EPA.PublicHearingCom

From: Ed Doty <ed.doty49@gmail.com>
Sent: Sunday, August 4, 2019 6:04 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice No. 7516c

PLEASE, PLEASE do NOT allow ANY coal mine to discharge its waste into the Big Muddy River, or any other body of water, stream, or ditch in our great state. (Yes. Even though our state is struggling and catching all kinds of bad press, I still consider it a great place to live.)

Although jobs are important to our area, we cannot sacrifice the environment in which we live to support those jobs.

Consider the long-term damage this could ultimately wreak upon our precious water, land, and wildlife and make the only decent decision....DENY THIS REQUEST!!!

Ed Doty
618.927.3938

Exhibit 102

EPA.PublicHearingCom

From: marilynwillis <mern17@peoplepc.com>
Sent: Sunday, August 4, 2019 7:19 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No7516c

To Whom It May Concern, The five of us: Ed and Marilyn Willis, Rob Willis, and Bill & Nora Weatherly are strongly opposed to allowing mining companies to dump pollutants into the Big Muddy River. We live in Murphysboro. Thanks

Exhibit 103

EPA.PublicHearingCom

From: Domenick Ronchetto <dmjrsronchetto@gmail.com>
Sent: Sunday, August 4, 2019 7:46 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Tried to send this before but keeps getting rejected. If you allow that polluted water to be dumped in the Big Muddy you just as well absolve the IEPA. It's your job to protect,I think that's what the P is for. I worked in one of the wettest coal mines that Murry Enterprises ever owned and don't recall one accident caused by wet conditions. He doesn't want to spend the money to pump and clean the water and that's the bottom line. At least make him dump above the sampling station so he can be monitored,you'll for sure have to.

Exhibit 104

EPA.PublicHearingCom

From: Rebekah Wilkerson <rebekah202003@yahoo.com>
Sent: Sunday, August 4, 2019 8:53 PM
To: LeCrone, Darin
Subject: [External] NPSES IL0077666 NOTICE NO. 7516c

Good Evening:

It was brought to my attention that Williamson Energy is requesting to dump polluted water into the Big Muddy River.

I am AGAINST any dumping into this river and request that it not be allowed.

I live along the banks of the Big Muddy River and am disgusted that this situation is even being considered. Won't be able to showcase Southern Illinois as a tourist location with beautiful scenery if it's polluted.

Thank you.

Rebekah Wilkerson
rebekah202003@yahoo.com
(618) 203-9117

Exhibit 105

EPA.PublicHearingCom

From: Oldway <oldinway@yahoo.com>
Sent: Sunday, August 4, 2019 8:59 PM
To: LeCrone, Darin
Subject: [External] IL0077666 Pond Creek mine

IL 0077666
Notice no. 7516c

Dear Sir,
The Pond Creek Mine, located in Williamson County about 14 miles south of the Rend Lake dam, is to discharge waste water into the Big Muddy River is not Avery good decision for our future generations. Please think about grand children and great grand children enjoy the rivers beauty. The amount of waste water predicted to be released will kill most if not all of the aquatic life down stream. Someone's future rides in your hands. Someone's loved ones do also.

Michael K. Calandro
10290 HWY 127
Murphysboro, Il. 62966

Sent from Yahoo Mail for iPad

Exhibit 106

EPA.PublicHearingCom

From: Brian Barker <heepwah99@hotmail.com>
Sent: Monday, August 5, 2019 9:08 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice number 7516c

Dear Illinois Government Workers,

Please, please, and please again - do not let this coal company dump wastewater into the Big Muddy River. The agricultural runoff is bad as it is. This will exacerbate the life that is trying to survive there.

If you decide to let this happen, many will have to live with the consequences of this decision. I wouldn't feel comfortable kayaking the Big Muddy again. Wildlife will be compromised. A southern Illinois treasure will be tainted forever.

Please put the "Protection" back in the IEPA. Better to be the Illinois Environmental Protection Agency than the Illinois Environmental Pollution Agency!

Rev. Brian Barker
600 N. Russell St.
Marion, IL 62959

Exhibit 107

EPA.PublicHearingCom

From: Pat Knox <prknox@msn.com>
Sent: Tuesday, August 6, 2019 11:52 AM
To: LeCrone, Darin
Subject: [External] Re: NPDES IL0077666 Notice No. 7516C

From: Pat Knox <prknox@msn.com>
Sent: Tuesday, August 6, 2019 3:45 PM
To: darin.lecrone@illinois.gov
Subject: NPDES IL0077666 Notice No. 7516C

I am registering my opinion concerning wastewater dumping in the Big Muddy River.

As a lifelong resident of Royalton, Illinois my life has always been connected to the Big Muddy.

As a child my Dad often took me to fish and gather nuts around the river. The local joke was often made that we were "special" because we drank it's water.

I believe that if dumping more wastewater into the river
by the mines is allowed, the joke may come true.

I have no doubt that there will be UNFORSEEN DAMAGE to the ecosystem of
the Big Muddy if it is made a wastewater dump site.

I am **against** allowing the mine to pollute these waters with ANY of their waste.

Patricia Knox
2931 State Highway 149
Royalton, Illinois 62983

EPA.PublicHearingCom

Exhibit 108

From: Eichholz, Michael W <eichholz@siu.edu>
Sent: Tuesday, August 6, 2019 12:05 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

I am writing to express my dismay over the potential of a permit being provided to Williamson Energy to allow the dumbing of diluted mine waste water into the Big Muddy River. The majority of my relatives either farm or have worked in coal mines in the past and I believe strongly that responsible resource development is critical for maintaining the economy of Southern Illinois. However, the owners of Williamson Energy have proven themselves over and over not to be responsible developers and the potential for increased flooding associated with the additional water and potential contamination from the waste far out way the limited economic benefits. This may be the most irresponsible development scheme I have observed proposed and potentially authoraized Southern Illinois.

Mike Eichholz Ph.D.
Director – PSM Program in Wildlife Administration and Management
Avian Ecologist – Cooperative Wildlife Research Lab. and Center for Ecology
Associate Professor, Dept. of Zoology
Southern Illinois University Carbondale
eichholz@siu.edu
http://eichholz.wix.com/avian-ecology-lab
http://zoology.siu.edu/graduate/research-emphasis/wildlife-admin.php

Phone: 618-453-6951
Fax: 618-453-6944

Exhibit 109

EPA.PublicHearingCom

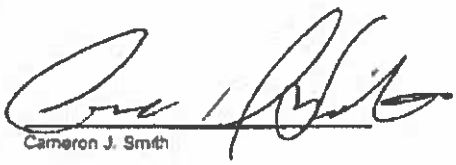
From: Cameron Smith <cjs@artapult.com>
Sent: Tuesday, August 6, 2019 12:56 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 and Notice No. 7516c
Attachments: NPDES IL0077666 and Notice No. 7516c.pdf

Mr. Darin LeCrone,

Attached you will find my request for a public hearing regarding **NPDES IL0077666 and Notice No. 7516c.** I hope the IEPA will take the right action and allow the citizens of Southern Illinois to be heard.

Please keep me informed of any public hearing about this permit in a timely manner.

Sincerely,



Cameron J. Smith
Douglass School Art Place
900 Douglass St.
Murphysboro, IL 62966
618 203-1405

Virus-free. www.avast.com

Douglass School Art Place
900 Douglass St.
Murphysboro, IL 62966
618-687-3791
thedoug@artapult.com

Darin LeCrone
IEPA Bureau of Water
Water Pollution Control Permit Section
1021 North Grand Ave. East
Springfield, IL 62794-9276

Mr. Darin LeCrone,

Regarding: NPDES IL0077666 and notice No. 7516c

I am writing to you and the Department of the Illinois Environmental Protection Agency (IEPA) to request a public hearing regarding NPDES IL0077666 and notice No. 7516c. I am a co-owner of the Douglass School Art Place, 900 Douglass St. Murphysboro, IL. The historic Douglass School (The Doug) was Murphysboro's segregated school for 75 years, first built in 1897. It has withstood two tornados, one on March 18, 1925 and another on December 18, 1957, and the record flood of May 3, 2011. Since The Doug was Murphysboro's segregated school, it was built in the low lying area of town close to the Big Muddy River.

On May 3, 2011 the Big Muddy River reached a record high of 40.47 feet at the Murphysboro, IL gauge station on the Route 127 Bridge. At that time the 127 Bridge was closed and under water. The river water was so high you could no longer see the guard rails on either the side of the bridge. The Route 13 Bridge was being threatened too, but remained open and was closely monitored by IDOT. During that time the flood water was so high and strong that the water was vibrating the bridge, so it was decided by IDOT to rebuild and raise the level of the Route 13 Bridge. I have to wonder what that cost the state of Illinois.

Meanwhile when this flood was happening I was busy sandbagging around, and pumping the water out of the basement of The Historic Douglass School of Murphysboro. I believe I was on the sixth day of running three sump pumps in two basements on May 3. At the crest of the river I calculated that the water would have been 20 inches deep in the basements without the pumps. If the river had risen to the projected height of 42 feet above flood level, as predicted, the water would have flowed directly over the basement door threshold, rather than just infiltrating from below.

Regarding: NPDES IL0077666 and notice No. 7516c

And now the IEPA is considering the permit application from Pond Creek Mine to allow the mine to dump 2.5 to 3.5 million, with a peak of 7 million gallons of waste water per day. How can anyone think this is a good idea? Where is the protection, and whose environment is the IEPA protecting? It would be only one problem if it was clean fresh water being dumped into the Big Muddy River but the Pond Creek Mine wants to dump its unfiltered groundwater and coal production wash water into the river.

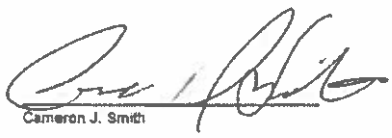
This infiltrated groundwater is full of chloride and sulfate; this would produce the discharge into the Big Muddy River of up to 1.2 million pounds of chloride and 476,000 pounds of sulfate per day. This increased pollution will kill the river life as we know it. Plus it will destroy nearby farmers' fields and disrupt the balance of the underground water wells along the river, making them undrinkable. What agency will protect them if this project goes through?

What agency will monitor the discharge of pollution? Hypothetically speaking, if the Pond Creek Mine is so caring about its workers and the environment why do they propose to place the diffusing pipe outlet downstream of the Big Muddy River second gauge station at Plumfield? There are only three river gauge stations on the Big Muddy River: the one at Rend Lake, Plumfield and Murphysboro, which is about 2000 feet upstream from the Douglass School. By putting the outlet pipe downstream of the Plumfield gauge station, the Corps of Engineers will not have a true reading of the water level and may release more water from Rend Lake, causing more flooding and pollution downstream.

It would be unconscionable to let a multibillion dollar private business take advantage of other private businesses and citizens. The Southern Illinois citizens need to be heard. We need a public hearing so the IEPA can meet the citizens face to face. The IEPA needs to see whose lives will be destroyed forever if this fiasco were to take place.

IEPA, please grant a hearing so our voices will be heard, and please do not permit this project.

Sincerely,



Cameron J. Smith
Douglass School Art Place
900 Douglass St.
Murphysboro, IL 62966
618 203-1405
cjs@artapult.com

Exhibit 110

EPA.PublicHearingCom

From: Les Winkeler <Les.Winkeler@thesouthern.com>
Sent: Tuesday, August 6, 2019 4:01 PM
To: LeCrone, Darin
Subject: [External] Pond Creek Mine NPDES IL0077666 & Notice No. 7516c

Mr. Lecrone,
I want to voice my extreme displeasure that the Illinois Environmental Protection Agency and Illinois Department of Natural Resources is considering the permit to allow the Pond Creek Mine to dump vast quantities of waste water into the Big Muddy River.
This makes no sense on a variety of levels.
The Big Muddy River belongs to the people of Illinois. What right does Williamson Energy have to turn the river into its private sewer. Disposing of the waste water is part of the mine's cost of doing business. The state doesn't provide waste removal services for other businesses.
Some of the most environmentally sensitive lands in Illinois are downstream from the mine. The Shawnee National Forest's famed Snake Road could be adversely affected. Snake Road is closed each year for the migration of cottonmouths, timber rattlesnakes and copperheads. It is unique in the State of Illinois. It is also in the Big Muddy's floodplain.
Third, who is going to monitor the effluent.
Will IDNR have someone there on a daily basis when water is being released. Please don't rely on Murray Energy to police itself.
This is a terrible idea that should never be considered. Please turn down the application.

Les Winkeler
Sports editor
The Southern Illinoisan
618-351-5088 (Office)
618-841-7862 (Cell)
On Twitter: @LesWinkeler

Exhibit 111

EPA.PublicHearingCom

From: Joseph Stafford <joe13stafford@gmail.com>
Sent: Tuesday, August 6, 2019 6:56 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

i am writing to object to the proposal to allow Williamson Energy to dump contaminates into the Big Muddy River. This group made money extracting coal and made an environmental mess in the process. They should be required to clean up the mess and store the contaminents properly. Pouring the mess into a river for others to worry about must become a thing of the past. The Big Muddy flows by cities and parks and empties into the Mississippi and eventually into the Gulf. Illinois cannot put itself in the position of further polluting our waterways and the waterways of other states. We have to protect the biodiversity that we have left and that we have not already ruined. We have to protect the animals, the soil and water quality along the whole water way. I request that the Illinois Environmental Protection agency block this proposal. Thank you.
Joseph H. Stafford, Carbondale, Illinois

Exhibit 112

EPA.PublicHearingCom

From: pineridgeplace@frontier.com
Sent: Tuesday, August 6, 2019 9:03 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

I am writing to express my opposition to the proposal by Williamson Energy Coal Company to be permitted to dump wastewater into the Big Muddy River. Here in southern Illinois we are blessed to have beautiful and pristine waterways winding through the landscapes of the most beautiful area of the State of Illinois. A variety of wildlife is in abundance and utilize the waterways.
Discharging wastewater is a hazard to the waters of the Big Muddy River and its many living organisms and the wildlife that depend upon the water for survival.
Making a quick buck for a coal company at the expense of the natural environment is not a good plan for the near future and generations to come.
The IEPA exists to protect our environment and thus should deny the permit to discharge wastewaters into the Big Muddy River.

Thank you,
Lee M. Fronabarger
1140 S Morningside Drive
Carbondale, IL 62901

Exhibit 113

EPA.PublicHearingCom

From: Karen Fiorino <claylickcreek@gmail.com>
Sent: Tuesday, August 6, 2019 10:02 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & NOTICE No. 7516C

Dear Mr. LeCrone,

After seeing the articles in the Southern Illinoisan about the Pond Creek Mine discharging pollutants into the Big Muddy along with other unnamed tributaries, I decided to take a look at the draft permit for such discharging.

It is a hard read, but a few points:

1.) on page 13, there is an error in the name of the bird Chuck's-Will-Widow, not Willow. I found at least 2 instances of this. I am told researchers and the papers they write go through at least 5 editors. Obviously, this got missed. I have a background in biology/zoology, and this error jumped out at me. It makes me wonder what other errors are included in this draft permit.

2.) I find it disrespectful to list the Big Muddy as a waterway that is not a biological significant stream. This attitude shows the utter disregard humans have for the land and water around them and monitizes everything. I did check the publication where this information came from, Integrating Multiple Taxa in a Biological Stream Rating System, which in their own words state, "One of the goals of the previous BSC initiatives was to update stream ratings on an annual basis and to publish the revised ratings every five years. However, the original BSC stream ratings were updated only once based on data that were collected through 1993. Similarly, the BSS project was based on data collected through 1991 and has not been updated since. Therefore, stream designations identified in these projects are based on data that is at least 14 years old. Given that these ratings are used by a diverse group of stakeholders, it was clear that an updated version was required. "

3.) The 303 jobs employed by the mine, coal mining is a dying industry, if anything it will become more and more mechanized. If this mine has produced so much wealth, where is it?

4.) Dilution is not the solution in this case. In your own words the chloride and sulfates would remain dissolved in the water and more through the downstream continuum. I am not really reassured that no adverse impacts to streams would occur as all water quality standards *are expected* to be met in the receiving water.

Finally, as companies, are now given "personhood" via Citizens United, they should have to pay a fee to the people impacted by them dumping pollutants into a public waterway, since everything always relates to the dollar. I know personal friends who would be impacted by this dumping as their business in Murphysboro, the Douglas School Glass Studio, is prone to flooding.

In conclusion, I urge that a public hearing is called in a central area where the people who are impacted most can attend and so that an individual with a second opinion can look at the numbers and give a plain and clear answer to the real amount of pollutant discharge.

Sincerely,

Karen Fiorino

--

****

Karen Fiorino
Clay Lick Creek Pottery
45 Old US HWY 51
Makanda, IL 62958
618-521-5602
www.etsy.com/shop/ClayLickCreekPottery
www.facebook.com/ClayLickCreekPottery
www.ClayLickCreekPottery.com

Exhibit 114

EPA.PublicHearingCom

From: C.R. W. <crdoubleu99@ymail.com>
Sent: Wednesday, August 7, 2019 12:40 AM
To: LeCrone, Darin
Subject: [External] Regarding NPDES IL 0077666 & Notice 7516c

Hello,

I'm writing to state my opposition to the dumping of the mine waste water into the Big Muddy River. Please do not grant the final permit that will allow them to do this. Our environment has taken enough of a beating and we should do our very best to be mindful & start repairing the damage. For the sake of the ecosystem & all its creatures and the people around here too, I hope you will pay prompt attention to this matter.

Thank you,
Craig Wilson
Carbondale, IL

EPA.PublicHearingCom

Exhibit 115

From: Stephanie Solbrig <stephsolbrig@gmail.com>
Sent: Wednesday, August 7, 2019 5:49 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Keep our water safe and clean. The state does not have the authority to sublet an entire river to subsidize a failing industry. The thoughts expressed here echo my own.

https://thesouthern.com/opinion/editorial/voice-of-the-southern-the-state-should-not-turn-big/article_48661aa8-8a68-5a4a-9b82-e38b4e2bff20.html?fbclid=IwAR0Vd8QE9QfzgBemQyxwaLpCTozYAjFeFNxJWoP-jgdftz1un8qZ6uSjr-c

Stephanie Solbrig
Carbondale, Illinois

Exhibit 116

EPA.PublicHearingCom

From: Patrick Mcguire <pat1kris2@aol.com>
Sent: Wednesday, August 7, 2019 10:42 AM
To: LeCrone, Darin
Subject: [External] NPDES IL007766 & notice No. 7516c

I am writing today to oppose allowing Williamson Energy to dump polluted waste water from it's Pond Creek Mine into the Big Muddy River. This river is the water supply for Rend Lake and therefore many southern Illinois communities. Additionally, it draws tourists and outdoors people to enjoy the stunning beauty of the region. The IEPA regulates farm chemicals so they do not poison the water so why would you allow a coal company to do so? Tourism is as much of an economic driver as a coal company. You simply must not allow this corporation to ruin our environment.

Kristine B. McGuire
103 S. Parrish Road
Carbondale, IL 62901
618-529-1680

Exhibit 117

EPA.PublicHearingCom

From: Simpson, Randie <Randie.Simpson@ssmhealth.com>
Sent: Wednesday, August 7, 2019 10:42 AM
To: LeCrone, Darin
Subject: [External] do not Allow Waste water from the coal mines to be dumped in the big muddy

Do not allow the waste water to be dumped vote no !!!

Randie Simpson, RN, Case Manager
Good Samaritan Regional Health Center
#1 Good Samaritan Way
Mt. Vernon , IL 62864
Ascom - 618-899-2993 Office - 618-899-1403

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Exhibit 118

EPA.PublicHearingCom

From: Gordon & Zoë Smith <zglsmith@mcn.org>
Sent: Wednesday, August 7, 2019 11:54 AM
To: LeCrone, Darin
Subject: [External] Public Hearing Request NPDES IL0077666 Notice No. 7516c

I wish request a public hearing to address this permit # NPDES IL0077666 Notice No. 7516c concerning pumping of mining water into the Big Muddy. The plan allows 2.5 million to 3.5 millions gallons of unfiltered water per day. Increasing the flow of the big muddy by 10 to 20% each day.
My concerns are:
1. The potential for flooding down stream is greatly increased. I have a personal connection in that my brother and his wife own property and a business right along the Big Muddy down stream from the discharge, in Murphysboro. It has been close to flood stage almost every year. With the extra water that is proposed, the risk is much higher. It a concern that the core of Engineers would allow the water to be discharged below the "Plufield Gage Station". By allowing this there seems like there is no way to keep track of the extra water coming into the Big Muddy, making it unclear whose responsible for the damage.
2. On my Brother's land is the Historic building Fredrick Dougless School which was founded in 1897 as Murphyboro's only segregated school. If it became flooded more than money would be lost. Next door to the School is Hud low cost housing in which many African American families live. Flooding would add insult to injury and it would be one more mark on the wrong side of history.
3. Most of the Big Muddy River bottom is covered in mud, which means the sediment is deposited rather than flushed down stream. With the addition of the unprocessed water carrying high volume of chlorides and sulfates it seems most likely that they will be deposited as well, changing the environment of the river for plant and animal life. Who will take responsibility for the loss that will incur.
4. I am concerned about the loss of jobs, disruption of lives the flooding will cause.

Respectfully Gordon Smith

Exhibit 119

EPA.PublicHearingCom

From: randalllsnyder@aol.com
Sent: Wednesday, August 7, 2019 12:16 PM
To: LeCrone, Darin
Subject: [External] NPOES IL 0077666

Dear Mr. Lecrone:

This is in regards to NPOES IL 0077666, Notice 7516c.
Please add my name to those in opposition to granting a permit for Williams Energy to discharge wastewater from Pond Creek Mine into the Big Muddy River. As much as the area could use the jobs, the potential negative impact on a fragile environment outweighs the economic advantages.

Randall Snyder

Exhibit 120

EPA.PublicHearingCom

From: Jason Wild <jasonwildworks@yahoo.com>
Sent: Wednesday, August 7, 2019 12:59 PM
To: LeCrone, Darin
Subject: [External] IL0077666 & Notice No. 7516c

As a former Southern Illinois resident of 25 years, current homeowner in the area, and current proponent to all who will listen that Southern Illinois is a wonderful vacation destination because of the beautiful natural features available, I implore you to keep our waterways safe and clean by not allowing a company with an obvious lack of foresight to pollute the Big Muddy. It's the duty of the EPA to PROTECT the environment. There is NOTHING resembling protection in allowing Williamson Energy to dump it's waste in our natural waterways...in fact, quite the opposite. If you were to approve this, I don't know how you would be able to sleep at night. This is our children's future and the future of Southern Illinois we're talking about.

Jason Wild

Exhibit 121

EPA.PublicHearingCom

From: Gary Lukuc <gary.lukuc.cpa@frontier.com>
Sent: Wednesday, August 7, 2019 1:12 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

I am writing to oppose the proposal by the Pond Creek Mine to discharge wastewater into the Big Muddy River. As an outdoorsman and owner of farm and timberland near the river, I am concerned about the potential harm to the river ecosystem. I am also concerned about the potential for increasing the likelihood, or increasing the intensity of flooding that occurs along the river. I cannot see any potential positive impact that this proposal can have for the river ecosystem or the residents living near the river.

If you have any questions, you may contact me by e-mail or at 618-942-6717. Thank you.

Gary Lukuc
3101 Big Buck Lane
Herrin, IL 62948

Exhibit 122

EPA.PublicHearingCom

From: Cheryl Klopcic <cjklopcic@gmail.com>
Sent: Wednesday, August 7, 2019 2:46 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice No. 7516C

I oppose the dumping of waste water into the Big Muddy River. I am a firm believer in keeping our natural resources - natural. This does not sound like a good situation and I would worry about who and what type of oversight would occur.

Cheryl Klopcic
1003 Cheryl Drive
Carterville, IL 62918

618-534-7303

Exhibit 123

EPA.PublicHearingCom

From: Beth Martell <has20birds@yahoo.com>
Sent: Wednesday, August 7, 2019 3:44 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Williamson was the most productive underground coal mine in the United States during the first five years of its history based on clean tons produced per man hour worked—according to MSHA data. It reclaimed this title in 2017.

The mine has not provided any valid data on alternatives to dumping this mine problem water into the public's lap via a pipe to the Big Muddy River. Meeting regulations is part of doing business and the mine should be required to manage their pollution without shifting the risks and potential problems and costs to the public. This groundwater is stated to be coming into the underground sections of the mine and is listed as being as much as 3,500,000 gallons per day. How much coal mine waste water do you want us to drink in a day?

This mine should be required to build a water treatment plant on-site to insure their water discharges meet all regulations instead of using the Big Muddy River as this mine's "dilution solution." The Big Muddy River flows into the Mississippi River and is considered a water of the state. Public entities pay to treat their sewage and millions have been spent on efforts to clean up Mississippi River.

According to the Shawnee Group of the Sierra Club:

- No assessment is provided of the biological or other environmental impacts of the proposed mixing of this contaminated mine water on the ecosystem and current uses (fishing, livestock, recreation, etc.) of the Big Muddy River

- No assessment is provided of the cumulative water quality impacts on the Big Muddy River from this proposal over the many years of continued coal mining

- No assessment is given either of what such a large groundwater withdrawal quantity could be doing to the local area or what implications this might have for the future

What's more, we live downsteam. The mine's activity will pollute the drinking water of Cedar Lake and Lake Kinkaid. Fewer regulations is not the answer.

Here are the highlights of a past study stating, "Over 50% of the Big Muddy River drainage is in agriculture, much of which is under intensive tillage and subject to severe erosion. The drainage, nevertheless, serves as a major center in Illinois for water-based activities such as boating, fishing, waterfowl hunting, and camping" and "Early studies conducted by students of W. M. Lewis, Sr. at Southern Illinois University at Carbondale concluded that toxic pollution in the drainage was spasmodic and localized and that the most toxic conditions were confined to tributaries." (Burr 1991)

Here's a list of the stream names, cities, counties, and reservoirs of the Big Muddy River drainage. A, Rend Lake; B, Crab Orchard Lake; C, Devil's Kitchen Lake; D, Little Grassy Lake; E, Cedar Lake; F, Kincaid Lake. 1, Big Muddy River; la, Casey Fork; lb, Rayse Creek; lc, Fraine Creek; ld, Pond Creek; le, Long Creek; lf, Hurricane Creek; lg, Cedar Creek; lh, Kincaid Creek; li, Worthen Bayou. 2, Little Muddy River; 2a, Reese C reek; 2b, Six Mile Creek. 3, Middle Fork Big Muddy River; 3a, Ewing Creek; 3b, Sugar Camp Creek. 4, Beaucoup Creek; 4a, bust Creek; 4b, Swanwick Creek; 4c, Galurn Creek; 4d, Rattlesnake Creek. 5, Crab Orchard Creek; 5a, Wolf Creek; 5b, Drury Creek; 5c, Little Crab Orchard Creek.

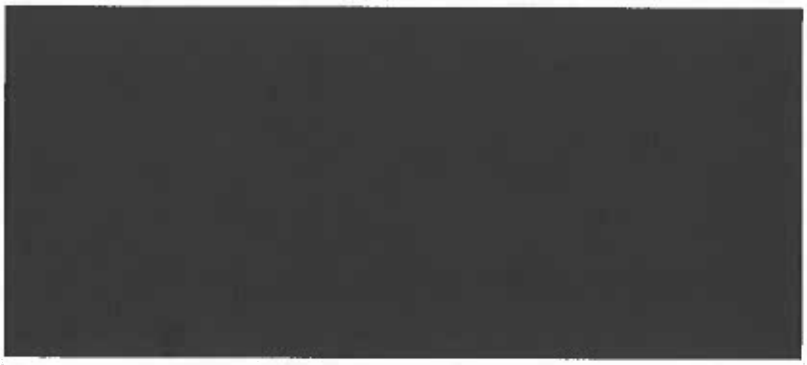
[Source: Burr, Brooks M. and Warren, Melvin L., Jr. 'Fishes of the Big Muddy River Drainage With Emphasis on Historical Changes.' Biological Report 19].
https://www.srs.fs.usda.gov/pubs/ja/ja_burr002.pdf

Here's the information on the web regarding Williamson Energy's Pond Creek No 1 Mine

Located in Williamson and Franklin Counties in southern Illinois, it was their first greenfield project. They began development in 2005 and started its longwall operation in 2008. Williamson was the most productive underground coal mine in the United States during the first five years of its history based on clean tons produced per man hour worked—according to MSHA data. It reclaimed this title in 2017.

Mach #1 Mine
Operated by Mach Mining LLC
MSHA ID: 1103141

One longwall mine
Two continuous miner units
2,000 tons per hour preparation plant
Productive Capacity: 7.5 million tons per year
Coal Production: 6.3 million tons in 2017
Coal Reserves: 370.6 million tons
Heat Content: 11,893 Btu/lb
Transportation: Rail (Canadian National with potential access to Union Pacific), barge on the Ohio River and the Mississippi River (via truck or railroad)
http://www.foresight.com/operations/



Operations | Foresight Energy

I am very concerned and will continue to ask a lot of questions.Pond Creek Mine dumping chloride and sulfate into the Big Muddy River is toxic to fish reproduction and livestock.

The Big Muddy leads to Drury Creek. Drury Creek drains into Midland Hills Lake where I live. Midland Hills Lake falls into Cedar Lake where C'dale's drinking water comes from.

Early studies conducted by students of W. M. Lewis, Sr. at Southern Illinois University at Carbondale concluded that toxic pollution in the drainage was spasmodic and localized and that the most toxic conditions were confined to tributaries.

Our environment is our economy, eh SIU?

Beth Martell
540 Contentment Rd
Makanda, IL 62958

Exhibit 124

EPA.PublicHearingCom

From: Roberts-Jacquot, Beth A <bethannr@siu.edu>
Sent: Wednesday, August 7, 2019 4:20 PM
To: LeCrone, Darin
Cc: Terri Bryant
Subject: [External] Pine Creek Mine/NPDES IL0077666 Notice No. 7516c

IEPA, Bureau of Water,
I am requesting a public hearing in regards to the request NPDES IL0077666 notice No. 7516c. As a Jackson County resident, with a back yard inundated by Big Muddy River overflow numerous times, every year, sometimes for months at a time, this request needs to be considered in a public hearing.
My family (which includes infant grandchildren) harvests catfish from the river, boats on the river, plays in the river, hunts along the river, and resides along the Big Muddy River.
Please allow a public hearing with regards to this permit request.

BA Roberts-Jacquot
618-534-6259

Exhibit 125

EPA.PublicHearingCom

From: Old Wives <oldwivesbootcamp@gmail.com>
Sent: Wednesday, August 7, 2019 4:37 PM
To: LeCrone, Darin
Subject: [External] Pond creek

I demand a hearing by the iepa on this matter before August 12th

Exhibit 126

EPA.PublicHearingCom

From: BETHANN <michaelnmom0404@yahoo.com>
Sent: Wednesday, August 7, 2019 6:28 PM
To: LeCrone, Darin
Cc: bryant@ilhousegop.org
Subject: [External] NPDES IL0077666 notice No. 7516c

IEPA, Bureau of Water,
I am requesting a public hearing in regards to the request NPDES IL0077666 notice No. 7516c. As a Jackson County resident, with a back yard inundated by Big Muddy River overflow numerous times, every year, sometimes for months at a time, this request needs to be considered in a public hearing.
My family farms hundreds of Big Muddy Riverfront acres. This produces food items including raising beef and poultry for untold numbers of families. We also live of the land with fishing and game hunting as a generational staple in our households. We boat on the river, play on the river, and sustain our way of life on this river.
To have a company propose to use my backyard as a filter for their chemical waste is unconscionable. The suggestion of saving Pond Creek Coal Mine money at the cost of my communities safety and health is beyond unreasonable, it is criminal.
I am requesting a public hearing on the matter.

Earl Ray Jacquot
Murphysboro Illinois
618-521-1148

Exhibit 127

EPA.PublicHearingCom

From: Hayley Mason <haylynnmason@gmail.com>
Sent: Wednesday, August 7, 2019 8:47 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Good evening,

In no way, shape, or form should the Illinois government be allowing the pollution of a major waterway. Subletting the river to a private company is disgusting. Denying Williamson Energy's request to dump into the Big Muddy should, without a doubt, be denied.

Hayley Mason

Exhibit 128

EPA.PublicHearingCom

From: Amy Acorn <amyacorn@gmail.com>
Sent: Wednesday, August 7, 2019 10:18 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Do NOT allow Williamson Energy to dump ANY waste water into the Big Muddy River!

NPDES IL0077666 & Notice No. 7516c

Exhibit 129

EPA.PublicHearingCom

From: Ivy, Rodger P <siu50521@siu.edu>
Sent: Thursday, August 8, 2019 5:50 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 and Notice No. 7516c

Attn: Darin LeCrone,

I am requesting a public hearing regarding the community concerns with NPDES IL0077666 and Notice No. 7516c.

Thank you,

RP Ivy

EPA.PublicHearingCom

Exhibit 130

From: Michelle Wiseman <wisetm96@gmail.com>
Sent: Thursday, August 8, 2019 9:51 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

I am against waste water from any sources/ businesses being allowed to be dumped into our river. Putting polutants in our rivers will have ill effects on our waters, aquatic life, plant life, crops, animals and even people. Please do NOT allow this to happen.

A very concerned Illinois resident,
Michelle Wiseman

Exhibit 131

EPA.PublicHearingCom

From: Roger Davis <grodydavis@gmail.com>
Sent: Thursday, August 8, 2019 10:09 AM
To: LeCrone, Darin
Subject: [External] NPDESIL 0077666 & NoticeNo. 7516C

No! no! no!

Exhibit 132

EPA.PublicHearingCom

From: Mel Morrison <morrisonmel44@gmail.com>
Sent: Thursday, August 8, 2019 10:42 AM
To: LeCrone, Darin
Subject: [External] Big Muddy River

I would like to to comment and oppose the dumping of waste water from the coal company from Williamson Energy Company into our Big Muddy River. That river flows through a very precious treasure of the La Rue Pine Hills swamp area that has one of the most diverse varieties of life anywhere. People come to visit and study its rich diversity. What a disaster it would be to jeopardize destroying such a beautiful part of our eco system. To trust that "man" will honor chemical levels being dumped in our part of the state is foolish.

Very Concerned Citizen

Melanie Morrison
Cobden,IL

Sent from my iPhone

EPA.PublicHearingCom

From: Mel Morrison <morrisonmel44@gmail.com>
Sent: Thursday, August 8, 2019 10:46 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

I would like to to comment and oppose the dumping of waste water from the coal company from Williamson Energy Company into our Big Muddy River. That river flows through a very precious treasure of the La Rue Pine Hills swamp area that has one of the most diverse varieties of life anywhere. People come to visit and study its rich diversity. What a disaster it would be to jeopardize destroying such a beautiful part of our eco system. To trust that "man" will honor chemical levels being dumped in our part of the state is foolish.

Very Concerned Citizen

Melanie Morrison
Cobden,IL

Sent from my iPhone

Exhibit 133

EPA.PublicHearingCom

From: nancy spear <spearhead10000@yahoo.com>
Sent: Thursday, August 8, 2019 10:43 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

To whom it may concern:

I am a resident of Murphysboro, IL and I strenuously object to the Illinois EPA determination approving Williamson Energy's request to dump 3.5 millions of gallons of water PER DAY into the Big Muddy River.

I understand that jobs are critical to Southern Illinois, but this is wrong to put residents' health at risk who live along all the miles of the Big Muddy. The Big Muddy belongs to all residents of the state of Illinois, not just one company.

Yours truly

Nancy Spear
1 E. Lake Drive
Murphysboro, IL 62966

Exhibit 134

EPA.PublicHearingCom

From: Madigan, Michael T <madigan@micro.siu.edu>
Sent: Thursday, August 8, 2019 10:54 AM
To: LeCrone, Darin
Subject: [External] Big Muddy Dumping

Dear Mr. Lecrone: I find it almost unbelievable that the IL EPA has given initial approval of Williamson Energy's request to use the Big Muddy River as a dumping ground for their waste.

As a long-time professor of microbiology and expert in microbial ecology, I can guarantee you, that the substances in the mine wastewater that you feel should be allowed to pollute the Big Muddy will have a significant impact on the microbial communities that reside in the water and the sediments. You wana' see downstream problems—boy or boy, you will see problems.

The highly diverse and supportive existing microbial communities will be replaced by fast-growing weed species of microbes that will alter the geochemistry of the river even beyond the damage that Williamson Energy's fouling will cause and could make the river totally uninhabitable. Have you never seen the effects of acid mine drainage? This will be a whole new version of such.

I strenuously object to the environmentally fatal dumping request of Williamson Energy. The few jobs that last but a few years are not worth the long term damage you will cause by allowing this pollution event. Please deny the needed permit and save the Big Muddy for the residents of Illinois.

Yours sincerely, M. T. Madigan.

****

Michael T. Madigan, Ph.D
Distinguished Professor Emeritus
Department of Microbiology
Southern Illinois University
Life Science II, 1125 Lincoln Drive
Carbondale, IL 62901 USA
US
Phone/Fax: +1-618-453-5130
E-mail: madigan@siu.edu

****


Merlyn: 2 months/1 year

Don't kill time; it will die of its own accord—Garrison Keillor
The average dog is a better person than the average person—Andy Rooney
If there are no dogs in Heaven, when I die, I want to go where they went—Will Rodgers

Exhibit 135

EPA.PublicHearingCom

From: Kathy Wills <kwills62950@gmail.com>
Sent: Thursday, August 8, 2019 1:05 PM
To: LeCrone, Darin
Subject: [External] public meeting
Attachments: File.PDF

--
Kathy Wills
Legislative Asst.
Paul Schimpf
State Senator
618-684-1100


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R03035

DISTRICT OFFICES:
2929 BROADWAY, STE. 3
MT. VERNON, ILLINOIS 62864
618. 242. 8115
618. 242. 8118 FAX

1032 W. INDUSTRIAL PARK RD.
MURPHYSBORO, ILLINOIS 62966
618. 684. 1100
618. 529. 2788 FAX

CAPITOL OFFICE:
207-N STRATTON BUILDING
SPRINGFIELD, ILLINOIS 62706
217. 782. 0387
EMAIL: STATEREPTERRIBRYANT@GMAIL.COM

TERRI BRYANT
STATE REPRESENTATIVE · 115TH DISTRICT

08/06/2019

Daren LeCrone
IEPA Bureau of Water, Water Pollution control Permit Section
1021 North Grand Ave. East
Springfield, IL 62794

Dear Daren,

I have received feedback from several of my constituents on Pond Creek Mine and water being dumped into the Big Muddy River.

As the public comment period is still open I am requesting a public hearing to be held in Murphysboro, Illinois prior to issuing any permits.

Sincerely,

Terri Bryant

State Representative
115th District

Exhibit 136

EPA.PublicHearingCom

From: Kathy Wills <kwills62950@gmail.com>
Sent: Thursday, August 8, 2019 1:34 PM
To: LeCrone, Darin
Subject: [External] public hearing
Attachments: File0001.PDF

--
Kathy Wills
Legislative Asst.
Paul Schimpf
State Senator
618-684-1100



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DISTRICT OFFICE:
2929 BROADWAY
SUITE 3
MT. VERNON, IL 62864
PHONE: 618/242-8115

DISTRICT OFFICE:
342 NORTH STREET
SUITE C
MURPHYSBORO, IL 62966
PHONE 618/684-1100

SENATOR PAUL SCHIMPF
58TH SENATE DISTRICT

SPRINGFIELD OFFICE:
105D STATE HOUSE
SPRINGFIELD, IL 62706
PHONE: 217/782-8137
FAX: 217/782-0116

08/08/2019

Daren LeCrone
IEPA Bureau of Water, Water Pollution control Permit Section
1021 North Grand Ave. East
Springfield, IL 62794

Dear Daren,

I am requesting a public hearing in Murphysboro, IL regarding Pond Creek Mine's plan to dump water into the Big Muddy River.

If you have any questions please feel to contact my office at 618-684-1100.

Sincerely,

Paul Schimpf
State Senator
58th Disrict

Exhibit 137

EPA.PublicHearingCom

From: Russell Miner <ramrlmseth@yahoo.com>
Sent: Thursday, August 8, 2019 1:36 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice No. 7516c

This is Ruth and Russell Miner 10188 Hwy 127 Murphysboro Illinois 62966-5484 and we are strongly opposed to the above projected proposal re the dumping of contaminated mine water into the Big Muddy River. The Big Muddy River is a large natural resource for the southern part of Illinois and drains directly into the Mississippi River.

We feel the IEPA has NOT ordered enough research into this plan to adequately assess the HUGE impact on the natural resources along the Big Muddy River and the MIssissippi River.

-No assessment og the cumulative water quality impacts in the Big Muddy River from this proposal over the many years of continued coal mining.

-No assessment of potential to add to flooding, river bank erosion, and downstream impacts.

-No assessment of what such a large groundwater withdrawal quantity(millinois of gallons a day infiltrating underground mine works) could be doing to the local area or what implications this might have for the future

-No assessment of the full social, health,environmental and climate costs of this mine and whether those are greater the the claimed $78 million in local, state and federal revenues it claims to generate each year.

PLEASE reconsider this porposal. Ask for further clarification from the mining company re the FULL impact this proposal presents.

Resepctfully,

Ruth and Russell Miner
Life Long Residents of Murphysboro, Illinois

Exhibit 138

EPA.PublicHearingCom

From: Madeline Meadows <meadowsbt@gmail.com>
Sent: Thursday, August 8, 2019 2:46 PM
To: LeCrone, Darin
Subject: [External] Public Hearing Request NPDES IL0077666 Notice No. 7516c

Mr. LeCrone:

This is to voice our objection to the IEPA's tentative approval of the the project proposed by Williamson Energy LLC that involves dumping mine wastewater into the Big Muddy River. We find it hard to believe that, after so many years of being the watchdog of our environment, your institution would even consider approving such a request. At any rate, in addition to protesting this action, we are requesting a well-publicized public hearing on this matter.

We live a quarter mile from the river, and spring rains cause repeated flooding. Generations of our family have been involved in mining, so we are no strangers to this subject. We are concerned about ground water contamination, soil contamination, and contamination of aquatic animals.
Since there has been no assessment of these subjects, we don't see how your approval could be granted.

Please respond to concerned voters and safeguard the people of this state.

Respectfully,

Allen and Madeline Meadows

5319 Mitchell Road

Mulkeytown, IL 62865

EPA.PublicHearingCom

Exhibit 139

From: Barbara Mckasson <babitaji@aol.com>
Sent: Thursday, August 8, 2019 3:42 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666, Notice No. 7516c
Attachments: NPDES permit IL0077666 - Barbara McKasson.docx

Dear Mr. LeCrone,

Attached are my comments on the proposed permit for Williamson Energy, LLC to discharge mine waste into the Big Muddy River. I am asking for a public hearing, and extension of the public comment period, and also additional study by IEPA in the form of a Environmental Impact Statement. Please include my comments in the official record for this proposed permit.

Sincerely,
Barbara McKasson
2 Hillcrest Drive
Carbondale, IL 62901
babitaji@aol.com
618-549-9684

Barbara McKasson
2 Hillcrest Drive
Carbondale, IL 62901
babitaji@aol.com
618-549-9684

Darin LeCrone
IEPA Bureau of Water
Water Pollution Control Permit Section
1021 North Grand Ave. East
Springfield, IL 62794-9276

August 8, 2019

Re: Williamson Energy Pond Creek Mine NPDES IL0077666, Notice Number 7516c

Dear Mr. LeCrone:

I am requesting a public hearing and extended public comment period for the proposed discharge outfall 011 from Pond Creek Mine into the Big Muddy River. I also urge IEPA to conduct a full Environmental Impact Statement on this proposed pollution increase in this permit application. I am concerned about the extremely high concentration and volume of chlorides and sulfates and also heavy metals that would be going into the Big Muddy River for the following reasons:

> This proposed increase in water volume and pollution affects me directly because I go canoeing and kayaking on the Big Muddy River, when I come into direct contact with the water in the Big Muddy river.

> There is commercial fishing on the Big Muddy River, which would be directly affected by the proposed discharge since high levels of chlorides and sulfates are toxic to fish. Some people trap muskrats and other fur bearers that depend on the river for survival. IEPA should be consulting with these people to assess the possible damage to the trappers' and fishers' livelihood.

> LaRue-Pine Hills area of Shawnee National Forest is the most biologically diverse area in Illinois and arguably in the whole country, with many state threatened and endangered species. The Big Muddy River floods this area annually, but how would increased flooding and pollution on the Big Muddy affect this area? IEPA should take into account how the red headed woodpecker and other sensitive species in this area would be affected.

> Other wildlife that would be directly affected includes the bald eagles that nest next to the river and depend on the fish from the river. River otters, which also depend on fish, are returning to southern Illinois, ducks nest in the riparian areas of the Big Muddy, and migrating waterfowl depend on plants growing in the river for energy needed in their migration. What are the likely effects of this additional pollution on wildlife?

> There is already flooding in the City of Murphysboro and other areas next to the Big Muddy River. Is the IEPA taking account of increased damage in those areas in your evaluation of the economic and environmental impacts of the proposed discharge?

Re: Williamson Energy Pond Creek Mine NPDES IL0077666, Notice Number 7516c, Comments from Barbara McKasson, 2 Hillcrest Drive, Carbondale, IL 62901

> The Illinois Natural History Survey Technical Report 2012 (11) states "Freshwater mussel populations have been declining for decades and are among the most seriously impacted aquatic animals worldwide. (Bogan 1993, Williams et.al. 1993). It is estimated that nearly 70% of the approximately 300 North American mussel taxa are extinct, federally-listed as endangered or threatened, or in need of conservation status (Williams, et.al., 1993, Strayer et. Al. 2004). In Illinois, 25 of the 62 extant species (44%) are listed as threatened or endangered (Illinois Endangered Species Protection Board 2011)." Further on, the study states: "It is possible that the Big Muddy River provides a haven for the recruitment of many mussel species, based on the dead shells less than 3 years of age found at site 30, the nature of its substrates, and the river's connection with the Mississippi River."
What is the effect of high levels of chlorides, sulfates, iron and other heavy metals on populations of mussels, fish and other wildlife that depend on the Big Muddy River?

> The mine owners are required to monitor the level of the chlorides and sulfates, but by what means and how often would the IEPA check to make sure the mining company is monitoring correctly?

> The closest EPA water monitor for the Big Muddy River is upstream of the proposed wastewater discharge area. How far downstream from the proposed discharge area is the next water monitor? IEPA should consider adding an additional water monitoring station directly below the proposed #011 discharge area.

> The Big Muddy River already is carrying a heavy load of pollutants from farm runoff, acid mine drainage and other sources. What is the cumulative effect of the current pollutants?

> The Pond Creek Mine has been one of the most lucrative mines in the whole country for several years. There is no reason why the public, wildlife and the environment should bear the cost of the pollution that this mine creates. Foresight Energy, the corporate mine owner, is making so much money from this mine that it should not be an economic hardship for the company to build a water treatment plant on the mine site in order to reduce the amount of chlorides and sulfates being discharged into public waters.

> The IEPA should conduct an Environmental Impact Statement for this proposed discharge so that the agency, the government and the public will better know the true cost of the proposal to the environment, local economy, public and private land, and wildlife. It appears that this discharge is likely to have very significant effects since, according to the IEPA anti-degradation assessment cited in the permit notice, the levels to be discharged to the Big Muddy River could be as high as 12,000 mg/L chloride and 2,120 mg/L sulfate, totaling up to 1.2 million pounds/day of chloride and 476,000 pounds/day of sulfate.

> The anti-degradation document that IEPA is using in its assessment is outdated and is not even specific to the Big Muddy River and this proposed discharge. The anti-degradation studies should be conducted again specifically for this new proposed permit.

Re: Williamson Energy Pond Creek Mine NPDES IL0077666, Notice Number 7516c, Comments from Barbara McKasson, 2 Hillcrest Drive, Carbondale, IL 62901

> Pond Creek Mine operations get up to 6.5 MGD of raw water indirectly from Rend Lake, through Johnston City and possibly other sources. What effect is this likely to have during drought conditions, especially considering future droughts that are likely to be more severe due to climate change. How will this affect water available to cities and towns in Southern Illinois that get their water from Rend Lake. Pond Creek Mine is consuming more water than per day than any of the cities on the Rend Lake water system.

> Other corporations have to adhere to environmental regulations, so why is Foresight Energy, which was just fined $80,000 because of multiple permit violations at Pond Creek Mine, being allowed to continue to even operate when they have not been adhering to best management practices, as documented by IEPA in reference to the Illinois Pollution Control Board case # 2019-085? In addition, this shows that the operators of this mine cannot really be trusted to monitor and report correct measurements of pollutants and volume of discharge.

> What is the status of the Total Maximum Daily Load (TMDLs) at Pond Creek and in this section of the Big Muddy River for sulfates, chlorides, iron and other metals (mercury, arsenic, etc.)? This should be determined in order to correctly assess the effects of the proposed additional discharge from Pond Creek Mine.

Respectfully submitted,
Barbara McKasson
babitaji@aol.com
618-549-9684

Exhibit 140

EPA.PublicHearingCom

From: Dave and Barb Elam <Yeswer1@earthlink.net>
Sent: Thursday, August 8, 2019 3:56 PM
To: LeCrone, Darin
Subject: [External] Public Hearing Request NPDES IL0077666 Notice No. 7516c

IEPA Bureau of Water
Water Pollution Control Permit Section

Dear IEPA representative

Please allow a hearing on the potential pollution of our Illinois waterways from mines. Public Hearing Request NPDES IL0077666 Notice No. 7516c
I live in Southern Illinois where we are trying to build tourism as an industry and our lakes and waterways are host to fishermen and others seeking to enjoy clean water.
It is not right to allow a private company to profit off public lands, leaving us locals with polluted waterways. Thank you.

Mrs. Elam
789 Boskydell Rd.
Carbondale IL 62902

Exhibit 141

EPA.PublicHearingCom

From: Kaitlin Battaglia <ktcoosh@hotmail.com>
Sent: Thursday, August 8, 2019 9:07 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Mr. LeCrone,

I would like to let you know that I am opposed to dumping of wastewater into the Big Muddy River (NPDES Permit No. IL0077666 Notice No 7516c). Please do not let this happen. Let's preserve Southern Illinois and do the right thing by not polluting our river. I know that coal mining is important for our area's economy, but surely there must be a better way for the mine to dispose of their waste. For the sake of our environment and the health of the people of Southern Illinois, please do not allow the polluting of the Big Muddy River by the Pond Creek Mine. Thank you for your time.

Kaitlin Battaglia
714 Walnut Rd
Royalton, IL
62983

Sent from my iPhone

EPA.PublicHearingCom

Exhibit 142

From: Matt Battaglia <mmbattaglia@gmail.com>
Sent: Thursday, August 8, 2019 9:20 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice No. 7516c

Mr. Lecrone,

My name is Matt Battaglia I am a fourth generation farmer. I am writing this email regarding the permit application(NPDES IL0077666, Notice No. 7516c) for the Pond Creek mine to allow the disposal of waste water from its mine into the Big Muddy River. Allowing this will greatly impact the agricultural productivity of our ground and livelihood and I am asking that this permit be reconsidered.

Thank You, Matt Battaglia
714 Walnut Road
Royalton, IL 62983 Sent from my iPhone

Exhibit 143

EPA.PublicHearingCom

From: Josh Crouch <joshuacay@gmail.com>
Sent: Thursday, August 8, 2019 9:54 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

I do NOT support this. This will ruin much of the wildlife and recreation my friends and family have enjoyed on the big muddy for years. They can pay to properly dispose of waste. Just because it isnt their way of life doesn't make it less valuable.

Exhibit 144

EPA.PublicHearingCom

From: Debbie Connell <speechlanguagern@msn.com>
Sent: Friday, August 9, 2019 1:32 AM
To: LeCrone, Darin
Cc: terribryant3@aol.com
Subject: [External] FW: NPDESIL0077666 No7516c

Importance: High

From: Debbie Connell <speechlanguagern@msn.com>
Date: Friday, August 9, 2019 at 1:24 AM
To: <darin.lecrone@illinois.gov>
Cc: <terribryant3@aol.com>, <daveseverin.com>, <senatorfowler.com>, <senatorshimpf.com>, <letters@thesouthern.com>, <bost.house.gov>
Subject: NPDESIL0077666 No7516c

This letter is in regard to: NPDESIL0077666 No.7516c

To Whom This May Concern,

I would like to voice my objection to the POND CREEK mining company dumping their waste into OUR BIG MUDDY RIVER!

As POND CREEK MINE states they need to dump their waste (2.5 to 3.7 million gallons per day) to protect their employees from seepage into the mines, I believe It is the responsibility of this ONE COAL MINE POND CREEK, to protect their coal mining employees from seepage but not at the expense of the safety of our citizens, the demise of our wildlife, and our environment. If the private company POND CREEK MINE believes it is too expensive for them to handle their own waste in an environmentally sound way, and the costs of managing their waste exceeds the value of the coal out of the ground, then as with any business it is time to close their doors in Southern Illinois. This PRIVATE COMPANY should NOT BE ALLOWED to dump their waste into OUR public waterway. Unfortunately it seems the poorest communities seem to suffer the most to facilitate Corporate Profits, in this case PRIVATE Corporate Profits.

It is my understanding POND CREEK MINE operated by Williamson and Foresight Energy (controlled through majority interest by Murray Energy Company) is currently dumping THEIR waste into an unnamed tributary to Pond Creek. According to NexStar Broadcasting 6-5-2019 Murray energy company is being sued by a group of West Virginia Environmental Advocacy Groups for their Harrison County Coal Mine discharging 220 times the permitted limit of aluminum into a tributary of the West Fork and Ohio Rivers. This indicates current compliance issues with Murray Energy Company. Murray Energy Company has also had lawsuits against the EPA and the Obama Administration for what they perceive to be unfair regulations. With more study the reader will learn of generous political campaign contributions from Foresight Energy (Parent Company for Williamson Energy LLC) who owns POND CREEK MINE to a few past governors and many well known Southern Illinois elected officials. The article continues to inform the reader after Brandon Phelps retirement he soon became a as lobbyist for Foresight Energy (Lyderisen, K. , Neighbors Say State and Federal Regulators Haven't Held Foresight Energy Accountable for Hundreds of Safety and Environmental Violations, Energy News Network, 3-21-2018).

A Private company being allowed to dump their wastes into OUR PUBLIC BIG MUDDY RIVER will have everlasting effects on humans, wildlife, adjoining forests, contaminating groundwaters, watersheds and the Mississippi River which empties into the Gulf of Mexico. Typical waste discharge is highly acidic water containing heavy metals like selenium, mercury, arsenic, copper, and lead. Federal regulations for coal water pollution are decades out of date. The chloride and sulfate will exceed allowed standards and negatively impact fish reproduction and other aquatic species. Swimming in or eating fish from these waters

are linked to cancer, neurological disorders and cardiovascular disease (Hitt, M.A., EPA Must Enact Strong Water Pollution Standards. Sept 29, 2015 Sierra Club). After coal is mined it is typically washed to remove impurities. The resultant coal slurry can leak into nearby water sources, documented in numerous studies.

Page 2 NPDESIL0077666 no7516c

I grew up with the Big Muddy River near my front yard, I as well as many other southern Illiniosans have fished and boated played in the waters of the Big Muddy River. I hope that today and tomorrows children will enjoy the same pleasures of playing in local streams/rivers, fishing, boating, camping and enjoying the plants and wildlife which live along the banks of the river. I among many others feel OUR BIG MUDDY RIVER should continue to belong to the people NOT be sublet to a Private Company with intent to destroy our waterway.

I only pray our government officials will fight against this Corporate ruin which will compromise the health of families and communities in the long run.
I would like to request a public hearing on this issue.

Respectfully
Deborah Saylor Connell
105 Janeal Court
Goreville, Ill 62939

EPA.PublicHearingCom

Exhibit 145

From: murphy_momma <murphy_momma@frontier.com>
Sent: Friday, August 9, 2019 7:57 AM
To: LeCrone, Darin
Subject: [External] NPDESIL0077666 & Notice No. 7516c

I oppose Pond Creek Mine's dumping into the Big Muddy River. Please grant a Public Hearing. Thank you in advance.

Sent from Mail for Windows 10

Virus-free. www.avast.com

Exhibit 146

EPA.PublicHearingCom

From: Kathleen Foster <ktfost9@hotmail.com>
Sent: Friday, August 9, 2019 8:25 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice No. 7516c

Hi,
My name is Kathleen Gunkel. I live in Herrin, Il and have been a Southern Illinois resident my entire 33 years of life.
Address- 820 N 13th St, Herrin, IL 62948

I cannot express how much I oppose the proposal to dump millions of gallons of wastewater into the Big Muddy River. This will be detrimental to many forms of wildlife that live in the Big Muddy and the surrounding areas. I am requesting a public hearing on this matter.

This is regarding NPDES IL0077666 Notice No. 7516c

Thank you for your time.
Kathleen Gunkel

Exhibit 147

EPA.PublicHearingCom

From: Megan Flexter <meganflexter@gmail.com>
Sent: Friday, August 9, 2019 8:50 AM
To: LeCrone, Darin; EPA.PublicHearingCom
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Hello,

I along with many Southern Illinoisans oppose any dumping of waste water into our Big Muddy River. I request a public hearing on the matter. My name is Megan Flexter and I live on 12173 E Bunny Farm Rd in Mount Vernon, Il.

Thank you,

Megan Flexter & Family

Exhibit 148

EPA.PublicHearingCom

From: Elizabeth Connell <sumak.1027a@gmail.com>
Sent: Friday, August 9, 2019 10:47 AM
To: LeCrone, Darin
Subject: [External] NPDESDIL0077666 Notice No.7516c

Please do not allow dumping of toxic water into the Big Muddy River. The safety of their coal miners belongs to the coal companies and should not take presidence over the safety of all Southern Illinois residents.
Southern Illinois needs clean water for the livelihood of citizens, agriculture, wildlife, recreation, camping, and our tourism industry. Please see that the IDNR does NOT support the Pond Creek mine request to dump toxic chemicals into our water.
Clean water...priceless!
Sincerely
Beth Connell
601 N 7th St
Herrin, Illinois 62948
I would like to be kept updated on this issue and ask for a Public forum in Murphysboro to discuss this issue
Thank you in advance.

Exhibit 149

EPA.PublicHearingCom

From: Tom Harbert <tharbert61@gmail.com>
Sent: Friday, August 9, 2019 11:46 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice 7516c

My name is Tom Harbert. I am an Illinois resident at 401 Victor Ln, Carterville IL 62918.

Please do not allow Williamson Energy to discharge any waste water into the Big Muddy River. There is no justification to allow a company to willingly pollute this river. It's home to sensitive biological areas and allowing even diluted wastewater will impact this area in ways you cannot predict. The damage will only surface after the deed is done and then who pays? Keep our waterway safe. Do not grant Williamson Energy's request to pollute our river.

Tom Harbert

Exhibit 150

EPA.PublicHearingCom

From: edb00 <eldon.benz@gmail.com>
Sent: Friday, August 9, 2019 12:27 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

The Big Muddy River shouldn't be a dump for a coal mine!
What are you people thinking?

Eldon Benz

Sent from my crunchy fruit phone
618 303-3074

Exhibit 157

EPA.PublicHearingCom

From: lisacollins60 <lisacollins60@mediacombb.net>
Sent: Friday, August 9, 2019 1:35 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice No. 7516c

Please consider this email a request from a voting citizen to hold a public hearing on the above references case. My concerns include and are not limited to existing levels of contaminates in the Big Muddy River, impact on flooding which is already at record levels and climate costs. PLEASE ALLOW THE RESIDENTS TO BE HEARD

Sent from my Verizon, Samsung Galaxy smartphone

Exhibit 152

EPA.PublicHearingCom

From: catherine@fieldhughes.net
Sent: Friday, August 9, 2019 3:08 PM
To: LeCrone, Darin
Subject: [External] The plan to discharge polluted water from Pond Creek Mine into the Big Muddy River

NPDES IL0077666 and Notice No. 7516cl

Please don't.

Request a public hearing.

The Big Muddy River is already impacted by permitted and pre-regulations mine pollution from upstream and downstream sources.

No more.

Catherine M. Field

610 S. Tower Rd, Carbondale IL 62901

Exhibit 153

EPA.PublicHearingCom

From: jerlinwyatt@juno.com
Sent: Friday, August 9, 2019 3:35 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No 7156c

Dear IEPA official;
I first became aware of the permit application 456 and Pond Creek Mine desiring to dump a massive amount of water containing contaminants into the Big Muddy river. At that time I wrote the IDNR concerning my questions and concerns. I am sending a copy of that letter below which expresses my feelings on the subject. I do not see how this additional water could not increase flooding which is already a concern with the Big Muddy. I am very concerned it will cause other problems as shown in my questions in the letter below.
I appreciate you reading and considering the concerns I expressed in it.
My address is shown at the bottom of that letter.
Thank you.
Linda Wyatt
jerlinwyatt@juno.com.
Dear officials of IDNR,
I just became aware of the permit application 456 (Pond Creek Mine dumping water into Big Muddy). I have read the public meeting Oct 23,2018 transcripts and exhibits from your site, I could not get the application and maps to open but have reviewed maps from ISGS site. That said it does leave me with concerns about unanswered questions in the minds of those who spoke and in my mind.
I feel mine jobs are important but mining needs to include safety for the miners, the public, for wildlife, and with as little harm as possible to the environment.
At this point I question if the harm that will be caused has been carefully considered. We already know that the Big Muddy often cannot handle spring rains - would not this extra water cause the floods to be sooner and more damaging? That it is known that the chlorides and sulfates are above accepted levels is another big concern - how much above? and constantly above as it appears in the news report? How much affect would this have on tourism which is another major resource of southern Illinois? Why is there a need to change what is being done with the water now? or is there going to be an increase in water dumping from current levels? Has there been damage in the area the mine is now dumping water in?
What about iron, heavy metals, and bacteria often(always?) found in mine water? I have not seen that question asked.
I read in the transcript that a gentleman told of Sugar Creek's attempt to get a mixing zone with a ro process which would make the water safe to release - no reason given why they were not allowed to do that but it did sound like a solution for the contaminants in the water.
That the questions and concerns have not been openly publicly addressed and impact studies done or released, if they have been done, seems like good reasons for delaying or denying (whatever your rules permit) the application at this point. As I just found out about this, I am sure I am not totally up to speed on this.
To get an idea of how much water, I did research and find that RLCD sells in the neighborhood of 5 billion gallons a year, dividing that is 13,698,630 / day sold to, I believe to 60 communities in 9 counties - and the 2.7-3.5 million/ day would be 20-25% of that amount of water - dumped by one pipeline into the Big Muddy - it seems like it would cause big issues which brings me back to the questions of are they dumping that much now and is it causing problems now? If the answers are yes and no - why change? If they are increasing what they are dumping or if it is causing problems, then I am back to the need for impact disclosures to the public and careful consideration of how this will change/affect southern Illinois.
Thank you
Linda Wyatt
2131 Bridge St

Carterville IL 62918

Exhibit 154

EPA.PublicHearingCom

From: Perry, Denise M <dmperry@illinois.edu>
Sent: Friday, August 9, 2019 5:09 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Please do not allow Williamson Energy to pollute our waters by dumping coal waste and/or wastewater in the Big Muddy River or any waters.

Denise Perry
2006 Cynthia Drive
Champaign, IL 61821
(Formerly of Christopher, IL 62822)

Sent from my iPhone

Exhibit 155

EPA.PublicHearingCom

From: Dawn <dawn.a.roberts@gmail.com>
Sent: Friday, August 9, 2019 7:07 PM
To: LeCrone, Darin
Subject: [External] re: NPDES IL0077666 & Notice No. 7516c

To Whom it May Concern:

Please do not turn the Big Muddy into wastewater!
The river is not a dumping ground for corporate waste. It belongs to the People, not to be destroyed by some corporations.
This would create and environmental disaster, not just for southern Illinois, but further downriver too.

Dawn Roberts
Carbondale, IL
re: NPDES IL0077666 & Notice No. 7516c

Exhibit 156

EPA.PublicHearingCom

From: Jim Rodemaker <jimrodemaker@aol.com>
Sent: Saturday, August 10, 2019 8:19 AM
To: LeCrone, Darin
Subject: [External] npdes il0077666 Notice7516c

Sent please hold public hearing for Pond Creek Mine / BigMuddy River discharge proposal. NPDES. Jim rodemaker 2993 Dutch Ridge Rd. Carbondale I'll. 62903 We fish and hunt the river valley! thanks Jim

Exhibit 157

EPA.PublicHearingCom

From: Kim Swartz <calli1954@yahoo.com>
Sent: Saturday, August 10, 2019 12:27 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

As a Murphysboro resident and a life long user of this beautiful River I am opposed to the pumping anything into the river. You can't tell me no harm can come of this.
I've ridden s body since I was a child seeing wildlife feeding in and near it's banks.
Please stop this from happening, please.

Sincerely, Kim L Swartz
120 Hanover Lane
Murphysboro, IL

Sent from Yahoo Mail on Android

Exhibit 158

EPA.PublicHearingCom

From: Cade Bursell <cadebursell@gmail.com>
Sent: Saturday, August 10, 2019 11:01 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice#7516c Coomnts
Attachments: IL EPA NPDES IL0077666.Bursell.pdf

Der Mr. LeCrone,

Attached please find my comments concerning Pond Creeks Mine's permit request. I also request a public hearing on this matter.

Thank you
Cade Bursell

IL EPA, Bureau of Water
Darin LeCrone
Email: darin.lecrone@illinois.gov

NPDES IL0077666 Notice#7516C

8/09/2019

Dear Mr. LeCrone,

I request that you refuse to issue a permit for the construction of a pipeline and diffuser as requested by Pond Creek Mine. Do not allow this company to drain its toxic water through outfall 011 into the Big Muddy River or add other outfalls (points of pollution) to those it already possesses. I believe this to be detrimental to the environment and impact the health and well being of both human and non-human stakeholders (fish, other aquatic life, and wildlife.)

I am also requesting a public hearing where the questions of concerned citizens can be answered more fully with depth and clarity. I believe part of your mission as the Illinois Environmental Protection Agency is to address the questions and concerns of stakeholders, and this draft permit on its own is not helpful in this regard.

I request the IEPA create a fact sheet for public consumption. The draft NPDES raises more questions than it provides answers. Unless there is a public hearing, our comments, questions, and concerns are not addressed until you already have come to your conclusions. This process does not result in fair, transparent exchanges with stakeholders, such as myself.

In an August 9, 2019 article the US News and World reported that the "Environmental Protection Agency had gone above and beyond in response to President Donald Trump's 'two-for-one' executive order, according to an inspector general report. The investigation was intended to examine the agency's response to Trump's "two-for-one" executive order, which requires that "for every one new regulation issued, at least two prior regulations be identified for elimination. The inspector general also recommended the EPA "increase transparency when it comes to regulatory actions through additional outreach to stakeholders. "It is deeply concerning that the EPA is so eager to deregulate when the mandate for the organization to "protect the environment." It also becomes more evident why the EPA might want to make it more difficult for citizens to be involved. I hope this isn't true for the IEPA as well.

The Big Muddy River is an essential waterway for those of us who live nearby. We care about the river and want to stop the pattern of using it as a drainage facility for mining operations since it is already impacted by permitted and pre-regulation mine pollution upstream and downstream. According to your document, the stream segment N11 of the Big Muddy River receiving the discharge from Outfall 011 is on the list of impaired waters with problems including iron, sedimentation/siltation, total suspended solids, mercury, PCBs and fecal coliform. Pond Creek eventually flows into the Big Muddy River as well, and therefore the additional outfall pollution eventually ends up in the Big Muddy River. To this mix, you have deemed it safe to add high levels of chloride and sulfate? This does not make sense. You also seem to be monitoring cadmium in Outfalls 001 -006 but not in 008, 009, 009Es or 011. Why is this?

The NPDES permit describes your monitoring plan for each outfall but nowhere in this information do I see reference to the cumulative effects of adding these chemicals to a river that's impaired and continually receives discharges from other sources. Where is this information? Why has there been no assessment of the cumulative impacts on water quality?

The permit also references Special Condition 16 in the outfall to 011 "For any discharge not meeting the water quality standard for any of the above parameters, such discharge shall be subject to the limitations and monitoring requirements of Special Condition No. 16. "

> Pursuant to 35 Ill. Adm. Code Part 302.102, discharges from the referenced outfalls that otherwise would not meet the water quality standards of 35 Ill. Adm. Code Part 302 may be permitted if sufficient flow exists in the receiving stream to ensure that applicable water quality standards are met. That is, discharges not meeting the water quality standards of 35 Ill. Adm. Code Part 302 may only be discharged in combination with stormwater discharges from the basin, and only at such times that sufficient flow exists in the receiving stream to ensure that water quality standards in the receiving stream beyond the area of allowed mixing will not be exceeded.
>
> The permittee shall determine the effluent limitation for chloride and/or the maximum effluent flow rate allowable to maintain water quality in the receiving stream.

This doesn't make sense! Why would the permittee determine the effluent limitation for chloride and the maximum effluent flow? How would this be monitored? Given the violations related to this company concerning its other outfall sites, why would you trust that regulations will be followed?

Further, the NPDES permit does not include a reference to the impacts on the millions of gallons of groundwater infiltrating the mine and piped to the Big Muddy River. What are the long-term impacts of continual water usage and water withdrawal on nearby communities?

The Mine Creek mine defends its plan by suggesting the following as evidence of its importance to the community

> *The disposal of excess water, including the water infiltrating the mine, will allow the mine to continue to operate. The Pond Creek Mine is expected to generate 5 - 6 million tons of useable coal annually. According to the information given in a document dated November 18, 2016, entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit IL0077666, continued operation of the existing mine will continue to provide jobs for 203 employees with an annual payroll of approximately $18 million. In addition to these 203 direct employees, it is estimated that another 100 persons are employed in daily work associated with the Mine's production. This includes truck drivers, supply and support personnel, train crews, and technical personnel. In addition, other local businesses would also* benefit *from the wealth created by the mine. The operation of the mine provides tax revenues through payroll, coal severance, and mineral resource taxes for the surrounding counties and the State of Illinois. The total local, state and federal revenues generated by the continuation of this Mine are approximately $78 million annually. Current employment statistics indicate that the unemployment rate for Williamson County was 7.5%.*

While jobs are very important, there is no assessment in this document of the long-term health and environmental costs of this plan to the countless human and non-human stakeholders.

Several alternatives proposals were deemed too expensive. As an example:

> *Crystallization. Crystallization equipment is expensive to construct/install, operate, and maintain. The cost is estimated at $0.25/gallon, the mining company concludes that crystallization is not a viable option for disposal of the stormwater runoff mine effluent.*

Certainly, a mine that earns profits such as the Pond Creek Coal Mine or its parent company, Foresight Energy can afford the alternative to dumping its waste into a public waterway. Murray Energy recently acquired Foresight Energy. Robert Murray's personal estimated net worth as of August 2017 is 4.73 million dollars. Robert D. Moore, the chairman of the Board and Chief Executive Officer and Director of Foresight Energy, receives yearly compensation in the amount of 1.8 million. (St. Louis Post Dispatch) Billionaire Christopher Cline, who died in a helicopter accident on his way to his private island sold his interest in Foresight Energy for 1.4 billion. Cline donated 1 million to President Trump's inaugural committee and gave thousands to conservative causes. (Bloomberg News) That's a lot of money floating around and indeed appears to have resulted in President Trump's "two-for-one" executive order. The company and you the ILEPA who seem to be acquiescing to this plan want us to believe that Pond Creek Coal Mine and its parent companies don't have enough money to solve this problem without dumping their waste in public waters?

Again we can look to the behavior of the EPA and the inspector general's recent report. *Some of the agency's most cost-saving deregulatory actions over those two years include delaying water pollution limits for coal-burning power plants, increasing regulatory flexibility and decreasing monitoring for coal ash waste site operators.* Could it be that the IL EPA is under pressure from Representative Bost who voted to repeal the Stream Protection Rule? Alternatively, under pressure from the USEPA who has begun to roll back regulations? How is this affecting your decision-making process?

The 1977 Surface Mining Control and Reclamation Act says that mining companies should not cause "material damage to the environment to the extent that it is technologically and economically feasible." Given the company's profits and top executive earnings, I suggest an alternative (crystallization or water treatment plant on-site) would have less detrimental impacts on the environment and is economically feasible without affecting workers jobs. The mine should be able to manage its pollution. This is not the public's responsibility.

I don't care if the Big Muddy River is not listed as a "biologically significant stream" in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor is it given an integrity rating in that document." The Big Muddy River means a lot to me. I frequently visit Riverside Park in Murphysboro. Lewis Creek runs across my property and when the Big Muddy floods and backs up, its water enters the creek. I know from spending time on my land how much wildlife relies on these waters.

It is worth bringing up the history of the EPA as cited on your website. *The stage had been set by the first Earth Day that April and memorialized in the "new" 1970 Illinois State Constitution that contained a separate Environmental Article that declared: "The public policy of the State and the duty of each person is to provide and maintain a healthful environment for the benefit of this and future generations."* Please follow through on this declaration. Protect the streams that feed into the Big Muddy River. Protect the Big Muddy River and its inhabitants, especially the stakeholders who cannot speak for themselves.

Cade Bursell 301 Rubyfruit Lane Murphysboro, IL 62966 618-521-3804

Exhibit 159

EPA.PublicHearingCom

From: Tom Ebenhoh <tomeben@outlook.com>
Sent: Saturday, August 10, 2019 12:20 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

I OPPOSE granting Williams Energy permission to dump any amount of wastewater into the Big Muddy River.

I am a registered voter, and a resident of Cobden, IL.

Regards,

Tom Ebenhoh

Exhibit 160

EPA.PublicHearingCom

From: Diana Brawley Sussman <dibrawley@gmail.com>
Sent: Saturday, August 10, 2019 12:24 PM
To: LeCrone, Darin
Subject: [External] No: NPDESIL0077666 Notice Number 7516c

Dear Mr. Lecrone,

Regarding: NPDESIL0077666 Notice Number 7516c, I do not want Pond Creek Mine to discharge polluted water into the Big Muddy. The company's proposal is a short-sighted solution that benefits one company at the expense of our entire population. If Pond Creek Mine cannot continue to operate without polluting the Big Muddy, then I suggest the company cooperate with the EPA to seek state or federal dollars, matched by its own corporate dollars, to re-train its employees and transition its company to the production of sustainable green energy solutions. Whatever long-term solutions the company seeks, polluting our water is not an option. If the company cannot sustain operations, or seek alternative environmentally sound solutions, then it can shutter its business. One company's fate (and even one industry's fate) is a much lower priority than the collective health and safety of our land, water, and people.

Thank you for protecting our environment by denying this permit.

Sincerely,

Diana Brawley Sussman
506 S. 20th Street
Murphysboro, IL 62966

EPA.PublicHearingCom

Exhibit 161

From: John Reimbold <johnreimbold@gmail.com>
Sent: Saturday, August 10, 2019 12:55 PM
To: LeCrone, Darin
Subject: [External] Clean Water

My name is John Reimbold. I am an Illinois resident at
806 N. Billy Bryan St, Carbondale, IL 62901

Please do not allow Williamson Energy to discharge any waste water into the Big Muddy River. There is no justification to allow a company to willingly pollute this river. It's home to sensitive biological areas and allowing even diluted wastewater will impact this area in ways you cannot predict. The damage will only surface after the deed is done and then who pays? Keep our waterway safe. Do not grant Williamson Energy's request to pollute our river. Let's all try to do what's right.

Exhibit 162

EPA.PublicHearingCom

From: Daniel Hillyard <danielphillyard@gmail.com>
Sent: Saturday, August 10, 2019 12:58 PM
To: LeCrone, Darin
Subject: [External] npdes il0077666 & notice no 7516c

I ask the IEPA to hold a public hearing on the permit request to discharge millions of gallons of mine wastewater into the Big Muddy River. Scientists have proven that sulfates and chlorides are harmful to aquatic life and other organisms dependent on aquatic life. Evidence and public concern should be heard on this topic.

Sincerely,

Daniel Hillyard
808 S Taylor Dr.
Carbondale, IL
62901

Exhibit 163

EPA.PublicHearingCom

From: Jesslyn Jobe <jesj62901@yahoo.com>
Sent: Saturday, August 10, 2019 3:24 PM
To: LeCrone, Darin
Subject: [External] NPDESIL0077666-Notice No 7516c--request for a public hearing on plan discharge polluted water into Big Muddy River

Dear Mr. Lecrone,

Re: NPDESIL0077666, Notice No 7516c

I am writing to request a public hearing be held in Jackson County regarding the proposal to allow Pond Creek Mine discharge into the Big Muddy River. I am concerned about the environmental and health impacts of this discharge and fear that this will exacerbate flooding issues with the Big Muddy in the Murphysboro, IL area. I and other Jackson County residents would like to learn more at a public hearing.

Sincerely,

Jesslyn Jobe
1111 W. Walkup Ave.
Carbondale, IL 62901

Exhibit 164

EPA.PublicHearingCom

From: Susan Walch-Pimentel <susan.mwp@gmail.com>
Sent: Saturday, August 10, 2019 3:46 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

In regard to NPDES IL0077666 & Notice No. 7516c, it unfathomable to me that in this day and age and the science that we know about pollution and life cycles and environment disaster, that the IDNR would even be CONSIDERING the idea of Williamson Energy's request to dump millions of gallons of wastewater into the Big Muddy River. It was bad enough the IEPA approved the request, we certainly don't need a second governmental agency to give the final approval. Stand up for the people of the area, the animals and plants of the area and the future of the area.
The Big Muddy flows through agricultural lands downstream as well as some of the most unique and sensitive biological areas in the state. The coal company says it needs to be able to dump trash into the river to keep miners safe. But, an "IEPA fact sheet that accompanies a draft permit for the project shows that there were other alternatives to dumping the diluted wastewater into the river, but they were ultimately passed on for a variety of reasons, including financial and technological concerns." So, the concerns of drinking water and water which will flow through and damage wild life aren't big enough concerns?
The coal company has been required to amend its proposal more than a dozen times. At one point, it had asked to pump water with high concentrations of chlorides and sulfates, both of which are toxic to aquatic organisms, into the river. The latest proposal apparently calls for water to be diluted through a system of tanks prior to being discharged. Who's going to monitor this so it doesn't happen because once it happens, will IEPA and IDNR just say, "oh, bad, bad company. Here's your fine." Because, I'm going to guess that the fine(s) will be far less expensive to Williamson Energy so it is a better financial way for them to do business. It's certainly not a better way for them to be a responsible business nor for the IEPA and IDNR to do business.
Vote no. Say no. Do not give Williamson Energy the right or opportunity to pollute our waterways. I thought those practices were deemed bad back in the 70s/80s/90s. Why would we go backwards?

Sincerely,

Susan Walch-Pimentel
79 Roosevelt Road
Carbondale, IL 62901
18-559-8027

--
To be early is to be on time.
To be on time is to be late.
To be late is a waste of my time.

Exhibit 165

EPA.PublicHearingCom

From: Shannon Griffin <shannongriffin1980@gmail.com>
Sent: Saturday, August 10, 2019 5:14 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 and notice No. 7516c

Mr LeCrone,

Regarding: NPDES IL0077666 and notice No. 7516c

We the People of Illinois respectfully request a public hearing for the Pond Creek application which seeks to allow upwards of 3.5 millions gallons of mine waste water to be discharged into the Big Muddy River north of Murphysboro. This discharge includes mine process water and ground water seeping into the mine during normal operations. The mining waste will have concentrations of dangerous levels of chlorides and sulfates that will be harmful to all aquatic life downstream of the discharge point.
Big Muddy River is already impacted by permitted and pre-regulation mine pollution. The cumulative impact will not be good for Southern IL or the Big Muddy River.

There has been no assessment of cumulative water quality impacts from continued coal mining.
There has been no assessment of increased water volume with regard to flooding, sedimentation, and downstream impacts.
There has been no assessment for the large withdrawals of underground water resources and the impact and implications that might have on future groundwater resources.
And there has been no assessment of the full social, health, environmental, economic or climate cost this mine will cost IL tax payers.

For these reasons, we ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c

Sincerely,
Shannon L Griffin
341 San Francisco Road
Carbondale, IL 62901

Shannon L Griffin
Independent Scholar

Exhibit 166

EPA.PublicHearingCom

From: Keith Pharis <kpmacao@gmail.com>
Sent: Saturday, August 10, 2019 6:31 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice No.7516c

Dear Sir:
I am writing this email to urge the Illinois EPA to reject Williamson Energy's request to use the Big Muddy River as a dumping site for toxic waste water. The Big Muddy River belongs to the people of Illinois and not the mining industry. Please prevent an environmental disaster and reject this request.
Regards,
Keith Pharis
Carbondale,Illinois

Exhibit 167

EPA.PublicHearingCom

From: Tony Graham <tonygracing@gmail.com>
Sent: Saturday, August 10, 2019 6:54 PM
To: LeCrone, Darin
Subject: [External] Fwd: IL0077666 & Notice No. 7516c

---------- Forwarded message ---------
From: **Tony Graham** <tgraham@emacinc.com>
Date: Fri, Aug 9, 2019, 3:57 PM
Subject: IL0077666 & Notice No. 7516c
To: <tonygracing@gmail.com>

darin.lecrone@illinois.gov

To whom it may concern,

This is in response to the proposal that states that up to 3.5 million gallons of water per day could be released into the big muddy river by Williamson Energy. My family lives on a creek that feeds the big muddy river, when the river floods it moves this water well up into my back yard. This is the backyard in which my dog and family visit often when not under water. I am deeply concerned about the proposal not just from my prospective but the impact that it will have on the water way and the natural world that depends on the river. Please do not allow this proposal to proceed.

Tony Graham

DeSoto Illinois

EPA.PublicHearingCom Exhibit 168

From: Mark Coats <markscoats@yahoo.com>
Sent: Saturday, August 10, 2019 8:47 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 and notice No. 7516c

Mr LeCrone,

Regarding: NPDES IL0077666 and notice No. 7516c

We the People of Illinois respectfully request a public hearing for the Pond Creek application which seeks to allow upwards of 3.5 millions gallons of mine waste water to be discharged into the Big Muddy River north of Murphysboro. This discharge includes mine process water and ground water seeping into the mine during normal operations. The mining waste will have concentrations of dangerous levels of chlorides and sulfates that will be harmful to all aquatic life downstream of the discharge point.

Big Muddy River is already impacted by permitted and pre-regulation mine pollution. The cumulative impact will not be good for Southern IL or the Big Muddy River.
There has been no assessment of cumulative water quality impacts from continued coal mining.

There has been no assessment of increased water volume with regard to flooding, sedimentation, and downstream impacts.

There has been no assessment for the large withdrawals of underground water resources and the impact and implications that might have on future groundwater resources.

And there has been no assessment of the full social, health, environmental, economic or climate cost this mine will cost IL tax payers.

For these reasons, we ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c

Sincerely,

Mark Coats
4301 Valley Forge Rd Apt D
Mt Vernon IL 62864

Exhibit 169

EPA.PublicHearingCom

From: April Mortiz <april.n.moritz@gmail.com>
Sent: Saturday, August 10, 2019 10:45 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 and notice No. 7516c

Mr LeCrone,

Regarding: NPDES IL0077666 and notice No. 7516c

We the People of Illinois respectfully request a public hearing for the Pond Creek application which seeks to allow upwards of 3.5 millions gallons of mine waste water to be discharged into the Big Muddy River north of Murphysboro. This discharge includes mine process water and ground water seeping into the mine during normal operations. The mining waste will have concentrations of dangerous levels of chlorides and sulfates that will be harmful to all aquatic life downstream of the discharge point.
Big Muddy River is already impacted by permitted and pre-regulation mine pollution. The cumulative impact will not be good for Southern IL or the Big Muddy River.

There has been no assessment of cumulative water quality impacts from continued coal mining.
There has been no assessment of increased water volume with regard to flooding, sedimentation, and downstream impacts.
There has been no assessment for the large withdrawals of underground water resources and the impact and implications that might have on future groundwater resources.
And there has been no assessment of the full social, health, environmental, economic or climate cost this mine will cost IL tax payers.

For these reasons, we ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c

Sincerely,
April Moritz
331 Orange St
Elgin, IL 60123

Exhibit 170

EPA.PublicHearingCom

From: Jill Skinner <skinnerstudioscobden@gmail.com>
Sent: Sunday, August 11, 2019 5:02 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666. Notice No. 7516c

Please do not allow Williamson Energy/Pond Creek Mine to discharge its waste into the Big Muddy River.

Even if all this discharge did was poison the river and anything in it, it would devastate sensitive ecological systems in ways difficult if not impossible to ever repair.

The Big Muddy floods. It floods frequently. The toxins in the discharge will poison surrounding farmland, rendering it useless as farmland. Any food that might later be grown on that land might also carry those toxins.

Flood water has a way of moving to places no one could anticipate. Those toxins will end up in the groundwater, and in flooded homes and businesses. The state of Illinois cannot afford to clean up the mess. Illinois cannot afford to monitor the discharge to be sure any particular level of toxin or quantity is not exceeded. Illinois cannot afford to lose tax dollars from residents or businesses flooded out.

Unless Williamson Energy can purify the discharge to levels consistent with drinking water, and they pay for the monitoring, they should not be allowed to put any water into the Big Muddy.

Jill Skinner
Cobden, Illinois

EPA.PublicHearingCom Exhibit 171

From: Covell, Michael D <emike@siu.edu>
Sent: Sunday, August 11, 2019 8:55 AM
To: LeCrone, Darin
Subject: [External] Request for public hearing

Mr. Lecrone
I am requesting a public hearing in my area referring to NPDS IL0077666 Notice No. 7516.
This is also know as IEPA's positions on the proposed Pine Creek Mine Pipeline. Poisoning the Big Muddy River with toxic chemicals, killing wildlife, flooding the river, etc. is not acceptable to the public and destructive to the environment.
Thank you
My name and address is Michael D. Covell
1010 Rattlesnake Ferry Road
Alto Pass, Illinois 62905

Exhibit 172

EPA.PublicHearingCom

From: Rhonda Rothrock <rsrothrock@gmail.com>
Sent: Sunday, August 11, 2019 9:36 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 - Notice #7516c

August 10, 2019
Mr. Darin Lecrone
1021 North Grand Avenue East
Post Office Box 19276
Springfield, IL 62794-9276
RE: NPDES IL0077666 - Notice #7516c
Dear Mr. Lecrone:

I am requesting a Public Hearing on the Pond Creek Coal Mine water discharge plan. The public hearing held by IDNR last October was poorly publicized.

That said, I am adamantly opposed to approval of Pond Creek Coal Mine's application to dump millions of gallons of toxic water into the Big Muddy River.

•No assessment is provided of the biological or other environmental impacts of the proposed mixing of this contaminated mine water on the ecosystem and current uses (fishing, livestock, recreation, etc.) of the Big Muddy River.

•No assessment is provided of the cumulative water quality impacts on the Big Muddy River from this proposal over the many years of continued coal mining.

•No assessment is given either of what such a large groundwater withdrawal quantity could be doing to the local area or what implications this might have for the future.

•No environmental studies have been done on the long-term effects of proposal: cumulative water quality, effects on fish and wildlife, bank erosion, flooding, climate crisis, social and environmental costs to southernmost Illinoisans living along course of river, many of whom are already impoverished. As proven by this year's flooding and the reoccurring flooding, this waste water has the potential of ending up in the back yards of citizens who live along the Big Muddy River.

This wealthy corporation is offering little bonding to offset any problems that might arise, and no plans for detoxifying the water beyond a series of sediment ponds, which of course can overflow during periods of heavy rain. It appears likely that Illinois taxpayers will again get stuck with the bill to clean up the mess after the mine closes and/or the company sells out.

Also, there is no severance tax on coal in Illinois. Legislation to create one has stalled in the legislature since March 2019. And most, if not all, of Pond Creek Mine's coal will be sold abroad, also no benefit to Southernmost Illinoisans.

In light of the recent passing by boththe Illinois Senate and House of Senate Bill 9, The Coal Ash Pollution Prevention Act, it behooves you and the IEPA to recognize that the polluted waste

water from the Pond Creek Coal Mine is equally hazardous to human health and the environment. To approve sending it down stream is not acceptable.

Sincerely,
Rhonda Rothrock
7398 Hickory Ridge Rd.
Pomona, IL 62975
rsrothrock@gmail.com

cc: Lt Governor Juliana Stratton @ LtGovStratton@illinois.gov.
Governor J.B. Pritzker @ www2.illinois.gov/sites/gov/contactus/Pages/VoiceAnOpinion.aspx

--
Rhonda Rothrock
Pomona, IL
Planet Earth

EPA.PublicHearingCom

Exhibit 173

From: McCall, John C <jmccall@siu.edu>
Sent: Sunday, August 11, 2019 9:37 AM
To: LeCrone, Darin
Subject: [External] NPDS IL0077666 Notice No. 7516 Thank you SAVE THE BIG MUDDY RIVER

Dear Darin LeCrone,
I have been informed that you are the official responsible for representing our right to a public hearing on Williamson Energy's pending request for a permit to release mining waste into Big Muddy River. As a resident of Southern Illinois, I am strongly opposed to this plan to use the river as a toxic chemical dump. To rely on Williamson Energy's assurances that dumping millions of gallons of chloride and sulfate rich mining waste will have no environmental impact, would be to ignore the long history of back-room deals that have destroyed clean drinking water in so many communities. We are very lucky to have protected our clean tap water when so many communities have lost theirs. We don't want to have to buy bottled water like people in Flint. Please stand up to those who would take advantage of you and those you represent. You work for the citizens of Illinois, not Williamson Energy.

NPDS IL0077666 Notice No. 7516
Thank you SAVE THE BIG MUDDY RIVER

Dr. John C McCall
616 W. Elm St.
Carbondale, 62901

EPA.PublicHearingCom Exhibit 174

From: Barbara Luttenbacher <luttenbbr@msn.com>
Sent: Sunday, August 11, 2019 10:01 AM
To: LeCrone, Darin
Subject: [External] Save the Big Muddy River

I am against the Pond Creek Mine Pipeline proposal to dump waste into the Big Muddy River. Please conduct a hearing on IEPA's position on this proposed pipeline.

Exhibit 175

EPA.PublicHearingCom

From: William Terry <williamterry80@gmail.com>
Sent: Sunday, August 11, 2019 10:38 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice No. 7516c

I am writing to request that you hold a public hearing on the above referenced permit. As a sportsman who fishes this natural resource I have concerns. As a farmer who owns adjacent property I have concerns about downstream impacts. PLEASE ALLOW RESIDENTS TO HAVE THEIR CONCERNS HEARD IN A PUBLIC HEARING BEFORE MOVING ON THIS PERMIT.

Exhibit 176

EPA.PublicHearingCom

From: Tom <tomredmond@mchsi.com>
Sent: Sunday, August 11, 2019 12:16 PM
To: LeCrone, Darin
Cc: staterepterriibryant@gmail.com
Subject: [External] NPDESIL 0077666, Notice No. 7516c Williamson Energy, LLC, Pond Creek mine Williamson County

I would like to add my voice to those opposed to the proposed 12 mile pipeline to be constructed from the Pond Creek Mine in Williamson County, Illinois. I am concerned with up to 3.5 million gallons of mine infiltration water with the high concentrations of pollutants (including sulfites and chlorides) being piped through federal wildlife areas and rural farmland and then dumped into the Big Muddy River. I am concerned with the environmental and public health issues that will impact human, wildlife and plant life along the route of the pipeline and the Big Muddy River's watershed habitat. I am concerned with Foresight Energy's poor environmental record having been cited in the past for repeated violations of chloride and other pollutant discharge levels. I am concerned with the scheduling of previous public hearings on Pond Creek's pipeline request and provisions in the Total Maximum Daily Load (TMDL) that would allow the dumping of high concentrations of sulfites and chlorides into the Big Muddy River.

I urge the IEPA and DNR to address the many questions and concerns related to Pond Creek's application and the proposed TMDL. There are many concerned citizens living along or near the pipeline path and the Big Muddy River who need more information on the proposal before any final decisions are made.

Sincerely,

Tom Redmond
104N. Parrish Lane
Carbondale, IL.
618-457-0424

Exhibit 177

EPA.PublicHearingCom

From: tom tucker <ttucker241@gmail.com>
Sent: Sunday, August 11, 2019 12:47 PM
To: LeCrone, Darin
Subject: [External] Save the Big Muddy

Hello, my name is Thomas Tucker and I would certainly like a public hearing regarding dumping waste in the Big Muddy River. Wish I had heard of this sooner.
Anything I might be able to do aside from this email please let me know, as far as other information to research, or when and if a public hearing is achieved.
Thank you,
TT

Exhibit 178

EPA.PublicHearingCom

From: Darby Ortolano <darbyo@mchsi.com>
Sent: Sunday, August 11, 2019 12:56 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice No. 7516c

Dear Darin LeCrone,

I am sending this email to express my concern about the application by the Pond Creek coal mine to discharge mine water into the Big Muddy River.

I live in Murphysboro, IL. My name is Darby Ortolano, 239 S. 14th St., Murphysboro, IL 62966.

The mine water has very high levels of chloride and sulfates which, on a local level, will be harmful to fish reproduction and other aquatic life.

In addition, the Big Muddy River has a continuing problem of flooding in Murphysboro, and this will additionally add to that problem. We have a serious business interest that is planning on building a Holiday Inn Express on the intersection of Route 127 and 149, and this site is directly next to the Big Muddy. Murphysboro needs this facility to augment it's tourism traffic, in addition to any pollution concerns, and if the application is approved, the Holiday Inn Express may not be built.

Tourism has become important to Murphysboro (I am on the Murphysboro Tourism Commission), and the Big Muddy River lies directly next to our beautiful and famous Riverside Park. We hold many events in the park, including extremely popular and growing ones featuring Music and Craft Beer and our local wines. Additional water, contaminated with pollutants, could seriously hinder the use of the park.

PLEASE HOLD A PUBLIC MEETING ASAP TO HEAR THE PEOPLE OF THE AREA.

Thank you,

Darby Ortolano

Exhibit 179

EPA.PublicHearingCom

From: Edward Brunner <edw.j.brunner@gmail.com>
Sent: Sunday, August 11, 2019 1:01 PM
To: LeCrone, Darin
Subject: [External] Williamson Energy Pond Creek Mine NPDES IL0077666.Notice Number 7516c
Attachments: PondCreekNewDoc.docx

Dear Mr. LeCrone:

I am attaching a letter that is in regard to the Pond Creek Mine (owned by Williamson Energy). My letter requests a public hearing as well as an extension of the comment period by the public. My request is that you include this letter in the official record for the permit proposed for the Pond Creek Mine (owned by Williamson Energy).

Yours,

Edward J. Brunner
1010 South Oakland Avenue
Carbondale, Illinois 62901
edw.j.brunner@gmail.com
618 549 4673

Edward J. Brunner
1010 South Oakland
Carbondale, IL 62901
edw.j.brunner@gmail.com
618-549-4673

Darin LeCrone
IEPA Bureau of Water
Water Pollution Control Permit Section
1021 North Grand Ave. East
Springfield, IL 62794-9276

August 12, 2019

Re: Williamson Energy Pond Creek Mine NPDES IL0077666, Notice Number 7516c

Dear Mr. LeCrone:

I write as a long-time resident of Jackson County to add my voice to any others that request a public meeting regarding the plan under consideration to shuttle water that has been used in the Pond Creek mine to a point in the Big Muddy River. As one who has used the Big Muddy River as a recreational site, I am seriously concerned over any action that would increase the amount of water carried by that stream.

Anyone who has walked along that waterway during various times of the year would be quick to tell you that the amount of water handled by the Big Muddy River from an area near Herrin to an area near the old site of Brownsville (near Murphysboro) was certain to vary considerably. I've seen the water reduced to almost a trickle, with places in it where one might think it reasonable to wade from one to the other; I've also been astonished, at a later point in the year, to find that water so increased in its size and its flow that it would cause a problem for even a small boat to pass under one of the bridges that span it.

I understand that the Big Muddy rises and falls depending on a variety of circumstances. The river is a product of a number of small tributaries in this relatively flat region of that state, and a strong rainfall in some part of a faraway county will almost certainly have an impact in Jackson and Williamson CountyI also understand that the Mississippi River uses the Big Muddy as a channel to handle its excess. It's no surprise, then, the Big Muddy can change so radically, even within the course of a week or two. Adding another water source, then, would be like introducing a new avenue to the traffic at a busy crossroads, and the proposal deserves the chance for public review and comment.

I should add that one site where the Big Muddy is a subtle but effective asset is the region by the Walker's Bluff resort. This is a site, as is perhaps not yet well known, that has been identified as the place that the state has approved to develop a casino. That casino would bring new business that would contribute to the tax base of a number of communities in Southern Illinois. It may not be the case that its existence would be jeopardized by increased flow of the Big Muddy, but this possibility might need to be discussed, if there were any likelihood that it could occur.

Re: Williamson Energy Pond Creek Mine NPDES IL0077666, Notice Number 7516c

Thank you for considering my comments.

Yours,

Edward Brunner
1010 South Oakland Avenue
Carbondale, Illinois

Exhibit 180

EPA.PublicHearingCom

From: maryohara@mchsi.com
Sent: Sunday, August 11, 2019 1:44 PM
To: LeCrone, Darin
Subject: [External] RE: NPDESIL0077666 & notice no. 7516c --Williamson Energy Pond Creek

Dear Mr. Lacrone,

I am writing to request a public meeting on Foresight's Pond Creek Mine permit request (NPDESIL0077666 & notice no. 7516c)

I am particularly interested in how Public coal and water resources are subsidizing the "low costs" Foresight website declares for operating its' mines including Pond Creek.

Of particular interest to me, is how Foresight uses Rend Lake water in more initial stages of production, what is Foresight's mine daily Rend Lake Water use in initial stages of coal production and what does it pay both Adena Resources and the State of Illinois for this use. The 2007 agreement signed by Ron Blagojevich, "Rend Lake Water Agreement between the State of Illinois, Adena Resources and Adkin Water District" is unclear and does not specifically talk about the cost of the water. I am also interested in finding out if any of Tennessee Valley Authority's (TVA) Illinois coal reserves are being mined by the Pond Creek Mine. If so, what are they paying TVA for this coal? IEPA needs to help the public understand. Have a public hearing! Explain the Water contracts and Foresight's use of TVA Coal!

I would also like to have a hearing on how the unfiltered water discharged into the Big Muddy will be monitored and by whom? Could this water be filtered? Who and how is the discharge monitored? I called the IEPA project engineer on this request and they are on vacation, so I got a variety of responses from IEPA and IDNR officials and "yes" they said, the water could be filtered. One person said the water would be filtered. When I asked if all toxins, namely chlorides and sulfates, would be filtered I got a different response. "No" the discharge of these chemicals into the Big Muddy would be monitored by the owners of the Pond Creek Mine. "How?", I asked. The River discharges are monitored based on "Current Levels" of the Big Muddy. Current levels here refers to whether the River's water currents are "high or low" with the company water monitoring

occurring when the current is low. Company reports these levels to both the IEPA and IDNR. It seems to me that monitoring needs to occur at all times to assess chemical discharge. IEPA Have a hearing and help the public understand this process as proposed

Thank you,

Mary O'Hara, (618)713-0820 104 N. Parrish Lane Carbondale, Illinois

---

From: maryohara@mchsi.com <maryohara@mchsi.com>
Sent: Monday, August 5, 2019 3:06 PM
To: 'darin.lecrone@illinois.gov' <darin.lecrone@illinois.gov>
Subject: NPDESIL0077666 & notice no. 7516c --Williamson Energy Pond Creek

Dear Mr. Lacrone

Please forgive me getting into responding to this request late in the game. If you could Answer these questions or direct me to the places where these questions are addressed

1. I am interested in finding out what Water district Williamson Energy LLC Pond Creek Mine uses for its' operations? Does it pay for this water? I know that their Permit request IDNR(#456) addresses using Big Muddy Water for disposal of water and Rend Lake is the likely source but what water district provides its water. From some calls I have made I think the water may be from Rend Lake but the Mine gets the Rend lake water from a Water district that Rend Lake sells to.
2. Are options other than disposal of unfiltered water into the Big Muddy being discussed (reverse osmosis, filtration)?
3. Is Williamson Energy LLC buying coal rights from the Tennessee Valley Authority?

Thank You, Mary O'Hara (618)713-0820
104 N. Parrish Lane, Carbondale, Illinois 62901

Exhibit 181

EPA.PublicHearingCom

From: gailted@frontier.com
Sent: Sunday, August 11, 2019 5:11 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No.7516c

RE: NPDES IL0077666 & Notice No.7516c
Please do NOT allow Pond Creek Mine to dump tons of toxic water into the Big Muddy River.

Our rivers should never be used as a sewerage system. The Big Muddy, as you know slowly meanders through
Southern Illinois towns and farm lands, as well as preserved forests and Pine Hills Wildlife Area, before it empties
into the Mississippi River. It floods it's almost every year, and was above flood stage for months in 2019.

Please do not put the health and livelihood of those who live along the Big Muddy at risk by approving Pond Creek Min's application!

Sincerely,
Ted Mieling, former Supervisor of Cedar Lake
Gail Mieling. Ph.D.

183 Cedar Meadows Dr.
Makanda, IL 62958

Exhibit 182

EPA.PublicHearingCom

From: Jyotsna Kapur <jyotsnakapur7@gmail.com>
Sent: Sunday, August 11, 2019 9:27 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 and notice No. 7516c

Mr LeCrone,

Regarding: NPDES IL0077666 and notice No. 7516c

We the People of Illinois respectfully request a public hearing for the Pond Creek application which seeks to allow upwards of 3.5 millions gallons of mine waste water to be discharged into the Big Muddy River north of Murphysboro. This discharge includes mine process water and ground water seeping into the mine during normal operations. The mining waste will have concentrations of dangerous levels of chlorides and sulfates that will be harmful to all aquatic life downstream of the discharge point.
Big Muddy River is already impacted by permitted and pre-regulation mine pollution. The cumulative impact will not be good for Southern IL or the Big Muddy River.

There has been no assessment of cumulative water quality impacts from continued coal mining.
There has been no assessment of increased water volume with regard to flooding, sedimentation, and downstream impacts.
There has been no assessment for the large withdrawals of underground water resources and the impact and implications that might have on future groundwater resources.
And there has been no assessment of the full social, health, environmental, economic or climate cost this mine will cost IL tax payers.

For these reasons, we ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c

Sincerely
Jyotsna Kapur
Murphysboro

Exhibit 183

EPA.PublicHearingCom

From: Jennifer Haselhorst <jenniferhaselhorst@gmail.com>
Sent: Sunday, August 11, 2019 9:41 PM
To: LeCrone, Darin
Subject: [External] Pond Creek Mine - request for public hearing

Hello,

I'm writing to request a public hearing regarding the Pond Creek Mine permit number IL0077666 and 7516c.

As a citizen of Murphysboro who lives on the Big Muddy River, we cannot allow more dumping of waste into our waters and I oppose this pipeline. I've experienced three 50 year floods in the last decade and this excess water and waste would only exacerbate this problem. It would be extremely detrimental to the environment - plants, animals, and humans alike - all downstream from there. In this day and age, we need to take responsibility for the damage we do to the earth while we do business. We can't turn a business's waste problem into future human health and ecological problems.

Thank you,

Jen Haselhorst
124 Carlock Road
Murphysboro, IL

Exhibit 184

EPA.PublicHearingCom

From: oneshot7@frontier.com
Sent: Sunday, August 11, 2019 9:46 PM
To: LeCrone, Darin
Subject: [External] NPDES IL 0077666 & Notice NO. 7516c

This is the most absurd thing I've ever heard. There is not enough money on earth to restore the damages this chemical waste dumping would cause. We may be on the poor end of the state, but we are far from stupid. The remaining citizens in this state do not need one more reason to up and move. This will cause significant damage to wildlife, the landscape and most likely loss of many forms of life, Including humans. People all around this area camp, fish and swim in that river. They pay taxes, get licenses, spend money and enjoy the relaxation the Big Muddy brings. We have for generations. The fact that this was even considered blows my mind. SERIOUSLY? That mining outfit has no soul. They're just greedy. Not like toxic chemicals will be running through their backyard so to hell with it. This will save us tons.
Well, myself and many others do not agree. We do not see anything but devastation coming from this. PLEASE, PLEASE do not allow this to happen. It WILL be detrimental. Make the coal mine pay for cleansing and riddance of this water the same way every other company has to. It's called being responsible and running a business. The Big Muddy as well as all the other waterways in the land has never been intended to be a sewer.
P L E A S E.....STOP THIS INSANITY.
Thank you for your time. I pray common sense and pride in mother nature win this one.

Chistopher Brown
Taxpayer, voter and resident close to the Muddy

Exhibit 185

EPA.PublicHearingCom

From: Pam McLean <pemclean@hotmail.com>
Sent: Sunday, August 11, 2019 10:10 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

I am writing this email to adamantly oppose the mine's proposal concerning the Big Muddy River. The Big Muddy River is an important fishery and estuary in Southern Illinois. Many people who live in this area as well as visitors to the area use the Big Muddy for recreational fishing, canoeing, etc. The things that draw people to this area are of an outdoor nature, boating, camping, hiking, and of course the wine trail. We need to take care of and promote these activities, not destroy them. No one wants to eat from or be in contaminated water. Even if the coal companies tried to maintain their equipment so as to be safe, all it takes are a few hours of equipment malfunction to contaminate the river and kill the wildlife for years to come.
Please protect the Big Muddy River.

Sincerely,
The McLean Family

Exhibit 186

EPA.PublicHearingCom

From: alehx03 . <alehx03@gmail.com>
Sent: Sunday, August 11, 2019 11:11 PM
To: LeCrone, Darin
Subject: [External] Pond Creek mine discharge

Hey Darin,

My name is Alex Bishop. I'm a resident of Desoto, IL and am a licensed wastewater operator for the city of Carbondale. I've been seeing a considerable number of posts on social media concerning the proposed Pond Creek mine discharge. I've seen very little data on what the mine is actually discharging beyond 3.0MGD, sulfate, and chloride.

Has there been an actual chemical assay performed on the effluent? If so, is there adequate data from samples collected from above and below the proposed discharge location to show there is no impact on water quality? If a decision like this is going to be made I feel like this data should exist and be public knowledge. Because this information is not available, I'd like to request that a hearing be performed to thoroughly evaluate this decision. If the 3.0-MGD number I've been seeing is correct, that is just way too much flow to not be transparent about.

Thank you for reading this as well as any time you invest further investigating this matter.

Sincerely,

Alex Bishop

Exhibit 187

EPA.PublicHearingCom

From: Abby Cripps <abbycripps1234@gmail.com>
Sent: Sunday, August 11, 2019 11:14 PM
To: LeCrone, Darin
Subject: [External] re: Oppose Pond Creek Mine's application to dump millions of gallons of toxic water into the Big Muddy

NPDESIL0077666 & Notice No. 7516c

Hello, My Name Is Abby Cripps And I Am From Grand Tower, Illinois. I Would Like To Discuss How The Pond Creek Mine Wants To Dump Millions Of Gallons Of Toxic Waste Into The Big Muddy River Here In Southern Illinois. I Have Lived Here For Twenty Years As I Am Only Twenty Years Old My Parents Have Lived Here For Fifty One And Forty Years. My Mother Grew Up On The Same Property That I Have Grown Up On. She Has Never Lived On Any Other Property. This Is Our Home And I Know And Believe That If You Let This Happen My Small Town Won't Be Able To Exist. Flooding From Both The Mississippi And The Big Muddy Would Vanish Us. By Letting The Millons Of Gallons Of Toxic Waste Into The River You Are Not Just Affecting The Fish That Live In The River You Are Taking The Chance Of Hundreds Of Towns And So So So Many People Of Losing Their Homes And Lives Because Of The Even Bigger Chances Of Flooding. We All Want Our Families For Generations To Come To Live In Our Hometowns If They So Choose To. I Want To Be Able To Raise My Family Here One Day And For Them To Raise Their Families Here. You Are Not Only Going To Effect Southern Illinoisians That Live On The Big Muddy River But Also The People That Live On The Mississippi From Southern Illinois Where The Big Muddy River Dumps Into The Mississippi Just Below Grand Tower You Would Be Effecting Millions Of People And Fish From Southern Illinois Down To Louisiana Because It Would Kill The Fish And Rise The Rivers. Please Before Making Your Decison Just Take All Of Us And Future Generations Into Your Thoughts We Don't Want To Lose Our Homes Over Something That Doesn't Really Need To Be Done. Please Make The Right Decision And Not Hurt Thousands To Millions Of People.

Thank You I Hope You Take Time To Read This.

NPDESIL0077666 & Notice No. 7516c

Exhibit 188

EPA.PublicHearingCom

From: Cindy Skrukrud <cindy.skrukrud@sierraclub.org>
Sent: Monday, August 12, 2019 4:23 PM
To: LeCrone, Darin; Keller, Al; Sofat, Sanjay
Cc: Pierard, Kevin; Albert Ettinger; Andrew Rehn
Subject: [External] Comments and Request for Hearing NPDES Permit No. IL0077666, Notice No. 7516c Williamson Energy, LLC, Pond Creek Mine
Attachments: Comment and Request for Hearing on NPDES Permit No. IL0077666, Notice No. 7516c, Williamson Energy, LLC, Pond Creek Mine.pdf; Att. 3.Van Meter and Swan 2014.pdf; Att. 2.Dugan et al - salting US lakes.pdf; Att. 4.Lind et al 2018.pdf; Att.1.Rosen et al report.pdf

Dear Darin,

Please see the attached comments and request for hearing on the proposal to reissue a NPDES permit to Williamson Energy, LLC to allow mine waste from the Pond Creek mine to be discharged into Pond Creek, a Pond Creek tributary and the Big Muddy River.

I am also copying Al Keller and Sanjay Sofat as it looks like Darin is out of the office this week.

Please let us know if you have any questions.

Thank you.

Cindy Skrukrud
Clean Water Program Director
Sierra Club Illinois

--

SIERRA CLUB

I work Monday-Wednesday so I will be slow to respond to emails on other days.
Please do not feel obligated to respond to email after hours or on weekends.

Cindy Skrukrud PhD
Clean Water Program Director
Illinois Chapter, Sierra Club
312.251.1680 x1015
cindy.skrukrud@sierraclub.org

Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land.
Luna Leopold, Hydrologist

SIERRA CLUB
ILLINOIS CHAPTER
70 E. LAKE, SUITE 1500
CHICAGO, IL 60601
(312) 251-1680

prairierivers network

August 12, 2019

Sent via email to darin.lecrone@illinois.gov

Darin LeCrone
IEPA Bureau of Water, Water Pollution Control Permit Section
1021 North Grand Ave East
Springfield, IL 62794-9276

Re: Comment Regarding NPDES Permit No. IL0077666, Notice No. 7516c
Williamson Energy, LLC, Pond Creek Mine
REQUEST FOR PUBLIC HEARING

Dear Mr. LeCrone and other IEPA officials,

The Illinois Chapter of the Sierra Club and Prairie Rivers Network object to the provisions of the draft NPDES permit proposed to be reissued to Williamson Energy, LLC to allow mine waste from the Pond Creek mine to be discharged into Pond Creek, a Pond Creek tributary and the Big Muddy River. We request a hearing be held so our members and other members of the public can share our concerns and ask questions of Agency staff.

The Illinois Chapter of Sierra Club represents over 33,000 members and Prairie Rivers Network has 1,000 members in Illinois. Our members are affected by pollutant discharges into Pond Creek, the Pond Creek tributary, the Big Muddy River and downstream water bodies and would use these waters more frequently were they not affected by pollution from this facility and other sources. Our members and others rely on clean waters in the Big Muddy watershed for activities including hunting, recreational fishing, commercial fishing, trapping, paddling, boating, birdwatching and other wildlife viewing. We are concerned about the additional harm that this facility may cause if this permit is reissued without additional protections.

OBJECTIONS BASED ON THE CURRENT RECORD AVAILABLE TO COMMENTERS

Sierra Club and Prairie Rivers Network object to the permit on the following grounds, each described in greater detail below:

I. The facility has current and recent violations of their NPDES permit that have yet to be resolved.

II. In view of the frequent violations and the danger of discharges of chemicals that are toxic to aquatic life, the monitoring is inadequate.

III. The Chloride acute limit is too weak and the permit lacks a chronic chloride limit and thus fails to protect aquatic life and violates 35 Ill. Adm. Code 302.105(a), 302.210, 304.105. And 309.143.

IV. The Reasonable Potential Analysis is improper because the IEPA did not use the multipliers recommended by U.S. EPA to assure measure reasonable potential or require an adequate amount of testing. See *Des Plaines Watershed Alliance v. Illinois EPA*, 2007 Ill. Env. Lexis 149 *138 (IPCB 2007).

V. The potential effect of the increased discharges has not been determined as to flooding, groundwater use and other factors.

VI. Increased chloride levels may increase toxicity of algal blooms in Big Muddy and other waters.

I. The facility has current and recent violations of their NPDES permit that have yet to be resolved and better monitoring is necessary.

According to EPA's Enforcement and Compliance History Online (ECHO) database, this facility is currently in noncompliance with its CWA permit, and has been in noncompliance for 5 of the past 12 quarters reported.[1] The Detailed Facility Report shows additional information of concern, including:

- The last inspection was conducted almost 10 years ago on 09/09/2009
- The current compliance status is listed as "Violation Identified"
- The most recent quarter reported (04/01-07/26/19) reports a violation of the chloride limit by 38% and a violation of the sulfate limit by 108%
- Violations of the chloride and sulfate limit by 220% are reported for 3rd Quarter 2018, 367% for chlorides in 2nd Quarter 2017, and 620% for chlorides in 2nd Quarter 2016.
- It appears that the pH limit was violated in Spring 2018 according to IEPA records.
- IEPA should not issue a new and expanded permit without determining whether permittee has been filing DMRs properly under its existing permit. It appears that the discharger may be only filing data regarding pH and settleable solids and is otherwise failing to comply with reporting requirements in it current permits. For example, Outfall

[1] https://echo.epa.gov/detailed-facility-report?fid=110023026884

003 reports settleable solids and pH frequently between 2015 and 2019, but the measurements for chloride and other chemicals are reported as "no discharge." Other outfalls have similar issues. The lack of information on the quantity and nature of past discharges makes it impossible to determine the effect of potential future discharges. The monitoring required by the draft permit is inadequate under 35 Ill. Adm. Code 309.146.

II. In view of the frequent violations and the danger of discharges of chemicals that are toxic to aquatic life, the monitoring is inadequate.

The DMRs for 2018 that are kept by IEPA seem to only report on pH and settleable solids. Discharge monitoring should include data on volume of discharge to allow determination of impact on downstream water quality.

III. The Chloride acute limit is too weak and the permit lacks a chronic chloride limit and thus fails to protect aquatic life and therefore the permit violates 35 Ill. Adm. Code 302.105(a), 302.210, 304.105. And 309.143.

Studies and evidence presented in PCB 18-32 shows that acute limit should be less than 500 mg/L given hardness of 141 and temperatures in excess of 25 C in Big Muddy most of May to September. Mixing that would allow levels that exceed protective levels under 35 Ill. Adm. Code 302.102(b)(4) should not be allowed. No increased discharge should be allowed to any area where it might harm existing uses under 302.105(a). The lack of a chronic limit is intolerable given that permit allows dry weather discharges. As there is no chronic limit provided by Illinois numeric standards, chronic limit should be calculated using studies and calculations presented by Dr. Soucek in PCB 18-32 to establish chronic limits.

Additional pollution loading of the river, particularly at times of low flow, are a concern to us in addition to the known problems high levels of chlorides cause for fish and other aquatic life. Chlorides are stated in some sources to be accumulative. There is nothing in the application that was found to assess what the daily and long-term biological and water quality impacts of the high levels of chlorides and sulfates will do.

Additionally, the permit has granted mixing zone in Pond Creek (Outfall 009), and the modeling shows that chloride concentrations could be in the range of 188 to 411 mg/L, well above a potential future chronic standard of 283 mg/L.

IV. The Reasonable Potential Analysis is improper because the IEPA did not use the multipliers recommended by U.S. EPA to assure measure reasonable potential or require an adequate amount of testing. See *Des Plaines Watershed Alliance v. Illinois EPA*, 2007 Ill. Env. Lexis 149 *138 (IPCB 2007).

Despite the IPCB's New Lenox decision in Des Plaines Watershed Alliance v. Illinois EPA, 2007 Ill. Env. Lexis 149 *138 (IPCB 2007), in the reasonable potential analysis in this case IEPA declines to use the multipliers that have been determined by U.S. EPA in its Technical Support Document to properly analyze the risk of toxic discharges. The grounds given for this is that IEPA believes that the multipliers are too large when there are few samples.

There is, however, a way to avoid the alleged problem cited by IEPA. This is to require more samples. This will bring down the U.S. EPA multiplier without risking the environment.

V. The potential effect of the increased discharges has not been determined as to flooding, groundwater use and other factors.

The potential effect of the increased discharges has not been determined as to flooding, groundwater use and other factors all of which are relevant to determining whether the permit would in fact benefit social or economic development in the area. Further, increased chloride levels may increase toxicity of algal blooms in Big Muddy and other waters.

The Big Muddy River is indicated as Public Waters by IDNR (https://www.dnr.illinois.gov/WaterResources/Pages/PublicWaters.aspx). The full impacts of this added discharge do not appear to have been adequately evaluated and essential information for this application appears to be lacking. There is no information on what the added 2,700,000 to 3,500,000 gallons per day will mean to erosion impacts, river water levels, public use of the river for recreation or other public uses. This river is already prone to flooding and has documented low flows which clearly could mean different impacts from the proposed discharges that have not been adequately assessed.

There is no information on what the stated rate of groundwater pumping and groundwater drawdown are doing to the hydrology of the area. There is no information on the impacts to other springs, streams or non-potable water uses in the county or if there are any long-term concerns for this withdrawal of groundwater.

VI. Increased chloride levels may increase toxicity of algal blooms in Big Muddy and other waters.

There are studies indicating that increased chloride levels may increase the levels of cyanobacteria in water bodies and the potential for toxic algal blooms. (Attachments 1-4) IEPA must thoroughly consider this issue before allowing the levels of chloride discharger contemplated by this draft permit.

Also, the permit proposes to use conductivity as a surrogate for chlorides. Other factors may cause conductivity to be high without chlorides also being high. This could result in a poor calibration curve unless done properly.

QUESTIONS AND ISSUES FOR THE PUBLIC HEARING

There is a large level of public interest in this permit (See for example, https://thesouthern.com/news/local/environment/residents-still-concerned-as-idnr-decides-whether-to-grant-permit/article_a08dfa90-d882-5c01-90e2-83b24b4b3f34.html?fbclid=IwAR3wPxIKov0ReSj9DKVG26vlHRO9BvNmfJ13H_Bciq-JzC5LCe7vjB_nPes) and the complex facts and technical issues plainly require that a public hearing be held. In addition to discussion of the issues raised by our objections to the draft permit stated above, issues that should be discussed at the hearing include:

1. What are the daily water quality, biological, and downstream impacts of this proposal on the Big Muddy River?
2. What the actual discharges and pollutant levels have been for the last five years?
3. What will the proposed daily discharge of high levels of chlorides and sulfates do to existing fish and aquatic life in the Big Muddy River and to other downstream uses?
4. What volume of water will be discharged to the Big Muddy River? Is 11 cubic feet per second a hard limit?
5. What are the impacts of the ongoing pumping of groundwater at the mine and its potential effect on social and economic development in the area?
6. Whether use of groundwater to dilute mining waste will cause or contribute to violations of water quality standards in water bodies hydrologically connected to that groundwater?
7. Whether the monitoring that has been done of the applicant's effluent is adequate to determine its potential effect?

8. What fish and aquatic species are currently utilizing the proposed discharge section of the Big Muddy River and are there any locations downstream that have mussel populations? What are the biological and environmental impacts of the high chloride levels?
9. The uses of the Big Muddy River and other downstream waters that might be adversely affected by the proposed permit?
10. Whether there should be a total dissolved solids or conductivity limit given the science presented in the U.S. EPA conductivity guidance ? See Draft Field-Based Methods for Developing Aquatic Life Criteria for Specific Conductivity. EPA, December 23, 2016.
11. Wastewater treatments for the polluted water to be discharged under the permit that are alternatives to simple dilution and primitive lagoon treatment?
12. Whether there are alternatives to discharging the wastewater to rivers and streams?
13. Whether coal production can properly be considered as a benefit given the effects of coal combustion on the global climate?

A public hearing would allow an opportunity to have these and other questions answered, and would give our members and other local community members a chance to raise their questions and concerns.

Thank you for your attention to our comments. We look forward to your response.

Sincerely,

Cindy Skrukrud
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Andrew Rehn
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Champaign, IL 61820
217-344-2371 x 8208
arehn@prairierivers.org

cc: Williamson Energy, LLC (by mail)
Kevin Pierard, Region 5, USEPA (by email)
Al Keller and Sanjay Sofat (by email)

Attachment 1- Understanding the Effect of Salinity Tolerance on Cyanobacteria Associated with a Harmful Algal Bloom in Lake Okeechobee, Florida
Attachment 2- Salting our Freshwater Lakes
Attachment 3- Road Salts as Environmental Constraints in Urban Pond Food Webs
Attachment 4- Salty fertile lakes: how salinization and eutrophication alter the structure of freshwater communities

This page added by Illinois EPA as a place holder for the following attached document(s)

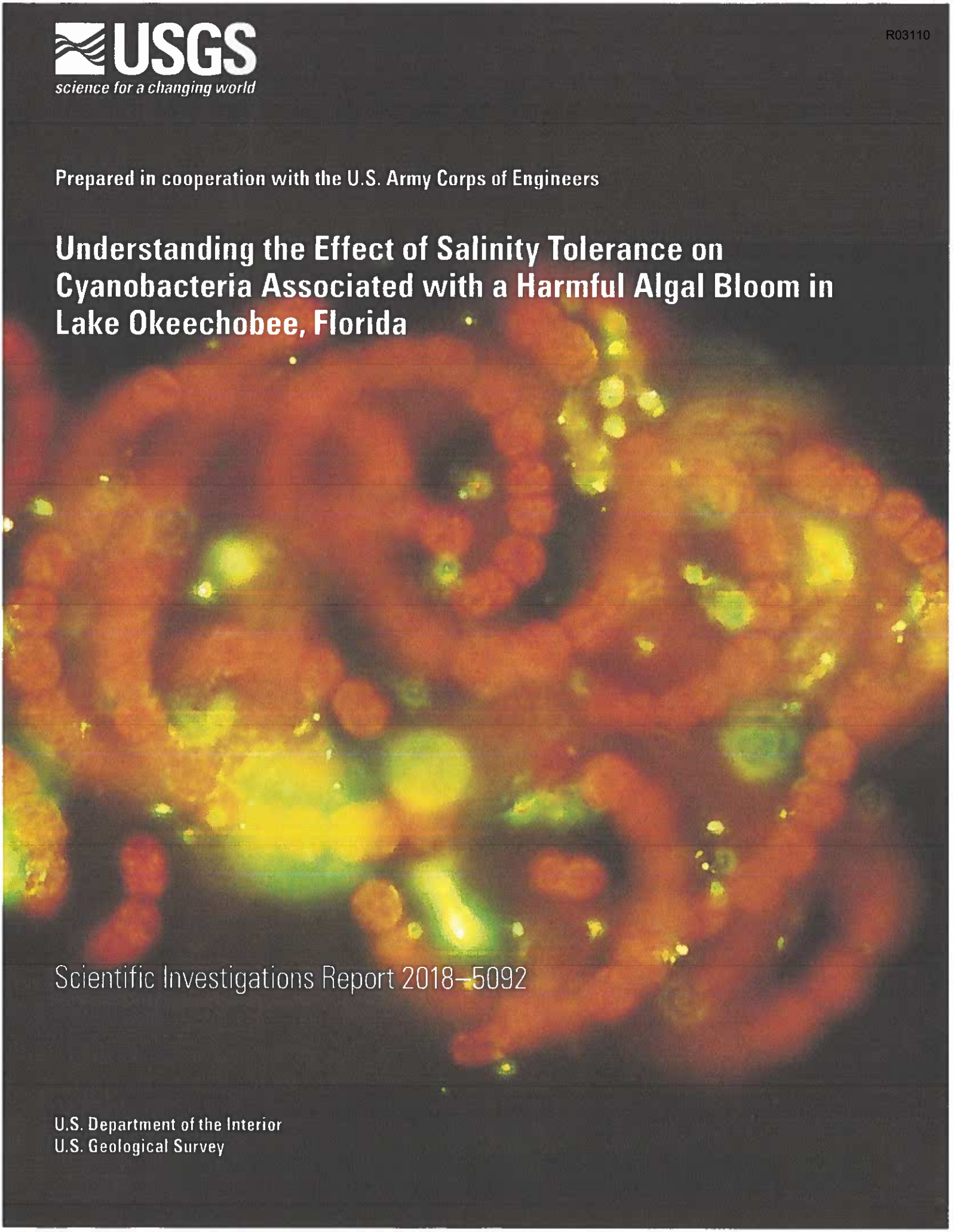
Attachment 1

R03110

USGS
science for a changing world

Prepared in cooperation with the U.S. Army Corps of Engineers

Understanding the Effect of Salinity Tolerance on Cyanobacteria Associated with a Harmful Algal Bloom in Lake Okeechobee, Florida



Scientific Investigations Report 2018–5092

U.S. Department of the Interior
U.S. Geological Survey

R03111

Cover. *Dolichospermum circinale* stained with SYTOX® Green. Photograph by Barry H. Rosen, U.S. Geological Survey, July 17, 2015, using an epifluorescence microscope.

R03112

Understanding the Effect of Salinity Tolerance on Cyanobacteria Associated with a Harmful Algal Bloom in Lake Okeechobee, Florida

By Barry H. Rosen, Keith A. Loftin, Jennifer L. Graham, Katherine N. Stahlhut, James M. Riley, Brett D. Johnston, and Sarena Senegal

Prepared in cooperation with the U.S. Army Corps of Engineers

Scientific Investigations Report 2018–5092

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
RYAN K. ZINKE, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2018

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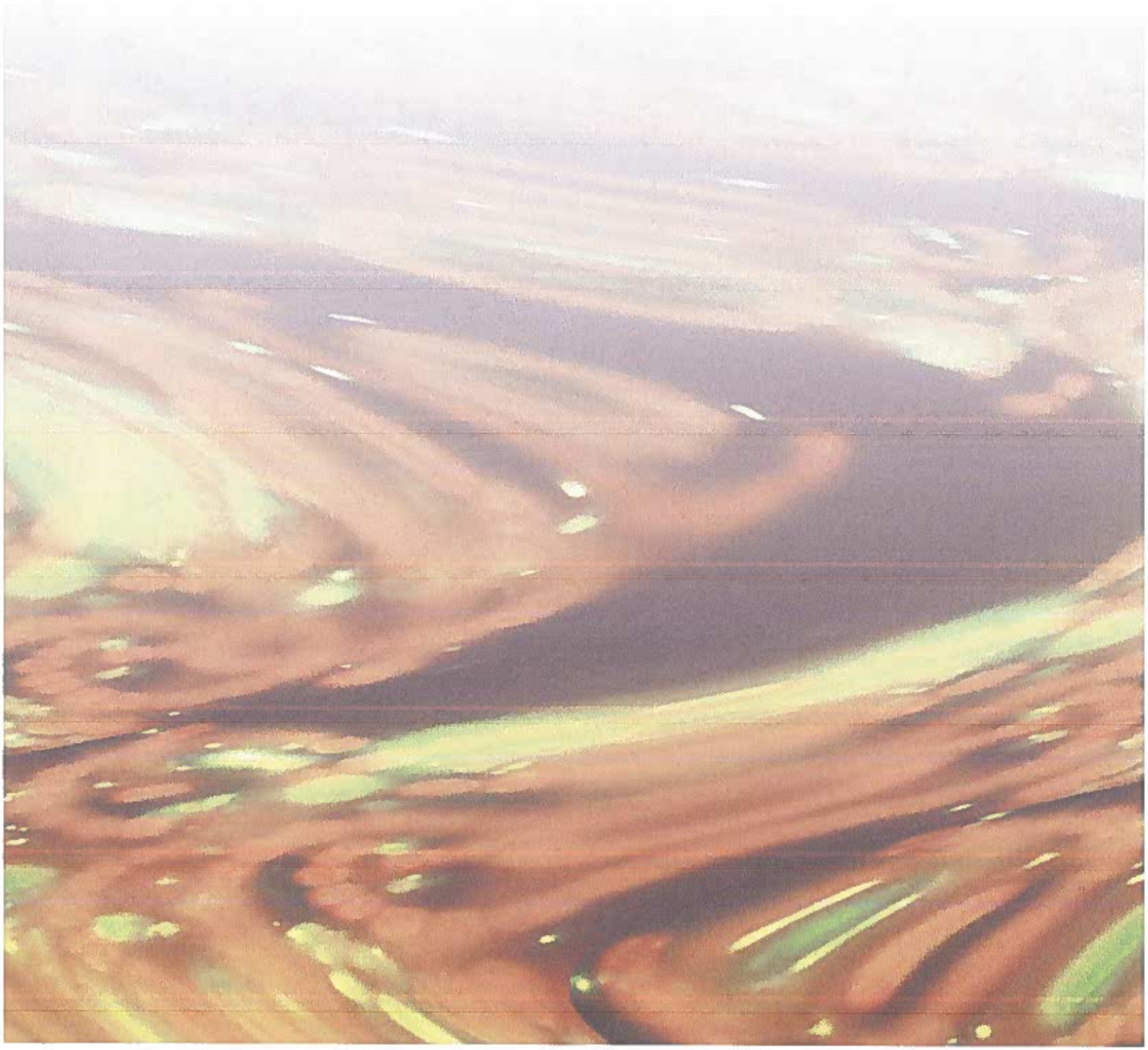
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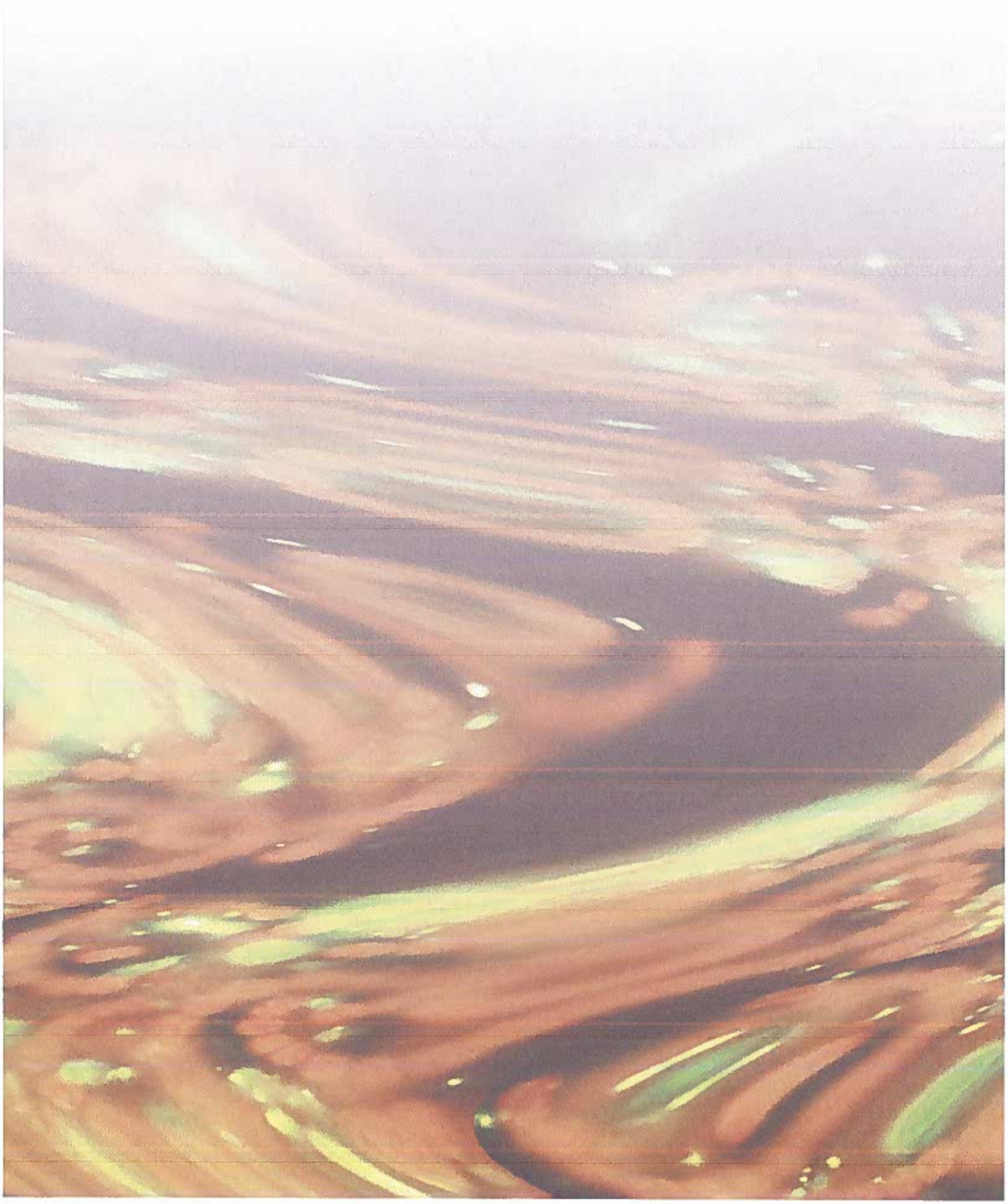
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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Area	
square kilometer (km^2)	247.1	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
liter (L)	33.81402	ounce, fluid (fl. oz)
liter (L)	2.113	pint (pt)
liter (L)	1.057	quart (qt)
liter (L)	0.2642	gallon (gal)
liter (L)	61.02	cubic inch (in^3)
	Flow rate	
meter per second (m/s)	3.281	foot per second (ft/s)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)

U.S. customary units to International System of Units

Multiply	By	To obtain
	Flow rate	
foot per second (ft/s)	0.3048	meter per second (m/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as

$$°F = (1.8 \times °C) + 32$$

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given in either milligrams per liter (mg/L) or micrograms per liter (µg/L).

Abbreviations

cells/mL	cells per milliliter
FDEP	Florida Department of Environmental Protection
LM	light microscopy
μWm^{-2}	microwatts per square meter
MCLR	microcystin-LR
mL	milliliters
µL	microliter
µg	microgram
µm	micrometer
NaCl	sodium chloride
PRSD	percent relative standard deviation
psu	practical salinity units
RFU	relative fluorescent units
SFWMD	South Florida Water Management District
USGS	U.S. Geological Survey
UV	ultraviolet
WB	wide blue

Understanding the Effect of Salinity Tolerance on Cyanobacteria Associated with a Harmful Algal Bloom in Lake Okeechobee, Florida

By Barry H. Rosen,[1] Keith A. Loftin,[1] Jennifer L. Graham,[1] Katherine N. Stahlhut,[1] James M. Riley,[2] Brett D. Johnston,[1] and Sarena Senegal[1]

Abstract

In an effort to simulate the survival of cyanobacteria as they are transported from Lake Okeechobee to the estuarine habitats that receive waters from the lake, a bioassay encompassing a range of salinities was performed. An overall decline in cyanobacteria health in salinity treatments greater than 18 practical salinity units (psu) was indicated by loss of cell membrane integrity based on SYTOX® Green staining, but this loss varied by the kind of cyanobacteria present. *Microcystis aeruginosa* was tolerant of salinities up to 18 psu; however, higher salinities caused leaking of microcystin from the cells. *Dolichospermum circinale*, another common bloom-former in this system, did not tolerate salinities greater than 7.5 psu. Stimulation of mucilage production was observed and is likely a mechanism used by both species to protect organism viability. At 7.5 psu, microcystin increased relative to chlorophyll-*a*, providing some evidence of biosynthesis when *M. aeruginosa* is exposed to this salinity. This study indicates that as freshwater cyanobacteria are transported to brackish and marine waters, there will be a loss of membrane integrity which will lead to the release of cellular microcystin into the surrounding waterbody. Additional research would be needed to determine the exact effect of salinity on this relationship.

Introduction

Lake Okeechobee (located at 27° north latitude and 81° west longitude) is a large shallow lake (1,900 square kilometers [km^2]) that receives inflow from the Kissimmee River and other smaller tributaries (fig. 1). The bloom material for this study came from Eagle Bay on the north side of the lake. An earthen dike that surrounds the lake was constructed to control adjacent flooding. When lake stage threatens the integrity of the dike, water is released to the Atlantic Ocean through the St. Lucie Canal and to the Gulf of Mexico through the Caloosahatchee River. Releases follow the Lake Okeechobee Regulation Schedule, developed and implemented by the U.S. Army Corps of Engineers and the South Florida Water Management District (SFWMD), to ensure the lake is at a low enough stage to accommodate summer season runoff and rainfall (U.S. Army Corps of Engineers, 2008).

Lake Okeechobee is classified as a moderately eutrophic (Brezonik and Engstrom, 1998) shallow waterbody that has undergone ecological changes because of external nutrient loading from agriculture (Havens and others, 1996) and, more recently, by internal loading of phosphorus from lakebed sediments (Pollman and James, 2011). Ample phosphorus and other nutrients create the ideal conditions for cyanobacterial blooms and have been documented in the lake since 1970 by the SFWMD (1989). The first large-scale bloom occurred in 1986, was dominated by *Dolichospermum circinale* (formerly *Anabaena circinalis*), and covered approximately 310 km^2.

Some of the conditions that lead to cyanobacterial blooms are warm temperatures, sunlight, water-column stability, and sufficiently high concentrations of nitrogen and (or) phosphorus. While all cyanobacteria need ample phosphorus to thrive, inorganic nitrogen limitation allows a subset of cyanobacteria, those capable of using atmospheric nitrogen, to be more successful. *Dolichospermum* (formerly *Anabaena*) has the ability to fix nitrogen (Rosen and others, 2017), compared to *Microcystis*, a nonnitrogen fixing genus, that needs to acquire nitrogen from inorganic sources.

During the summer of 2016, regulatory discharges from Lake Okeechobee into the Caloosahatchee River and the St. Lucie Canal and Estuary occurred during an extensive cyanobacterial bloom (National Aeronautics and Space Administration, 2016). The Florida Department of Environmental Protection (FDEP), in conjunction with the Florida Fish and Wildlife Commission, reports cyanobacteria species composition and microcystin concentrations weekly in Lake Okeechobee and attending waterways (FDEP, 2018). In late June 2016, a large cyanobacterial accumulation occurred

[1]U.S. Geological Survey.

[2]U.S. Army Corps of Engineers.

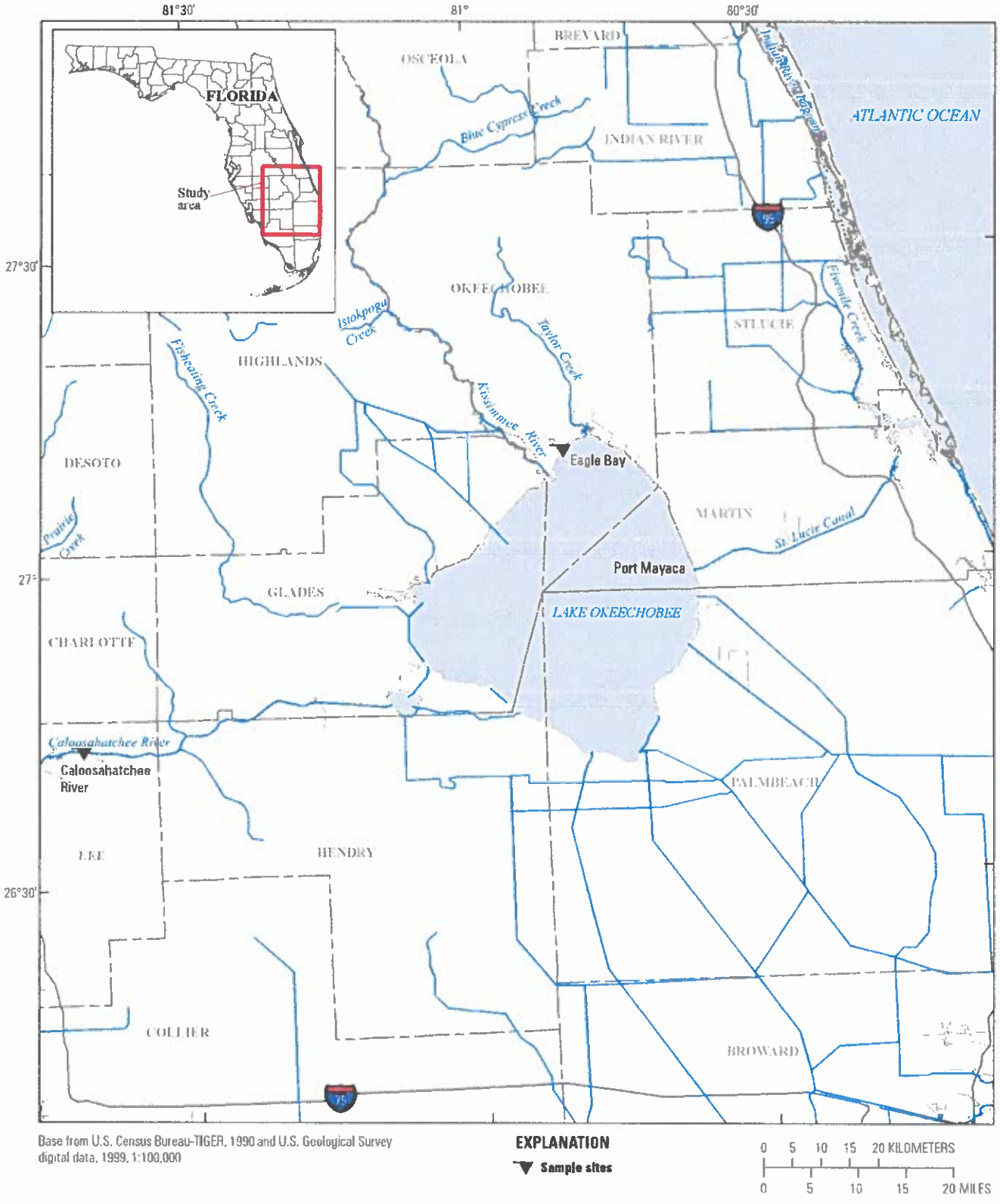


Figure 1. The location of Lake Okeechobee, the tributary system in and out of the lake, and Eagle Bay, where samples were taken for this study, July 7, 2017.

in the St. Lucie Estuary, prompting the Governor of Florida to issue a state of emergency for three affected counties. The FDEP data indicated that Lake Okeechobee and (or) the canal system had existing populations of cyanobacteria (FDEP, 2017) that were likely transported downstream when water was discharged from Lake Okeechobee. Local and coastal basin nutrient runoff, with cyanobacterial proliferation in the backwater areas, also contributed organisms to estuarine and marine habitats, mainly in the St. Lucie Estuary and Indian River Lagoon. In 2005, a similar event occurred with a large cyanobacteria population in the St. Lucie Estuary, which occurred during regulatory discharges from Lake Okeechobee (Phlips and others, 2012).

Salinity tolerance determines how long cyanobacteria originating from freshwater habitats will survive at the salinities typical of estuarine and marine environments (Batterton and Van Baalen, 1971; Orr and others, 2004; Tonk and others, 2007), and collectively, these studies indicate that many freshwater cyanobacteria experience mortality at salinities between 15 and 21 practical salinity units (psu). In the Dutch delta and its associated impoundments, such as Lake Volkerak in the Netherlands, water management strategies have been developed for *Microcystis* blooms (Verspagen and others, 2016) based on salinity tolerance in their systems.

Using cyanobacteria isolated from Lake Okeechobee, the U.S. Geological Survey (USGS), in cooperation with the U.S. Army Corps of Engineers, conducted a 4-day laboratory bioassay with four different salinity treatments and a control. Response variables included morphological changes to cyanobacterial filaments and colonies, changes in growth rate, physiological indicators, intracellular and extracellular (released) microcystin, and an approximation of cell membrane integrity. Collectively, these data provide converging lines of evidence about how Lake Okeechobee cyanobacteria might respond to increased salinity under natural conditions as water mixes in downstream estuaries. Additional data related to this study can be found in King and others (2018a, b).

Methods

The organisms used for the study were collected from Lake Okeechobee and brought into the laboratory in Orlando, Fla., for this study.

Initial Bloom Material

Water and floating bloom material were collected from the upper 10 cm of the water surface at noon on July 7, 2017, from Eagle Bay, Lake Okeechobee, Fla. (latitude 27°11'42.19"N, longitude 80°49'46.24"W). Approximately 35 liters (L) of water and bloom material (fig. 2) were collected in two large carboys and immediately transported to the laboratory, which was approximately 3 hours away, without being cooled or held in the dark. All water and bloom materials were blended and mixed thoroughly in the laboratory and distributed to eighteen 1-L glass graduated cylinders (fig. 3). The 1-L graduated cylinders were used to simulate a water column approximately 35 centimeters (cm) in depth to allow the diurnal migration typically exhibited by planktonic cyanobacteria. Cylinders were incubated in a west-northwest window, and they were treated as batch reactors. Daily temperature and solar irradiance was recorded by using a Li-Cor LI-200/R pyranometer. Average temperature ranged from 23 to 26 degrees Celsius (°C), and light readings yielded 8.9 microwatts per square meter ($\mu W m^{-2}$; plus or minus one standard deviation).

Approximately 20 hours after collection, triplicate cylinders were dosed with sodium chloride (NaCl) to increase salinity by 7.5, 10, 15, or 18 g L^{-1} to yield 7.5, 10, 15, or 18 psu; NaCl was not added to three control cylinders. The time zero samples were taken just prior to dosing the cylinders with the NaCl. Time one began after 24 hours of exposure, at approximately 9:00 every morning. The water in the cylinders was thoroughly mixed by completely inverting the cylinders 5 times, and the volume needed for all the analytical procedures was quickly poured from the cylinder. During the time period of the experiment, no attached algae grew on the cylinder walls. Although not part of the original planned bioassay, some of the original sample was placed into water with higher salinities (20, 25, 30, and 35 psu) in graduated cylinders 2 days after the main bioassay was started. The assessment of these treatments was limited to microscopic observations and physiological assessment.

Biomass Indicator—Chlorophyll-*a*

Chlorophyll provided an overall indication of algal biomass. Ten-milliliter (mL) subsamples collected from each cylinder daily were filtered as described in Hambrook Berkman and Canova (2007), stored (frozen with desiccant), and quantified by using a modification of U.S. Environmental Protection Agency Method 445.0 (Arar and Collins, 1997). Instead of acetone extraction, samples were extracted in heated ethanol (Sartory and Grobbelar, 1986), and the fluorometer was modified with a flow-through cell (Knowlton, 1984). Samples were analyzed in duplicate, and the results were reported as an average.

Biomass Indicator—Cell Numbers

A 10-milliliter (mL) sample from each of the 18 cylinders was collected by 10-mL graduated pipette dispensed into a 15-mL screw-cap plastic centrifuge tube, preserved with 100 microliters (µL) of Lugol's iodine, and refrigerated at 4 °C until it was processed. For counting, the samples were homogenized by vigorous shaking to disperse the colonies, an aliquot was withdrawn, and the precise weight was determined (x 0.0001 gram [g]) with an Ohaus Explorer EX224 Analytical Electronic Balance. The weight was considered equivalent to the volume (1 mL = 1 g) and evenly distributed under a

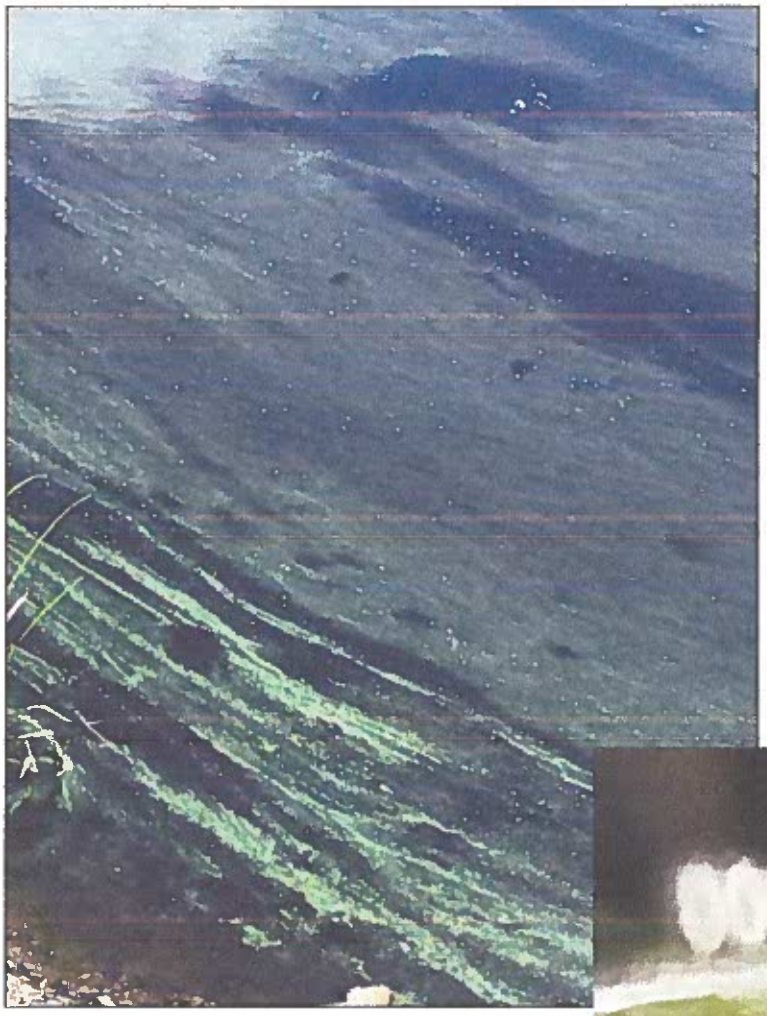


Figure 2. Area where water and bloom materials were collected for bloom bioassay, 2017 Eagle Bay, Lake Okeechobee, Florida. (Photograph by Barry H. Rosen, U.S. Geological Survey.)

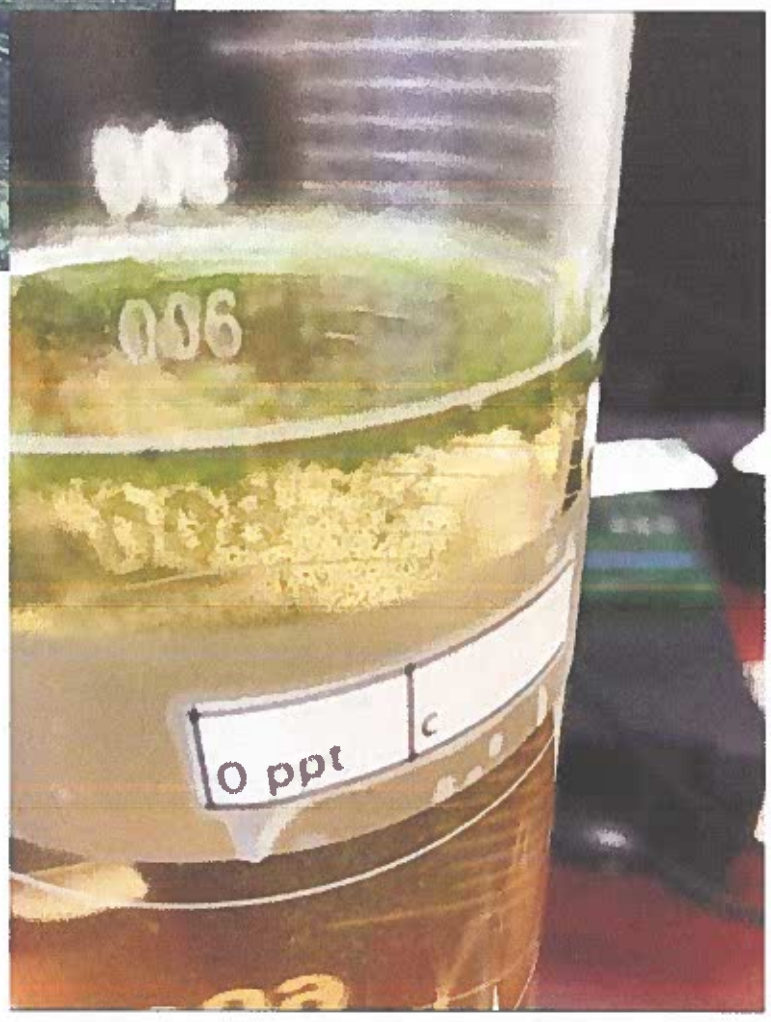


Figure 3. A 1-liter graduated cylinder with initial bloom material. (Photograph by Barry H. Rosen, U.S. Geological Survey.)

22-square-millimeter (mm^2) glass coverslip. Counting was conducted microscopically at 400x by enumerating the cyanobacteria observed in a linear strip along the full length of the coverslip. The diameter of the strip was measured with a stage micrometer. Using the volume distributed under the coverslip per unit area, the number of organisms per unit volume was calculated. For *Microcystis*, its dense, colonial form does not allow an exact direct cell count. We were able to enumerate the number of colonies and optically image a subset of colonies to obtain an average number of cells per colony. This average number of cells per colony was multiplied by the number of colonies found in each sample to get estimated cell count.

Live Organism Physiological Assessment

Approximately 0.020 mL of live material taken from each salinity treatment was examined daily to assess the health of cells by following the protocol of Rosen and others (2010). Microscopic observations were made with a BX51 Olympus microscope with differential interference contrast and epifluorescence using ultraviolet and wide blue excitation sources. SYTOX® Green (Invitrogen, Carlsbad, Calif.), a deoxyribonucleic acid (DNA) stain excluded from live cells, was added (Rosen and others, 2010) to assess if cells lost cellular membrane integrity.

Microcystin Analysis by Enzyme-Linked Immunosorbent Assay

For analysis of total microcystin, a 10-mL subsample was taken daily from each cylinder and frozen. For analysis of dissolved microcystin, the filtrate (Millipore Type TSTP 3.0-micrometer [µm], 25-millimeter [mm] diameter) from a 10-mL subsample was collected daily from each cylinder and frozen. These samples were processed and analyzed as described in Loftin and others (2016), except that an Abraxis streptavidin amplified enhanced sensitivity (SAES) enzyme-linked immunosorbent assay kit was used with a 5-psu sodium chloride microcystin-LR (MCLR) calibration curve custom made by Abraxis, Inc. (Warminster, Pa.). A four-parameter curve-fit was used for calibration. Measurements of kit diluent and laboratory reagent water were below the kit minimum reporting level (0.10 microgram per liter [µg/L]), 0.75-µg/L MCLR kit controls were analyzed every 10th sample, and 28 percent of samples were laboratory replicates. Mean kit control recovery was 106 percent, mean percent relative standard deviation (PRSD) was 9.6 percent, and laboratory replicate PRSD was 20 percent. Particulate microcystin was calculated by subtracting dissolved concentration from total concentration.

Additional Studies

The influence of circulation was evaluated in unamended water and bloom material. Three 4-L glass beakers were filled with 2.5 L of water and bloom material, set atop magnetic stir plates, and separately circulated at velocities of 0.00 foot per second (ft/s; "nonstirred"), 0.27 ft/s, and 0.95 ft/s. The beakers were sealed with plastic to prevent evaporation. Velocity was measured with a USGS pygmy current meter by using the 0.6-depth method (Turnipseed and Sauer, 2010). High-frequency sensor data were collected at 5-minute intervals. Data were collected by using a multiparameter sonde (Xylem/YSI EXO2), calibrated in accordance with manufacturer protocols (YSI Incorporated, 2017) to measure water temperature, specific conductance, dissolved oxygen, pH, chlorophyll-*a* fluorescence, and phycocyanin fluorescence. The high-resolution visualization resulting from these data provides insight into the biogeochemical processes in relation to the results from less frequently collected discrete analyses (Downing and others, 2017).

Results

The majority of the results center on the salinity bioassay conducted; however, ancillary data were collected from the same water and bloom material to provide some understanding of how stirred conditions affect physio-chemical parameters.

Initial Bloom Material

The bloom material collected from Lake Okeechobee on July 7, 2017, contained three species of *Microcystis*: *M. aeruginosa*, *M. flosaquae*, and *M. wesenbergii*. *Microcystis aeruginosa* was the most frequently observed species of this genus. Also present were *Dolichospermum circinale*, *Planktolyngbya contorta*, *Planktolyngbya limnetica*, and *Cuspidothrix tropicalis* (fig. 4). Microcystin concentration in the surface scum collected directly from Lake Okeechobee was 560 µg/L, indicating the presence of microcystin-producing species.

Although rare in the initial community of organisms, two additional cyanobacteria genera grew during the experimental treatments. *Planktothrix* was found on day eight of the experiment in water with salinity of 15 psu, and *Cuspidothrix tropicalis* was found on day four in water with salinity up to 18 psu.

Biomass Indicators

Chlorophyll-*a* concentrations and cyanobacterial abundance were used to quantify changes in algal biomass during the bioassay (figs. 5–7). For chlorophyll-*a*, all concentrations declined from day zero to day four, with the

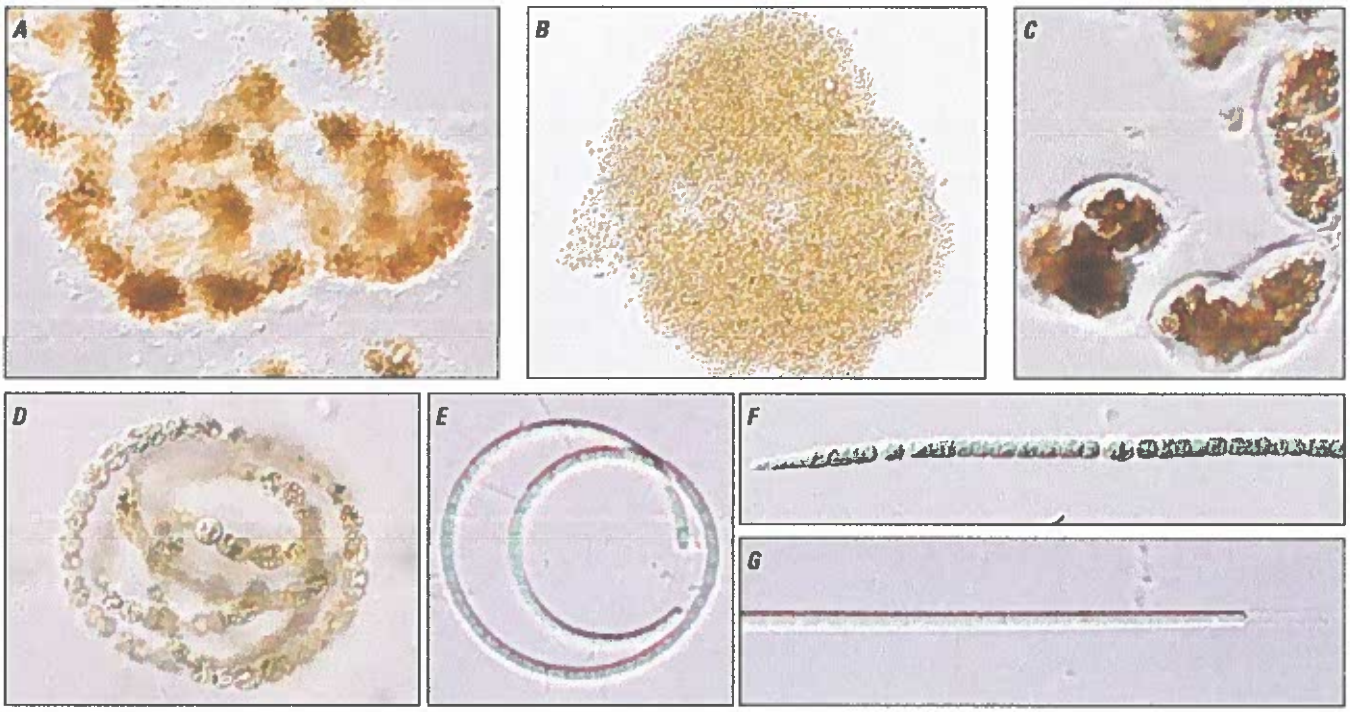


Figure 4. The initial cyanobacterial community in the water sample collected July 7, 2017, from Eagle Bay, Lake Okeechobee, Florida. *A, Microcystis aeruginosa* (most abundant); *B, M. flosaquae*; *C, M. wesenbergii*; *D, Dolichospermum circinale*; *E, Planktolyngbya contorta*; *F, Cuspidothrix tropicalis*; *G, Planktolyngbya limnetica*.

greatest declines in the control (0 psu) and 7.5-psu treatments (fig. 5). The 10, 15, and 18 psu treatments showed greater amounts of chlorophyll-*a* than the lower salinity treatments.

Microcystis aeruginosa and *Dolichospermum circinale* were the dominant cyanobacteria in the initial community used for the bioassay. For *Microcystis*, all of the treatments showed an initial increase in the number of cells during the first time interval from time zero through the first 24 hours, and then the number of cells decreased during the next 24-hour time period (fig. 6), including the control treatment with no added salt. Because the bloom collected from Eagle Bay had been thriving in full sunlight, this adaptation to a laboratory setting was an anticipated response.

Dolichospermum circinale abundance in the control and all of the treatments substantially decreased during the first 24 hours of the bioassay (fig. 7).

Microcystin

Microcystin was reported as a total concentration in whole water and as a dissolved phase in the water after the cells were removed by filtration. Total concentration (fig. 8*A*) decreased to less than 20 µg/L in the control. The 7.5- and 10-psu salinity treatments initially declined but increased to more than 40 µg/L by the end of the 4-day bioassay.

The dissolved phase (fig. 8*B*) is a combination of microcystin leaked from live or unhealthy cells and from those cells that died and released microcystin. In the control, the amount of dissolved-phase microcystin remained less than 2 µg/L, with the largest amounts in the 15- and 18-psu treatments (12–13 µg/L) and in the 7.5- and 10-psu treatments (8–10 µg/L). At all the salinities greater than the control, the amount of dissolved microcystin increased over time (fig. 8*B*), indicating that some of the cells in the treatments were leaking cellular microcystin and cell lysis was occurring. The partitioning of microcystin between the amount retained in cells (calculated particulate) and the dissolved phase (fig. 8*C*) has a similar pattern as the total microcystin (fig. 8*A*), with more retained or produced in the 7.5- and 10-psu treatments.

The calculated particulate microcystin to chlorophyll-*a* ratio was examined (fig. 8*D*) to normalize the toxin concentration to a cell abundance surrogate (chlorophyll-*a*). Cell abundance was not used for this calculation because chlorophyll-*a* was a more precise measurement then cell abundance, given the difficulty and potential variability in estimating cell numbers. In addition, particulate microcystin and particulate chlorophyll-*a* are both intracellular constituents. Using this calculation, by day four, the 7.5- and 10-psu treatments showed an increase in this ratio that is approximately double the ratios in the 15- and 18-psu treatments.

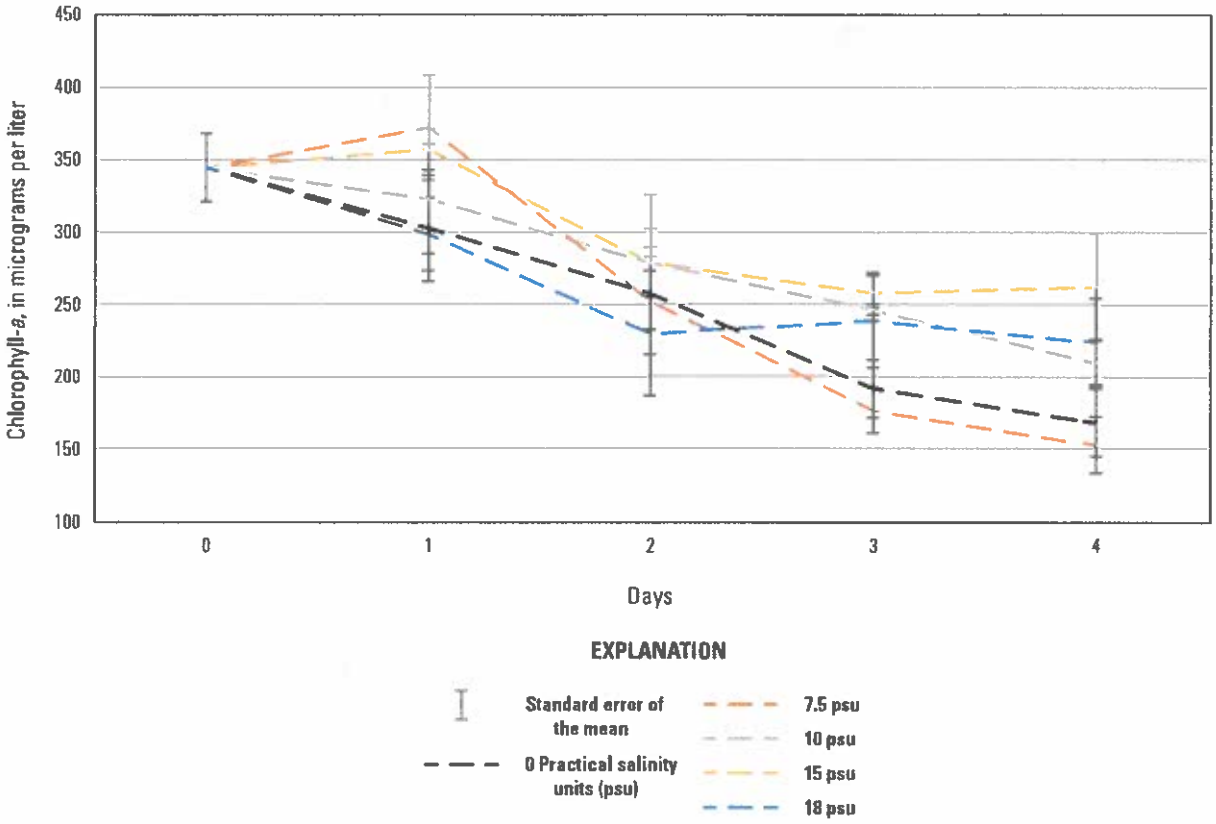


Figure 5. Chlorophyll-*a* concentrations during the bioassay.



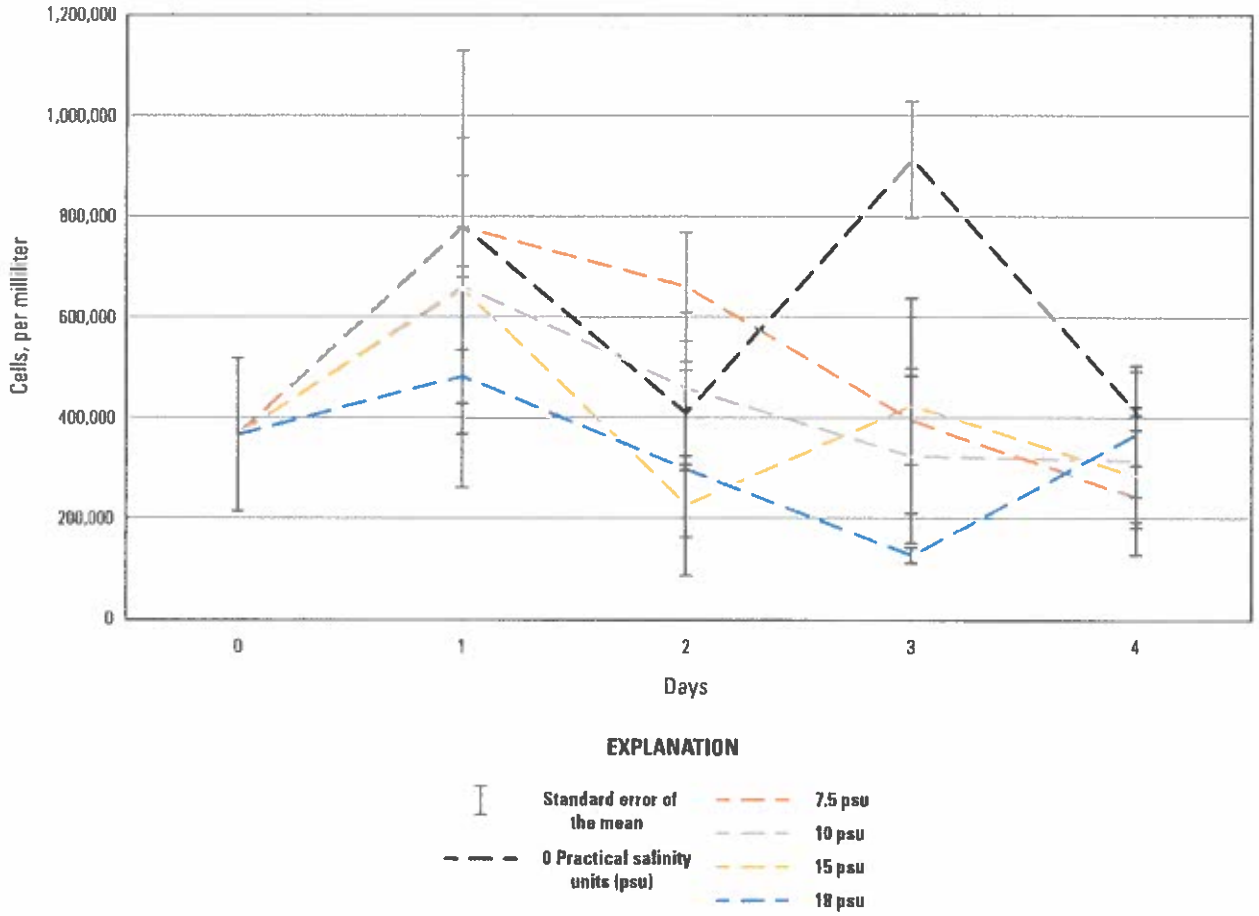


Figure 6. *Microcystis aeruginosa* abundance in response to salinity. The error bars are standard error of the mean.



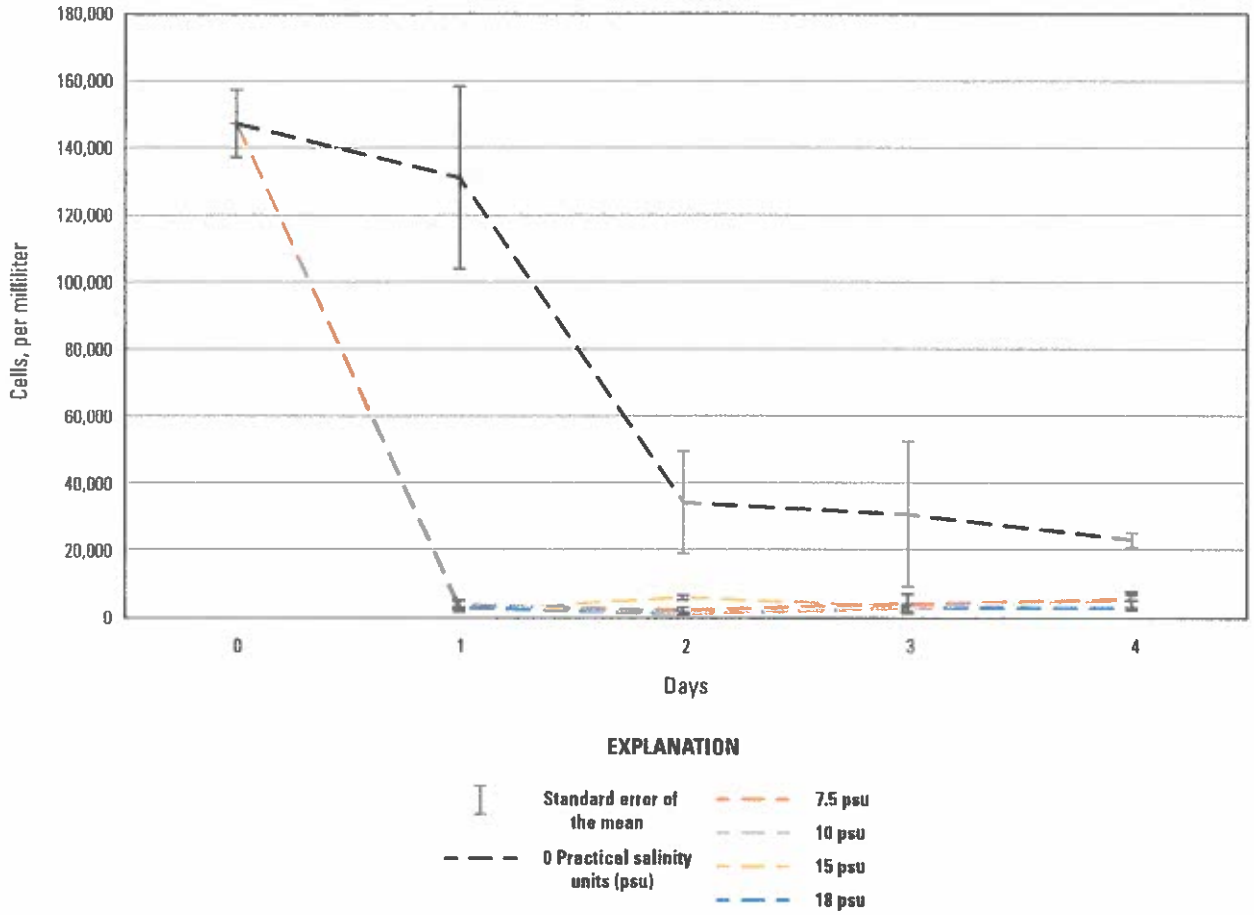


Figure 7. *Dolichospermum circinale* abundance in response to salinity. The error bars are standard error of the mean.



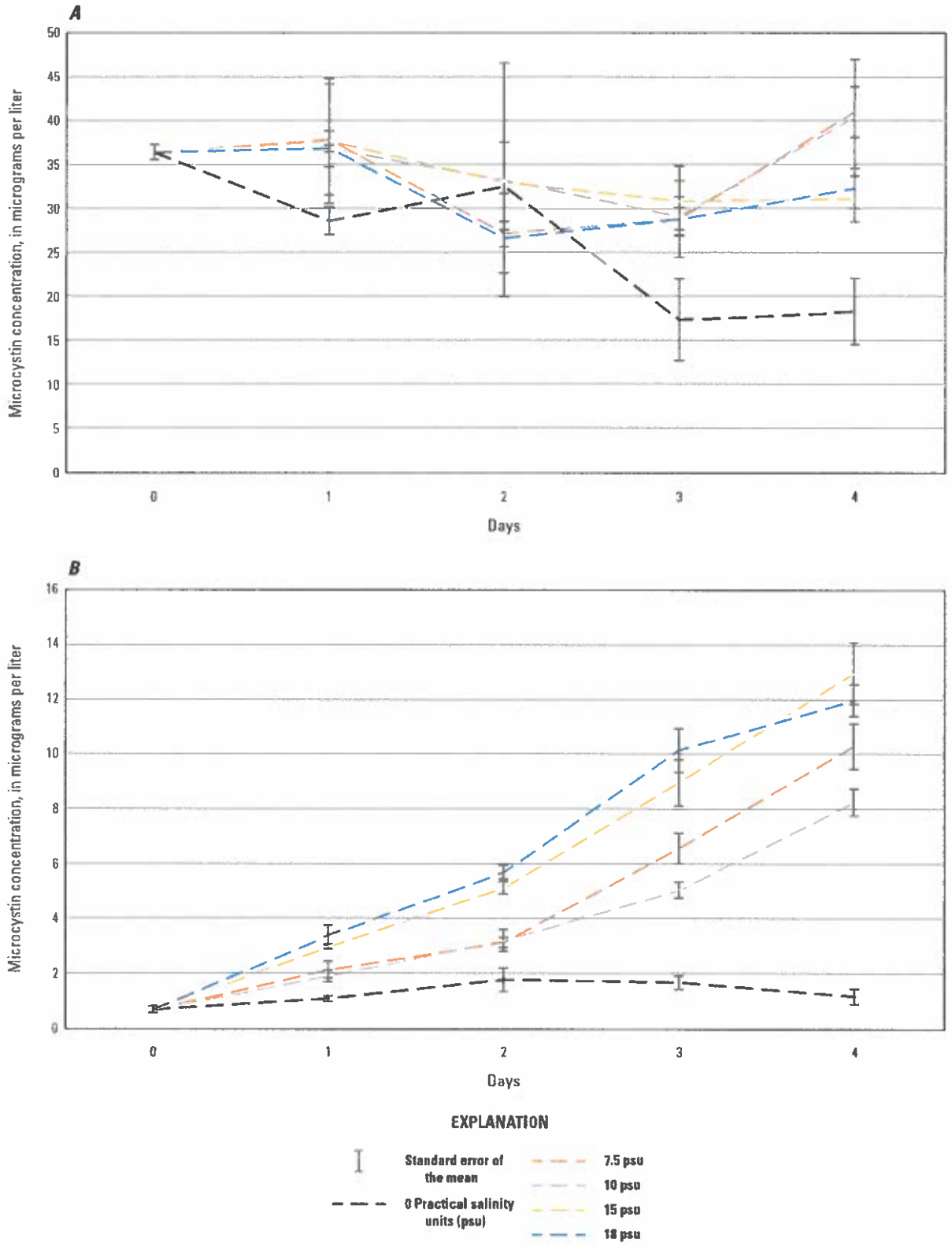


Figure 8. Microcystin response to salinity: *A*, total microcystin; *B*, dissolved phase; *C*, calculated particulate; *D*, calculated particulate microcystin:chlorophyll-*a* ratio. The error bars are standard error of the mean.

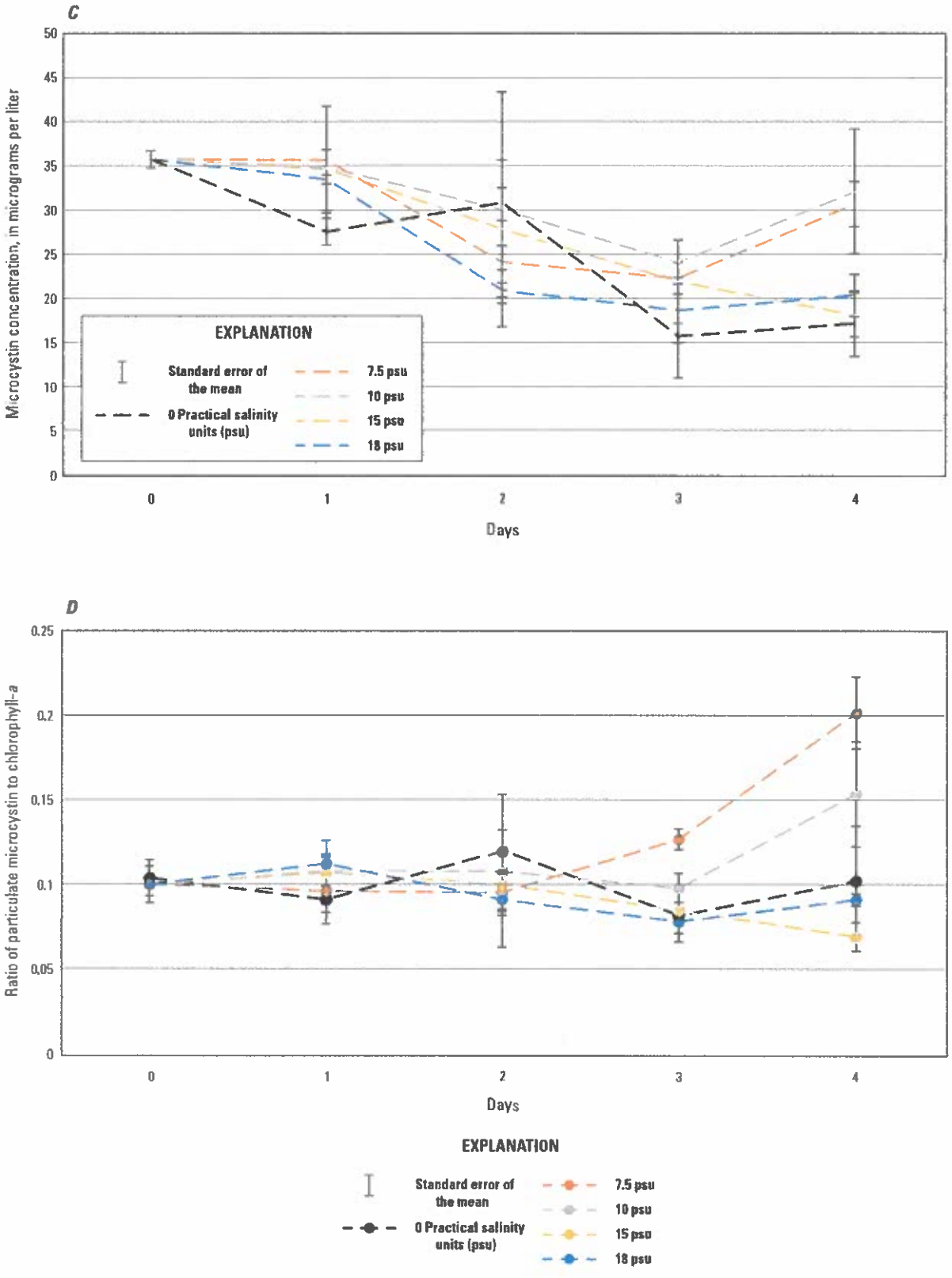


Figure 8. Microcystin response to salinity: *A*, total microcystin; *B*, dissolved phase; *C*, calculated particulate; *D*, calculated particulate microcystin:chlorophyll-*a* ratio. The error bars are standard error of the mean.—Continued

Physiological Response to Salinity

Overall, the *Microcystis aeruginosa* colonies maintained integrity during the first 24 hours of exposure at salinities up to 25 psu (fig. 9; 30 and 35 psu were not photographed at this time interval). After 4 days, complete disintegration of all *Microcystis aeruginosa* colonies did not occur, even up to 35 psu (fig. 10). Although most colonies remained intact, a few disintegrated to small clusters and individual cells (fig. 11).

Dolichospermum circinale was much less abundant, leaving a less complete picture of salinity effects. Intact filaments were present after 1 day; however, the cells seem to be separating in the 20- and 25-psu treatments (fig. 12). After 2 days of exposure, *Dolichospermum* has additional separation of cells at higher salinity (fig. 13). *Dolichospermum circinale* was tolerant of 7.5 psu and was in good condition after 8 days (fig. 14), but was not found at any salinity greater than 7.5 psu by the end of the bioassay.

In addition to overall morphological changes in colonies and filaments of these two genera of cyanobacteria, evidence of adaptation was observed microscopically. The production of mucilage was observed enveloping the filaments and the colonies (fig. 15).

Physiological Response as Determined by SYTOX® Green Visualization

Cell health was analyzed by using epifluorescence microscopy in conjunction with SYTOX® Green, a DNA stain that emits green light in the presence of DNA. If the cellular membrane of an organism is intact, SYTOX® Green does not penetrate, providing an indication of cell health. In figures 16–22, the denotation is (1) LM—organisms illuminated with differential interference light microscopy for overall cell and colony structure; (2) UV—organisms illuminated with ultraviolet light, with variations in pigment color an indicator of cell health; (3) WB—organisms illuminated with "wide blue" as the baseline color before adding SYTOX® Green; (4) SYTOX® Green—organisms stained with this dye are bright green when DNA is present (Rosen and others, 2010). The photographs are representative of the overall condition of the colonies or filaments in the treatments.

After 1 day of exposure, the SYTOX® Green is only seen outside of the *Microcystis* colony, with no penetration of the stain into the cells in all treatments (fig. 16). After 2 days of exposure, the SYTOX® Green penetrated the *Microcystis* cells in the 18-, 20-, and 25-psu treatments as seen in figure 17 where the cells are green compared to the 15-psu treatment. After 3 days of exposure, the SYTOX® Green is seen only external to the *Microcystis* colonies, with no penetration of the stain into the cells in all treatments, with the exception of the 15-psu treatment (fig. 18). In the 15-psu treatment, the SYTOX® Green penetration and the pigment shift to yellow under UV indicate that this colony was no longer viable. After 4 days of exposure, with one of two *Microcystis* colonies in the 15-psu treatment and all of the colonies in treatments of 20 psu or greater salinity, the SYTOX® Green penetration and the pigment shift to yellow under UV indicate that these colonies were no longer viable (fig. 19). After 8 days of exposure, the 18-psu treatments had some *Microcystis* colonies that were still viable and some that were not, while all lower salinity treatments had viable colonies (fig. 20).

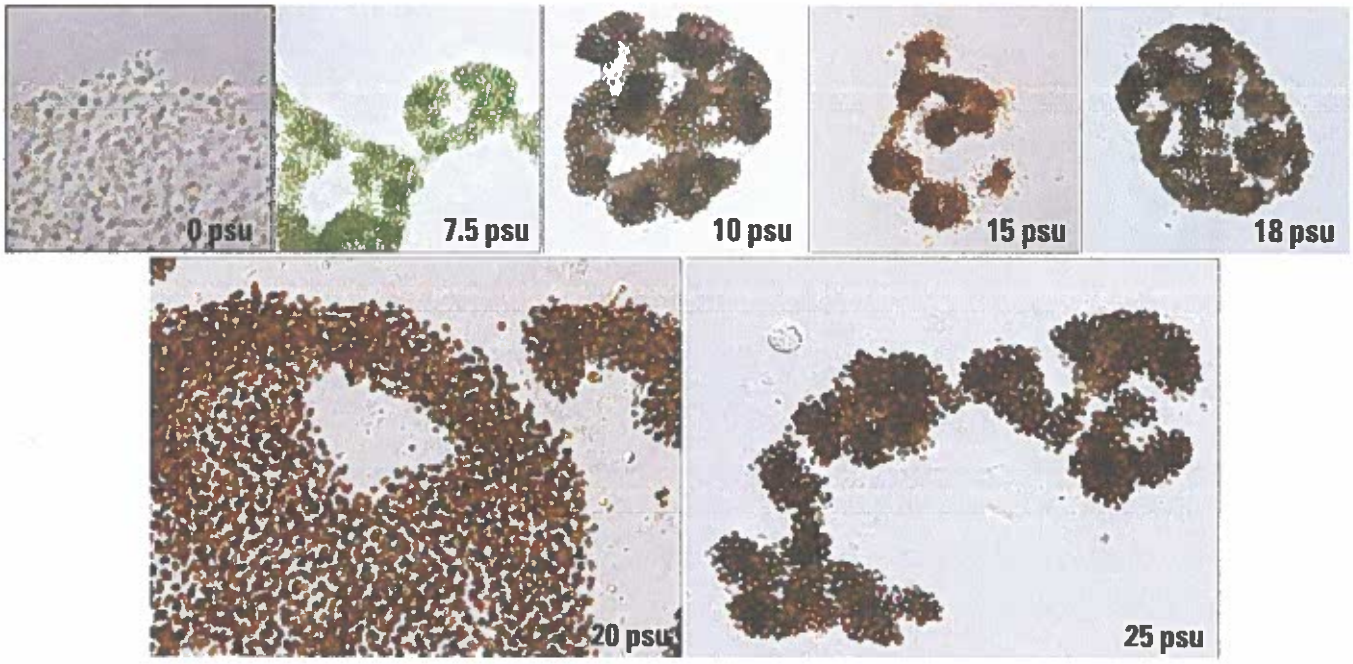


Figure 9. Colony morphology of *Microcystis aeruginosa* in various salinity treatments after 1 day of exposure.

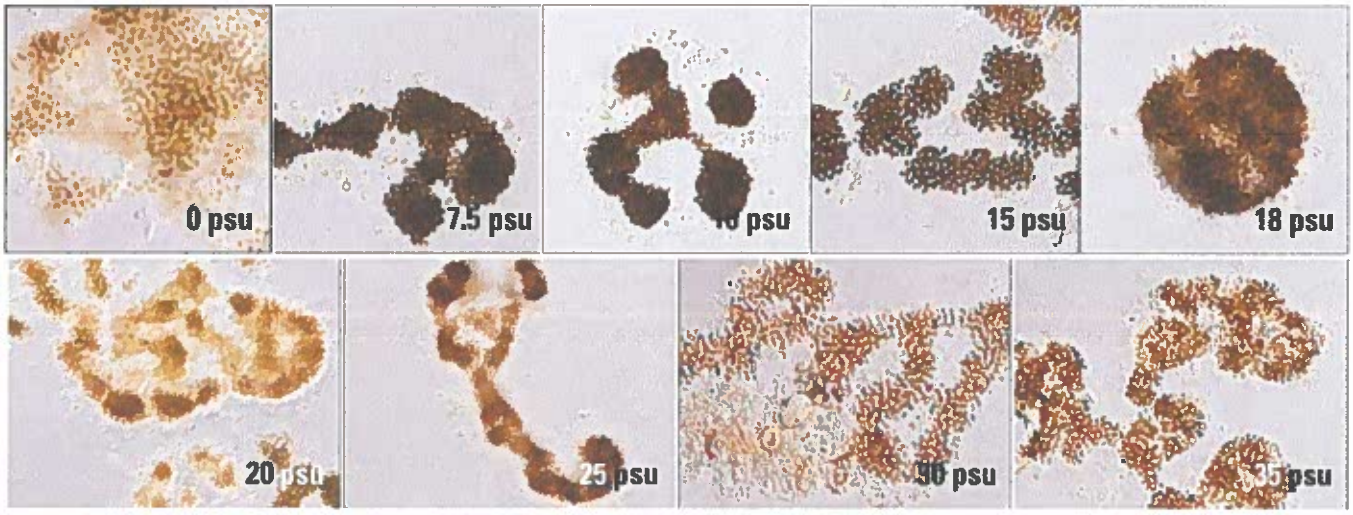


Figure 10. Colony morphology of *Microcystis aeruginosa* in various salinity treatments after 4 days of exposure.

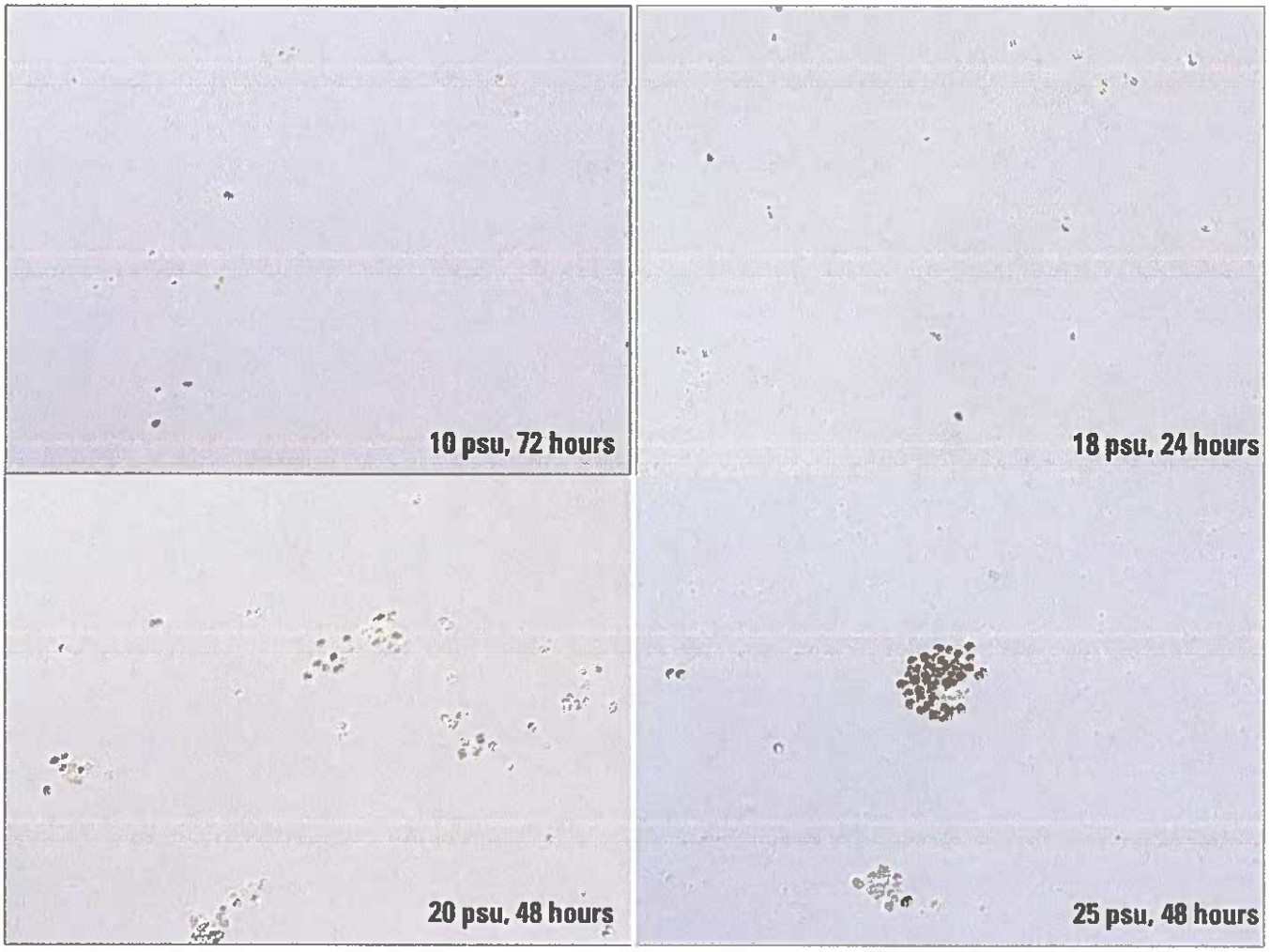


Figure 11. Disintegration of some of the *Microcystis aeruginosa* colonies in salinity treatments greater than 10 psu after 1 or more days of exposure.

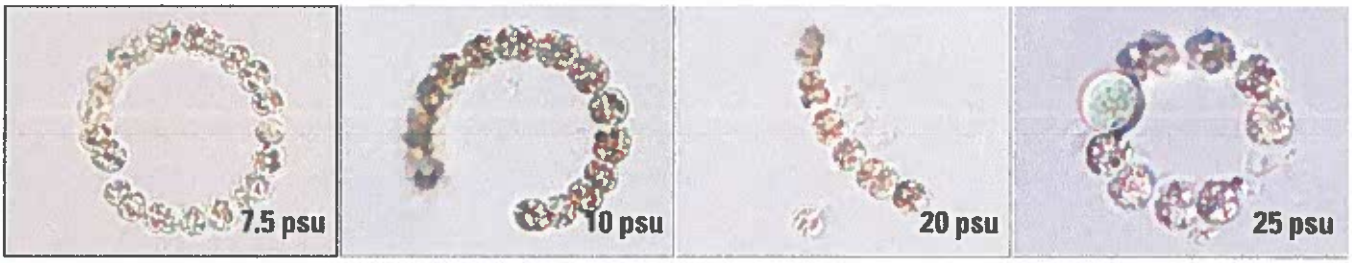


Figure 12. Response of *Dolichospermum circinale* filament morphology to salinity after 1 day of exposure.

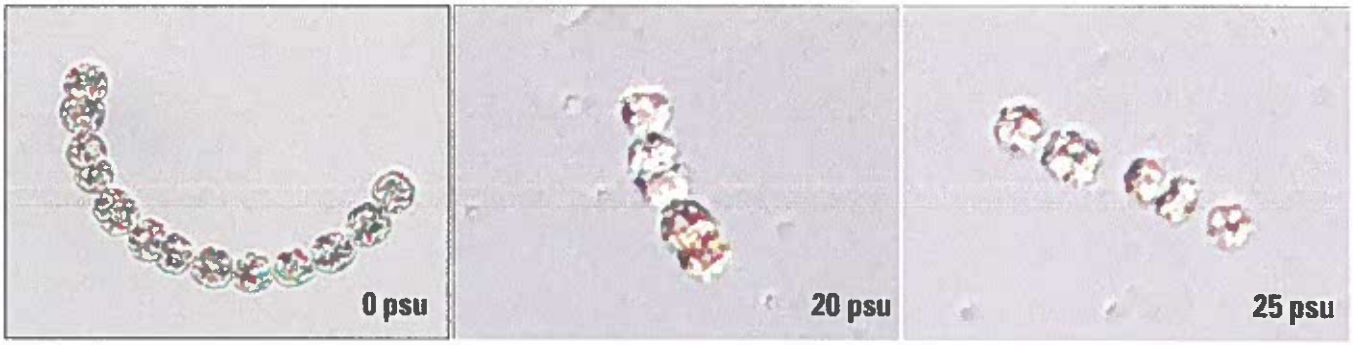


Figure 13. Response of *Dolichospermum circinale* filament morphology to salinity after 2 days of exposure.

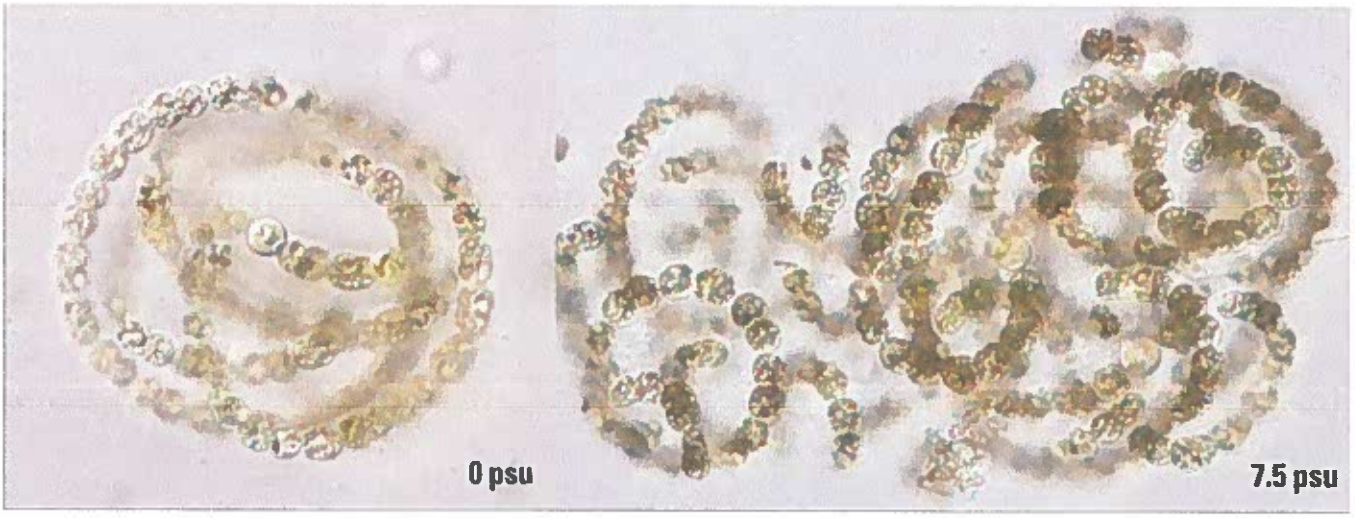


Figure 14. Response of *Dolichospermum circinale* filament morphology to salinity after 8 days of exposure.

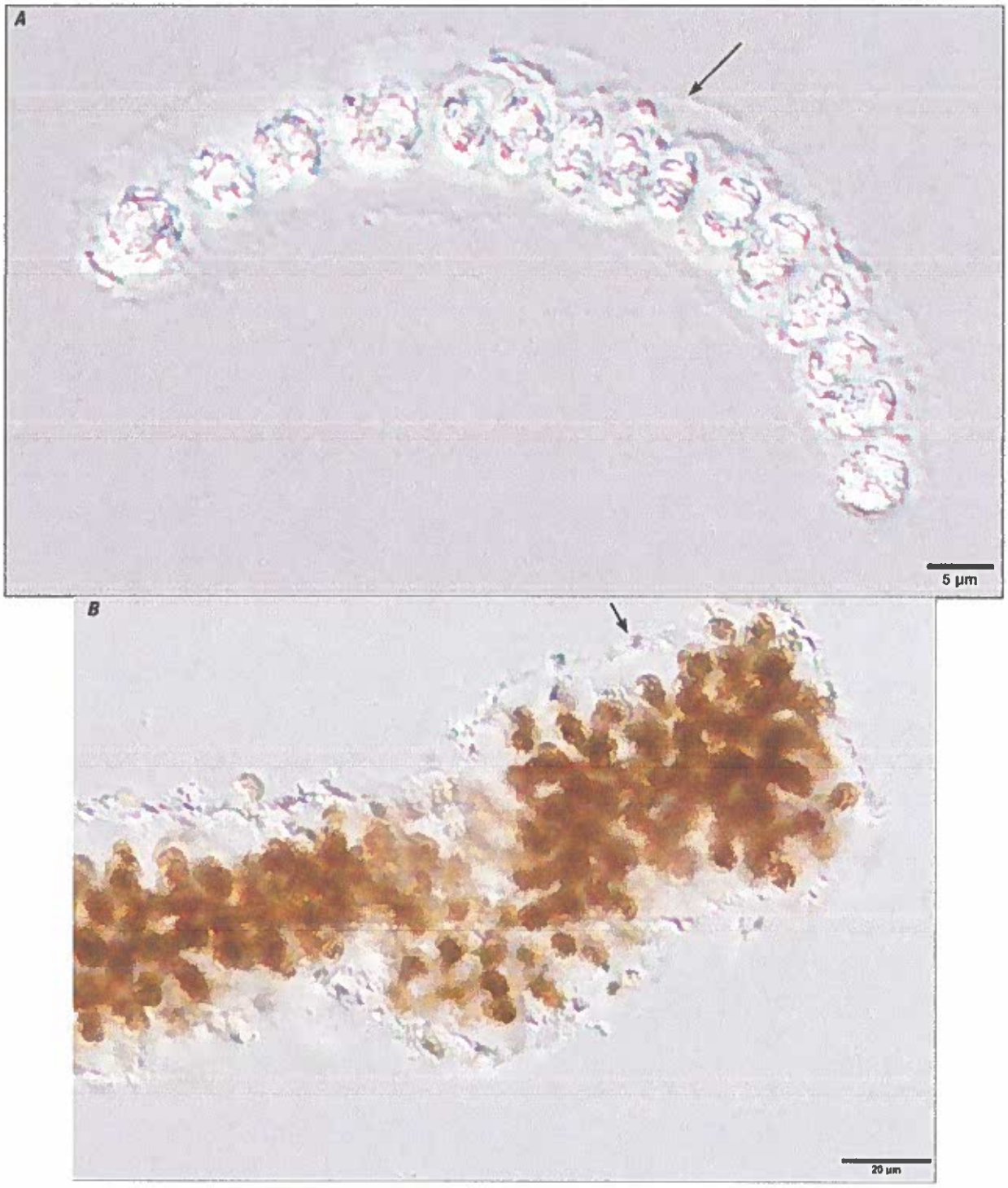


Figure 15. Extracellular mucilage, at arrows, in *A, Dolichospermum circinale*, day four at 25 psu; *B, Microcystis aeruginosa*, day three at 15 psu.

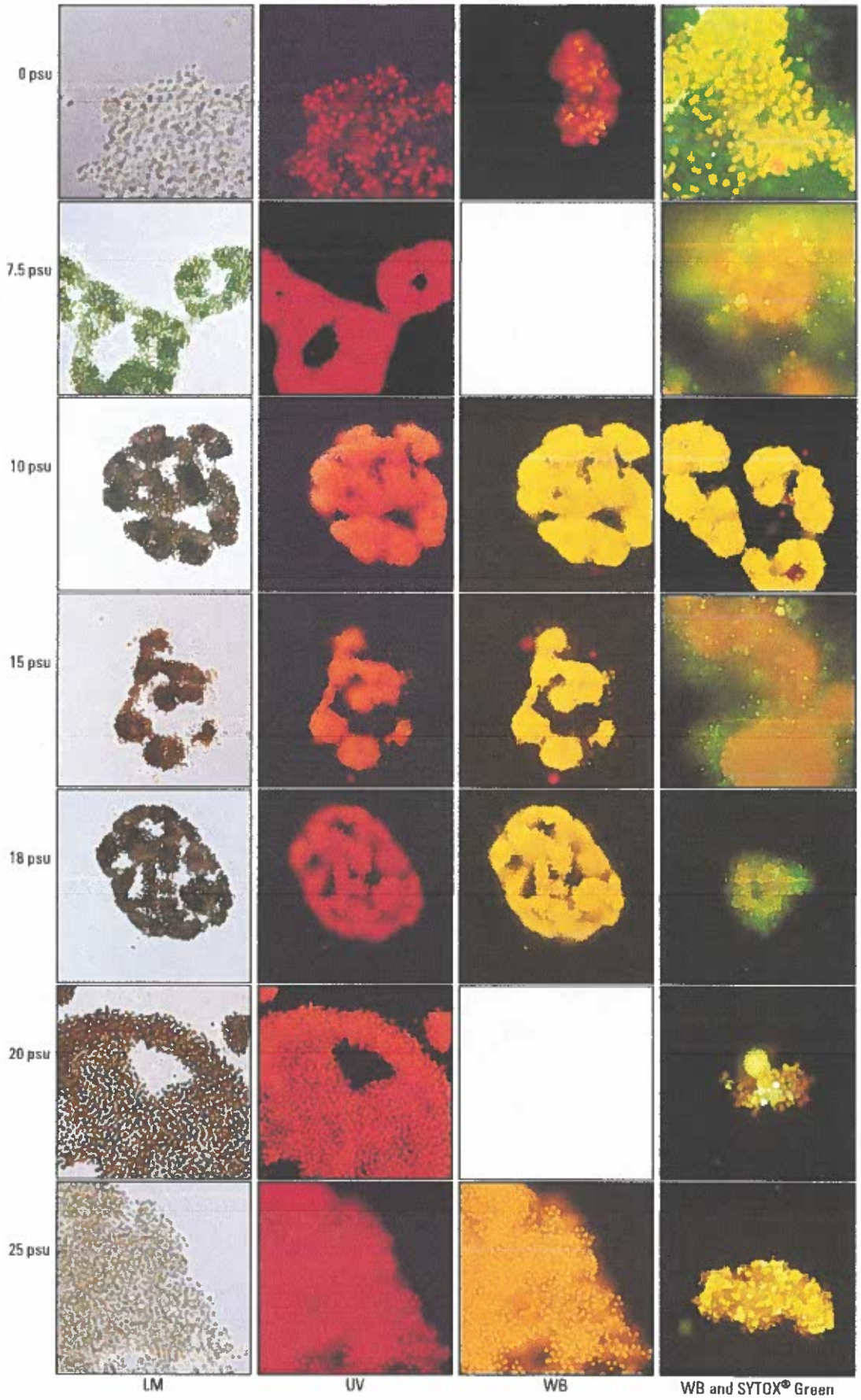


Figure 16. Response of *Microcystis aeruginosa* after 1 day of exposure to treatments with different salinities (psu, practical salinity units; LM, differential interference microscopy; UV, epifluorescence microscopy; WB, wide-blue epifluorescence microscopy; WB and SYTOX® Green, wide-blue microscopy with the DNA stain SYTOX® Green added. Blank boxes indicate that data were not available).

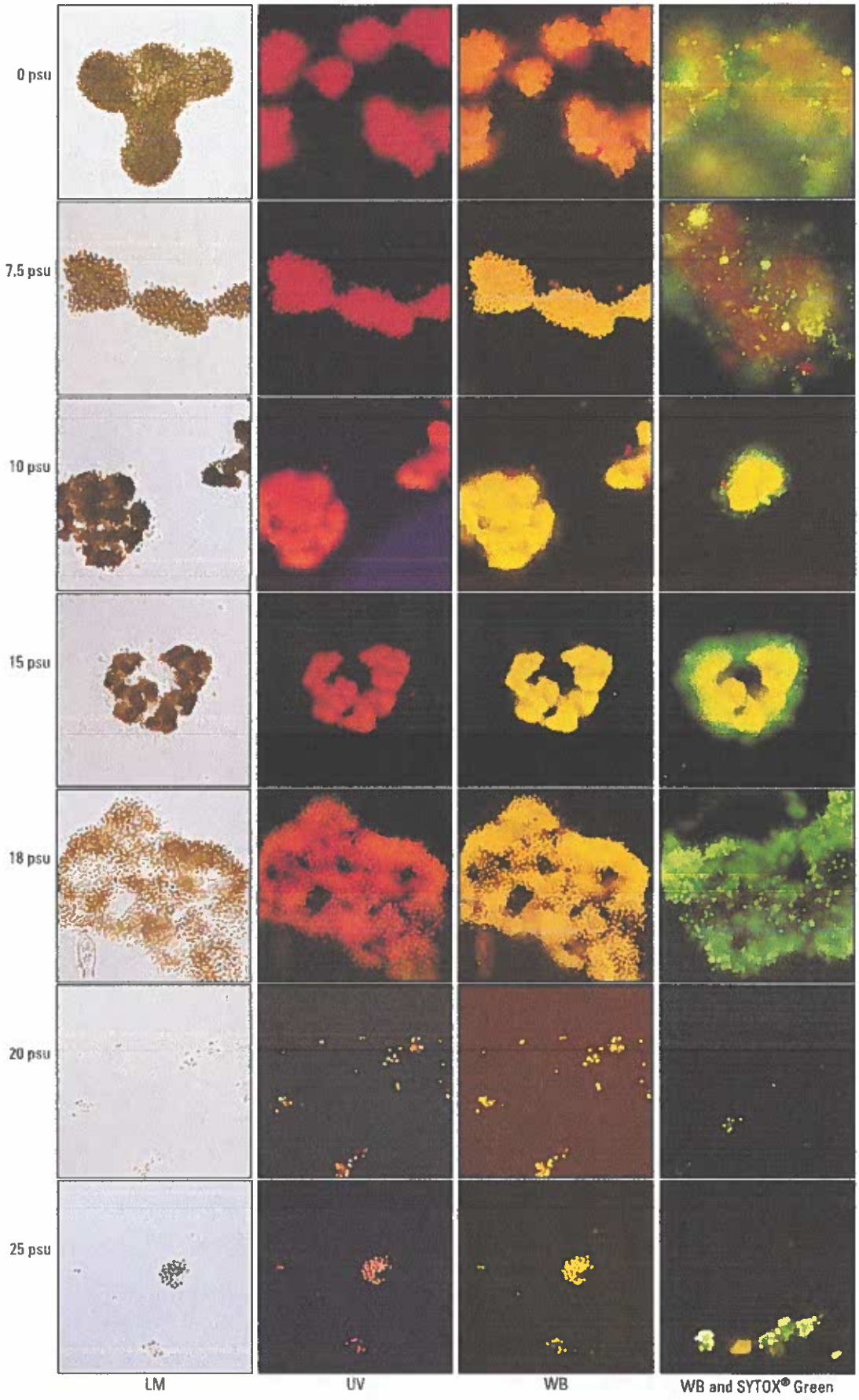


Figure 17. Response of *Microcystis aeruginosa* after 2 days of exposure to treatments with different salinities (psu, practical salinity units; LM, differential interference microscopy; UV, epifluorescence microscopy; WB, wide-blue epifluorescence microscopy; WB and SYTOX® Green, wide-blue microscopy with the DNA stain SYTOX® Green added).

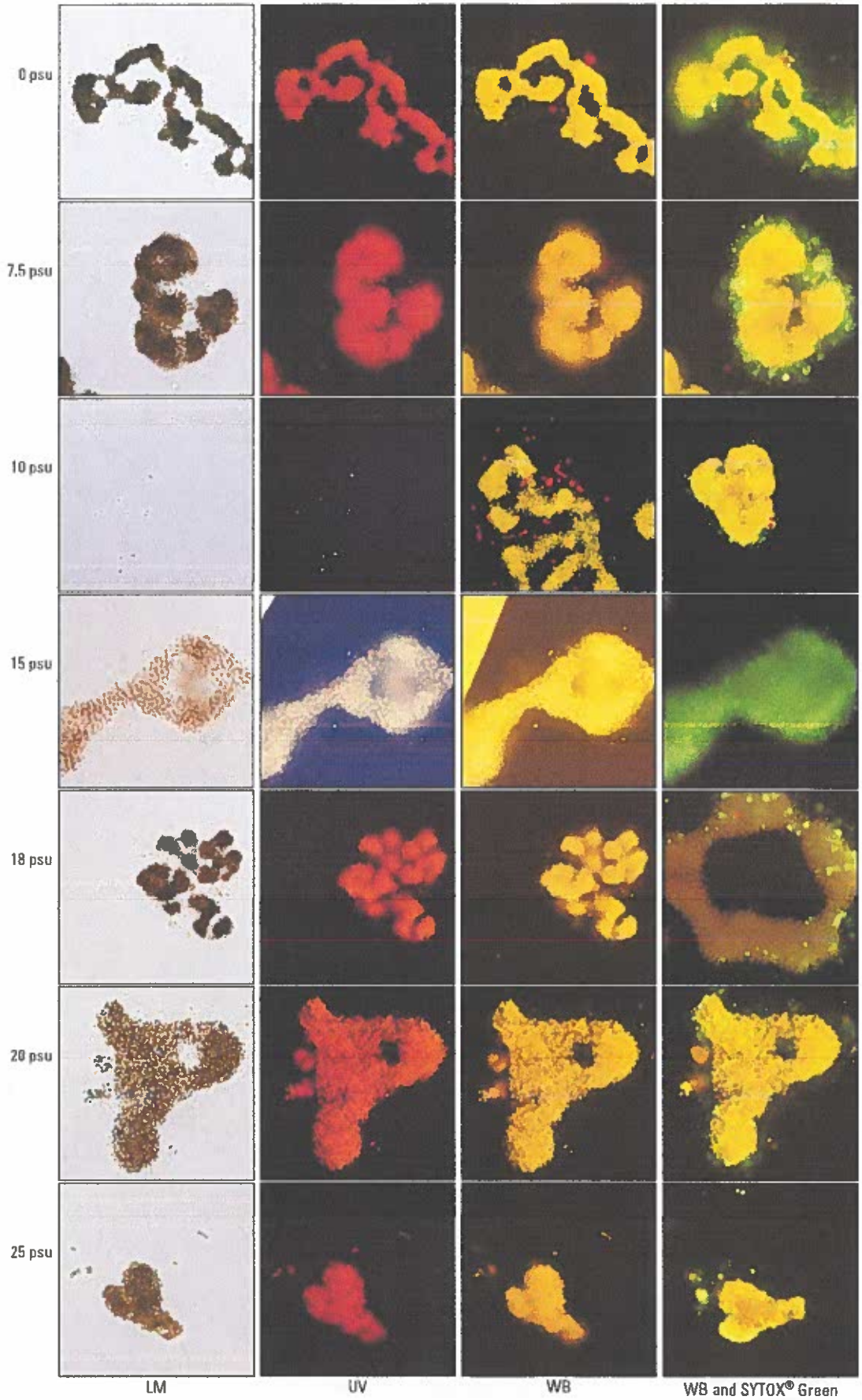


Figure 18. Response of *Microcystis aeruginosa* after 3 days of exposure to treatments with different salinities (psu, practical salinity units; LM, differential interference microscopy; UV, epifluorescence microscopy; WB, wide-blue epifluorescence microscopy; WB and SYTOX® Green, wide-blue microscopy with the DNA stain SYTOX® Green added).

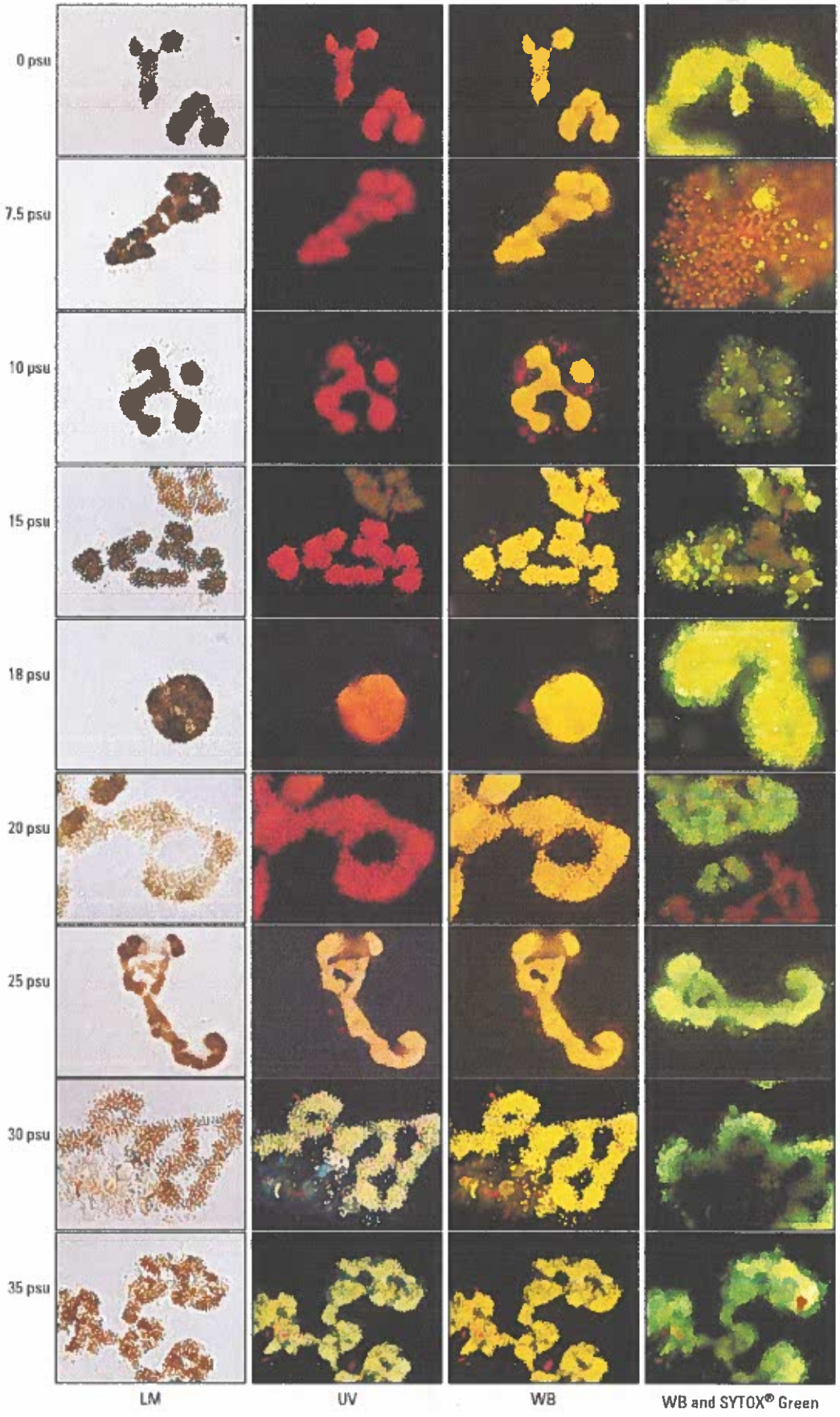


Figure 19. Response of *Microcystis aeruginosa* after 4 days of exposure to treatments with different salinities (psu, practical salinity units; LM, differential interference microscopy; UV, epifluorescence microscopy; WB, wide-blue epifluorescence microscopy; WB and SYTOX® Green, wide-blue microscopy with the DNA stain SYTOX® Green added).

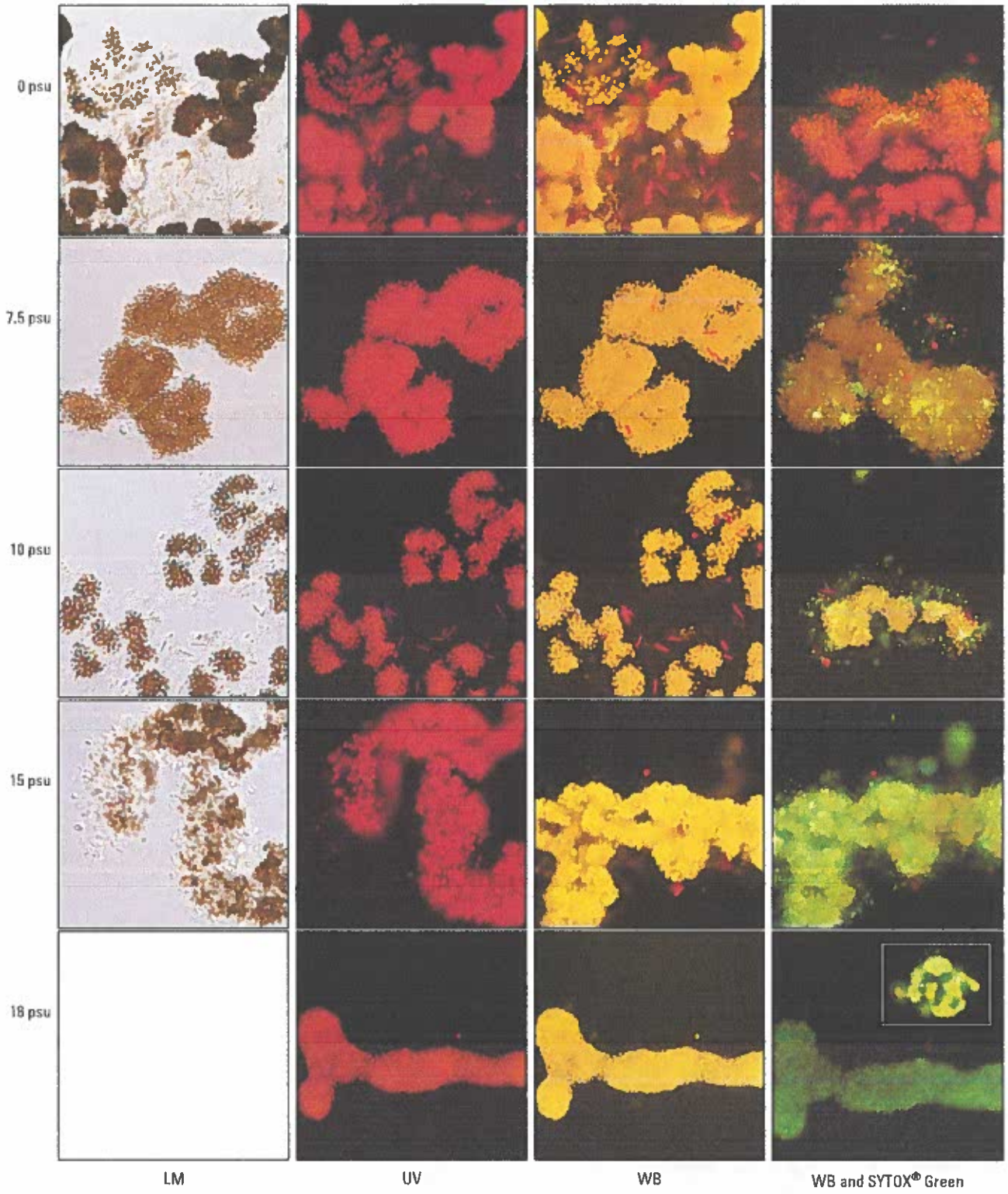


Figure 20. Response of *Microcystis aeruginosa* after 8 days of exposure to treatments with different salinities (psu, practical salinity units; LM, differential interference microscopy; UV, epifluorescence microscopy; WB, wide-blue epifluorescence microscopy; WB and SYTOX® Green, wide-blue microscopy with the DNA stain SYTOX® Green added. Blank boxes indicate that data were not available).

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After 1 day of exposure, *Dolichospermum* was much less abundant in the treatments, hence the sparse observations (fig. 21). The Green was observed to have penetrated one of two filaments observed after 1 day of exposure at 20 psu.

Dolichospermum filaments were seen in the control and in the 7.5-psu treatment, but were absent in salinity greater than 7.5 psu after day one. After 8 days, the only treatments with any *Dolichospermum* were the control and the 7.5-psu treatment, and *Dolichospermum* were rare in both samples (fig. 22). The few filaments observed in both of these treatments were viable and appeared healthy.

Physio-Chemical Conditions

Ancillary to the bioassay itself, a continuously recording sonde was used to collect physical and water-chemistry data from water associated with the initial cyanobacteria sample collection and a simulation of water flow without any salinity treatments. Material was placed in 4-L beakers that were either stirred or not stirred. The nonstirred treatment is the most similar to the actual bioassay in the sense that the graduated cylinders used for the bioassay were not stirred. Dissolved oxygen initially showed a small increase to 4 milligrams per liter (mg/L), then decreased and maintained a fairly constant level of 3 mg/L in the nonstirred treatment. A slight diurnal pattern was present that dissipated after day two (fig. 23). Both stirred treatments had higher dissolved oxygen than the nonstirred treatment, with the highest concentration of oxygen at the fastest rate of stirring, 0.95 ft/s, reaching 8 mg/L.

Temperature varied diurnally from a low of 23 °C to a high slightly greater than 27 °C in the nonstirred treatment (fig. 24). Water in both stirred beakers (on a magnetic plate with a stir bar) had elevated temperatures that were 2 to 4 °C higher than temperatures in the nonstirred treatment.

In the nonstirred treatment, specific conductance was 307 microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C) on the first day of the test; specific conductance increased to 322 µS/cm by the end of the test (fig. 25). The stirred treatments had the same initial specific conductance as that of the nonstirred treatment; however, specific conductance was approximately 30 µS/cm greater in the stirred treatments than in the nonstirred treatment by the end of the test.

The pH peaked at just over 7.3 in the nonstirred treatment (fig. 26). In the stirred treatments, pH values were higher on average. In the treatment that was stirred at a rate of 0.27 ft/s, the maximum pH was 7.6. In the treatment that was stirred at a rate of 0.95 ft/s, the maximum pH was 7.9.

For all treatments, chlorophyll-*a* fluorescence exhibited the greatest decrease during the first day as the bloom was moved from Lake Okeechobee to the laboratory setting (fig. 27). The decrease of chlorophyll-*a* fluorescence in the nonstirred treatment leveled off for the duration of the experiment; however, fluorescence in both stirred treatments was higher than in the nonstirred treatment, and chlorophyll-*a* fluorescence increased in the stirred treatments after day three.

Phycocyanin fluorescence decreased substantially across all treatments over the course of the experiment, though fluorescence did remain higher in the treatment that was stirred at the fastest rate (0.95 ft/s; fig. 28).



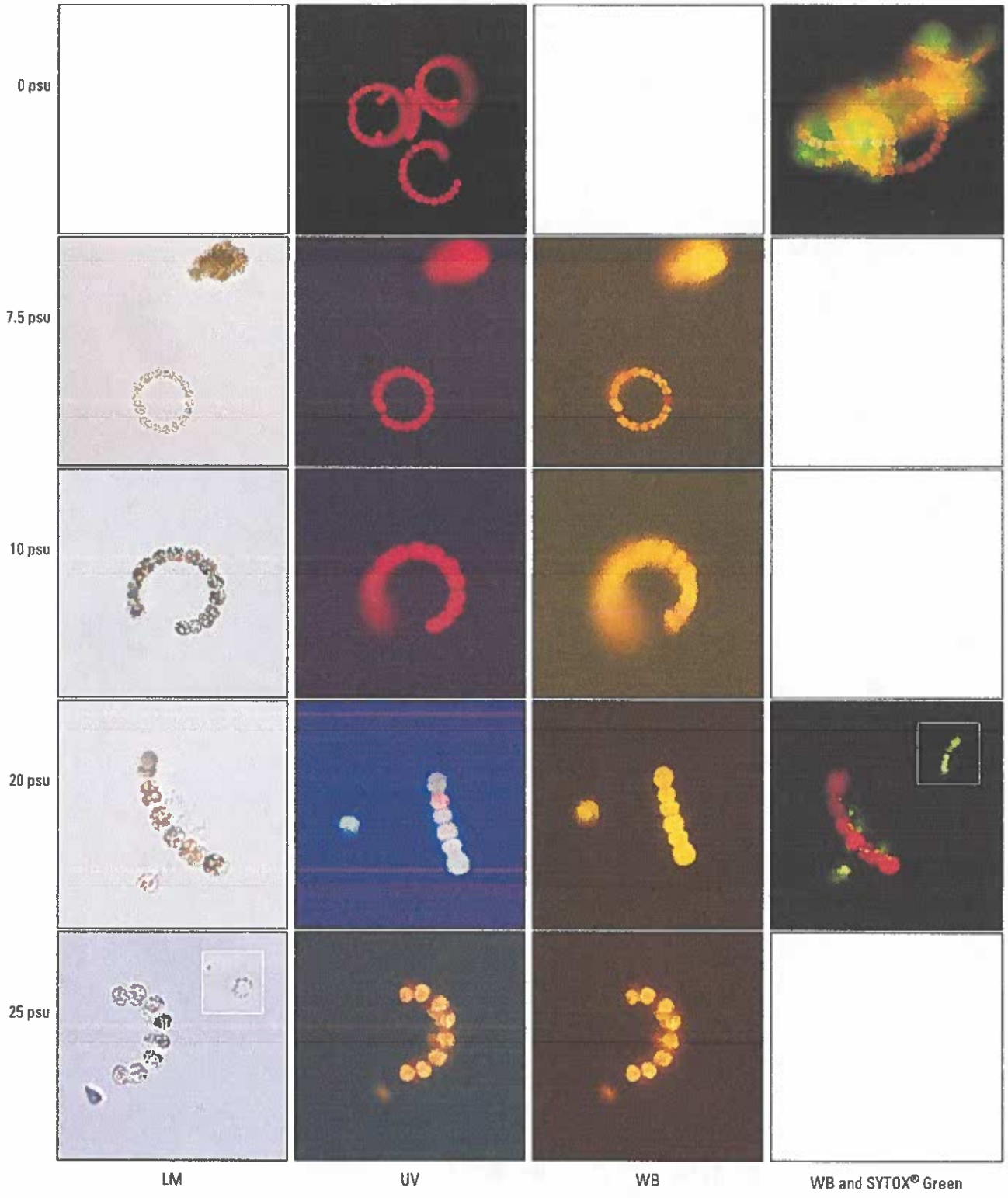


Figure 21. Response of *Dolichospermum circinale* after 1 day of exposure to treatments with different salinities (LM, differential interference microscopy; UV, epifluorescence microscopy; WB, wide-blue epifluorescence microscopy; WB and SYTOX® Green, wide-blue microscopy with the DNA stain SYTOX® Green added. Blank boxes indicate that data were not available).

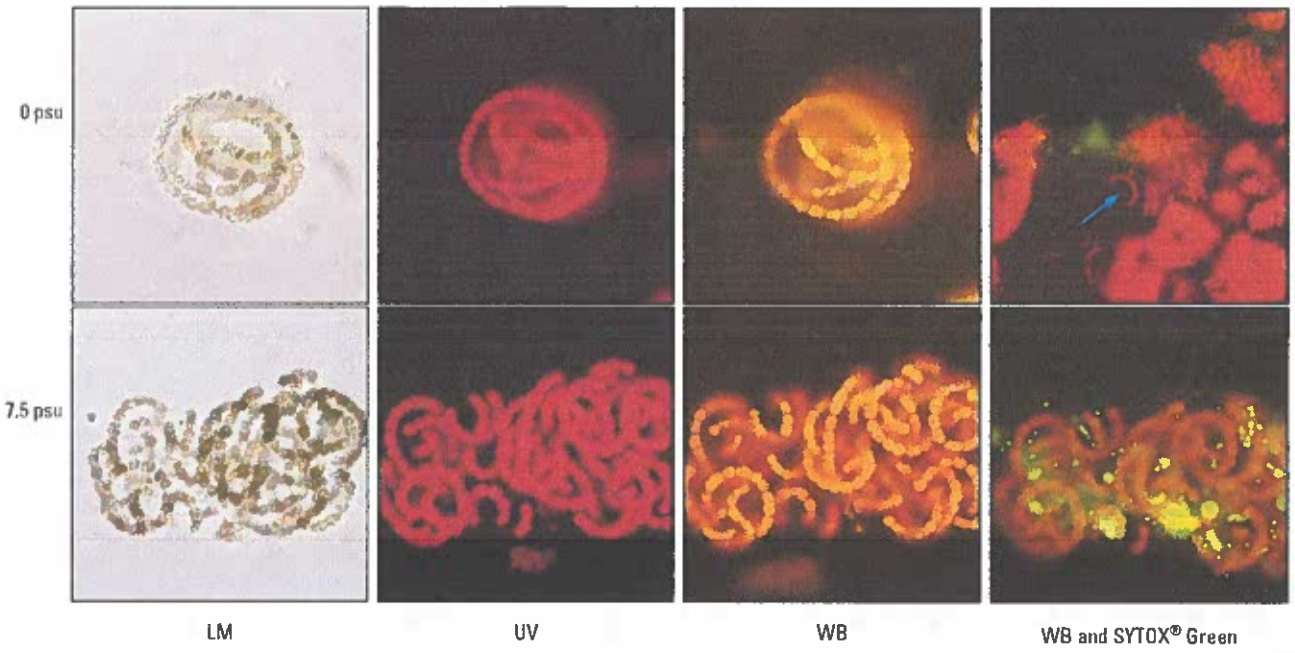


Figure 22. Response of *Dolichospermum circinale* after 8 days of exposure to treatments with different salinities (filament at blue arrow for image at upper right, among the *Microcystis* colonies; psu, practical salinity units; LM, differential interference microscopy; UV, epifluorescence microscopy; WB, wide-blue epifluorescence microscopy; WB and SYTOX® Green, wide-blue microscopy with the DNA stain SYTOX® Green added).

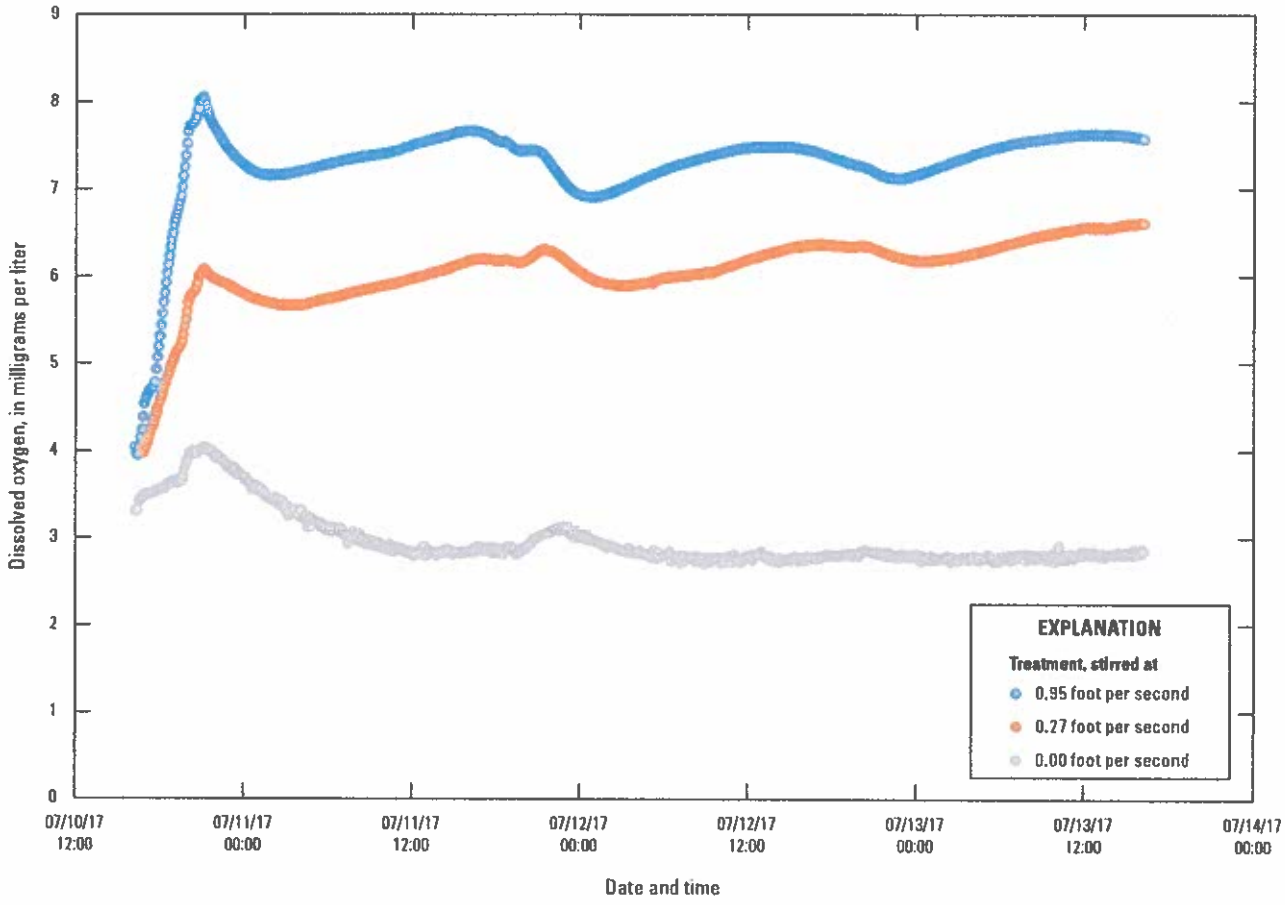


Figure 23. High frequency, optical sensor data for dissolved oxygen concentrations in three treatments: one not stirred, one stirred at 0.27 foot per second (ft/s), and one stirred at 0.95 ft/s.



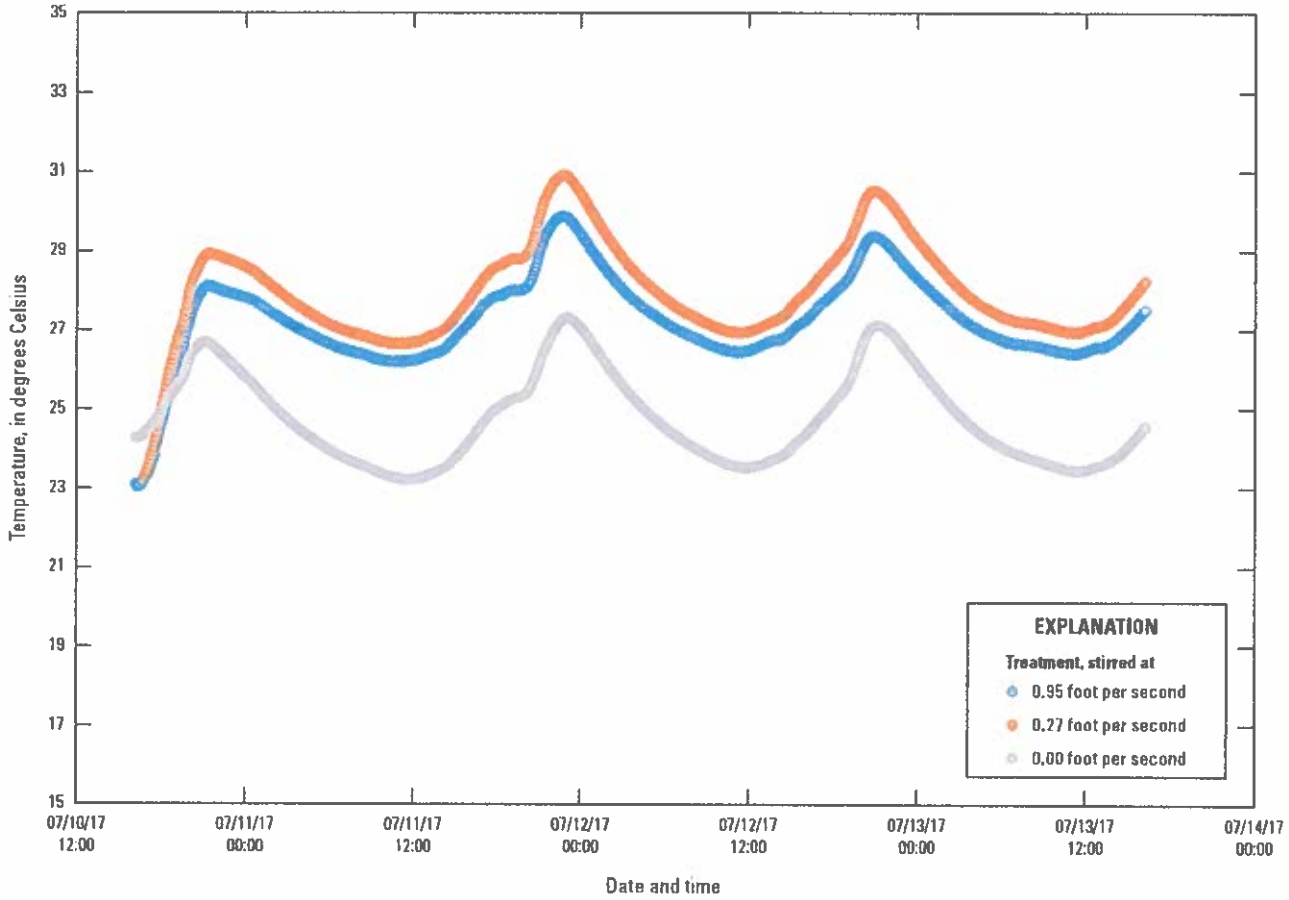


Figure 24. High frequency sensor data for temperature.



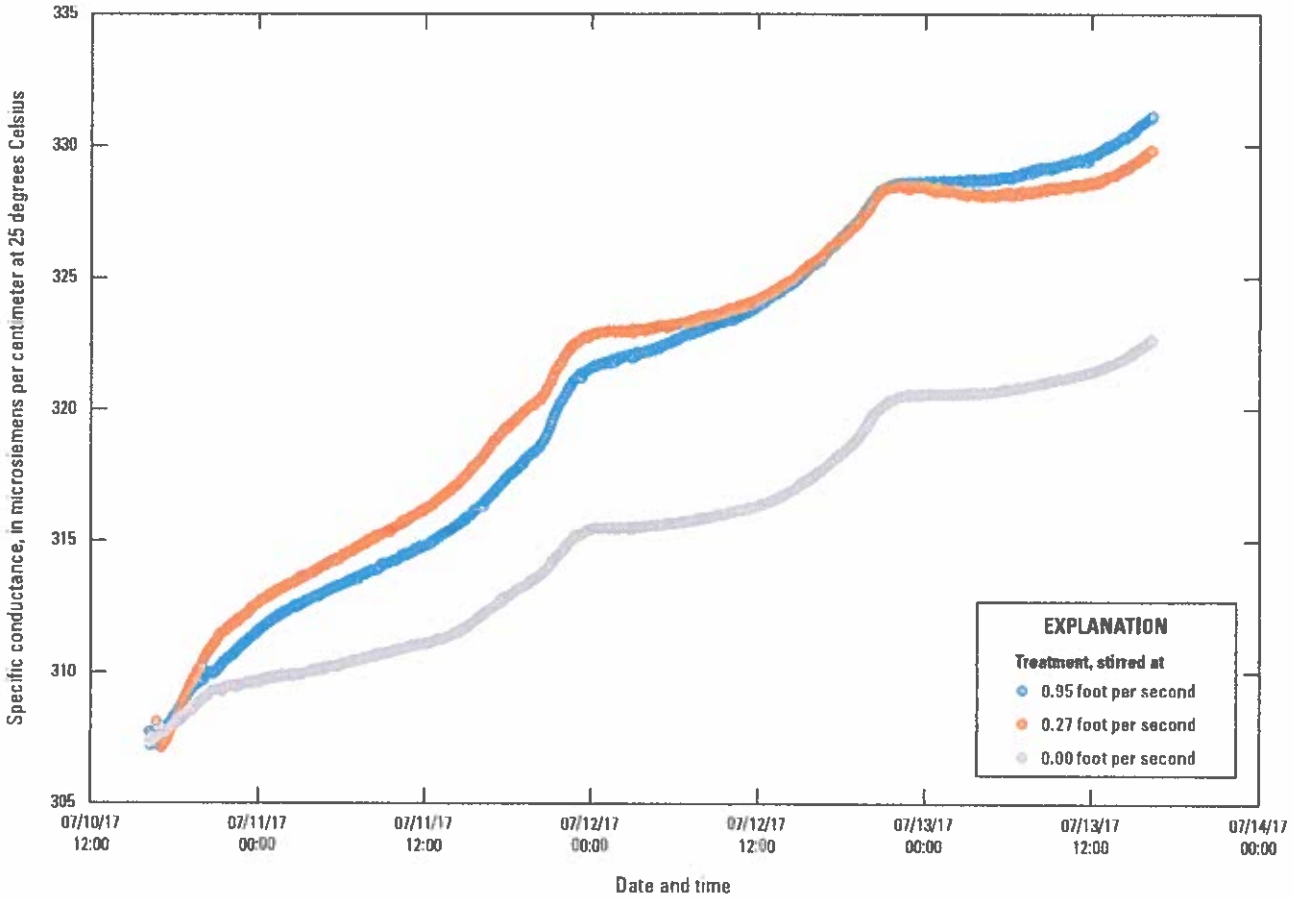


Figure 25. High frequency sensor data for specific conductance.



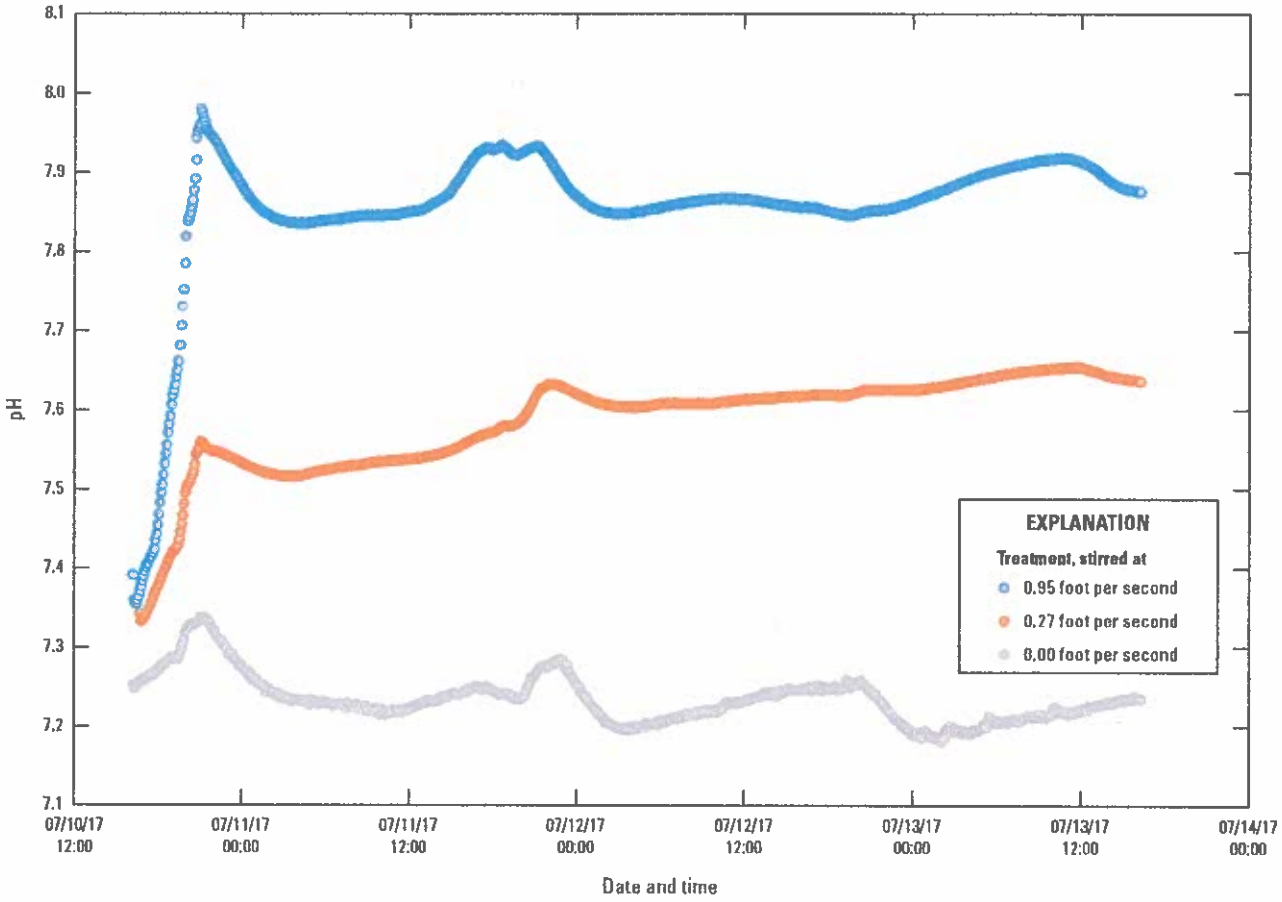


Figure 26. High frequency sensor data for pH.



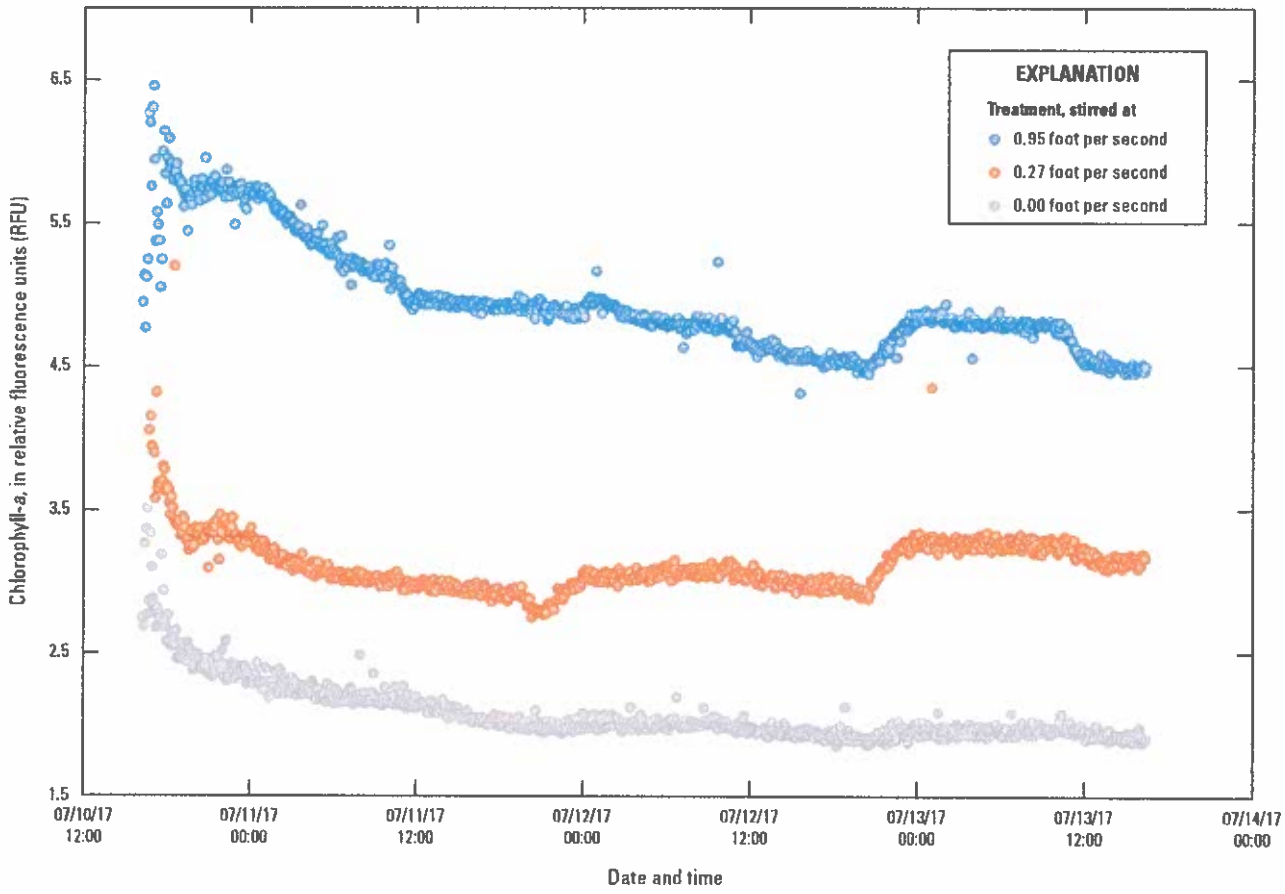


Figure 27. High frequency, optical sensor data for chlorophyll-*a* fluorescence.



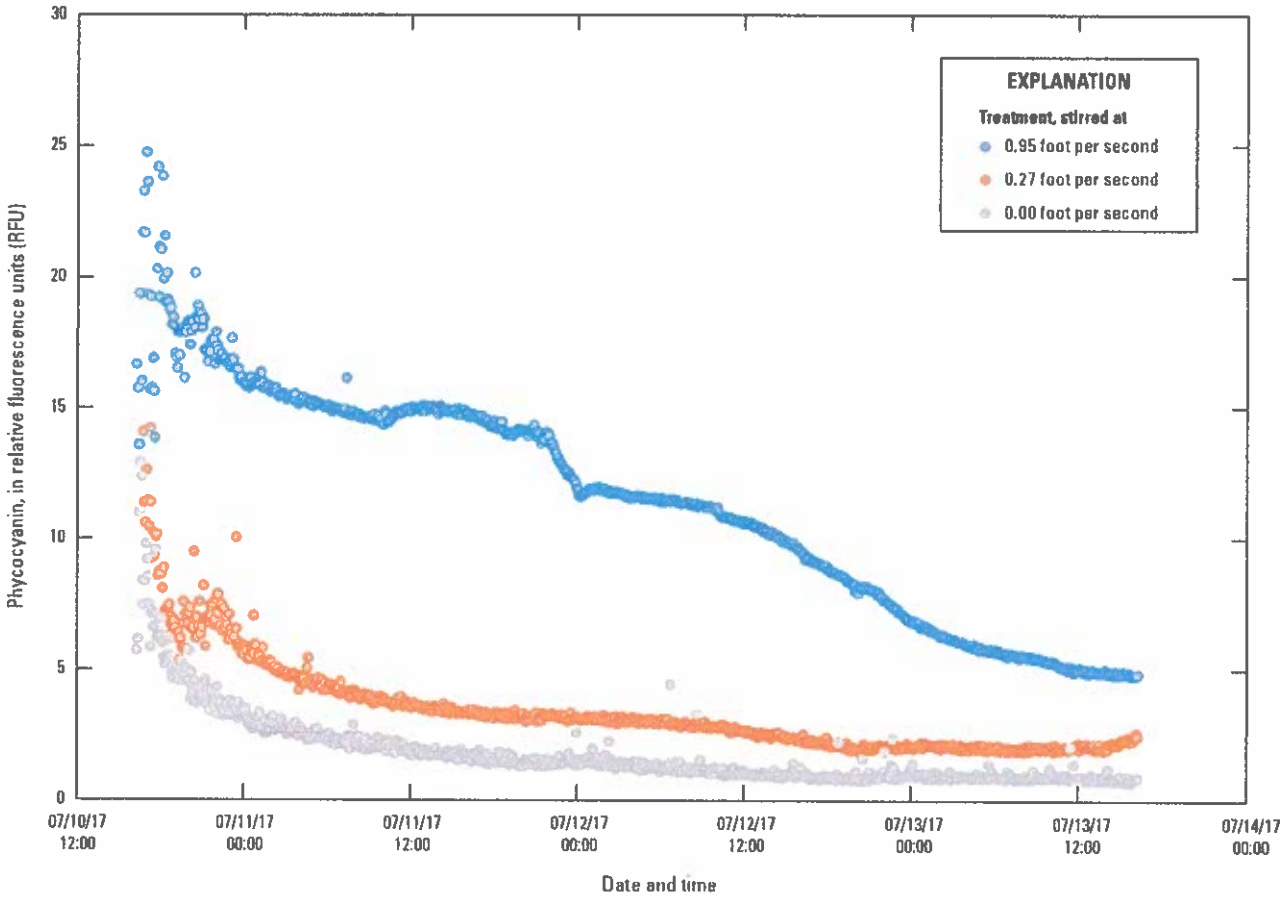


Figure 28. High frequency, optical sensor data for phycocyanin fluorescence.



Discussion

It is frequently assumed that when cyanobacteria from freshwater lakes, reservoirs, and rivers reach saline estuaries, they will die off after some period of time. The hydrologic dynamics in these transition areas influence the salinity conditions that these organisms experience. In a study that included a period of augmented flow from Lake Okeechobee in 2005, Phlips and others (2012) found that *Microcystis aeruginosa* persisted in the St. Lucie Estuary. The Phlips study reported that the South Fork of the St. Lucie Estuary had dense surface accumulations of cyanobacteria, with chlorophyll-*a* reaching 2,863 $\mu g/L^{-1}$ at the surface, and the cyanobacteria seem to have come from the St. Lucie Canal. Only a few studies have attempted to define the effects of salinity on cell growth, cell death, toxicity, pigmentation, and cell morphology (Batterton and Van Baalen, 1971; Orr and others, 2004). Tonk (Tonk and others, 2007) found the salinity tolerance of *Microcystis* did not exceed 20 psu.

The bloom used for this bioassay was collected from Eagle Bay, Lake Okeechobee, on July 7, 2017, and brought into a laboratory setting. The bloom was moved from an open-water habitat where it experienced wind and wave activity and nutrient and light variability associated with an open waterbody. Moving the community from its natural environment into the laboratory and into batch growth conditions (the graduated cylinders) altered many parameters that would equate to physiological stress on the organisms; however, the approach used in this study ensured physiological variables were similar across the treatments, leaving salinity changes as the only variable. The responses of dissolved oxygen and pH indicate the loss of a typical diurnal pattern that likely existed in the lake (figs. 23 and 26). The increase in specific conductance (fig. 25) may be explained by greater evaporation in the stirred treatments, which were also warmer than the nonstirred treatment (fig. 24) because of the heat produced by the stir plates. On a cellular level, if the cells were being disrupted and leaking cellular contents mineralized by bacteria, it could also explain the increase in specific conductance, as well as being a possible factor for the observed decline in fluorescence.

Overall, the control and treatments showed a downward trend in chlorophyll-*a* and phycocyanin fluorescence over time (figs. 27 and 28), and numerous possibilities exist for this phenomenon, including moving organisms from a high-light environment to a laboratory setting and changing nutrient dynamics that affect pigment fluorescence (Rosen and Lowe, 1984).

The water collected contained the targeted organism, *Microcystis aeruginosa,* with a density of approximately 400,000 cells per milliliter (cells/mL). This original sample contained ample microcystin (560 µg/L), which allowed us to monitor the presence of microcystin in cells and the amount released to the water as a result of salinity stress. Another major bloom-forming organism from the lake (Rosen and others, 2017), *Dolichospermum circinale*, was present at an initial density that was more than 140,000 cells/mL. The response of these two organisms provided information on the colonial and filamentous forms of cyanobacteria, *Microcystis* and *Dolichospermum*, respectively.

Generally, cyanobacteria health declined in salinity treatments greater than 18 psu as indicated by a loss of cell membrane integrity. In any given waterbody, the cyanobacteria colonies and filaments are not identical; rather, they are in various physiological states. Some colonies and filaments contain healthy cells that are likely better able to withstand stress, such as salinity changes, while others are unhealthy and more easily disrupted. Mucilage production, a mechanism commonly observed in response to desiccation in cyanobacteria (Pereira and others, 2009; Rosen and Mareš, 2016) and salinity (Ozturk and Aslim, 2010), was also an indicator of response to salinity in *Microcystis* and *Dolichospermum* (fig. 15). For mucilage production to occur, the filaments/colonies have to be alive and able to synthesize compounds that are excreted from the cells. The extracellular polymeric substance is mainly composed of complex polysaccharides that serve as a protective boundary between the cells and the water that surrounds them (Kehr and Dittmann, 2015). Nitrogen limitation has also been found to increase polysaccharide production in *Microcystis* cells, and light intensity seems to play an important role (Yang and others, 2012).

Initially, individual *Microcystis* colonies contained hundreds of cells (fig. 4*A*), and the effect of salinity on colony integrity did not show a single pattern. Some colonies maintain their overall shape with several hundreds of cells, even after 4 days of exposure in treatments up to 35 psu (fig. 10), while other colonies broke up into individual cells at 10 psu or greater (fig. 11). Although some cells of *Microcystis* lost integrity after 2 days of exposure to salinity greater than 18 psu, as indicated by being stained green with SYTOX® Green (fig. 17), other cells and colonies were left intact even after 4 days of exposure to salinity up to 20 psu. Cell mortality occurred after 4 days of exposure to salinity of 25 psu or greater (fig. 19), even if the colonies appeared to be intact. This range in colony breakdown in response to salinity is likely because of the natural variability in the health of each individual colony in a bloom, similar to the concept of the "paradox of the plankton" (Hutchinson, 1961).

Dolichospermum circinale cells decreased substantially in all treatments during the first 24 hours, indicating this species is not tolerant of the salinities in the ranges tested (fig. 7). Filaments were initially coiled (fig. 4*D*), but became shortened fragments within 1 day of salinity exposure (fig. 12). Separation of the cells in a filament was observed and likely the cause of fragmentation. *Dolichospermum*

tolerated the lowest salinity treatment, 7.5 psu (fig. 14*B*), for 8 days, but filaments were not observed in the higher salinities in this timeframe. From these observations, this other common Lake Okeechobee bloom-forming organism is much less tolerant of salinity compared to *Microcystis*. Although some of the fragments were stained with SYTOX® Green after 2 days of exposure to the 7.5-psu treatment, this salinity does not appear to cause complete mortality, as indicated by filamentous colonies that were still viable after 8 days at 7.5 psu. *Dolichospermum circinale* did not tolerate conditions greater than 7.5 psu.

Total, dissolved, or calculated microcystin concentrations, as total, dissolved, or calculated particulate, increased over time and were greater in the salinity treatments compared to the control. The amount of microcystin was greatest in the dissolved phase at the two highest salinities (fig. 8*B*), indicating that either a greater amount leaked from the cells in general or that cellular contents were released by dead cells. The particulate microcystin and chlorophyll-*a* give us information about the cellular content of organisms, hence we gain a more direct understanding of the cellular microcystin response as a function of salinity. The 7.5- and 10-psu treatments contained a greater amount of microcystin per unit of chlorophyll, indicating toxin stimulation at these concentrations. In contrast, in the 15- and 18-psu salinity treatments, the microcystin to chlorophyll ratios were similar to or lower than in the control, suggesting the inhibition of microcystin at these salinities. Additional experiments are needed to determine the mechanisms by which salinity stimulates or inhibits microcystin production.

Summary and Conclusions

This study documents an overall decline in cyanobacteria health in salinity treatments greater than 18 psu. A dominant bloom in this system, *Microcystis aeruginosa*, was tolerant of salinities up to 18 psu; however, higher salinities caused leaking of microcystin from the cells. *Dolichospermum circinale*, another common bloom-former in this system, did not tolerate salinities greater than 7.5 psu. Both organisms produced extracellular mucilage as a protective response to salinity, which is a common ecological strategy in cyanobacteria undergoing desiccation. At 7.5 psu, microcystin increased relative to chlorophyll-*a*, providing some evidence of biosynthesis when *M. aeruginosa* is stressed at these salinities. This study indicates that as freshwater cyanobacteria are transported to brackish and marine waters, there will be a loss of membrane integrity which will lead to the release of cellular microcystin into the surrounding waterbody. Additional research would be needed to determine the exact effect of salinity on this relation.

References

Arar, E.J., and Collins, G.B., 1997, U.S. Environmental Protection Agency Method 445.0, *in vitro* determination of chlorophyll-*a* and pheophytin-*a* in marine and freshwater algae by fluorescence, revision 1.2: Office of Research and Development, 22 p.

Batterton, J.C., Jr., and Van Baalen, C., 1971, Growth responses of blue-green algae to sodium chloride concentration: Archiv fur Mikrobiologie, v. 76, p. 151–165.

Brezonik, P.L., and Engstrom, D.R., 1998, Modern and historic accumulation rates of phosphorus in Lake Okeechobee, Florida: Journal of Paleolimnology, v. 20, p. 31–46.

Downing, B.D., Bergamaschi, B.A., and Kraus, T.E.C., 2017, Synthesis of data from high-frequency nutrient and associated biogeochemical monitoring in the Sacramento–San Joaquin Delta, northern California: U.S. Geological Survey Scientific Investigations Report 2017–5066, 28 p.

Florida Department of Environmental Protection [FDEP], 2017, June 2016 sampling results, accessed January 29, 2018, at https://floridadep.gov/comm/press-office/documents/june-2016-sampling-results.

Florida Department of Environmental Protection [FDEP], 2018, Algal bloom monitoring and response, accessed February 8, 2018, at https://floridadep.gov/dear/algal-bloom.

Hambrook Berkman, J.A., and Canova, M.G., 2007, Algal biomass indicators (ver. 1.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A7, section 7.4, accessed December 10, 2017, at https://water.usgs.gov/owq/FieldManual/Chapter7/7.4.pdf.

Havens, K.E., Aumen, N.G., James, R.T., and Smith, V.H., 1996, Rapid ecological changes in a large subtropical lake undergoing cultural eutrophication: Ambio, v. 25, p. 150–155.

Hutchinson, G.E., 1961, The paradox of the plankton: The American Naturalist, v. 95, no. 882, p. 137–145.

Kehr, J.C., and Dittmann, E., 2015, Biosynthesis and function of extracellular glycans in cyanobacteria: Life (Basel), v. 5, no. 1, p. 164–180.

King, L.R., Rosen, B.H., Loftin, K.A., Graham, J.L., Stahlhut, K.N., Johnston, B.D., and Senegal, Sarena, 2018a, Microcystin, chlorophyll, and cell-count data for assessing the effect of salinity tolerance on cyanobacteria associated with a harmful algal bloom in Lake Okeechobee, Florida, July 9 to 17, 2017: U.S. Geological Survey data release, https://doi.org/10.5066/P9FGIVCD.

King, L.R., Rosen, B.H., Loftin, K.A., Graham, J.L., Stahlhut, K.N., Johnston, B.D., and Senegal, Sarena, 2018b, Velocity test data for assessing the effect of salinity tolerance on cyanobacteria associated with a harmful algal bloom in Lake Okeechobee, Florida, July 10 to 13, 2017: U.S. Geological Survey data release, https://doi.org/10.5066/P996GAZP.

Knowlton, M.F., 1984, Flow-through microcuvette for fluorometric determination of chlorophyll: Water Resources Bulletin, v. 20, p. 1198–1205.

Loftin, K.A., Graham, J.L., Hilborn, E.D., Lehmann, S.C., Meyer, M.T., Dietze, J.E., and Griffith, C.B., 2016, Cyanotoxins in inland lakes of the United States: Occurrence and potential recreational health risks in the EPA National Lakes Assessment 2007: Harmful Algae, v. 56, p. 77–90.

National Aeronautics and Space Administration, 2016, Earth Observatory, Bloom in Lake Okeechobee, accessed October 18, 2017, at https://earthobservatory.nasa.gov/NaturalHazards/view.php?id=88311.

Orr, P.T., Jones, G.J., and Douglas, G.B., 2004, Response of cultured *Microcystis aeruginosa* from the Swan River, Australia, to elevated salt concentration and consequences for bloom and toxin management in estuaries: Marine and Freshwater Research, v. 55, p. 277–283.

Ozturk, S., and Aslim, B., 2010, Modification of exopolysaccharide composition and production by three cyanobacterial isolates under salt stress: Environmental Science and Pollution Research International, v. 17, p. 595–602.

Pereira, S., Zille, A., Micheletti, E., Moradas-Ferreira, P., De Philippis, R., and Tamagnini, P., 2009, Complexity of cyanobacterial exopolysaccharides: Composition, structures, inducing factors and putative genes involved in their biosynthesis and assembly: FEMS Microbiology Reviews, v. 33, p. 917–941.

Phlips, E.J., Badylak, S., Hart, J., Haunert, D., Lockwood, J., O'Donnell, K., Sun, D., Viveros, P., and Yilmaz, M., 2012, Climatic influences on autochthonous and allochthonous phytoplankton blooms in a subtropical estuary, St. Lucie Estuary, Florida, USA: Estuaries and Coasts, v. 35, p. 335–352.

Pollman, C.D., and James, R.T., 2011, A simple model of internal loading of phosphorus in Lake Okeechobee: Lake and Reservoir Management, v. 27, no. 1, p. 15–27.

Rosen, B.H., Davis, T.W., Gobler, C.J., Kramer, B.J., and Loftin, K.A., 2017, Cyanobacteria of the 2016 Lake Okeechobee Waterway harmful algal bloom: U.S. Geological Survey Open-File Report 2017–1054, 34 p., accessed April 4, 2018, at https://doi.org/10.3133/ofr20171054.

Rosen, B.H., Loftin, K.A., Smith, C.E., Lane, R.F., and Keydel, S.P., 2010, Microphotographs of cyanobacteria documenting the effects of various cell-lysis techniques: U.S. Geological Survey Open-File Report 2010–1289, 203 p.

Rosen, B.H., and Lowe, R.L., 1984, Physiological and ultrastructural responses of *Cyclotella meneghiniana* (Bacillariophyta) to light intensity and nutrient limitation: Journal of Phycology, v. 20, p. 173–183.

Rosen, B.H., and Mareš, Jan, 2016, Catalog of microscopic organisms of the Everglades, Part 1—The cyanobacteria: U.S. Geological Survey Open-File Report 2016–1114, 108 p.

Sartory, D.P., and Grobbelar, J.U., 1986, Extraction of chlorophyll-*a* from freshwater phytoplankton for spectrophotometric analysis: Hydrobiologia, v. 114, p. 117–187.

South Florida Water Management District [SFWMD], 1989, Interim Surface Water Improvement and Management (SWIM) Plan for Lake Okeechobee, Part 1: Water Quality, Part VII: Public Information, p. 150.

Tonk, L., Bosch, K., Visser, P.M., and Huisman, J., 2007, Salt tolerance of the harmful cyanobacterium *Microcystis aeruginosa*: Aquatic Microbial Ecology, v. 46, p. 117–123.

Turnipseed, D.P., and Sauer, V.B., 2010, Discharge measurements at gaging stations: U.S. Geological Survey Techniques and Methods book 3, chap. A8, 87 p.

U.S. Army Corps of Engineers, 2008, Central and Southern Florida Project—Water control plan for Lake Okeechobee and Everglades Agricultural Area, accessed October 18, 2017, at http://www.saj.usace.army.mil/Portals/44/docs/h2omgmt/LORSdocs/2008_LORS_WCP_mar2008.pdf.

Verspagen, J.M., Passarge, J., Jöhnk, K.D., Visser, P.M., Peperzak, L., Boers, P., Laanbroek, H.J., and Huisman, J., 2016, Water management strategies against toxic *Microcystis* blooms in the Dutch delta: Ecological Applications, v. 16, no. 1, p. 313–327.

Yang, Z., Linlin, G., Wang, W., and Zhang, J., 2012, Combined effects of temperature, light intensity, and nitrogen concentration on the growth and polysaccharide content of *Microcystis aeruginosa* in batch culture: Biochemical Systematics and Ecology, v. 41, p. 130–135.

YSI Incorporated, 2017, EXO user manual, accessed April 4, 2018, at https://www.ysi.com/File%20Library/Documents/Manuals/EXO-User-Manual-Web.pdf.

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Attachment 2

Salting our freshwater lakes

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The highest densities of lakes on Earth are in north temperate ecosystems, where increasing urbanization and associated chloride runoff can salinize freshwaters and threaten lake water quality and the many ecosystem services lakes provide. However, the extent to which lake salinity may be changing at broad spatial scales remains unknown, leading us to first identify spatial patterns and then investigate the drivers of these patterns. Significant decadal trends in lake salinization were identified using a dataset of long-term chloride concentrations from 371 North American lakes. Landscape and climate metrics calculated for each site demonstrated that impervious land cover was a strong predictor of chloride trends in Northeast and Midwest North American lakes. As little as 1% impervious land cover surrounding a lake increased the likelihood of long-term salinization. Considering that 27% of large lakes in the United States have >1% impervious land cover around their perimeters, the potential for steady and long-term salinization of these aquatic systems is high. This study predicts that many lakes will exceed the aquatic life threshold criterion for chronic chloride exposure (230 mg L^{-1}), stipulated by the US Environmental Protection Agency (EPA), in the next 50 y if current trends continue.

limnology | chloride | road salt | impervious surface | ecosystem services

Due to landscape position, lake ecosystems are influenced by surrounding terrestrial processes, and their generally long water residence times can contribute to the accumulation of external inputs and pollutants (1). Therefore, although lakes cover only 3% of the continental land surface (2), long-term trends in lakes are often early warning indicators of significant local, regional, or global changes (3). One such early warning indicator is change in lake chloride concentrations. Naturally occurring in freshwaters at low concentrations, chloride is a highly soluble and conservative ion that has also been shown to be a reliable proxy for chloride-based road salts (typically sodium chloride) (4, 5). Although chloride concentrations in freshwaters can vary cyclically due to climatic processes, such as extended periods of drought (6), elevated chloride concentrations in lakes often result from agricultural, industrial, and transportation practices (7). Elevated chloride concentrations can have adverse effects on water quality and aquatic ecosystems (8–11), including both immediate and long-term alterations to community structure, diversity, and productivity (12–14).

Salt application for de-icing roadways has been recognized as a major source of chloride to groundwater (15–17), streams and rivers (5, 10, 18, 19), and lakes (7, 9, 20, 21, 22) across north temperate climates in North America and Europe. In the United States, road salting became a standard practice in the 1940s, and road salt sales over the subsequent 50 y increased from 0.15 to over 18 million metric tons per year (4). In Canada, despite its addition to the List of Toxic Substances (23) and the implementation of the Code of Practice for the Environmental Management of Road Salts in 1999, an average of 5 million metric tons of road salt per year was applied to roadways between 1995 and 2001 (23, 24). Following application, road salt quickly dissolves and is transported into rivers and lakes through leaching and runoff (5, 25). A few studies have characterized the negative short term or localized impacts of elevated road salt concentrations in freshwaters (5, 15, 25), but there have been no large-scale analyses of chloride trends in freshwater lakes.

Here, we investigate trends in lake chloride concentration, using a dataset of long-term chloride concentrations in lakes and reservoirs in North America. We identify regions of high salinization, where aquatic ecosystems may be at risk, and contrast the role of climate versus the anthropogenic practice of road salting in driving chloride variability. Lakes included in the dataset were required to have at least 10 y of chloride data, a mean chloride concentration ≤ 1 g L^{-1} (to exclude brackish lakes), and a surface area ≥ 4 ha. The median length of an individual time series was

Significance

In lakes, chloride is a relatively benign ion at low concentrations but begins to have ecological impacts as concentrations rise into the 100s and 1,000s of mg L^{-1}. In this study, we investigate long-term chloride trends in 371 freshwater lakes in North America. We find that in Midwest and Northeast North America, most urban lakes and rural lakes that are surrounded by >1% impervious land cover show increasing chloride trends. Expanding on this finding, thousands of lakes in these regions are at risk of long-term salinization. Keeping lakes "fresh" is critically important for protecting the ecosystem services freshwater lakes provide, such as drinking water, fisheries, recreation, irrigation, and aquatic habitat.

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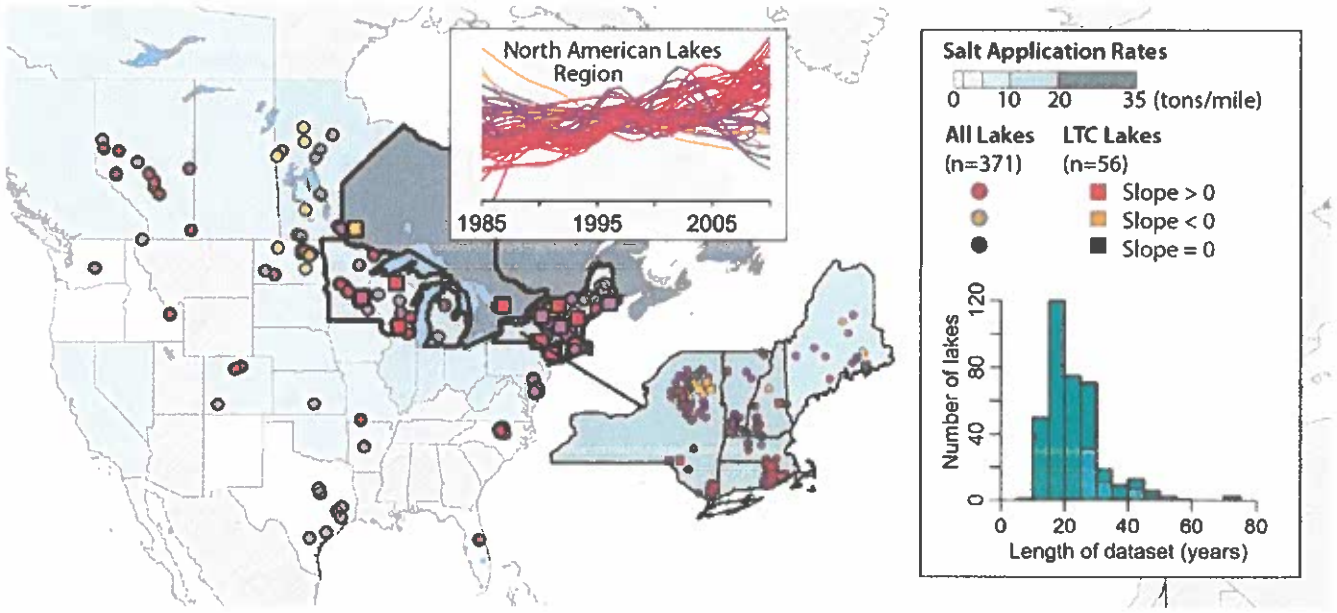


Fig. 1. Chloride trends for North American freshwater lakes (circles and squares, $n = 371$). The states and province included in the NALR are outlined in black. Points are colored by the slope value of linear regression models (red, positive slope; yellow, negative slope; purple, zero or nonsignificant slope). Squares denote lakes with at least biennial chloride concentrations recorded from 1985 to 2010 ($n = 56$). These LTC datasets are a subset of lakes in the NALR, which is a region of dense sampling ($n = 284$). *Upper Inset* of chloride time series from 1985 to 2010 are colored by slope value. Road salt application rates for North American provinces and states range from 0 to 35 US tons per mile and are shown in blue. No salt application rates were available in areas with hatched lines. The lengths of all individual datasets (dark green) as well as the lengths of LTC datasets (light green) are shown in the *Inset* histogram.

21 y. The dataset included lake morphometric characteristics, climate statistics on temperature and precipitation, and atmospheric sea salt deposition. As a proxy for road salt application, land cover metrics were calculated, including road density (26) [length of road in a given area (km km^{-2})] and percent impervious land cover (25) within a 100- to 1500-m buffer surrounding each lake. Road density and impervious land cover represent the best proxies for road salt application, given that variability in road salt application, both spatially and on a year-to-year basis, prevents application rates from being calculated at spatial and temporal scales relevant to lakes.

Lakes in this dataset were not randomly sampled and thus do not necessarily represent the distribution of lakes within each state or province. To limit sampling bias in this dataset, we focused our analyses on a geographic area with dense sampling coverage: a North American lakes region (NALR), which includes Connecticut, Maine, Massachusetts, Michigan, Minnesota, New Hampshire, New York, Ontario, Rhode Island, Vermont, and Wisconsin (Fig. 1). We excluded North Dakota lakes from this grouping, as many are part of the Devil's Lake watershed, an endorheic (closed-basin) system where water levels have risen ~10 m since 1992, and therefore, the hydrology is vastly different from exorheic (open) lakes (27). Likewise, Manitoba lakes were excluded, as many were enlarged or drained during hydroelectric construction along the Churchill and Nelson Rivers (28). Of the 371 North American lakes in our dataset, 284 were in the NALR (Fig. 1). Mean chloride concentrations in lakes across the NALR ranged from 0.18 to 240.8 mg L^{-1}, with a median value of 6.0 mg L^{-1}.

Chloride time series for each lake differed in the frequency, duration, and depth of sampling. We pooled all depth samples for analyses, based on observations that chloride concentrations track similar trends throughout the water column of most lakes and that previous studies of long-term chloride trends have shown similarity with depth (7, 29). To reduce autocorrelation due to seasonality, we reduced all time series to annual averages. To enable comparison of chloride trends across lakes, a linear model was fit to the annual data, where chloride (standardized to a distribution with mean = 0 and SD = 1) was a function of time. Lakes were classified by simple linear regression models into three possible long-term trends: decreasing ($n = 42$, slope < 0, $P < = 0.01$), stationary ($n = 204$, slope $= 0$, $P > 0.01$), or increasing ($n = 125$, slope > 0, $P < = 0.01$). Of the 125 lakes with a positive trend in chloride, 99 were in the NALR (Fig. 1).

To investigate both linear trends and time-series patterns over a comparable period, any site in the NALR that had at least biennial data from 1985 to 2010 was included in a subset of long-term continuous (LTC) data. Clustering the 56 LTC lakes into three groupings using a hierarchical clustering analysis revealed three characteristic trends in chloride concentrations: neutral/decreasing (cluster 1, $n = 16$), oscillating (cluster 2, $n = 4$), and increasing (cluster 3, $n = 36$) (Fig. 2*A*). Cluster 1 was a geographical mix of lakes with both decreasing and neutral slope trends, cluster 2 lakes were exclusively in Maine and had neutral slope trends, and cluster 3 lakes, 21 of which were in Minnesota, had predominantly increasing slope trends (35 of 38) (Fig. 2*B*).

Potential drivers of increasing lake chloride were first assessed by relating slope values to lake, climate, and landscape characteristics of lakes in the NALR (Fig. 3 *A*–*C*). Due to the prevalence of zero-values in the data, it was not possible to build robust log-linear models for most of the landscape characteristics. Therefore, we used both classification/regression trees and random forests to build predictive models for the NALR data. A classification/regression tree and a random forest were created for each of three response variables: linear slope, tested as both continuous numerical and categorical (positive, zero, negative) variables, and hierarchical cluster grouping (1, 2, or 3). Categorical slope was used as a response variable to further remove any bias in our linear model application by removing magnitude. The motivation for using two approaches and three response variables was to improve the accuracy of our analytics, in much the same way as ensemble modeling.

Results of the three classification/regression trees and three random forests revealed that impervious land cover and road

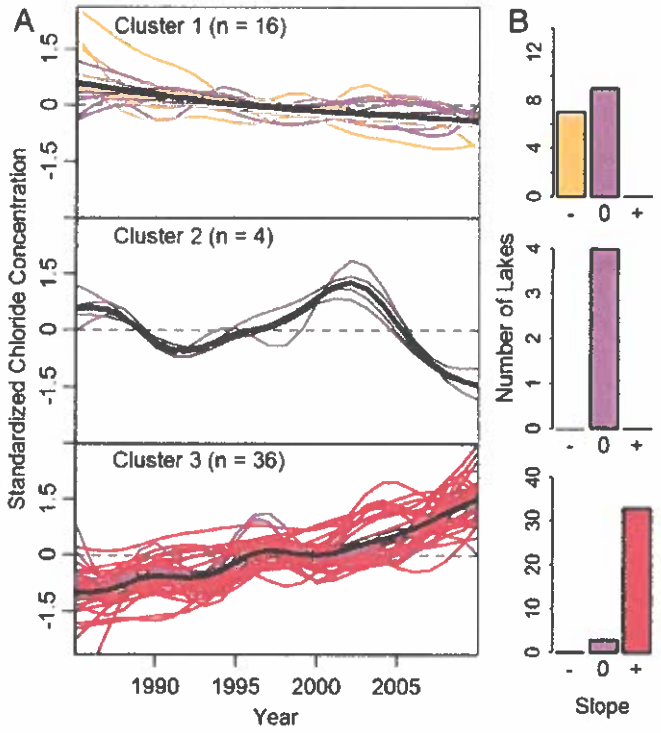


Fig. 2. (*A*) LTC lakes (n = 56) with biennial chloride data from 1985 to 2010 grouped into three clusters using a hierarchical cluster analysis. In general, the three clusters show a neutral/decreasing (cluster 1), oscillating (cluster 2), or increasing (cluster 3) pattern. Thick black lines are GAMs fit to all lakes within each cluster, to represent the average pattern. (*B*) Histograms display the number of lakes in each cluster by linear slope (yellow, negative slope; purple, zero slope; red, positive slope).

density surrounding each lake were the primary classification splits and the most important predictors for lake chloride trends and cluster grouping (Table 1).

The predictors used in the tree-based models were all static variables, meaning values did not vary with time. This limitation may misrepresent relationships between chloride concentrations and drivers that vary on a subannual basis (e.g., precipitation). Monthly precipitation data were obtained from the PRISM high-resolution spatial climate dataset, which covers the United States at a spatial resolution of 4 km (30). To account for the lag in chloride retention in a watershed (19), a LOESS curve was fit to mean monthly precipitation (mm/d) from 1985 to 2010 at each LTC site. A correlation between precipitation and chloride concentration at each LTC lake was calculated from annual data predicted from the LOESS precipitation curve and the generalized additive model (GAM) of chloride concentration. There was a strong negative correlation (r^2 = 0.71–0.87) between precipitation and chloride concentration for the four Maine lakes that group into cluster 2 (oscillating pattern). These four lakes are all less than 0.25 km^2 and receive ~1.25 m of precipitation per year and have no impervious land cover within 500 m. Without knowledge of the groundwater hydrology of these lakes, it may be that precipitation controls the chloride balance, with heavy rains and large snowfalls diluting the chloride concentrations. A strong relationship between precipitation and chloride is not evident for lakes that group into cluster 1 or 3 (median r^2 = 0.12, range = 0–0.61).

Of our NALR sites, 44% of freshwater lakes have undergone long-term salinization. Positive chloride trends were present in lakes with as little as 1% impervious coverage. This finding is consistent with studies of US streams that found increased chloride concentrations associated with any urban land cover (31) or roads (32, 33) and substantiates findings of ecological community thresholds associated with low levels of catchment urbanization (34). Across the NALR, lakes with mean chloride concentrations >1 mg L^{-1} (mean value of the time series) were more likely to be associated with positive trends in chloride (Fig. 3*D*). This suggests that high chloride concentrations in this region may be an indicator and warning sign of recent salinization.

If impervious land cover surrounding a lake is a robust predictor of water quality, it is important to understand the probability of its occurrence across all lakes within a region or country. Using national hydrography and land cover datasets for the continental United States, we found that the median percent impervious land cover within 500 m of all lakes greater than 4 ha is 0.31% (n = 149,350; Fig. 4). Of these US lakes, 28% had greater than 1% impervious land cover in a 500-m buffer zone. The density of roads and other impervious surfaces surrounding lakes in US regions where road salt is applied should therefore be of high concern. In the NALR, 70% (94 out of 134) of lakes with > 1% impervious land cover in the 500-m

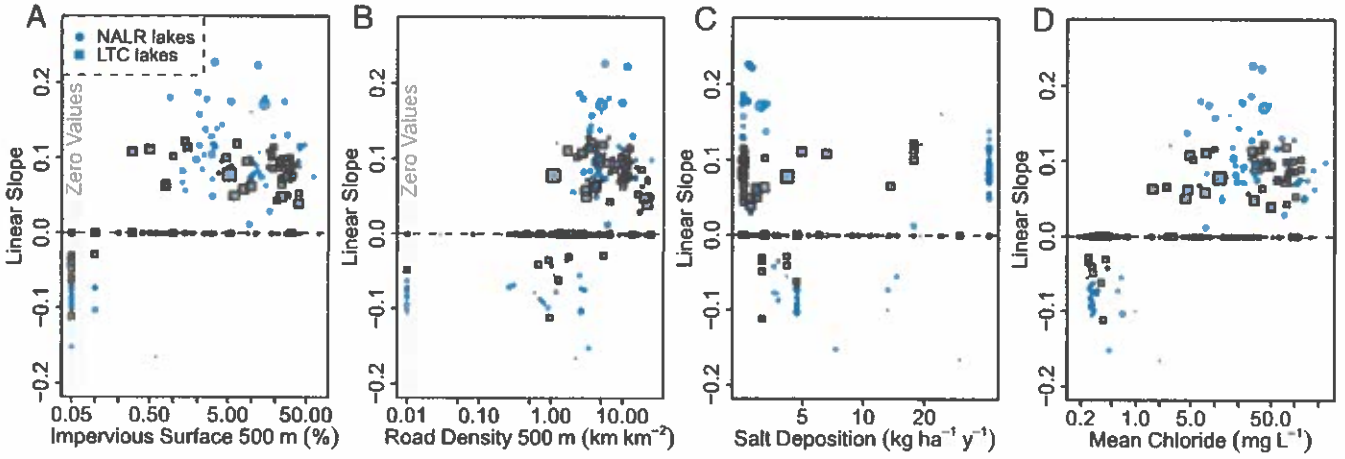


Fig. 3. Scatterplots of linear regression slope values versus (*A*) impervious surface within a 500-m buffer, (*B*) road density within a 500-m buffer, (*C*) rate of atmospheric salt deposition, and (*D*) mean in-lake chloride concentration over the entire time series for all NALR sites (n = 284). In all plots, the size of the symbol is scaled by lake area. Squares with black borders denote LTC lakes. In *A* and *B*, zero values have been adjusted to fit on the x axis and are highlighted in gray.

Table 1. Primary node splits from regression/classification tree models and the top predictor from random forest models

Response variable	Subset of data	Regression/classification tree primary node split	Random forest top predictor, variance explained
Linear slope, numerical	*NALR*	Impervious land cover 100 m	Road density 500 m, 50%
Linear slope, categorical	*NALR*	Impervious land cover 500 m	Impervious land cover 500 m
Cluster, categorical	*NALR LTC*	Impervious land cover 100 m	Impervious land cover 200 m

Models were built using linear slope (both as a number and a category), and cluster category as response variables for NALR lakes (all data $n = 284$ and LTC $n = 56$). Predictors included lake surface area, road density and impervious land cover (100-, 200-, 300-, 400-, 500-, 1,000-, 1500-m buffers), mean January air temperature, annual precipitation, wet/dry chloride deposition, and distance from the coast. For random forest models using a numerical response variable, % variance explained by the model is provided.

buffer had increasing chloride trends. If this result is extrapolated to all lakes in the US NALR (CT, MA, ME, MI, MN, NH, NY, RI, VT, and WI), ~7,770 lakes may be experiencing elevated chloride concentrations, likely due to road salt runoff. This is calculated as 70% of the 11,104 out of 38,603 lakes in the US NALR greater than 4 ha that have >1% impervious land

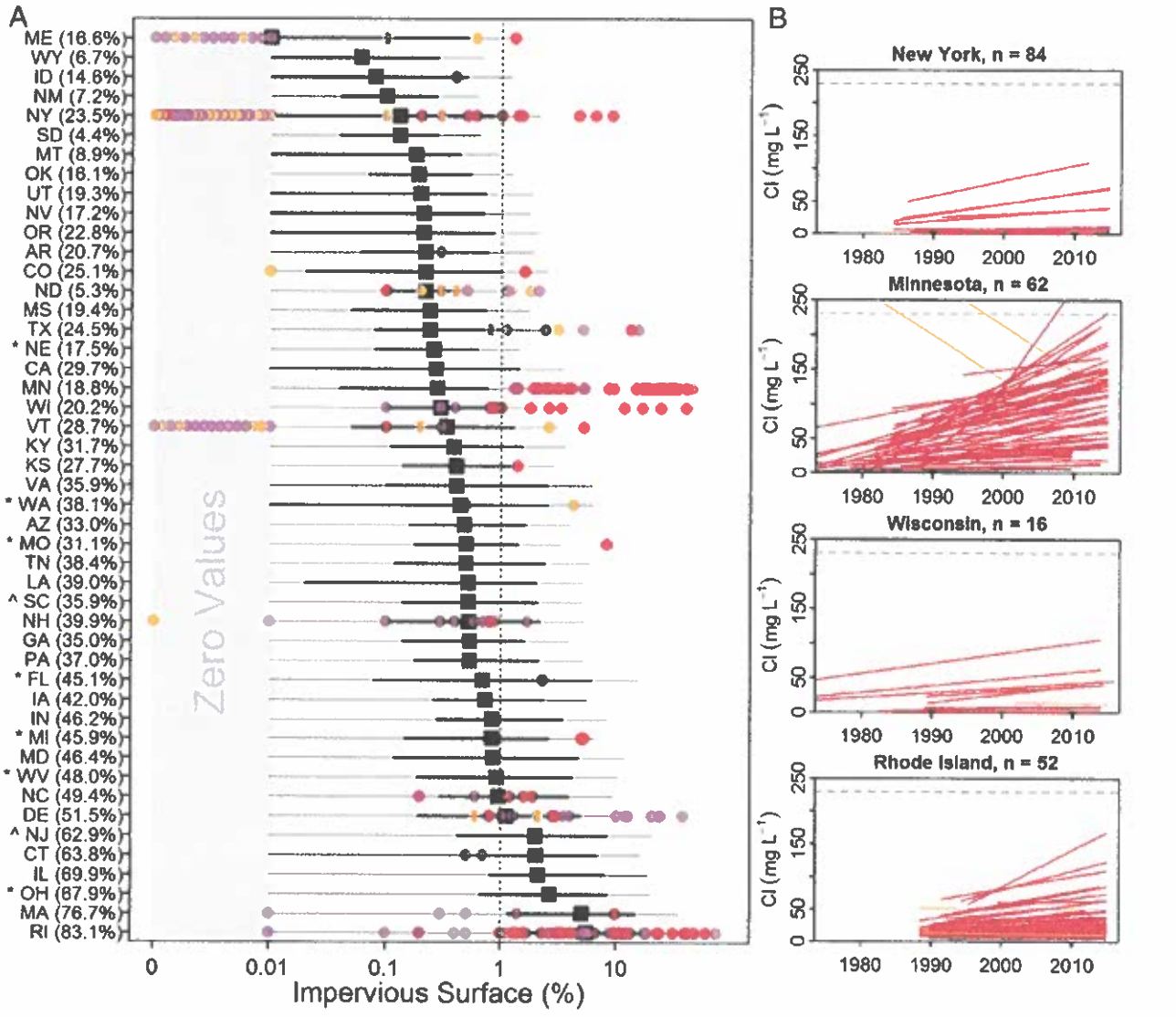


Fig. 4. (*A*) Distribution of impervious land cover within a 500-m buffer of all lakes >4 ha in the lower 48 United States ($n = 149{,}350$). Black squares represent the median impervious land cover percentage in each state. Thick horizontal black lines denote the interquartile range of the distribution, and thin black lines extend to 1.5 times the interquartile range. The vertical dashed line is shown at impervious land surface = 1%. Circles represent lakes included in this study, colored by slope (yellow, negative slope; purple, zero slope; red, positive slope). Due to the frequency of zero values on the *x* axis, circles are spread out within the gray rectangle. Percentages following *y* axis labels represent the percent of lakes in that state with greater than 1% impervious land cover within a 500-m buffer. In states with >10 lakes present in the dataset, an asterisk denotes that the sampling distribution in our dataset was significantly different from statewide distribution (Mann–Whitney test, $P < 0.05$), and ^ denotes that the sampling distribution was not significantly different from statewide distribution. (*B*) Chloride trends, as represented by linear regression model fits, are shown for four states with relatively large sample sizes (New York, Minnesota, Wisconsin, and Rhode Island). The dotted gray line demarcates the EPA's aquatic life criterion of 230 mg L^{-1}.

cover within 500 m. We note that data from Wisconsin and Minnesota are heavily biased toward urban lakes, whereas data from Maine, New York, and Vermont are heavily biased toward lakes in remote areas. This dataset (Fig. 4) includes lakes from all environments and should be representative of the Midwest and Northeast US region as a whole.

In North America, specifically in the Midwest and Northeast, local salt application leaves freshwater lakes vulnerable to salinization. Of the 284 lakes in the NALR, 26 already have a chloride concentration above 100 mg L^{-1} at their last sampling date. The median impervious land cover within a 500-m buffer surrounding these 26 lakes is 24.8%, compared with the US mean 0.31%. If a linear relationship between time and chloride concentration is extrapolated, 47 lakes are on track to reach 100 mg L^{-1} by the year 2050, and 14 are expected to surpass the EPA's aquatic life criterion concentration of 230 mg L^{-1} by 2050 (Fig. 4*B*). This is also the concentration at which a deterioration in drinking water taste is perceptible.

Elevated chloride concentrations in lakes can alter the composition and function of phytoplankton, zooplankton, macroinvertebrate, and fish communities (10–12, 35). As a consequence of salinization, aquatic species richness and abundance may decline, which could result in trophic cascades and altered water quality and ecosystem structure and function (36). In extreme cases, salinization can generate density gradients within the lake water column that prevent vertical mixing. Permanent stratification can result in anoxia and internal nutrient and metal resuspension, which decreases lake habitability and water quality (37). All of these ecosystem alterations can significantly affect lake water quality, which has millions of dollars in economic value (38, 39).

Our estimate that 7,770 lakes in the US NALR may be at risk for elevated chloride concentrations is likely an underestimate, as it does not consider regions of heavy road salt application where no long-term lake data were available, such as Québec or the Maritime provinces of Canada. Many states and municipalities are aware of the importance of shoreline management for maintaining healthy lakes; however, many shoreline zoning regulations are only enforced within 300 m or less of a lake (e.g., Wisconsin and Minnesota regulate 300 m, whereas Vermont and Maine only regulate 76 m). Because impervious surfaces and road density within at least 500 m of a lake are associated with increased chloride in areas that apply road salt, best management practices should recognize that lakeshore management extends well beyond the lake perimeter. Further, many jurisdictions lack consistent long-term monitoring programs, which provide data for predictive models and can be used to raise awareness and inform policy and management decisions used to curtail the threat of lake salinization. Clearly, keeping lakes "fresh" is critically important for protecting the ecosystem services freshwater lakes provide, such as drinking water sources, commercial fisheries, tourism, recreation, irrigation, and aquatic habitat.

Methods and Materials

Impervious land coverage at 20- to 30-m resolution was available for lakes in the United States as the degree of impervious surface per pixel (0–100%) and for Canadian and US lakes as a boolean value (0 or 1) representing whether the majority of each pixel was impervious surface. We adjusted Canadian values to match US values by using a conversion constructed from pooled impervious surface data from the United States ($r^2 = 0.91$, $P \sim 0$, Eq. 1), assuming that the relationship between boolean and percent impervious classifications would be similar in the United States and Canada:

$$\textit{Revised Impervious Surface} = \textit{Impervious Surface as Boolean(Canada)} * 0.388 \quad [1]$$

Using log-transformed, nonzero values ($n = 302$), we found that the means of impervious land cover across seven buffer sizes (100–500, 1,000, and 1,500 m) were statistically equal (Bartlett Test for homogenous variance $P = 1$; ANOVA $F = 0.18$, $P = 0.98$). For road density ($n = 435$), this was only true for buffer sizes of 400 m through 1,500 m (Bartlett Test $P = 0.11$; ANOVA $F = 2.58$, $P = 0.052$). Median road density across our 371 lakes decreased from 3.2 km km^{-2} to 1.9 km km^{-2} as the buffer size increased from 100 to 1,500 m. Because the variability in road density and impervious land cover was much greater between lakes than for a single lake within a range of buffer sizes, the choice of buffer size was not a determining factor in this analysis. Therefore, for most analyses we present road density and impervious land cover estimates within a 500-m buffer of each lake, and these generally represent average conditions.

Road salt (as sodium chloride) application rates were difficult to find at the local or regional level. If available, the rates were typically published as single values of average annual use or only included data for a single year. The best available data were at the state, provincial, or county level. In the United States, state-level highway data were obtained from the 1991 National Research Council published report on salt use (40), individual Department of Transportation reports [CT (41), KS (42), NC (43), PA (44), RI (45)], and by contacting individual states (ND). Many of these estimates were conservative, with much higher values being cited in recent years for some states, including IA (46), ME (47), and WI (48). Canadian provincial salt application rates were calculated by dividing metric tonnage per year (49) by the number of lane miles per province (50). All road salt data are presented in units of US tons per lane mile. State- and provincial-level application rates were multiplied by road density to give an approximation of potential road salt loading for North American lakes.

LTC lakes were fit with a GAM to predict chloride trends from 1985 to 2010 at a regularly spaced time interval. GAMs were fit using the mgcv package in R [v.1.8–12 (51)] using standardized chloride data and allowing *k* (basis dimension for smoothing term) to vary for each penalized thin-plate regression spline. A hierarchical cluster analysis was performed on the LTC time series to test if similar temporal patterns in chloride concentrations were present across multiple lakes. We used Ward clustering, under which dissimilarities were squared before clustering, on a dissimilarity matrix constructed from Euclidean distances [R package: TSclust v.1.2.3 (52)]. We performed a *k*-means clustering on the LTC data and visually identified the optimal number of clusters to be three, based on a sum of squares screen plot. No distinct trends were exposed by moving beyond three clusters.

Two statistical techniques were used to build predictive models:

i) Classification/regression trees [R package: rpart v.4.1–10 (53)]. Regression trees were split using the ANOVA method, which maximizes the sum of squares between groups. Classification trees were used only when cluster group was the response variable and used the Gini index as the splitting criterion.

ii) Random forest [R package: randomForest v.4.6–12 (54)].

Static predictor variables sourced from the dataset were lake area, road density, and percent impervious land cover (100-, 200-, 300-, 400-, 500-, 1,000-, and 1,500-m buffer) surrounding each lake, January mean monthly air temperatures, mean annual precipitation, distance to the coast, and mean annual sea salt deposition.

To assess the potential for salinization of lakes at the country scale, we calculated the percent impervious land cover in 500-m and 1,000-m buffers for all lakes ≥4 ha in the United States, using shapefiles from the National Hydrography Dataset ($n = 152{,}199$) and the 2011 US National Land Cover Database Percent Developed Impervious layer (55).

Analytical scripts are available from the corresponding author.

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1. Schindler DW (2009) Lakes as sentinels and integrators for the effects of climate change on watersheds, airsheds, and landscapes. *Limnol Oceanogr* 54:2349–2358.
2. Verpoorter C, Kutser T, Seekell DA, Tranvik LJ (2014) A global inventory of lakes based on high-resolution satellite imagery. *Geophys Res Lett* 41:6396–6402.
3. O' Reilly CM, et al. (2015) Rapid and highly variable warming of lake surface waters around the globe. *Geophys Res Lett* 42(24):10773–10781.
4. Jackson RB, Jobbágy EG (2005) From icy roads to salty streams. *Proc Natl Acad Sci USA* 102:14487–14488.
5. Thunqvist E-L (2004) Regional increase of mean chloride concentration in water due to the application of deicing salt. *Sci Total Environ* 325:29–37.
6. Webster KE, et al. (2000) Structuring features of lake districts: Landscape controls on lake chemical responses to drought. *Freshw Biol* 43:499–515.
7. Müller B, Gächter R (2011) Increasing chloride concentrations in Lake Constance: Characterization of sources and estimation of loads. *Aquat Sci* 74:101–112.
8. Findlay SEG, Kelly VR (2011) Emerging indirect and long-term road salt effects on ecosystems. *Ann N Y Acad Sci* 1223:58–68.
9. Chapra SC, Dove A, Rockwell DC (2009) Great Lakes chloride trends: Long-term mass balance and loading analysis. *J Great Lakes Res* 35:272–284.
10. Corsi SR, Graczyk DJ, Geis SW, Booth NL, Richards KD (2010) A fresh look at road salt: Aquatic toxicity and water-quality impacts on local, regional, and national scales. *Environ Sci Technol* 44:7376–7382.
11. Brown AH, Yan ND (2015) Food quantity affects the sensitivity of Daphnia to road salt. *Environ Sci Technol* 49:4673–4680.
12. Van Meter RJ, Swan CM (2014) Road salts as environmental constraints in urban pond food webs. *PLoS One* 9:e90168.
13. Herbert E, et al. (2015) A global perspective on wetland salinization: Ecological consequences of a growing threat to freshwater wetlands. *Ecosphere* 6:1–43.
14. Evans M, Frick C (2001) *The Effects of Road Salts on Aquatic Ecosystems* (Environment Canada, Saskatoon, Canada).
15. Howard KWF, Maier H (2007) Road de-icing salt as a potential constraint on urban growth in the Greater Toronto Area, Canada. *J Contam Hydrol* 91:146–170.
16. Panno SV, et al. (2006) Characterization and identification of na-cl sources in ground water. *Ground Water* 44:176–187.
17. Williams DDD, Williams NE, Cao Y (2000) Road salt contamination of groundwater in a major metropolitan area and development of a biological index to monitor its impact. *Water Res* 34:127–138.
18. Kaushal SS, et al. (2005) Increased salinization of fresh water in the northeastern United States. *Proc Natl Acad Sci USA* 102:13517–13520.
19. Kelly VR, et al. (2008) Long-term sodium chloride retention in a rural watershed: Legacy effects of road salt on streamwater concentration. *Environ Sci Technol* 42:410–415.
20. Novotny EV, Murphy D, Stefan HG (2008) Increase of urban lake salinity by road deicing salt. *Sci Total Environ* 406:131–144.
21. Likens GE, Buso DC (2009) Salinization of Mirror Lake by road salt. *Water Air Soil Pollut* 205:205–214.
22. Swinton MW, Eichler LW, Boylen CW (2014) Road salt application differentially threatens water resources in Lake George, New York. *Lake Reserv Manage* 31:20–30.
23. Environment Canada (2012) *Five-Year Review of Progress: Code of Practice for the Environmental Management of Road Salts* (Environment Canada, Ottawa).
24. Code of practice for the environmental management of road salts. Canadian environmental Protection Act, 1999 (2004) (Environment Canada, Ottawa).
25. Daley ML, Potter JD, McDowell WH (2009) Salinization of urbanizing New Hampshire streams and groundwater: Effects of road salt and hydrologic variability. *J N Am Benthol Soc* 28:929–940.
26. Nimiroski M, Waldron M (2002) *Sources of Sodium and Chloride in the Scituate Reservoir Drainage Basin, Rhode Island.* Available at https://pubs.usgs.gov/wri/wri024149/pdf/scituate3.pdf. Accessed September 26, 2016.
27. Todhunter PE, Fietzek-DeVries R (2016) Natural hydroclimatic forcing of historical lake volume fluctuations at Devils Lake, North Dakota (USA). *Nat Hazards* 81:1515–1532.
28. Krotz L (1991) Dammed and diverted. *Can Geogr* 111:36–44.
29. Aota Y, Kumagai M, Ishikawa K (2003) Over twenty years trend of chloride ion concentration in Lake Biwa. *J Limnol* 62:42–48.
30. Daly C, Gibson W, Taylor G, Johnson G, Pasteris P (2002) A knowledge-based approach to the statistical mapping of climate. *Clim Res* 22:99–113.
31. Corsi SR, De Cicco LA, Lutz MA, Hirsch RM (2015) River chloride trends in snow-affected urban watersheds: Increasing concentrations outpace urban growth rate and are common among all seasons. *Sci Total Environ* 508:488–497.
32. Kelting DL, Laxson CL, Yerger EC (2012) Regional analysis of the effect of paved roads on sodium and chloride in lakes. *Water Res* 46:2749–2758.
33. Regalado SA, Kelting DL (2015) Landscape level estimate of lands and waters impacted by road runoff in the Adirondack Park of New York State. *Environ Monit Assess* 187:510.
34. King RS, Baker ME, Kazyak PF, Weller DE (2011) How novel is too novel? Stream community thresholds at exceptionally low levels of catchment urbanization. *Ecol Appl* 21:1659–1678.
35. Jones DK, et al. (2017) Investigation of road salts and biotic stressors on freshwater wetland communities. *Environ Pollut* 221:159–167.
36. Hintz WD, et al. (2016) Salinization triggers a trophic cascade in experimental freshwater communities with varying food-chain length. *Ecol Appl*, 10.1002/eap.1487.
37. Sibert RJ, Koretsky CM, Wyman DA (2015) Cultural meromixis: Effects of road salt on the chemical stratification of an urban kettle lake. *Chem Geol* 395:126–137.
38. Walsh JR, Carpenter SR, Vander Zanden MJ (2016) Invasive species triggers a massive loss of ecosystem services through a trophic cascade. *Proc Natl Acad Sci USA* 113:4081–4085.
39. Dodds WK, et al. (2009) Eutrophication of U.S. freshwaters: Analysis of potential economic damages. *Environ Sci Technol* 43:12–19.
40. National Research Council (1991) *Road Salt Use in the United States* (Transportation Research Board, Washington, DC).
41. Frisman P (2015) *Research Report 2015-R-0252: Study of Winter Highway maintenance in Connecticut* (Connecticut General Assembly, Hartford, CT).
42. Kansas Department of Transportation (2015) *Kansas Department of Transportation: Managing Snow and Ice* (Kansas Department of Transportation, Topeka, KS).
43. Winston RJ, Hunt WF, Pluer WT (2012) *Road Salt and its Effects on Amphibians: A Concern for North Carolina?* (North Carolina Department of Transportation, Raleigh, NC), Technical Assistance TA-2015-05.
44. Pennsylvania Department of Transportation (2011) *Winter Services Guide* 10.1002/ejoc.201200111.
45. Rhode Island Division of Planning (2014) *Road Salt/Sand Application in Rhode Island* (Rhode Island Department of Administration, Providence, RI).
46. Casey PC, Alwan CW, Kline CF, Landgraf GK, Linsenmayer KR (2014) . *Impacts of Using Salt and Salt Brine for Roadway Deicing* (CTC & Associates, Madison, WI).
47. Rubin J, et al. (2010) *Maine Winter Roads: Salt Safety, Environment and Cost* (Margaret Chase Smith Policy Center, Orono, ME).
48. Wisconsin Department of Transportation (2016) *Wisconsin Department of Transportation. Winter Facts.* Available at wisconsindot.gov/Pages/doing-bus/local-gov/hwy-mnt/winter-maintenance/facts.aspx. Accessed January 16, 2016.
49. Morin D, Perchanok M (2000) *Road Salt Loadings in Canada* (Environment Canada, Hull, Canada).
50. Transport Canada (2008) *Transportation in Canada 2007: An Overview* (Transport Canada, Ottawa).
51. Wood SN (2011) Fast stable restricted maximum likelihood and marginal likelihood estimation of semiparametric generalized linear models. *J R Stat Soc Ser B Stat Methodol* 73:3–36.
52. Montero P, Vilar JA (2014) Tsclust: An *r* package for time series clustering. *J Stat Software* 62:1–43.
53. Therneau TM, Atkinson B, Ripley B (2010) rpart: Recursive partitioning. *R Packag Version* 3, ppp1–46.
54. Liaw A, Wiener M (2002) Classification and regression by randomForest. *R News* 2/3, 18–22.
55. Xian G, et al. (2011) Change of impervious surface area between 2001 and 2006 in the conterminous United States. *Photogramm Eng Remote Sensing* 77:758–762.

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Road Salts as Environmental Constraints in Urban Pond Food Webs

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Abstract

Freshwater salinization is an emerging environmental filter in urban aquatic ecosystems that receive chloride road salt runoff from vast expanses of impervious surface cover. Our study was designed to evaluate the effects of chloride contamination on urban stormwater pond food webs through changes in zooplankton community composition as well as density and biomass of primary producers and consumers. From May – July 2009, we employed a 2×2×2 full-factorial design to manipulate chloride concentration (low = 177 mg L^{-1} Cl^-/high = 1067 mg L^{-1} Cl^-), gray treefrog (*Hyla versicolor*) tadpoles (presence/absence) and source of stormwater pond algae and zooplankton inoculum (low conductance/high conductance urban ponds) in 40, 600-L mesocosms. Road salt did serve as a constraint on zooplankton community structure, driving community divergence between the low and high chloride treatments. Phytoplankton biomass (chlorophyll [a] μg L^{-1}) in the mesocosms was significantly greater for the high conductance inoculum ($P<0.001$) and in the high chloride treatment ($P=0.046$), whereas periphyton biomass was significantly lower in the high chloride treatment ($P=0.049$). Gray treefrog tadpole time to metamorphosis did not vary significantly between treatments. However, mass at metamorphosis was greater among tadpoles that experienced a faster than average time to metamorphosis and exposure to high chloride concentrations ($P=0.039$). Our results indicate differential susceptibility to chloride salts among algal resources and zooplankton taxa, and further suggest that road salts can act as a significant environmental constraint on urban stormwater pond communities.

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Introduction

Regional and local factors such as dispersal, competition, timing of colonization events and environmental filters in concert determine community composition [1]. In particular, environmental constraints can present very stressful conditions, such as high pollutant loads or changes in hydroperiod, that exceed species' tolerances and prevent successful colonization to new habitats [1–2]. Environmental constraints or stressors, as detailed and studied herein, refer to anthropogenic influences to aquatic ecosystems. In systems that experience fluctuating environmental stress, such as pulses of contaminant loads, food web dynamics can be very cyclic when species are well adapted to specific abiotic conditions. Species adapted to opposite ends of the contaminant spectrum will be intermittently dominant within the community as the environment changes or they may even be lost from the system completely [1,3]. However, species that are able to withstand intense environmental stresses may do so at the expense of being less competitive when biotic factors regulate community composition [4]. Pollutants of rising concern can serve as environmental filters by limiting community composition to those species that are able to withstand the stress. In human dominated landscapes, environmental constraints may be the prevailing local factor in determining community assembly.

The importance of environmental constraints in structuring aquatic communities has been emphasized within the last decade as concerns of habitat alteration and degradation continually increase. Studies of freshwater zooplankton communities show that variability in water chemistry is often the best predictor of community composition. Gradients or changes in pond turbidity, hydroperiod, salinity or conductivity and pH can result in distinct zooplankton assemblages [5–9]. Similar water quality parameters are reported as main factors in community assembly among diatoms [10], phytoplankton [11], aquatic invertebrates [6] and amphibians [4]. To better predict community composition in rapidly changing landscapes, gaining a better understanding of the relationship between species tolerance thresholds and relevant environmental constraints is essential.

Across the northeast United States, freshwater salinization is becoming a year-round phenomenon due to long-term storage and transport of dissociated road salt ions (e.g., chloride, sodium, magnesium) in groundwater and soils [12–15]. This emerging environmental contaminant is of particular concern in urban areas where natural wetland acreage continues to decline and man-made stormwater ponds are common watershed features [16]. While stormwater detention ponds are designed to accumulate a myriad of contaminants, recent research has highlighted the susceptibility of these urban aquatic ecosystems to road salt deicers

resulting in freshwater salinization [17]. An unintended consequence of installing numerous stormwater detention ponds is that many organisms have been documented making use of these man-made habitats despite their extremely poor water quality [18–24 and others]. Given their position within urbanized landscapes, stormwater detention ponds present a unique system for exploring road salts as an environmental constraint on aquatic community structure.

Road salt exposure at sub-lethal concentrations can result in significant direct and indirect effects within a community, as well as alter ecosystem structure of freshwater habitats. Van Meter et al. [25] obtained algae, zooplankton and frogs from pristine wetland communities and reported a decline in zooplankton densities in experimental pond mesocosms at chloride concentrations known to be sub-lethal to gray treefrog larvae. As a result of the loss of this algal grazer from the ecosystem, gray treefrog larvae gained access to algal resources and metamorphosed faster and at a larger mass [25]. Our current study expands on this previous work by considering the potential for adaptation and altered community structure among urban stormwater pond communities that experience high chloride levels year-round. Recent work by Petranka and Doyle [26] indicated that road salts can alter seasonal pond communities in favor of salt tolerant insects such as mosquitoes, which may serve as competitors to larval amphibians and zooplankton. Jose de Paggi et al. [27] described unique zooplankton communities between the inlet and outlet of an urban stormwater pond receiving chloride inputs, and Olding [28] found distinct algal assemblages between stormwater ponds retaining different chloride concentrations. Given that road salt contamination is a rising concern to freshwater ecosystems and differential susceptibility exists among aquatic organisms to these contaminants, exploring patterns in stormwater pond communities is essential in understanding the ecology of the urban landscape.

While several studies have explored the effects of chloride contamination on pond populations and communities, none have evaluated such effects in habitats experiencing perpetual disturbance through contaminated runoff. The purpose of this study was to evaluate the impact of a hypothesized environmental constraint, road salt (low and high chloride treatments), on the community structure in experimental stormwater pond systems assembled from different colonist pools (i.e., zooplankton and algal inoculum source) and in the presence of a major biotic factor, gray treefrog (*Hyla versicolor*) tadpoles. While previously published studies have explored experimental road salt effects on pristine pond communities [25–26] and have surveyed community structure in stormwater ponds with high chloride levels [27–29] as detailed above, our experiment was designed to evaluate whether chloride salts serve as an environmental stressor to pond communities thriving in urban ecosystems where chloride levels are consistently elevated for much of the year. Our hypothesis was that road salt inputs do serve as an important environmental constraint on pond communities and that urban pond communities experiencing continual salt stress would contain a species pool that is more tolerant of elevated chloride.

Materials and Methods

Ethics Statement

This research was approved by the University of Maryland Baltimore County Institutional Animal Care and Use Committee (protocol #CS070210710) and carried out in accordance with the Association of Ichthyologists and Herpetologists Guidelines for Use of Live Amphibians and Reptiles in Field and Laboratory Research. Permission to collect gray treefrogs for this study was given by the Maryland Department of Natural Resources (Scientific Collecting Permit #46158). Collection of periphyton, phytoplankton and zooplankton did not require specific permissions as these samples were obtained from public stormwater ponds. This study did not involve the use or collection of endangered or protected species.

Our experimental design was a 2×2×2 full factorial (Table 1) with a chloride treatment as an environmental effect (high, low), tadpole treatment as a biotic effect (present, absent), and algae/zooplankton inoculum treatment as the colonist pool (low conductance pond, high conductance pond) applied randomly to 40 polyethylene mesocosms, each 600 L in volume. These mesocosms were arranged in a 5×8 grid in a grassy, open field at the University of Maryland, Baltimore County (UMBC), Baltimore, Maryland, USA. The open field provided uniformity in the amount of ambient light, wind and rain that the mesocosms received over the course of the study. On May 6–7, 2009, we filled the mesocosms with tap water and allowed the water to age for 24–48 hours before adding 12.5 g of rabbit chow to supply nutrients, 95 g of dry leaves (*Quercus* sp.) to provide cover, and 10 unglazed ceramic tiles, each 103.2 cm^2, as a surface for periphyton colonization in all mesocosms. We obtained inoculum for periphyton, phytoplankton and zooplankton from two stormwater detention ponds in the Red Run Watershed, Owings Mills, Baltimore County, Maryland. These ponds were part of two stormwater detention pond surveys between 2007–2009 (ponds E94 and H85; [29–30]. Gallagher et al. [30] analyzed sediment samples for trace metals and polycyclic aromatic hydrocarbons and water samples for major ions in 68 stormwater ponds in the Red Run Watershed, including the two ponds used in this study. A strong correlation between chloride ions and conductivity was reported for all ponds sampled [30]. Pond E94 was classified as having a low conductance (average specific conductance from April – June 2009 = 153±15.5 (SE) µS, n = 4) while pond H85 was classified as having a high conductance (average specific conductance from April – June 2009 = 1924±303 (SE) µS, n = 4; [25]. Before adding to the mesocosms, we filtered the pond water inoculum through a 500 µm sieve to remove larger invertebrates and debris. We added 5 L of low conductance inoculum to 20 mesocosms and 5 L of high conductance inoculum to the remaining 20 mesocosms on May 8, 14 and 20, 2009 for a total of 15 L to each mesocosm. We covered each mesocosm with 60% shade cloth, secured covers with drawstrings to prevent insect colonization, then allowed them to remain undisturbed until June 7, 2009.

This study was designed to be sublethal to gray treefrog (*Hyla versicolor*) larvae; therefore, the higher chloride concentration used reflected the uppermost limit for successful embryonic and larval survival as determined by Brand et al. [31]. The stormwater ponds used to collect inoculum were representative of those in Red Run Watershed that can support successful amphibian development and survival [23]. We measured specific conductance (µS) and temperature (°C) for each mesocosm 3 times between June 6 and July 21 (study day 0, 24 and 45), 2009 using a YSI-85 handheld probe. Specific conductance of the aged tap water added to each mesocosm before chloride addition was 260 µS (68.5 mg L^{-1} Cl^-) (for chloride-conductivity equation see Karraker [32]). On May 8, 2008 we oven-dried granular sodium chloride (99% NaCl) at 30°C for two hours, then added 89.7 g NaCl to 20 mesocosms receiving the low chloride treatment and 823.8 g NaCl to the remaining 20 mesocosms receiving the high chloride treatment. This resulted in a final chloride concentration of 177.2 mg L^{-1} in 500 L of water and average specific conductance of 675.5±4.3 (SE) µS for the 20 mesocosms receiving the low chloride treatment and a final

Table 1. 2×2×2 factorial design applied to 40 outdoor mesocosms (n = 5 per treatment combination) with a road salt treatment (low or high), tadpole treatment (present or absent) and inoculum treatment (collected from low or high conductance stormwater pond).

Mesocosm #	Road Salt	Tadpoles	Inoculum Source
8,20,22,30,31	Low	Absent	Low
7,14,21,27,35	Low	Present	Low
2,9,16,33,40	Low	Absent	High
3,6,15,29,32	Low	Present	High
5,11,18,24,37	High	Absent	High
1,12,25,34,38	High	Present	High
10,13,17,26,39	High	Absent	Low
4,19,23,27,36	High	Present	Low

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chloride concentration of 1067 mg L^{-1} and average specific conductance of 3016±21.9 (SE) µS for the 20 mesocosms receiving the high chloride treatment.

On May 29, 2009 we collected 5 amplexed pairs of gray treefrogs (*Hyla versicolor*) from a stormwater detention pond in the Red Run Watershed and transported them to UMBC in pond water collected from the breeding site (specific conductance 270 µS). After oviposition was complete, we removed adult treefrogs and allowed the embryos to develop in aquaria until they reached Gosner stage 17 [33]. To mix clutches, we transferred all treefrog larvae into three large plastic bins filled with 50 L of aged tap water (specific conductance 315 µS). Treefrog larvae were reared in these bins until they reached the free feeding stage (Gosner stage 25; [33]). On June 7, 2009 (day 1), we added 30 gray treefrog (*Hyla versicolor*) tadpoles (Gosner stage 25; [33]) to the 20 mesocosms assigned the tadpole treatment.

The first gray treefrog metamorph emerged from the experimental mesocosms at day 25 (July 1, 2009) after tadpole addition to the mesocosms. After emergence of the first metamorph we performed daily checks for metamorphs until the study was terminated at day 54 (July 30, 2009). Upon emergence, all metamorphs were housed in the laboratory at UMBC until tail resorption was complete (Gosner stage 46), at which point all individuals were weighed. On the last day of the study, we collected, measured wet weight and staged [33] any remaining tadpoles in each mesocosm.

We analyzed both periphyton and phytoplankton samples for chlorophyll [a] concentration (µg L^{-1}) using the non-acidified chlorophyll [a] module on a Trilogy fluorometer [34]. On days 3, 24 and 45 (June 9, June 30 and July 21, 2009), we collected periphyton samples from each mesocosm by scraping the entire surface of one ceramic tile and bringing the sample to a total volume of 100 mL using distilled water. We vacuum filtered a 25 mL subsample onto a 47 mm Whatman GF/F [35]. On days 5, 26 and 47 (June 11, July 2 and July 23, 2009), we collected phytoplankton samples by submerging a 1.27 cm diameter PVC tube spanning the entire depth of the water column in three haphazard places within each mesocosm. We then filtered 100 mL of the resulting composite water sample onto a 47 mm Whatman GF/F. We stored all filtered periphyton and phytoplankton samples in 90% acetone in the dark at 4°C for a maximum of 96 hours before analysis.

We collected zooplankton samples on day 47 by submerging a 5.1 cm diameter PVC tube vertically into the water column making sure to sample the entire depth of the mesocosm and collecting 2 L of water. We poured this water sample through a 63 µm sieve and stored zooplankton samples in 80% ethanol. To estimate zooplankton density, we standardized the volume of each mesocosm sample by bringing total volume to 500 mL using distilled water. We homogenized the 500 mL sample by stirring with a plastic pipette, and then viewed 10, 2 mL subsamples under a compound microscope using a 1 mm^2 gridded Sedgewick Rafter. We sorted and counted the zooplankton into the following groups for density estimates: adult copepods, copepod nauplii (juveniles), ostracods, rotifers and daphnia. To estimate zooplankton species composition across treatments, we further identified zooplankton to order or family, and in some occasions to genus and species when possible. For species identification, we brought each sample to a total of 50 mL and viewed 1, 2 mL subsample to generate a species area curve for each mesocosm.

We measured dissolved oxygen (mg L^{-1}) on one sampling date, day 24, using a YSI 20 handheld meter. Although we cannot rule out large changes in dissolved oxygen or pH over the course of the study, our previous research in these artificial pond systems suggested there would be no dramatic shifts in either of these parameters and no systematic shifts with our study treatments [25]. Given the high nitrogen content of waste released by developing tadpoles [36], we also collected water samples on day 45 to obtain nitrate estimates. We filtered water samples using 25 mm Whatman GF/F, prepared samples using LaMotte Nitrogen kits and analyzed for absorbance (AB) using the absorbance module on a Trilogy fluorometer [34]. To obtain final nitrate estimates in mg L^{-1}, we made sodium nitrate standards and created a standard curve of sodium nitrate (g L^{-1}) versus absorbance.

Statistical Analysis

We performed all statistical analyses related to algal biomass and zooplankton density, as well as tadpole time to and mass at metamorphosis, in SAS version 9.1.3 [37]. To determine the effects of the tadpole, chloride and inoculum treatments on phytoplankton and periphyton we used a repeated measures analysis of variance (RMANOVA) with compound symmetry covariance structure to account for any correlation among experimental units. We used a 3-way analysis of variance (ANOVA) to determine the effects of tadpole, chloride and inoculum treatments on zooplankton density. All periphyton, phytoplankton and zooplankton data was $\log_{10}$ transformed to maintain normality and homogeneity of variances. When necessary, we grouped residual variances by treatments using the GROUP option in PROC MIXED following the method of Littell et al. [38]. We performed a logistic regression using PROC GENMOD to assess the impact of the chloride treatment on percent tadpole survival. We used the scale = deviance option within PROC GENMOD to handle over-dispersion of data. Mass at metamorphosis among gray treefrogs was analyzed using analysis of covariance (ANCOVA) with chloride and inoculum treatment modelled as a class variable and time to metamorphosis as a continuous variable. Time to metamorphosis was analyzed using a Generalized Linear Model (GLM) with chloride and inoculum treatment modelled as a class variable and survival as a continuous variable. When survival was found to have no significant effect, time to metamorphosis was analyzed using ANOVA.

To evaluate any effects of the tadpole, chloride and inoculum treatments as well as study day on conductivity, temperature or

dissolved oxygen we performed factorial ANOVA with Type 3 Sums of Squares analyses using the aov() and drop1() functions in R statistical computing environment [39]. To determine if chloride served as an environmental constraint on zooplankton community composition, we also performed analyses in R. We approached analyzing zooplankton community composition in two ways. First, we examined compositional divergence using the adonis() function on a Bray-Curtis dissimilarity matrix. This analysis is a non-parametric permutation MANOVA that determines if dissimilarity was related to the factorial design. Second, since we hypothesized that road salt served as a significant constraint on zooplankton communities, we analyzed turnover, or variation in community structure among mesocoms within and across treatments. This was carried out using the betadisper() function in R, which is an analysis of multivariate homogeneity of group dispersions, an analogue of the univariate Levene's test for homogeneity of variance [40]. If the presence of deicer is an environmental filter, variation in community structure, or taxonomic turnover, should be lower among mesocosms receiving road deicer. This procedure is a permutation test based on 999 randomizations, resulting in a p-value associated with an F-test comparing the two salt treatment groups. Results were visualized using non-metric multidimensional scaling based on the Bray-Curtis dissimilarity matrix. Points closer together represent communities more similar in taxonomic composition than those further apart.

Results

Abiotic Environmental Variables

Specific conductance (µS) in both the low and high chloride treatments remained stable over the duration of the study, with some minor dilution across the study period due to periods of heavy rainfall (Low = 568±6.7 (SE) µS; High = 2856±14.7 (SE) µS). Mean specific conductance (µS) and water temperature (°C) measured three times between days 0 and 45 are reported in Table 2 along with dissolved oxygen (mg L^{-1}) as measured once on day 24 and nitrate (mg L^{-1}) values measured on day 45 (Table 2; Table S1). There were only nominal concentrations of nitrate present in the mesocosms at the end of the study.

Table 2. Mean abiotic environmental variables measured in all mesocosms (n = 20 per chloride treatment) from study days 0–47± standard error.

	Chloride Treatment	
Environmental Variable	**Low**	**High**
Specific Conductance (µS)		
Day 0	675.5±4.3	3016±28.7
Day 24	536.5±3.1	2815±16.8
Day 45	513.8±2.9	2705±16.9
Water Temperature (°C)		
Day 0	22.2±0.1	21.9±0.1
Day 24	25.5±0.1	25.5±0.0
Day 45	26.3±0.1	25.8±0.1
Nitrates (mg/L)		
Day 45	<0.003	<0.004
Dissolved Oxygen (mg/L)		
Day 24	5.2±0.2	5.3±0.2

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Phytoplankton and Periphyton Biomass

Phytoplankton was 29% more abundant in the high chloride treatment relative to the low chloride treatment (RMANOVA chloride main effect; Table 3; Table S2) and 53% greater in mesocosms receiving inoculum from the high conductance stormwater ponds as compared to ponds receiving inoculum from the low conductance stormwater ponds (RMANOVA inoculum main effect; Table 3, Fig. 1A). Neither the tadpole treatment (RMANOVA tadpole main effect; Table 3) nor sampling date (RMANOVA sampling date main effect; Table 3) had a significant main effect on phytoplankton biomass. There was a significant 3-way interactive effect of chloride treatment, inoculum source and sampling date on phytoplankton (RMANOVA chloride x inoculum x date effect $F = 4.68_{2,64}$; $P = 0.0126$). On the first sampling date, phytoplankton biomass was much lower in the low chloride, low inoculum treatment relative to all other chloride and inoculum treatments (mean phytoplankton biomass: day 1 low chloride, low inoculum = 9.11 µg L^{-1}; low chloride, high inoculum = 28.28 µg L^{-1}; high chloride, high inoculum = 23.62 µg L^{-1}; high chloride, low inoculum = 27.25 µg L^{-1}). This trend continued throughout the second and third sampling dates for the low chloride, low inoculum treatment relative to the high chloride, high inoculum treatment (mean phytoplankton biomass: day 2 low chloride, low inoculum = 12.72 µg L^{-1}; high chloride, high inoculum = 28.14 µg L^{-1}; day 3 low chloride, low inoculum = 11.13 µg L^{-1}; high chloride, high inoculum = 18.53 µg L^{-1}).

Periphyton biomass was 15% greater in the low chloride treatment than the high chloride treatment (RMANOVA chloride effect; Table 3; Table S3). In the mesocosms where tadpoles were present, periphyton biomass was 28% lower than in the mesocosms without tadpoles (RMANOVA tadpole effect; Table 3). Inoculum source had no significant effect (RMANOVA inoculum effect; Table 3, Fig. 1B). Periphyton biomass differed by sampling date (RMANOVA sampling date effect; Table 3) and there was a significant interaction between tadpole treatment and sampling date (RMANOVA tadpole x sampling date effect $F = 7.67_{2,64}$; $P = 0.001$). Periphyton was least abundant mid-way through the study on June 30 (day 24), and this decline was most apparent in the mesocosms receiving high chloride, tadpoles and high conductance inoculum treatment (mean periphyton biomass: day 2 = 216.64±17.61 (SE) µg L^{-1}; day 24 = 86.52±30.74 (SE) µg L^{-1}; day 45 = 95.26±21.37 (SE) µg L^{-1}day).

Zooplankton Density & Community Composition

Total zooplankton density was significantly affected by the chloride treatment (ANOVA chloride effect; Table 3) but not by the tadpole (ANOVA tadpole effect; Table 3) or inoculum (ANOVA inoculum effect; Table 3) treatments. Total zooplankton density was 80% greater in the high chloride treatment relative to the low chloride treatment, largely due to an overwhelming abundance of rotifers in the high chloride treatment (see details on community composition below). None of the interactive effects between chloride, tadpole and inoculum treatments were significant with respect to total zooplankton density (ANOVA; Table 3).

Across all treatments, we identified four rotifer families and 2 genera (family Brachionidae (genus *Brachionus* and *Keratella*), Synchaetidae, Notommatidae and Lecanidae), two copepod orders (Harpacticoid and Copepoid) and four families of cladocerans belonging to seven genera (family Sididae (genus *Diphanosoma*), Daphniidae (genus *Ceriodaphnia*, *Simocephalus*, *Scapholeberis* and *Daphnia*), Chydoridae (genus *Chydrous*) and Moinidae (genus *Moina*))

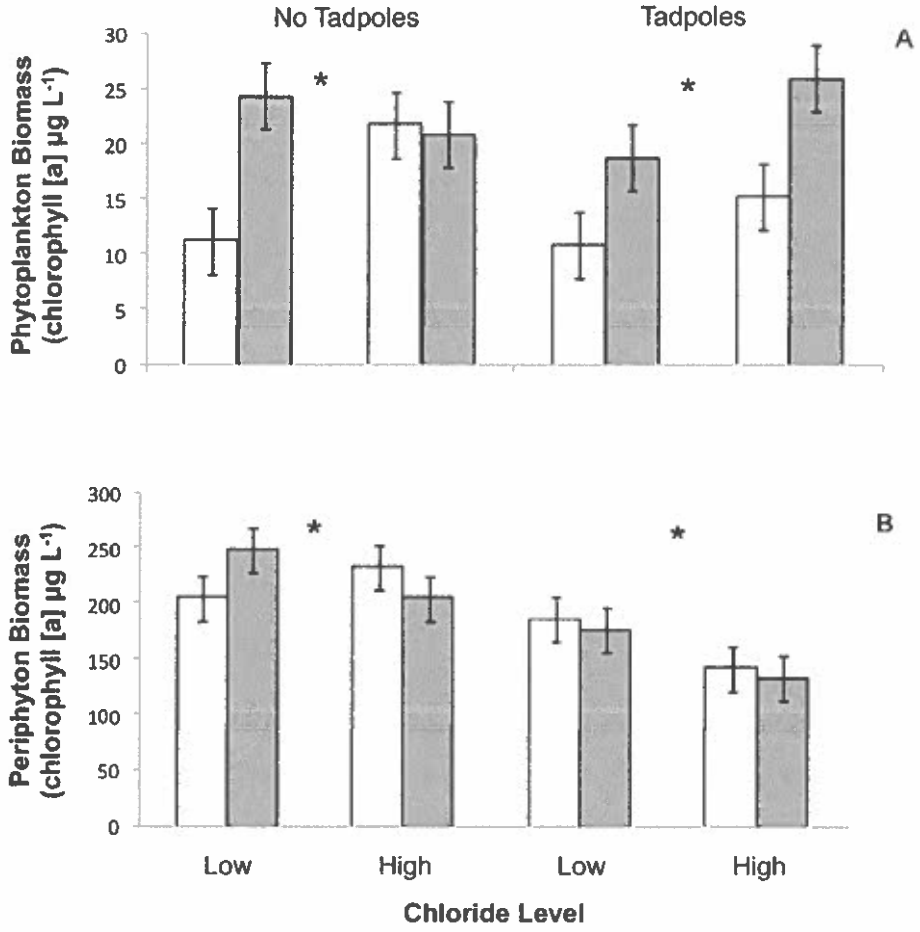


Figure 1. Mean phytoplankton (A) and periphyton (B) biomass (measured as chlorophyll [a] concentration in µg L^{-1}) across chloride (low/high), tadpole (absent/present) and pond inoculum conductance level (low/high) treatments (n = 5 per treatment combination) over the duration of the study. Open bars represent low pond inoculum conductance levels and shaded bars represent high pond inoculum conductance levels. Asterisks indicate a statistically significant difference ($p<0.05$) between low and high chloride treatments using RMANOVA. Error bars represent standard error.
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(Table S4). We did not identify ostracods or copepod nauplii (juveniles) beyond order. The zooplankton community in the high chloride treatment was dominated (93% of total zooplankton) by the rotifer family Brachionidae (3586 individuals belonging to family Brachionidae out of 3853 total zooplankton individuals counted in the high chloride treatment) (Fig. 2). Within this family, *Brachionus plicatilus*, a species common to salt and brackish waters [41], was the most abundant (data not shown). In contrast, the Brachionidae only accounted for 27% of total zooplankton community composition in the low chloride treatment (103 individuals belonging to family Brachionidae out of 379 total zooplankton individuals counted in the low chloride treatment). Ostracods, cladocerans, copepod adults and nauplii and other rotifers were much more abundant in the low chloride treatment relative to the high chloride treatment (Fig. 2).

The addition of chloride to the mesocosms resulted in a significant divergence in zooplankton community composition (chloride effect $F_{1,36} = 22.5$; $P = 0.001$). However, neither the inoculum source nor the tadpole treatment played a role in driving zooplankton community composition (inoculum effect $F_{1,36} = 1.32$; $P = 0.204$ and tadpole effect $F_{1,36} = 1.04$; $P = 0.320$). Similarly, there were no interactive effects between the chloride, tadpole and inoculum source treatments on the zooplankton community (all 2- and 3-way interactions $P > 0.05$).

Zooplankton community composition within chloride treatments was much more similar (Bray-Curtis index High:High = 0.468; Low:Low = 0.666) than between chloride treatments (Bray-Curtis index values High:Low = 0.886). Furthermore, there was a significant difference in zooplankton species turnover between the high and low chloride treatments ($F_{1,35} = 9.764$; $P = 0.003$) suggesting high chloride served as a strong environmental constraint on taxon membership among mesocosms, and thus lower compositional turnover rate (Fig. 3). NMDS analysis results in 3-axes requiring an acceptable stress level of 0.159. Axis 1 is plotted against axes 2 and 3 separately, as visualizing axes 2 vs 3 is redundant.

Tadpoles Survival, Mass at and Time to Metamorphosis

Average gray treefrog survival across all mesocosms was 90%. Neither chloride (X^2 df = 1; $P = 0.3175$) nor inoculum (X^2 df = 1; $P = 0.8853$) had an effect on survival. Mass at and time to metamorphosis were not affected by survival when used as a covariate, therefore survival was removed from the final analysis (Table S5). There was no significant effect of chloride, inoculum or

Table 3. Repeated measures analysis of variance (RMAVNOVA) with compound symmetry covariance structure on mean values of log_{10} transformed phytoplankton abundance and periphyton abundance and analysis of variance (ANOVA) on mean values of log_{10} transformed total zooplankton density.

	Dependent Variable		
Effect	**Phytoplankton**	**Periphyton**	**Total Zooplankton**
Chloride			
df	1,32	1,32	1,32
F	4.31	4.19	20.56
P	**0.046**	**0.049**	**<0.0001**
Tadpole			
df	1,32	1,32	1,3
F	1.64	27.35	0.41
P	0.209	**<0.0001**	0.525
Inoculum			
df	1,32	1,32	1,32
F	14.6	0.04	0.40
P	**<0.001**	0.848	0.533
Chloride x Tadpole			
df	1,32	1,32	1,32
F	0.00	2.56	3.63
P	0.999	0.119	0.066
Chloride x Inoculum			
df	1,32	1,32	1,32
F	3.23	2.15	0.00
P	0.082	0.152	0.999
Tadpole x Inoculum			
df	1,32	1,32	1,32
F	0.03	0.72	0.01
P	0.862	0.401	0.937
Chloride x Tadpole x Inoculum			
df	1,32	1,32	1,32
F	1.34	0.43	1.67
P	0.256	0.517	0.206
Sampling Date			
df	2,64	2,64	–
F	1.9	10.69	–
P	0.1581	**<0.0001**	–

df = degrees of freedom; *F* = f-ratio; *P* = p-value; values in bold indicate statistical significance ($p<0.05$).

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the interaction between chloride and inoculum (chloride effect, inoculum effect, chloride x inoculum effect; Table 4) on days to metamorphosis.

When days to metamorphosis was used as a covariate, there was a significant effect of both chloride (chloride effect; Table 4) and the interaction between chloride and days to metamorphosis (chloride x days to metamorphosis effect; Table 4) on mass at metamorphosis. The higher chloride concentration in the mesocosms increased mass at metamorphosis by 8.5%. This chloride effect was only significant, however, for tadpoles experiencing a faster time to metamorphosis (25^{th} percentile = 46.65 days to metamorphosis). Among tadpoles experiencing faster time to metamorphosis, the average mass of metamorphs in the high chloride treatment was 326±18.2 (SE) mg and 270±18.0 (SE) mg in the low chloride treatment. This chloride effect was not significant for tadpoles reaching metamorphosis at or beyond the average number of days (average = 49.12 days; average mass in high chloride = 318±13.9 (SE) mg, low chloride = 295±13.8 (SE) mg; 75^{th} percentile = 51.63 days; average mass in high chloride = 309±16.2 (SE) mg, low chloride = 321±18.0 (SE) mg). The inoculum treatment had no significant main or interactive effects on gray treefrog mass at metamorphosis (Table 4).

Discussion/Conclusions

Road salt run-off in urban areas has been documented as a pollutant source to freshwater ecosystems [17] and associated lethal and sublethal impacts to aquatic organisms continue to emerge [25,29,31–32,42–46]. Our study highlights the potential

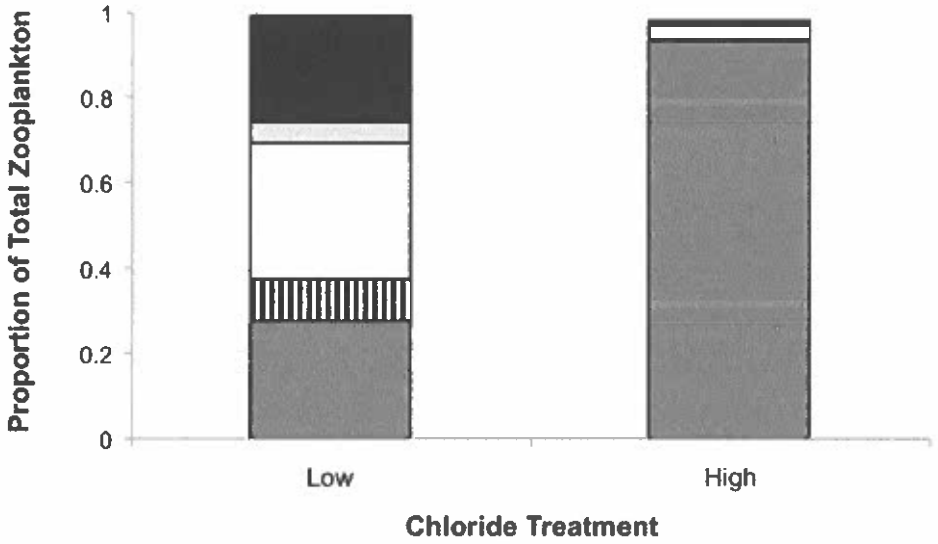
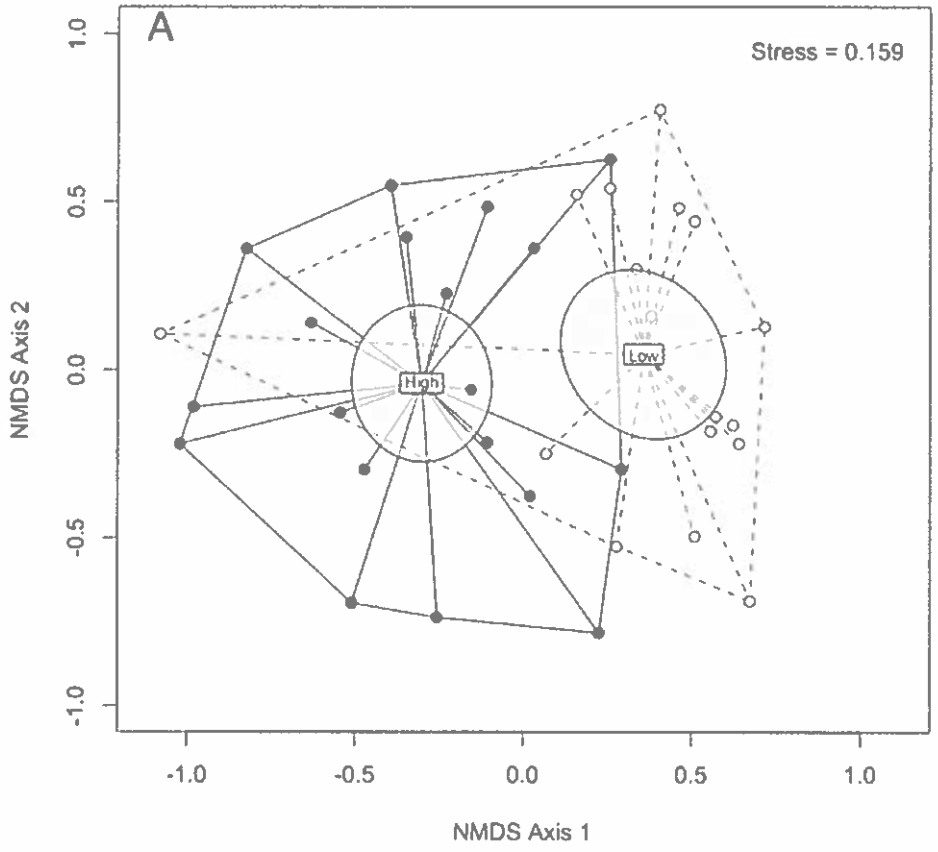


Figure 2. Zooplankton class or family as a proportion of total count across high and low chloride treatments. Dark gray bars represent the rotifer family Branchionidae, striped bars represent all other rotifers, open bars represent copepods, light gray bars represent ostracods and black bars represent cladocerans.
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for chloride salts to act as a significant environmental constraint on pond communities experiencing different specific conductance or road salt concentrations by limiting the aquatic community to more tolerant species. As predicted, the changes in phytoplankton biomass, zooplankton community composition and, to a smaller extent, the tadpole mass at metamorphosis results we obtained from our experimental mesocosm work does support the likelihood of environmental filtering in urban ponds by chloride salts. Furthermore, through identifying zooplankton taxa by colonist pool and across chloride treatments, our research emphasizes the role that tolerance to perceived environmental stressors plays in shaping impacted communities and in eliciting both direct and indirect effects within an aquatic food web. Chloride road salts, an emerging local environmental filter, may alter community composition and structure by presenting novel physiochemical conditions in typical freshwater habitats where species tolerances and thresholds are exceeded beyond their capacity for adaptation.

Our earlier surveys of stormwater ponds in the Red Run watershed, Owings Mills, Baltimore County, Maryland [29] revealed greater algal biomass in stormwater ponds across an increasing chloride gradient; this concurs with our current phytoplankton data. Relative to the low chloride treatment, phytoplankton biomass in the high chloride treatment was 29% greater in our experimental mesocosms. Furthermore, phytoplankton biomass was 53% greater in mesocosms that received the inoculum from higher conductance stormwater ponds in the Red Run watershed. Although we did not identify phytoplankton by class or species, we hypothesize that the phytoplankton communities developing in our mesocosms were filtered or sorted by their ability to acclimate to or tolerate high chloride loads. At concentrations even lower than those used in our study, salinity was identified as the main environmental driver of phytoplankton community composition and biomass in artificial sea salt-harvesting ponds in Tunisia [47]. Hypersaline ponds were dominated by phytoplankton class Chlorophyceae, a halophilic type of green algae. At its peak in 2003, phytoplankton biomass ranged from 2.5–12.5 times greater in a high salinity pond relative to the 3 lowest salinity ponds. Due to extreme saline conditions, phytoplankton communities in the hypersaline ponds were considered mature to the point of competitive exclusion [47]. Similarly, conductivity was reported as one of five major local environmental factors in predicting phytoplankton community structure in ponds in Belgium [11]. The conductivity range of these ponds was low relative to the conductivity we established in our experimental ponds. In considering community shifts in ponds with specific conductance values that closely resemble both our high and low chloride treatments, Olding [28] documented the dominance of marine and brackish water diatoms (e.g., *Caloneis amphibaena, Entomeoneis alata*) in a high conductance stormwater pond in Ontario, Canada while a lower conductance pond was dominated by nutrient tolerant taxa (e.g., *Euglena*). Pilkaityte et al. [48] found that sodium chloride shifts phytoplankton communities in favor of filamentous cyanobacteria at much higher salinities than those used in our study. Shifts in algal community structure and physiological parameters should be measured in future studies of algal resources experiencing salt stress. Given that species sorting toward tolerant taxa has been reported in a variety of studies at salinities both above and below those used here, is likely that salt stress contributed substantially to increases in phytoplankton biomass measured in our study.

Previous research exploring algal resources in stormwater ponds indicates that variation in tolerance to chloride inputs exists among species [27–28]. Differing from our predictions, we measured significantly greater periphyton biomass under low chloride conditions, regardless of inoculum source. These results do not indicate that chloride salts act as an environmental filter on periphyton in urban stormwater ponds, but likely reflect an observed interaction between phytoplankton and periphyton resources where abundant phytoplankton blooms can indirectly reduce periphyton biomass through shading effects [49]. Given that there was no significant interactive effect between chloride and tadpoles treatments, this precludes heavier tadpole grazing in high chloride treatments as a likely explanation for reduced periphyton biomass. To determine whether periphyton resources are declining as an indirect result of phytoplankton shading or through direct negative effects of elevated chloride and associated


A
Stress = 0.159
High
Low
NMDS Axis 2
NMDS Axis 1
1.0
0.5
0.0
-0.5
-1.0
-1.0
-0.5
0.0
0.5
1.0

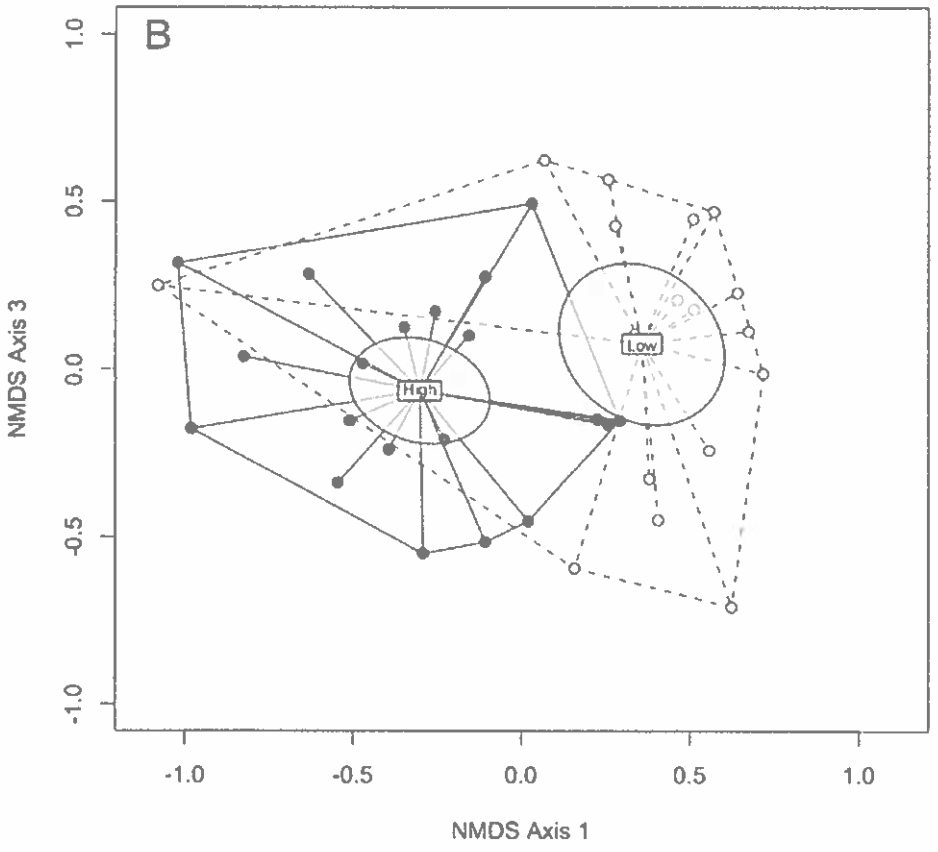

B
High
Low
NMDS Axis 3
NMDS Axis 1
1.0
0.5
0.0
-0.5
-1.0
-1.0
-0.5
0.0
0.5
1.0

Figure 3. Non-metric multi-dimensional scaling (NMDS) results representing mesocosms receiving high (filled points) and low (open points) chloride. Points closer together indicate higher taxonomic similarity than those further apart. Centroids for each treatment reside under the "High" and "Low" labels. The shaded areas are the 95% confidence ellipses for the centroids. Each treatment group is bounded by the convex hull to aid in visualizing compositional spread about the centroids. The NMDS required three axes to produce a satisfactory stress (0.159). Therefore, axis 1 vs 2 (A) and 1 vs 3 (B) are portrayed. Note the scales of each are the same.
doi:10.1371/journal.pone.0090168.g003

filtering, it would be necessary to study these algal resources in mesocosms independent of one another. However, this is logistically very difficult.

Filtering of zooplankton communities from salt loading in aquatic systems has been well documented in recent studies. Research on zooplankton assemblages from the Patuxent Wildlife Research Center (PWRC), Laurel, Maryland, a relatively pristine habitat, showed that elevated chloride levels (645 mg L^{-1} Cl^{-} = 2200 µS) were most harmful to adult copepods and cladocerans, however, copepod nauplii, ostracods and rotifers were unaffected [25]. Stormwater pond survey results showed that zooplankton densities differ across a chloride gradient with several taxa (ostracods, rotifers and cladocerans) colonizing medium conductance ponds (mean specific conductance ~1150–2150 µS) at greater densities relative to high conductance ponds (mean specific conductance ~ 6090–8370 µS; [29]). Zooplankton results from this study follow similar trends indicating that certain rotifers, particularly those belonging to family Branchionidae, proliferate under moderate conductance levels (~3000 µS). Likewise, experimental research with wetland sediments from South Australia that were artificially flooded with a range of fresh to saline waters (300–15,000 mg L^{-1} salinity) resulted in substantially different zooplankton communities after a 21-day incubation period [50]. Sediments with higher natural salinities developed similar zooplankton communities to one another regardless of overlying water salinity, while the sediment with low natural salinity produced distinct communities with lower zooplankton species richness under more saline conditions. As confirmed by our study, more salt-tolerant zooplankton, such as the rotifer *Brachionus plicatilus* (Family Brachionidae), were most abundant in the microcosms containing high salinity sediments and water [50].

Tolerance thresholds to chloride salts differ greatly among zooplankton taxa and are known to serve as an important variable in determining zooplankton community composition and species richness. Previous research in southern France indicates that copepods are quite tolerant of high salinity conditions in temporary wetlands as 29% of cladoceran species recorded were found in high salinity waters [7]. Some cladoceran species are known as sensitive to the chloride concentrations similar to our low chloride treatment [51–52] while others are much more tolerant of elevated chloride levels [7,53–55]. Bilkovic et al. [56] reported significant increases in total zooplankton densities in meso-

Table 4. Analysis of variance (ANOVA) on mean values of gray treefrog (*Hyla versicolor*) days to metamorphosis and analysis of covariance (ANCOVA) on mean values of mass at metamorphosis with days to metamorphosis as covariate.

	Dependent Variable	
Effect	**Days to Metamorphosis**	**Mass at Metamorphosis**
df	1,16	1,12
Chloride		
F	0.06	5.83
P	0.808	**0.033**
Inoculum		
F	0.48	2.47
P	0.498	0.142
Chloride x Inoculum		
F	0.00	4.00
P	0.996	0.069
Days to Metamorphosis		
F	–	1.62
P	–	0.228
Chloride × Days to Metamorphosis		
F	–	5.4
P	–	**0.039**
Inoculum × Days to Metamorphosis		
F	–	2.46
P	–	0.143
Chloride × Inoculum × Days to Metamorphosis		
F	–	4.06
P	–	0.067

df = degrees of freedom; *F* = f-ratio; *P* = p-value; values in bold indicate statistical significance ($p<0.05$); values in bold indicate statistical significance ($p<0.05$).
doi:10.1371/journal.pone.0090168.t004

oligohaline marshes after substantial periods of rainfall and subsequently lower salinities. While this increase in density was primarily due to proliferation of calanoid copepods under more freshwater conditions, cyclopoid copepods and cladoceran densities also increased. In two interrelated mesocosms studies, Nielson et al. [57–58] reported that with salinity increases (up to 15,000 mg L^{-1} sea salt), the developing zooplankton communities diverged greatly from the original freshwater species pool and ultimately resulted in domination by a small number of salt-tolerant species. As salinity levels in these artificial ponds were subsequently decreased (<2500 mg L^{-1} sea salt), zooplankton communities became increasingly similar with more taxa representative of freshwater systems. While freshwater zooplankton eggs can remain dormant under extremely elevated chloride levels and later successfully hatch, success of freshwater zooplankton is fully dependant on a return to lower salinity levels. Given substantial variability in tolerance to chloride salts among zooplankton, species composition is likely to differ within urban aquatic ecosystems experiencing perpetual road salt contamination and relative to more pristine habitats.

While there is strong evidence of direct effects of road salts in shaping the zooplankton community, indirect effects of salt on zooplankton and phytoplankton may also be prevalent in our study given that zooplankton are grazers of phytoplankton. Under elevated chloride conditions, tolerant phytoplankton species may have shaped the zooplankton community by providing species-specific preferred food resources. Conversely, chloride filtering among the zooplankton community may have indirectly resulted in dominance of non-preferred algal resources, thus accounting for increases in algal biomass under elevated salt conditions through a release in grazing pressure. A shift in community composition in stormwater ponds towards more tolerant taxa, whether propagated through direct or indirect effects, is likely given the temporal variation of chloride inputs and fluctuating hydrologic regime.

Much like zooplankton communities, research on the impacts of road salt deicers on tadpole grazers has revealed differential susceptibility among species. Early spring breeding Wood frog tadpoles (*Rana sylvatica*) have relatively low survival in the presence of road salts [23,45] while later spring and summer breeding green frog tadpoles (*Rana clamitans*) have high survival rates [32]. Gray treefrogs (*Hyla versicolor*), the species used in our study, experience very low embryonic survival at chloride levels exceeding 1050 mg L^{-1} Cl- (~ 3000 µS; [31]). However, gray treefrog larvae that persist during these early developmental stages do have high survival rates as they develop through metamorphosis in high salt concentrations [31]. Furthermore, these individuals reared under elevated chloride conditions experience faster time to and larger size at metamorphosis [25,31]. We obtained gray treefrog embryos for these previous studies from PWRC which is a rather pristine and protected environment. Since the treefrogs used in the current study were obtained from stormwater detention ponds and presumably experience more consistent exposure to road salt inputs, we predicted that gray treefrogs living in or near stormwater detention ponds in urban areas would be better adapted to elevated chloride concentrations. As a result, changes in the time to and size at metamorphosis would only be apparent if elevated chloride inputs directly reduced the competing zooplankton population, thereby indirectly providing tadpole grazers with access to greater algal resources.

The urban gray treefrog population used in our study appears to be tolerant to elevated chloride road salt concentrations as common to stormwater detention ponds. Neither chloride nor inoculum treatment had direct effects on tadpole survival or mass at metamorphosis among gray treefrogs in the current study. Tadpoles in the high chloride treatment that metamorphosed quickly (within the 25th percentile of days to metamorphosis) had a greater mass relative to those individuals at the average or greater than the average number of days to metamorphosis. This concurs with previous work [25,31] and is unusual as frogs typically exhibit a trade-off between mass at and time to metamorphosis in which those that undergo metamorphosis early are usually smaller in size [59]. From previous research [25], we speculated that tadpoles developing under chloride salt stress had access to more abundant algal resources as a result of declines in zooplankton density. We cannot preclude the possibility of competitive release between tadpole and zooplankton grazers as a possible mechanism resulting in the greater size at metamorphosis in the high chloride treatment as seen in this study. Zooplankton belonging to family Brachionidae may not serve as strong competitors for gray treefrog tadpole preferred algal resources, but it is difficult to determine the magnitude of this interaction since our study was not designed with this species-specific competitive interaction in mind. Another possible explanation for increases size at metamorphosis is an osmoregulatory shift in tadpoles reared in the high chloride treatment. It is likely that chloride addition created a more isosmotic environment for the developing gray treefrog tadpoles, which are typically hyperosmotic to the surrounding aquatic environment [36]. Under isomotic conditions, tadpoles might redirect energy away from osmoregulation and redirect that energy towards feeding and growth. Given serious concerns about the long-term survival of amphibians in a human-dominated landscape [60], studies that evaluate road salt effects across generations and in combination with other biotic and abiotic stressors is strongly encouraged.

Environmental constraints, such as that due to chloride road salts, contribute substantially to the formation and development of urban aquatic communities and will play increasingly larger roles in developing urban ecosystems. Tolerance among urban pond dwelling organisms may be critical to their long-term survival in a constantly changing environment. Gaining a better understanding of tolerance thresholds and adaptive responses to pollutants in urban stormwater pond habitats will be important in evaluating potential changes in competitive and predatory interactions between and within trophic levels. As chloride salt loading in urban ponds fluctuates over time, dominant species within a community may oscillate in correspondence with environmental conditions and tolerance levels. Despite the fact that wetland acreage continues to decline across the globe [61–62] and urban ponds are compromised by high contaminant loads, these unique aquatic communities persist. With continued salinization of freshwaters, community composition may be shifted away from freshwater species and towards more brackish or marine species, thereby permanently altering the species pool in urban aquatic habitats.

Supporting Information

Table S1 Environmental variables across treatments and study days.
(DOC)

Table S2 Phytoplankton biomass on study days 5, 26 and 47.
(DOC)

Table S3 Periphyton biomass on study days 3, 24 and 45.
(DOC)

Table S4 Zooplankton count data.

(XLS)

Table S5 Tadpole metamorphosis data.
(DOC)

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Author Contributions

Conceived and designed the experiments: RJV CMS. Performed the experiments: RJV CMS. Analyzed the data: RJV CMS. Contributed reagents/materials/analysis tools: CMS. Wrote the paper: RJV CMS.

References

1. Leibold MA, Holyoak M, Mouquet N, Amarasekare P, Chase JM et al. (2004) The metacommunity concept: a framework for multi-scale community ecology. Ecology Letters 7: 601–613.
2. Loeuille N, Leibold MA (2008) Evolution in metacommunities: On the relative importance of species sorting and monopolization in structuring communities. Amer Nat 171(6): 788–799.
3. Steiner CF, Leibold MA (2004) Cyclic assembly trajectories and scale-dependent productivity- diversity relationships. Ecology 85(1): 107–113.
4. Urban MC (2004) Disturbance heterogeneity determines freshwater metacommunity structure. Ecology 85(11): 2971–2978.
5. Lopes PM, Caliman A, Carneiro LS, Bini LM, Esteves FA et al. (2011) Concordance among assemblages of upland Amazonian lakes and the structuring role of spatial and environmental factors. Ecological Indicators 11: 1171–1176.
6. Vanschoenwinkel B, Waterkeyn A, Jocque M, Bovern L, Seaman M et al. (2010) Species sorting in space and time – the impact of disturbance regime on community assembly in a temporary pool metacommunity. J N Am Benthol Soc 29(4): 1267–1278.
7. Waterkeyn A, Grillas P, Vanschoenwinkel B, Brendock L (2008) Invertebrate community patterns in Mediterranean temporary wetlands along hydroperiod and salinity gradients. Freshwater Biol 53: 1808–1822.
8. Medley KA, Havel JE (2007) Hydrology and local environmental factors influencing zooplankton communities in floodplain ponds. Wetlands 27(4): 864–872.
9. Cottenie K, Michels E, Nuytten N, De Meester L (2003) Zooplankton metacommunity structure: Regional vs. local processes in highly interconnected ponds. Ecology 84(4): 991–1000.
10. Soininen J, Weckström J (2009) Diatom community structure along environmental and spatial gradients in lakes and streams. Fundam Appl Limnol 174(3): 205–213.
11. Vanormelingen P, Cottenie K, Michels E, Muylaert K, Vyverman W et al. (2008) The relative importance of disperal and local processes in structuring phytoplankton communities in a set of highly interconnected ponds. Freshwater Biol 53: 2170–2183.
12. Jackson RB, Jobbagy EG (2005) From icy roads to salty streams. Proc Natl Acad Sci USA 102(41): 14487–14488.
13. Howard KWF, Maier H (2007) Road de-icing salt as a potential constraint on urban growth in the Greater Toronto Area, Canada. J Contam Hydrol 91: 146–170.
14. Kelly VR, Lovett GM, Weathers KC, Findlay SEG, Strayer SL et al. (2008) Long-term sodium chloride retention in a rural watershed: legacy effects of road salt on streamwater concentration. Environ Sci Technol 42: 410–415.
15. Mullaney JR, Lorenz DL, Arntson AD (2009) Chloride in groundwater and surface water in areas underlain by the glacial aquifer system, northern United States. U.S. Geological Survey Scientific Investigations Report 2009–5086, 41.
16. National Research Council (2008) Report: Urban stormwater management in the United States. The National Academies Press, Washington, DC.
17. Kaushal SS, Groffman PM, Likens GE, Belt KT, Stack WP et al. (2005) Increased salinization of fresh water in the northeastern United States. Proc Natl Acad Sci USA 102(38): 13517–13520.
18. Bishop CA, Struger J, Barton DR, Shirose LJ, Dunn L et al. (2000) Contamination and wildlife communities in stormwater detention ponds in Guelph and the Greater Toronto Area, Ontario, 1997 and 1998 Part I – Wildlife Communities. Water Qual Res J Canada 35(3): 399–435.
19. Bishop CA, Struger JS, Shirose JL, Dunn L, Campbell DG (2000) Contamination and wildlife communities in stormwater detention ponds in Guelph and the Greater Toronto Area, Ontario, 1997 and 1998 Part II – Contamination and biological effects of contamination. Water Qual Res J Can 35(3): 437–474.
20. Blackwell BF, Schafer LM, Helon DA, Linnell MA (2008) Bird use of stormwater-management ponds: Decreasing avian attractants on airports. Landscape Urban Plann 86(2): 162–170.
21. Brand AB, Snodgrass JW (2010) Value of artificial habitats for amphibian reproduction in altered landscapes. Conserv Biol 24(1): 295–301.
22. Foltz SJ, Dodson SI (2009) Aquatic Hemiptera community structure in stormwater retention ponds: a watershed land cover approach. Hydrobiologia 621: 49–62.
23. Gallagher M (2009) Wood frog (*Rana sylvatica*) use and reproductive success in stormwater ponds of varying contaminant levels. MS Thesis, Towson University, Department of Biological Sciences, Towson, Maryland, USA.
24. Woodcock TS, Monaghan MC, Alexander KF (2010) Ecosystem characteristics and summer secondary production in stormwater ponds and reference wetlands. Wetlands 30: 461–474.
25. Van Meter RJ, Swan CM, Leips J, Snodgrass JW (2011) Road salt stress induces novel food web structure and interactions. Wetlands 31: 843–851.
26. Petranka WJ, EJ Doyle (2010) Effects of road salts on the composition of seasonal pond communities: can the use of road salts enhance mosquito recruitment? Aquat Ecol 44: 155–166.
27. Jose de Paggi S, Paggi P, Collins P, Collins J, Bernal G (2008) Water quality and zooplankton composition in a receiving pond of the stormwater runoff from an urban catchment. J Environ Biol 29(5): 693–700.
28. Olding DD (2000) Algal communities as a biological indicator of stormwater management pond performance and function. Water Qual Res J Canada 35(3): 489–503.
29. Van Meter RJ, Swan CM, Snodgrass JW (2011) Salinization alters ecosystem structure in urban stormwater detention ponds. Urban Ecosystems 14: 723–736.
30. Gallagher MT, Snodgrass JW, Ownby DR, Brand AB, Casey RE (2011) Watershed-scale analysis of pollutant distributions in stormwater management ponds. Urban Ecosystems 14(3): 469–484.
31. Brand A, Snodgrass J, Gallagher M, Casey R, Van Meter R (2010) Lethal and sublethal effects of embryonic and larval exposure of *Hyla versicolor* to stormwater pond sediments. Arch Environ Contam Toxicol 58(2): 325–331.
32. Karraker NE (2007) Investigation of the amphibian decline phenomenon: novel small-scale factors and a large-scale overview. Ph.D. dissertation, State University of New York, College of Environmental Science and Forestry, Syracuse, New York, USA.
33. Gosner KL (1960) A simplified table for staging anuran embryos and larvae with notes on identification. Herpetologica 16: 183–190.
34. Turner Designs (2006) Trilogy Laboratory Fluorometer User's Manual. Version 1.1. P/N 998-7210, 38. Sunnyvale, CA.
35. Hauer FR, Lamberti GA, eds (2006) *Methods in Stream Ecology*, 2nd Edn. Academic Press, San Diego, CA.
36. McDiarmid RW, Altig R, eds (1999) *Tadpoles: The Biology of Anuran Larvae*. The University of Chicago Press, Chicago.
37. SAS Institute Inc., SAS 9.1.3 Help and Documentation, Cary, NC: SAS Institute Inc., 2000–22004.
38. Littell RC, Milliken GA, Stroup WW, Wolfinger RD, Cary NC (1996) SAS Systems for mixed models. SAS Institute Inc., 633.
39. R Development Core Team (2011) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.
40. Anderson MJ, Ellingsen KE, McArdle BH (2006) Multivariate dispersion as a measure of beta diversity. Ecology Letters 9(6): 683–693.
41. Thorp JH, Covich AP, eds (2001) Ecology and classification of North American freshwater invertebrates. Academic Press, San Diego.
42. Blasius BJ, Merrit RW (2002) Field and laboratory investigations on the effects of road salt (NaCl) on stream macroinvertebrate communities. Environ Pollut 120: 219–231.
43. Benbow ME, Merritt RW (2004) Road-salt toxicity of select Michigan wetlands macroinvertebrates under different testing conditions. Wetlands 21(1): 68–76.
44. Dougherty CK, Smith GR (2006) Acute effects of road de-icers on the tadpoles of three anurans. App Herpetol 3: 87–93.
45. Sanzo D, Hecnar H (2006) Effects of road de-icing salt (NaCl) on larval wood frogs (*Rana sylvatica*). Environ Pollut 140: 247–256.
46. Snodgrass JW, Casey RE, Joseph D, Simon JA (2008) Microcosm investigation of stormwater pond sediment toxicity to embryonic and larval amphibians: Variation in sensitivity among species. Environ Pollut 154(2): 291–297.
47. Khemakhem H, Elloumi J, Moussa M, Aleya L, Ayadi H (2010) The concept of ecological succession applied to phytoplankton over four consecutive years in five ponds featuring a salinity gradient. Estuarine, Coastal and Shelf Science 88: 33–44.
48. Pilkaityte R, Schoor A, Schubert H (2004) Response of phytoplankton communities to salinity changes – a mesocosm approach. Hydrobiologia 513: 27–38.
49. Hansson LA (1988) Effects of competitive interactions on the biomass development of planktonic and periphytic algae in lakes. Limnol Oceanogr 33(1): 121–128.
50. Torunn RL (2012) Zooplankton community emerging from fresh and saline wetlands. Ecohydrology and Hydrobiology 12: 53–63.
51. Harmon SM, Specht WL, Chandler GT (2003) A comparison of the Daphnids *Ceriodaphnia dubia* and *Daphnia ambigua* for their utilization in routine toxicity

testing in the Southeastern United States. Arch Environ Contam Toxicol 45: 79–85.
52. Elphick JRF, Bergh KD, Bailey HD (2011) Chronic toxicity of chloride to freshwater species: Effects of hardness and implications for water quality guidelines. Environ Toxicol Chem 30: 239–246.
53. Lilius H, Hastbacka T, Isomaa B (1995) A comparison of the toxicity of 30 reference chemicals to *Daphnia magna* and *Daphnia pulex*. Environ Toxicol Chem 14(12): 2085–2088.
54. Environment Canada (2001) Priority substances list assessment report on road salts under the Canadian Environmental Protection Act.
55. Sarma SSS, Nandini S, Morales-Ventura J, Delgado-Martinez I, Gonzalez-Valverde L (2006) Effects of NaCl salinity on population dynamics of freshwater zooplankton (rotifers and cladocerans). Aquat Ecol 40: 349–360.
56. Bilkovic DM, Mitchell MR, Hersnher CH, Havens KJ (2012) Transitional wetland faunal community characterization and response to precipitation-driven salinity fluctuations. Wetlands 32: 425–437.
57. Nielsen DL, Brock MA, Vogel M, Petrie R (2008) From fresh to saline: a comparison of zooplankton and plant communities developing under a gradient of salinity with communities developing under constant salinity levels. Mar Freshwater Res. 58. : 549–559.
58. Nielsen DL, Smith D, Petrie R (2012) Resting egg banks can facilitate recovery of zooplankton communities after extended exposure to saline conditions. Freshwater Biol 57: 1306–1314.
59. Wilbur HM, Collins JP (1973) Ecological aspects of amphibian metamorphosis. Science 182: 1305–1314.
60. Hamer AJ, McDonnell MJ (2008) Amphibian ecology and conservation in the urbanising world: A review. Biol Conserv 141: 2432–2449.
61. Dahl TE (1990) Wetlands: losses in the United States 1780's to 1980's. U.S. Fish and Wildlife Service, Biological Services Program, Washington, D.C.
62. Environmental Protection Agency (EPA) (2001) Growth and Water Quality Fact Sheet, EPA 842-F-01-007.

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Salty fertile lakes: how salinization and eutrophication alter the structure of freshwater communities

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Abstract. The quality of freshwater ecosystems is decreasing worldwide because of anthropogenic activities. For example, nutrient over-enrichment associated with agricultural, urban, and industrial development has led to an acceleration of primary production, or eutrophication. Additionally, in northern areas, deicing salts that are an evolutionary novel stressor to freshwater ecosystems have caused chloride levels of many freshwaters to exceed thresholds established for environmental protection. Even if excess nutrients and road deicing salts often contaminate freshwaters at the same time, the combined effects of eutrophication and salinization on freshwater communities are unknown. Thus by using outdoor mesocosms, we investigated the potentially interactive effects of nutrient additions and road salt (NaCl) on experimental lake communities containing phytoplankton, periphyton, filamentous algae, zooplankton, two snail species (*Physa acuta* and *Viviparus georgianus*), and macrophytes (*Nitella* spp.). We exposed communities to a factorial combination of environmentally relevant concentrations of road salt (15, 250, and 1000 mg Cl^-/L), nutrient additions (oligotrophic, eutrophic), and sunlight (low, medium, and high) for 80 d. We manipulated light intensity to parse out the direct effects of road salts or nutrients from the indirect effects via algal blooms that reduce light levels. We observed numerous direct and indirect effects of salt, nutrients, and light as well as interactive effects. Added nutrients caused increases in most producers and consumers. Increased salt (1000 mg Cl^-/L) initially caused a decline in cladoceran and copepod abundance, leading to an increase in phytoplankton. Increased salt also reduced the biomass and chl *a* content of *Nitella* and reduced the abundance of filamentous algae. Added salt had no effect on the abundance of pond snails, but it caused a decline in banded mystery snails, which led to an increase in periphyton. Low light negatively affected all taxa (except *Nitella*) and light levels exhibited multiple interactions with road salt, but the combined effects of nutrients and salt were always additive. Collectively, our results indicate that eutrophication and salinization both have major effects on aquatic ecosystems and their combined effects (through different mechanisms) are expected to promote large blooms of phytoplankton and periphyton while causing declines in many species of invertebrates and macrophytes.

Key words: algae; eutrophication; food web; freshwater ecosystems; macrophyte; salinization; zooplankton.

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Introduction

Lake ecosystems offer multiple ecosystem services, such as the provisioning of drinking water, water for industry and agriculture, recreation, and fisheries (Malmqvist and Rundle 2002, Keeler et al. 2012). Humans have exploited and contaminated lake resources causing extensive degradation and loss of biodiversity (Naiman et al. 2002). The contaminants can dramatically alter the structure and function of freshwater lake ecosystems, triggering a loss of ecosystem services (Hintz et al. 2017). Eutrophication and salinization are two major threats to lake ecosystems (Carpenter et al. 1985, Jackson et al. 2016, Dugan et al. 2017) and, while they co-occur throughout much of the world, their additive and synergistic effects are not well understood. Thus, it is important to understand whether these co-occurring disturbances interact to affect lakes ecosystems and food webs, and what the implications might be for lake ecosystem services and future mitigation efforts.

Over the last two centuries, human activities have enriched freshwater ecosystems with nutrients that have altered the trophic state of systems around the world (Conley et al. 2009). Nutrient pollution frequently occurs in human-dominated systems, causing eutrophication, harmful algal blooms, hypoxia, and changes in aquatic food webs (Conley et al. 2009, Paerl and Paul 2012). Moreover, algal blooms can reduce light availability, negatively affecting primary producers that are unable to migrate, drift, or extend toward the water surface (e.g., vascular plants and benthic algae; Cronin and Lodge 2003, Havens et al. 2003). Therefore, increased pelagic primary productivity might limit the persistence and growth of benthic primary producers (Scheffer et al. 1993).

Human activities in higher latitudes have also contaminated freshwater ecosystems by the usage of deicing salts, for the purpose of increasing driving safety during winter (Novotny et al. 2008, Corsi et al. 2010, Cañedo-Argüelles et al. 2016). The most common deicer is rock salt that consists mainly of sodium chloride (NaCl; Thunqvist 2004, Novotny et al. 2008, Rogora et al. 2015), and in 2013, the annual rock salt use on roads was 20.4 million metric tonnes in the United States, 5 million tonnes in Canada, and 0.2–0.3 million tonnes in Sweden (Thunqvist 2004, Howard and Maier 2007, Bolen 2013). As snow and ice melt, the dissolved salt runs off into streams, rivers, and lakes or infiltrates soil and groundwater (Thunqvist 2004. During runoff events, chloride levels can reach 4300 mg/L in streams and 5000 mg/L in ponds and wetlands (Environment Canada 2001). These levels far exceed the current chronic (230 mg Cl^-/L) and acute (860 mg Cl^-/L) thresholds that were established for the protection of freshwater biota by the U.S. Environmental Protection Agency (EPA 1988).

Organisms in freshwater ecosystems vary in their tolerance to NaCl, and both chronic and acute chloride concentrations (from NaCl) negatively affect macroinvertebrate species richness in streams (Horrigan et al. 2005, Kefford et al. 2006). Chronic and acute chloride concentrations also negatively affect the abundance of lake and pond zooplankton (Sarma et al. 2006, Van Meter et al. 2011, Hintz et al. 2017, Stoler et al. 2017). Increased chloride concentrations have also been linked to algal blooms, which can reduce light availability and alter food-web structure in freshwater ecosystems (Dananay et al. 2015, Cañedo-Argüelles et al. 2016). Consequently, increased salinization can alter the freshwater community structure (Petranka and Doyle 2010, Cañedo-Argüelles et al. 2016). Although studies have been conducted on the salinity tolerance of freshwater macrophytes, these studies often focus on biogeochemical and molecular mechanisms on a cellular level, and not on food-web implications or changes in macrophyte abundance (Haller et al. 1974, Rout et al. 1997, Rout and Shaw 2001, Parida and Das 2005).

It is particularly valuable to understand how macrophytes respond to changes in their environment (e.g., light conditions), since macrophytes play an essential role in freshwater ecosystems (Carpenter and Lodge 1986, Scheffer et al. 1993), and since conditions in waterbodies have been altered by different types of pollution and invasion of species (Anderson et al. 2002, Kovalenko et al. 2010). Most aquatic plants cannot tolerate salt concentrations greater than 10 g/L, but tolerance varies among species, life stage, type of salt, and the duration and intensity of the exposure (Deegan et al. 2005, Lacoul and Freedman 2006). Furthermore, environmentally relevant chloride concentrations have been shown

to favor salt-tolerant species and alter the biomass of primary producers (Petranka and Doyle 2010, Van Meter et al. 2011, Hintz et al. 2017).

Our objective was to examine the combined effects of salt contamination and nutrient pollution on freshwater communities. We expected both contaminants to cause an algal bloom, but through different mechanisms. Road salts would indirectly cause an algal bloom by reducing the abundance of zooplankton (i.e., top-down), whereas nutrients would directly increase the growth rate of algae (i.e., bottom-up). Because algal blooms can have cascading effects on food webs and ecosystems by reducing light transmission through the water column, we also manipulated light levels to parse out the direct and indirect effects of an algal bloom caused by nutrients or salt. We employed outdoor mesocosms, which are commonly used to test the effects of anthropogenic impacts on aquatic systems, because they provide a venue to manipulate and replicate conditions in a controlled manner (e.g., Rowe and Dunson 1994, Downing and Leibold 2002, Hua and Relyea 2014).

We hypothesized that the combination of stressors would cause additive and interactive effects on primary and secondary biomass and abundance. Specifically, we predicted that (1) higher chloride concentrations will cause a decrease in zooplankton and other animals and a subsequent bloom in phytoplankton, (2) higher nutrient concentrations will cause an increase in productivity of all primary producers, (3) increased phytoplankton production due to elevated nutrient or salt levels will have an indirect negative effect on the benthic macroalgae (*Nitella* spp.) and grazers, due to reduced light availability, (4) low light levels will mimic the effects of reduced light transparency caused by algal blooms produced by increased salt and nutrients, and (5) increased salt, increased nutrients, and reduced light will have multiple interactive effects.

Materials and Methods

Experimental design

We conducted the experiment at Rensselaer Polytechnic Institute's Aquatic Research Laboratory in Troy, New York, USA, during the summer of 2015. We used a completely randomized design that employed a full factorial combination of three salt concentrations (15, 250, and 1000 mg Cl^-/L), two nutrient levels (high eutrophic and ambient oligotrophic), and three light levels (low [10%], medium [35%], and high [70%] of ambient sunlight). As noted earlier, the three sunlight manipulations acted as a proxy for the shading effect of an algal bloom that is independent of the other impacts that an algae bloom can have on a food web. Four replicates of each of the 18 treatment combinations resulted in 72 experimental units.

Our experimental units were 1200-L plastic mesocosms (i.e., cattle tanks). On 15 June, we filled the mesocosms with 850 L of water from Lake George (Warren County, New York, USA) due to its low chloride concentration (15 mg Cl^-/L) and oligotrophic state. Two days later, we added 140 L (5 cm deep) of sand substrate to the mesocosms and allowed the water to sit undisturbed for 10 d, until the soil particles settled. When the water was clear, we placed two unglazed clay tiles (10 × 15 cm) vertically on the north side of each mesocosm to serve as periphyton samplers during the experiment.

We established highly similar ecological communities in each mesocosm. We initiated a zooplankton community on 27 June by collecting zooplankton from Lake George using a zooplankton net (64 μm) and adding 600 mL of the concentrated zooplankton slurry to each of the mesocosms. In addition to zooplankton, the collected water also introduced microbial and algal assemblages to each mesocosm. On the same day, we collected banded mystery snails (*Viviparus georgianus*) from a local lake and added six individuals (two large and four small) to each mesocosm. On 1 July, we collected a mixture of the *Nitella* species (*N. flexilis*, *N. opaca*, and *N. tenuissima*) from Lake George and placed 200 g (wet weight) on the bottom of each mesocosm after rinsing and removing undesirable species (e.g., macrophytes and snails) that were visible. *Nitella* spp. are macroalgae (Characeae) that live in monoculture meadows in deep water (7–12 m; Boylen et al. 2014), and since its growth form resembles an aquatic plant, it is categorized as a macrophyte (Cushing and Allan 2001). The collected *Nitella* also contained attached pond snails (*Physa acuta*), so we quantified the number of attached pond snails and estimated that an average of four individuals (3–6) were introduced to each mesocosm.

On 7 July (defined as day 1 of the experiment), we applied the light treatments by covering the mesocosms with mesh lids with three different light transmittance percentages (10, 35, and 70% sunlight). Prior to this date, all mesocosms had identical mesh lids that allowed 35% light transmittance. These lids also prevented organisms from colonizing or leaving the mesocosms (Howeth and Leibold 2010).

On 10 July, we added road salt to the mesocosms in the form of NaCl (Solar Salt; Morton Salt, Chicago, Illinois, USA; 99.8% pure NaCl; 60.7% chloride, free of additives). Given that the ambient chloride concentration of the lake water was 15 mg Cl^-/L, we added salt to reach medium and high concentrations (250 and 1000 mg Cl^-/L, respectively). We chose these three concentrations because the U.S. EPA maximum acceptable level for drinking water is 250 mg Cl^-/L (EPA, 2016), and 1000 mg Cl^-/L exceeds the standards for acute events but is representative of North American lakes with the highest road salt concentrations (Novotny et al. 2008). The highest concentration observed in North American ponds and wetlands is approximately 4300 mg Cl^-/L (Environmental Canada 2001). We added the sodium chloride to each mesocosm by extracting 5 L of water and mixing the salt with the water until it was dissolved. We added the chloride to each mesocosm assigned to a salt treatment in a slow, circular movement to ensure that the mixture was evenly dispersed. On the next day, we measured the chloride concentrations to ensure that we reached our goals for each mesocosm.

On the same day as salt additions, we applied our nutrient treatments. In the low-nutrient treatment, no nutrients were added to represent an oligotrophic lake (Lake George, TP mean of 4.36 μg/L over 30 yr; Boylen et al. 2014). For the high-nutrient treatment, we added 0.185 g of potassium phosphate and 4.2 g of sodium nitrate (16N:1P) on 10 July. We set the target eutrophic conditions at 100 μg/L of P and 1600 μg/L of N (see, e.g., Schuler et al. 2017*a*). We dosed the mesocosms assigned to the high-nutrient treatment a second time on 4 August to maintain higher nutrient levels since there is a 5% day^{-1} loss of nutrients to the bottom substrate (Howeth and Leibold 2010). To control for disturbance, we gently agitated the surface water of all mesocosms not receiving nutrients or salt.

Response variables

We quantified phytoplankton abundance on days 8, 16, 20, 30, 42, and 78, with an average of 13 days between sampling occasions (Table 1). Phytoplankton were sampled to reflect when we observed the most dramatic changes. We sampled phytoplankton by collecting 450 mL of water from the middle of each mesocosm and vacuum-filtered all samples through GF/C glass fiber filters (Whatman, Inc., Massachusetts, USA). Each filter was wrapped in aluminum foil and frozen (−20°C) to prevent chlorophyll breakdown. We later measured the concentration of chlorophyll *a* in each filter using a fluorometer (Model ED-700; Turner Designs) following Arar and Collins (1997).

We measured periphyton biomass on days 32 and 77 (Table 1), by removing one tile each time from each mesocosm and scrubbing the tile with a brush. We rinsed the tile and brush, and the resulting slurry was filtered through pre-dried (60°C for 48 h) and pre-weighed 1.2-μm glass fiber filters (Whatman GF/C). After drying the filters at 60°C for 48 h, we re-weighed them to determine dry periphyton biomass.

We also sampled the living *Nitella* from each mesocosm on day 80 (Table 1) to assess final biomass and chlorophyll *a* content. We rinsed the samples to remove attached filamentous algae and snails and then dried the *Nitella* samples at 60°C for 48 h. After drying, we weighed each sample. From each *Nitella* sample, we also clipped a 4-cm piece to analyze it for chlorophyll *a* content. The *Nitella* pieces were wrapped in aluminum foil and frozen (−20°C) to prevent chlorophyll breakdown. We later measured the concentration of chlorophyll *a* in each sample by shaking the bottle for 1 min until the fragile plant tissue had become suspended in acetone solution (Gitelson et al. 2003). We then used the fluorometer to quantify

Table 1. Schematic overview of sampling intensity of each response variable or group of response variables.

Response variables	Day					
	7–8	14–16	19–21	30–32	42–43	77–80
Phytoplankton	X	X	X	X	X	X
Periphyton	–	–	–	X	–	X
Macroalgae	–	–	–	–	–	X
Snails	–	–	–	–	–	X
Zooplankton	–	–	X	–	–	X
Abiotic	X	X	X	X	X	X

chlorophyll *a* (Model ED-700; Turner Designs) following Arar and Collins (1997).

On day 80, we also estimated the abundance of the filamentous algae (floating and submerged). Three observers each made a single estimate of the amount of filamentous algal cover in each mesocosm by ranking it from 1 to 5 (1 = 1–5%, 2 = 5–10%, 3 = 10–25%, 4 = 25–65%, 5 = 65–100%), and these rankings were then averaged.

We quantified the abundance of juvenile snails on day 80 (Table 1) by collecting a benthic sample of snails. The benthic sample was collected by sweeping an aquarium net (width = 10 cm, mesh size = 250 μm) against the bottom, from the center of the mesocosm advancing to the side wall in all four cardinal directions. We preserved all snails in 70% ethanol and later enumerated the number of banded mystery snails and pond snails (juveniles were <0.5 cm). We only enumerated the number of juvenile snails because adult snails were very rare in all samples.

To quantify zooplankton abundance when they were diverging among treatments, we sampled the mesocosms two times during the experiment (Table 1). On days 19 and 78, we sampled 450 mL of water from six locations in a given mesocosm and then pooled the six samples. We poured the pooled sample through a 64-μm net and preserved the collected zooplankton in 30% ethanol to ensure that the zooplankton stayed intact. We later enumerated the zooplankton in three taxonomic categories: copepods, cladocerans, and rotifers.

Throughout the 80 d of the experiment, we quantified temperature (°C), pH, dissolved oxygen (mg O_2/L), and chloride concentrations (mg Cl^-/L) on days 7, 14, 21, 32, 43, and 78 (Table 1) using a calibrated digital water meter (YSI Professional Plus, Yellow Springs, Ohio, USA). We measured all abiotic parameters at approximately half the water depth. The nominal salt concentration of 15 and 1000 mg Cl^-/L differed from actual salt concentrations of 11 and 1072 mg Cl^-/L by 26%, and 7%. On average there was no difference between actual and nominal concentration for 250 mg Cl^-/L.

Statistical analysis

This study includes a large number of response variables, some of which were measured multiple times. Therefore, we used several different analyses to examine the effects of our treatments. We used univariate repeated-measures analysis of variance (ANOVA) for phytoplankton (sampled at six time points) and periphyton (sampled at two time points). We conducted two additional multivariate analyses of variance (MANOVAs): one on macroalgae (*Nitella* dry biomass, *Nitella* chlorophyll *a* content, and filamentous algae rank abundance) and one on juvenile snail abundance (pond snails and banded mystery snails). For *Nitella* biomass, we analyzed the dry mass of *Nitella* because wet and dry mass were highly correlated (Pearson correlation = 0.98). We conducted repeated-measures MANOVAs (rm-MANOVA) on zooplankton (cladocerans, copepods, and rotifers) which were sampled at two time points and on the abiotic water quality variables which were measured at six time points (temperature, pH, and DO). When we found significant multivariate effects, we conducted subsequent univariate repeated-measures ANOVAs on each response variable. When we detected time-by-treatment interactions, we used ANOVAs to analyze the treatment effects on each sample date. For all significant ANOVAs, we conducted Tukey's HSD post hoc test because the number of possible mean comparisons was low. Data were log-transformed when needed to fit parametric assumptions of normality and homogeneity of variance. All analyses were preformed in R version 3.3.1, using packages vegan and car.

Results

Phytoplankton

We found effects of salt, light, nutrients, and salt-by-light and nutrient-by-light interactions with time on phytoplankton chlorophyll *a* concentration; the other interactions were not significant. (Appendix S1: Table S1). Given the time-by-treatment interactions, we analyzed phytoplankton for each sample date, and detailed descriptions are available in Appendix S1.

On the first sample date, there was no main effect of salt, but there was a main effect of light, nutrients, and a light-by-nutrient interaction (Table 2, Fig. 1a). Added nutrients caused an increase of phytoplankton, and the magnitude of the increase was greatest under high light. On the second sample date (day 16), there were main effects of salt, light, and nutrients, but no

Table 2. Results of an ANOVA for phytoplankton chl *a* concentration at each sample day based on significant interactions from rm-ANOVA.

	Salt (df = 2,54)		Light (df = 2,54)		Nutrient (df = 1,54)		Salt × Light (df = 4,54)		Light × Nutrient (df = 2,54)	
Day	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*
8	2.6	0.083	**14.4**	**<0.001**	**37.3**	**<0.001**	1.54	0.201	**15.83**	**<0.001**
16	**8.0**	**<0.001**	**3.5**	**0.038**	**6.3**	**0.015**	1.07	0.380	1.0	0.363
20	0.1	0.922	**4.9**	**0.011**	**6.3**	**0.015**	0.29	0.887	**3.4**	**0.039**
30	**5.0**	**0.010**	1.4	0.266	**4.1**	**0.047**	1.17	0.334	0.4	0.648
42	**5.5**	**0.006**	0.6	0.553	0.8	0.376	1.18	0.330	1.4	0.260
78	**4.1**	**0.022**	0.7	0.524	0.1	0.756	1.01	0.409	1.2	0.310

Notes: Bold numbers indicate statistical significance at the alpha level of 0.05. Additional interactions were not significant in the rm-ANOVA (Appendix S1: Table S1).

interactions among treatments (Table 2, Fig. 1b). Once again, the combination of added nutrients and high light caused an increase in phytoplankton. In addition, the high chloride concentration caused an increase in phytoplankton. On the third sample date (day 20), there was no effect of salt, but there were effects of light, nutrients, and a light-by-nutrient interaction (Table 2, Fig. 1c). The increase in phytoplankton with added nutrients and high light was once again apparent. On the fourth sample date (day 30), there was an effect of salt and nutrients on phytoplankton, but not light (Table 2, Fig. 1d). The added nutrients and high salt concentration both caused an increase in phytoplankton. On the fifth and sixth sampling dates (days 42 and 78), phytoplankton was only affected by salt (Table 2, Fig. 1e–f). In both cases, the high concentration of salt caused an increase in phytoplankton.

Periphyton

The repeated-measures ANOVAs on periphyton revealed effects of salt and nutrients, but no effects of light or any interactions (Appendix S1: Table S1). However, there was a nearly significant effect of time, because it was only at the second sampling that elevated nutrients caused a 68% increase in periphyton biomass (day 32: $F_{1,54} = 2,1$, $P = 0.149$; day 78: $F_{1,54} = 6.3$, $P = 0.015$; Fig. 2). In 1000 mg Cl^-/L, periphyton biomass was 110% and 78% higher, respectively, compared to 15 mg Cl^-/L (day 32: $F_{2,54} = 3,9$, $P = 0.024$; day 78: $F_{2,54} = 3.1$, $P = 0.051$).

Macroalgae

The MANOVA on *Nitella* dry biomass, *Nitella* chl *a*, and filamentous algae rank abundance indicated a multivariate effect of salt (Wilks' λ, $F_{2,54} = 11.5$, $P < 0.001$) and a nearly significant effect of light (Wilks' λ, $F_{2,54} = 2.0$, $P = 0.072$), but no effect of nutrients (Wilks' λ, $F_{1,54} = 1.2$, $P = 0.314$) or any treatment interactions. We then conducted separate ANOVAs for each response variable.

In the analysis of *Nitella* dry biomass, we found main effects of salt, light, and a salt-by-light interaction (Table 3, Fig. 3a). The post hoc comparison revealed that the *Nitella* biomass in low light declined by about half with 250 mg Cl^-/L ($P = 0.013$) and by 98% with 1000 mg Cl^-/L ($P < 0.001$), compared to 15 mg Cl^-/L. In medium sunlight, *Nitella* biomass was 77% higher in 15 mg Cl^-/L than in 1000 mg Cl^-/L ($P = 0.003$). In high sunlight, *Nitella* biomass was much lower and there were no effects of salt treatments ($P > 0.7$). When we examined the effect of sunlight within each salt treatment, we found that *Nitella* biomass declined by 65% between high and low light in 15 mg Cl^-/L ($P = 0.004$). However, there were no effects of light within the 250 and 1000 mg Cl^-/L salt treatments (all: $P > 0.7$).

The analysis of chlorophyll *a* in *Nitella* revealed an effect of salt (Table 3, Fig. 3b) and a nearly significant negative effect of light, but no salt-by-light interaction. Post hoc comparisons showed that there was 53–54% higher chl *a* concentration in *Nitella* exposed to 15 or 250 mg Cl^-/L compared to *Nitella* exposed to 1000 mg Cl^-/L (all: $P < 0.001$). There was also 29% lower chl *a* concentration in *Nitella* with high light compared to low light ($P = 0.049$; Fig. 3b).

In our analysis of the filamentous algae rank abundance, we found an effect of salt, but no effects of light or nutrients (Table 3). Post hoc

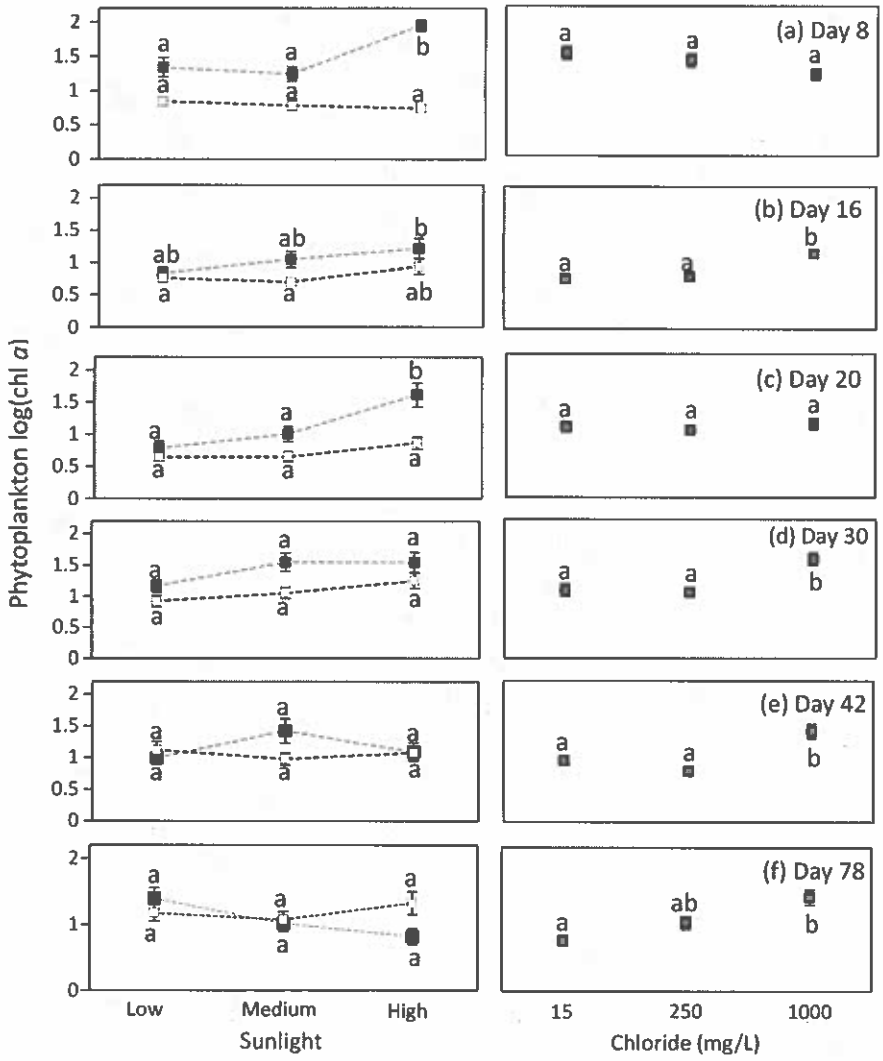


Fig. 1. Effects of nutrients (black boxes indicate high and white boxes indicate low nutrient concentration), sunlight (low 10%, medium 35%, and high 70%), and salt (15, 250, and 1000 mg Cl^-/L) on phytoplankton (chl *a*) concentration on six sampling dates (a–f). Letters indicate significant difference between and within treatments. Data are logged means ± 1 SE.

comparisons showed that there was no difference between 15 and 250 mg Cl^-/L ($P = 0.822$). However, filamentous algae did not decline from 15 to 250 mg Cl^-/L, but it did decline from 15 and 1000 mg Cl^-/L ($P < 0.001$) and 250 to 1000 mg Cl^-/L ($P < 0.001$).

Snails

The MANOVA on juvenile snail abundance revealed a multivariate effect of salt, light, nutrients, and a salt-by-light interaction (Appendix S1: Table S2). In the subsequent univariate analysis on pond snails, we found main effects of light and nutrients, with a 70% increased abundance from low to high light ($F_{1,54} = 14.9$, $P < 0.001$) and a 60% increased abundance in mesocosms with added nutrients ($F_{2,54} = 4.5$, $P = 0.019$; Fig. 4a). There was no effect of salt ($F_{2,54} = 1.9$, $P = 0.158$) or a salt-by-light interaction ($F_{4,54} = 0.9$, $P = 0.496$).

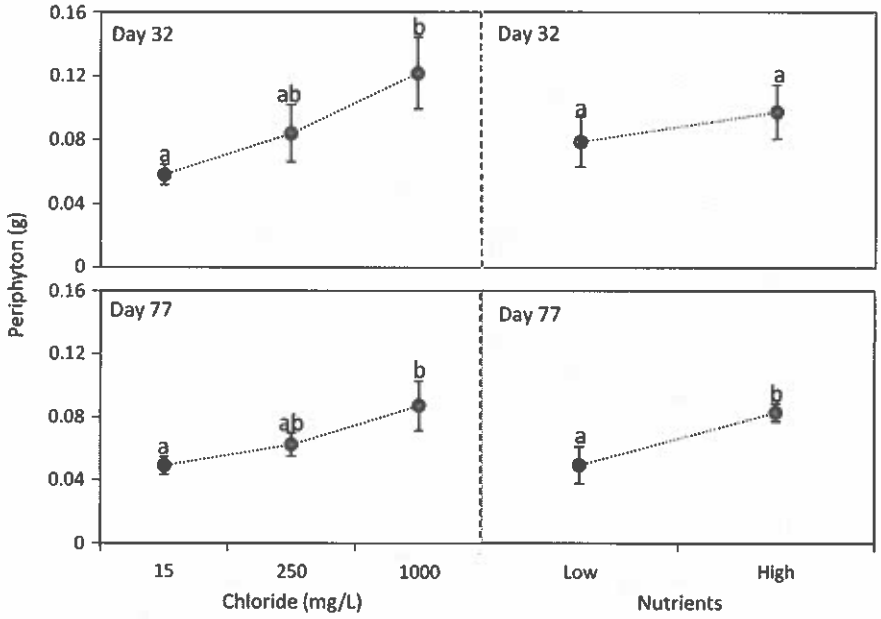


Fig. 2. Effects of nutrients (low and high) and salt (15, 250, and 1000 mg Cl^-/L) on total periphyton biomass (g/15 cm^2) on two sampling dates. Data are means ± 1 SE.

Table 3. ANOVA table for *Nitella* biomass, *Nitella* chlorophyll, and filamentous algae rank abundance.

Source of variation	*Nitella* biomass		*Nitella* chl *a*		Filamentous algae rank	
	F	*P*	*F*	*P*	*F*	*P*
Salt	**$24.9_{2,54}$**	**<0.001**	**$19.6_{2,54}$**	**<0.001**	**$29.8_{2,54}$**	**<0.001**
Light	**$5.5_{2,54}$**	**0.006**	$2.9_{2,54}$	0.060	$2.1_{2,54}$	0.134
Salt × Light	**$2.9_{4,54}$**	**0.029**	$2.0_{4,54}$	0.101	$0.2_{4,54}$	0.961

Notes: Bold numbers indicate statistical significance at the alpha level of 0.05. Subscripted numbers indicate degrees of freedom. The preceding MANOVA indicated no effects of nutrients or its interactions.

In the univariate analysis on banded mystery snails, there were no effects of nutrients, but we found effects of salt ($F_{2,54}$ = 18.8, P < 0.001), light ($F_{2,54}$ = 13.1, P < 0.001), and a salt-by-light interaction ($F_{4,54}$ = 5.0, P = 0.002; Fig. 4b). Under low-light conditions, snail abundance was low and there were no differences among the salt treatments. Under medium-light conditions, banded mystery snail abundance was 83% higher with 250 mg Cl^-/L than with 1000 mg Cl^-/L (P = 0.001), but there was no difference between 15 and 250 mg Cl^-/L (P = 0.131) or between 15 and 1000 mg Cl^-/L (P = 0.777). Under high-light conditions, snail abundance declined sharply by 92% and 94% with 1000 mg Cl^-/L compared to 15 and 250 mg Cl^-/L, respectively (all: P < 0.001).

Zooplankton

The MANOVA on cladocerans, rotifers, and copepods revealed multivariate effects of light, nutrient, time, and a salt-by-time interaction; no other interactions were significant (Appendix S1: Table S3). The subsequent univariate analyses also showed interactions between salt and time, and we therefore analyzed all groups of zooplankton within sampling dates for salt treatments (Tables 4 and 5).

For cladoceran abundance, there was a main effect of light and nutrients, and there was also an interaction between salt and time (Table 4, Fig. 5). Cladocerans also showed a 43% increase from low to medium light (P = 0.043) and a 53% increase from low to high light (P = 0.009). They

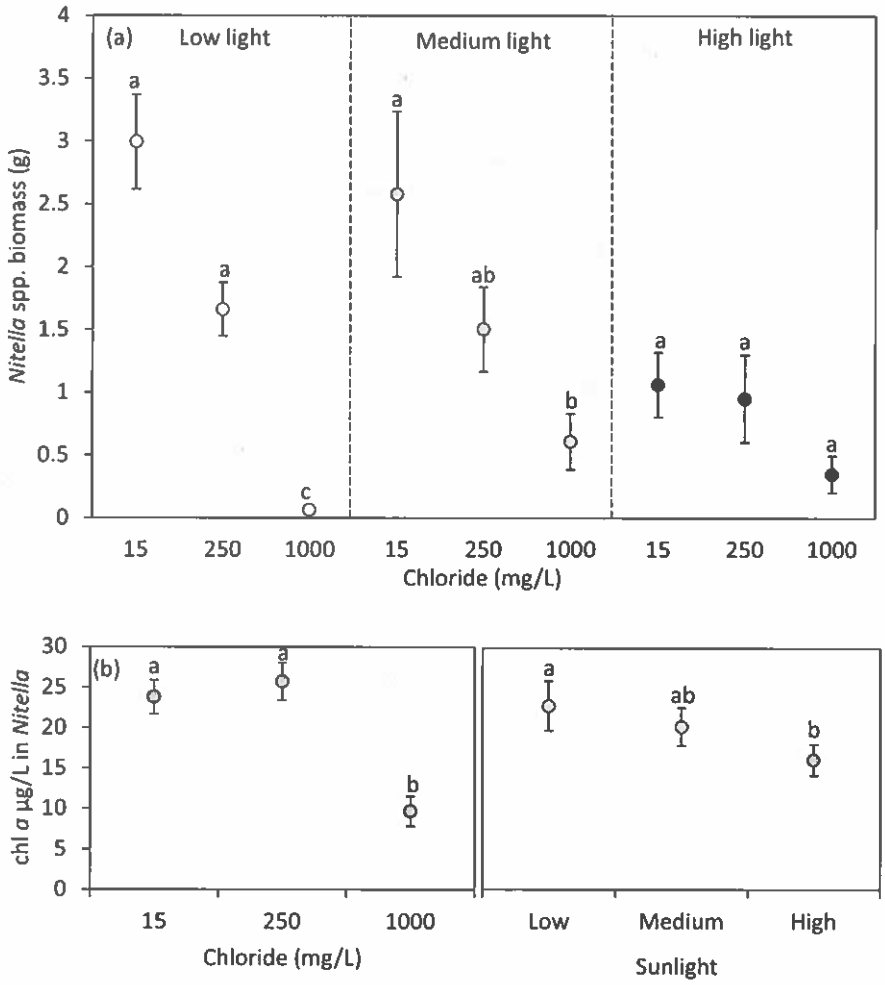


Fig. 3. (a) Effects of sunlight (low 10%, medium 35%, and high 70%) and salt (15, 250, and 1000 mg Cl^-/L) on *Nitella* biomass. (b) Effects of salt (15, 250, and 1000 mg Cl^-/L) and sunlight (low 10%, medium 35%, and high 70%) on the chlorophyll *a* content in *Nitella*. Data are means ± 1 SE.

experienced a 41% increase from low to high nutrients ($P = 0.004$). On the first sample date, cladocerans exhibited a 38–40% lower abundance with 1000 mg Cl^-/L compared to the 250 and 15 mg Cl^-/L (all: $P \leq 0.04$). On the second sample date, there was no effect of salt.

For rotifer abundance, there was a main effect of nutrients and light and a marginal effect of salt (Table 4, Fig. 5). Post hoc comparisons showed that rotifers were also 57–70% less abundant in low light compared to medium and high light ($P \leq 0.05$). They also experienced a 50% increase with added nutrients ($P = 0.031$). On the second sample date, there was a 53–63% higher abundance with 1000 mg Cl^-/L compared to 15 and 250 mg Cl^-/L ($P \leq 0.049$). On the first sample date, there were no effects of salt.

Copepod abundance was affected by salt, nutrients, and a salt-by-time interaction (Table 4, Fig. 5). Copepods experienced a 64% increase with increased nutrients (Table 5). On the first sampling, copepods were 76% more abundant with 15 mg Cl^-/L than with 1000 mg Cl^-/L ($P = 0.006$). On the second sample date, copepods were 86% more abundant with 250 mg Cl^-/L than with 1000 mg Cl^-/L treatments ($P < 0.001$).

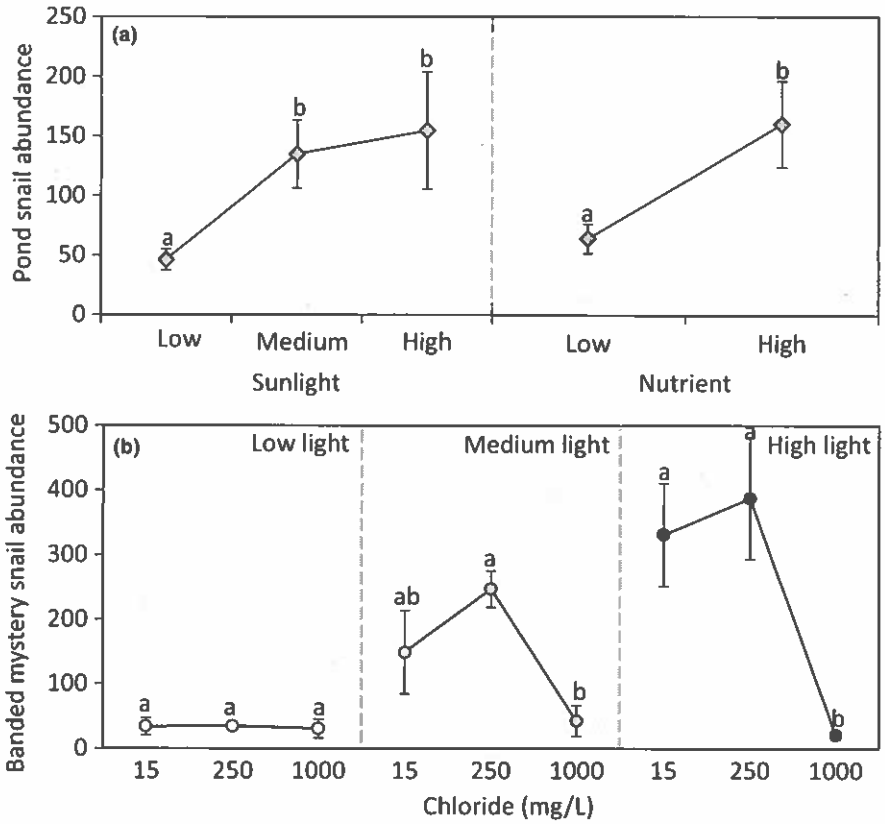


Fig. 4. Effects of sunlight (low 10%, medium 35%, and high 70%) and salt (15, 250, and 1000 mg Cl^-/L) on (a) juvenile pond snails and (b) juvenile banded mystery snails. The white, gray, and black dots represent different sunlight levels (10, 35, and 70%). Data are means ± 1 SE.

Abiotic conditions

The analysis of abiotic measurements detected multivariate effects of salt, light, nutrients, time, and their interactions (Appendix S1: Table S4). We therefore conducted rm-ANOVAs on each response variable to understand which response variables were driving the multivariate effects and then used subsequent ANOVA for each response variable at

Table 4. Univariate repeated-measures ANOVA on copepods, cladocerans, and rotifers for those factors found to be significant in the rm-MANOVA (see Appendix S1: Table S3).

Source of variation	df	Copepods		Cladocerans		Rotifers	
		F	*P*	*F*	*P*	*F*	*P*
Salt	2,54	8.5	**<0.001**	1.8	0.166	2.8	0.065
Light	1,54	2.0	0.134	6.6	**0.002**	5.8	**0.004**
Nutrient	2,54	21.8	**<0.001**	8.6	**0.004**	4.7	**0.032**
Salt × Time	2,54	3.0	**0.053**	4.7	**0.011**	1.0	0.387

Notes: Bold numbers indicate statistical significance at the alpha level of 0.05. Subscripted numbers indicate degrees of freedom.

Table 5. Univariate tests on copepods, cladocerans, and rotifers within each sample time for effect of salt.

Zooplankton	Salt	
	F	*P*
Day 19		
Copepods	$5.1_{2,54}$	**0.009**
Cladocerans	$4.2_{2,54}$	**0.020**
Rotifers	$0.4_{2,54}$	0.670
Day 78		
Copepods	$8.1_{2,54}$	**0.001**
Cladocerans	$2.5_{2,54}$	0.086
Rotifers	$4.3_{2,54}$	**0.018**

Notes: Bold numbers indicate statistical significance at the alpha level of 0.05. Subscripted numbers indicate degrees of freedom.

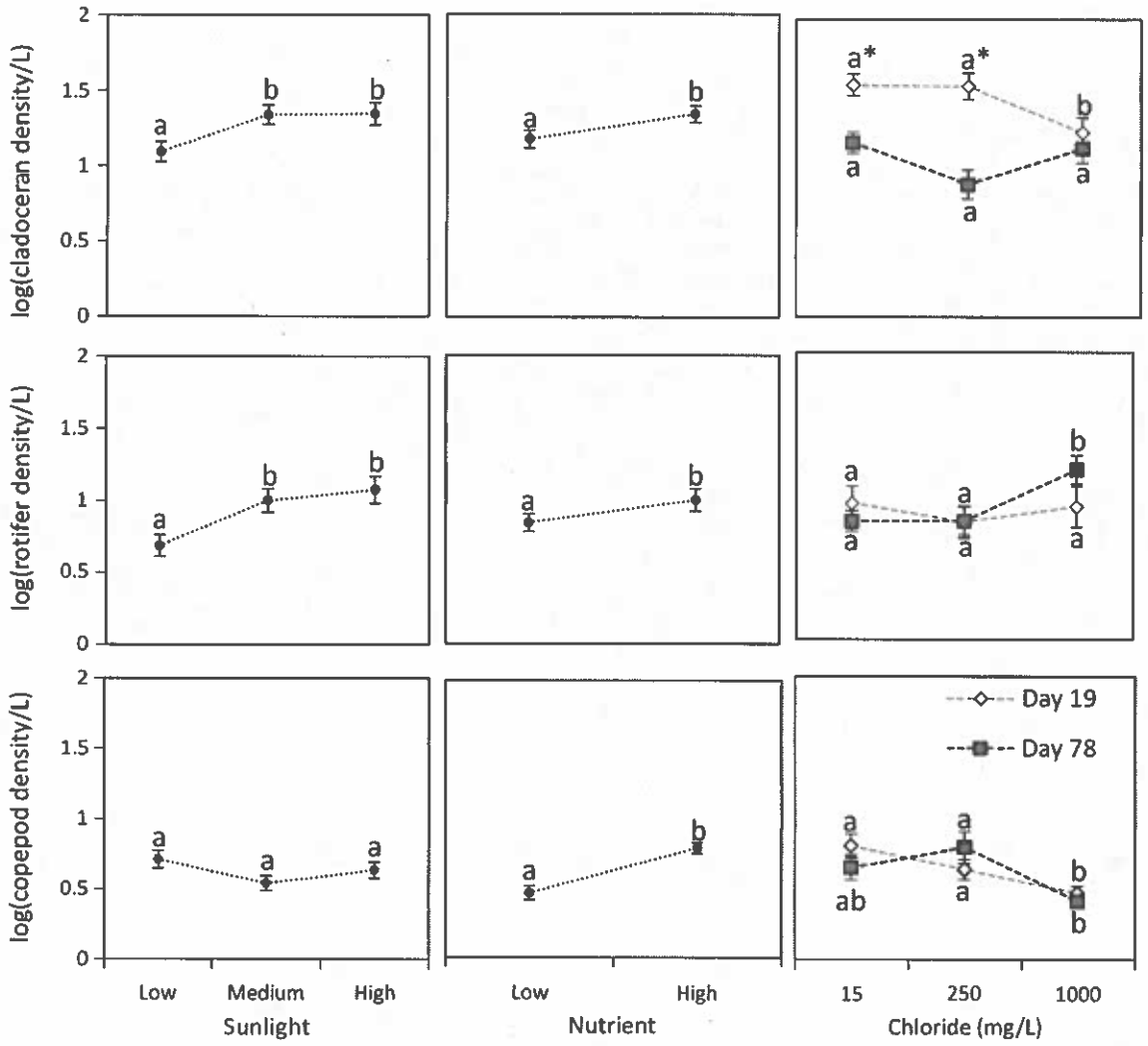


Fig. 5. Effects of nutrients (low and high), sunlight (low 10%, medium 35%, and high 70%), and salt (15, 250, and 1000 mg Cl^-/L) on cladocerans, rotifers, and copepods on two sampling dates (days 19 and 78). Letters indicate significant differences between treatments, and asterisks (*) indicate significant differences between sampling occasions. Data are logged means ± 1 SE.

each sample date if treatments interacted with time (Fig. 6, Appendix S1: Tables S5–S6). Detailed supplementary results for each sampling date for DO, temperature, and pH are available in Appendix S1. During the experiment, the chloride concentrations remained the same; that is, they did not have an interaction with time (all: $P > 0.1$).

The univariate analysis of DO revealed effects of light, salt, nutrients, time, and light-by-nutrient, salt-by-time, and nutrient-by-time interactions (Appendix S1: Table S5). Averaged over time, DO levels were higher with high light and added nutrients (Fig. 6; Appendix S1: Table S6).

For temperature, the analysis revealed effects of light, time, and light-by-time interaction (Fig. 6; Appendix S1: Tables S5–S6). During the first part of summer, temperatures were highest in high sunlight treatment, whereas in the later parts of summer, temperatures were highest in the low sunlight treatment.

Analysis of pH showed effects of salt, light, nutrient, time, and salt-by-time and nutrient-by-time

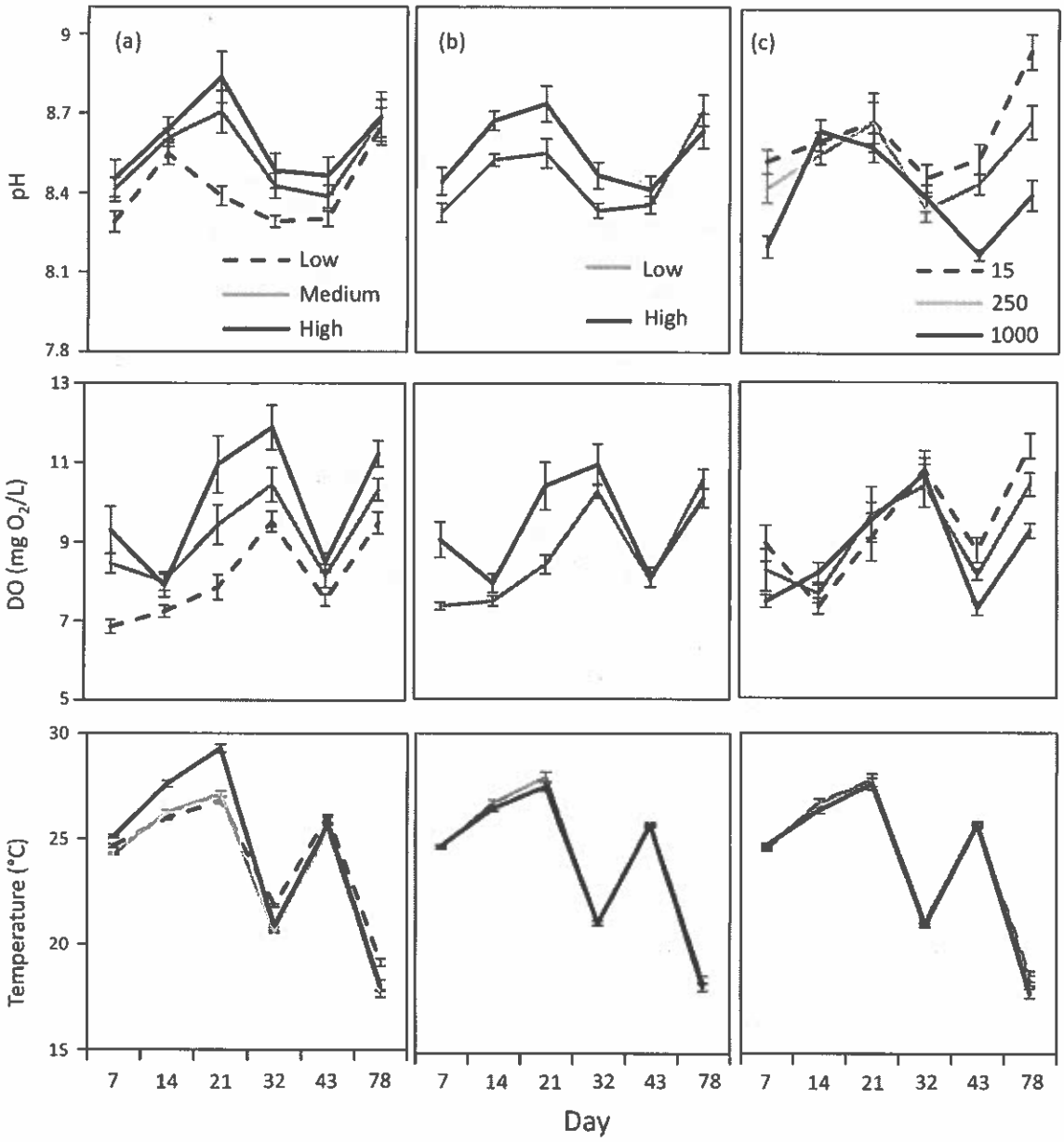


Fig. 6. pH, DO (dissolved oxygen; mg O_2/L), and temperature (°C) for each sampling day and each treatment: (a) sunlight (low 10%, medium 35%, and high 70%), (b) nutrients (low and high), and (c) salt (15, 250, and 1000 mg Cl^-/L).

interactions (Fig. 6; Appendix S1: Tables S5–S6). The pH levels were generally increasing with increasing light and nutrients levels while decreasing with increasing salt concentrations. The pH ranged between 7.46 and 9.95 with an average of 0.2 pH units lower in 1000 vs. 15 mg Cl^-/L.

Discussion

Salinization and eutrophication in freshwater ecosystems is a serious environmental problem (Van Meter et al. 2011, Paerl and Paul 2012, Cañedo-Argüelles et al. 2016, Hintz et al. 2017).

We discovered that altered nutrients, sunlight, and salt concentrations altered the structure of ecological communities by causing direct effects as well as top-down and bottom-up indirect effects that altered the abundance of primary producers and consumers. Adding nutrients caused our community to experience increased productivity, including the increased growth of phytoplankton and periphyton, one of the two snail species, and all three zooplankton groups. Adding salt caused declines in two of the three zooplankton groups, an increase in phytoplankton and periphyton, sharp declines in the *Nitella* macroalgae, and sharp declines in the abundance of banded mystery snails. In short, we found that the combination of increased chloride and nutrients creates a highly eutrophied ecosystem with decreasing macrophyte coverage, higher pelagic primary production, and altered abundances of consumers for higher trophic levels. Reduced sunlight caused a decline in the abundance of pond snails and banded mystery snails (although the latter depended on salt concentration), declines in phytoplankton (although only under high-nutrient conditions), and declines in cladocerans and rotifers. However, there was no evidence that declines in sunlight caused by salt- and nutrient-induced increases in phytoplankton or macroalgae caused any indirect effects on the food web. Below, we elaborate on these findings and interpretations.

Phytoplankton and periphyton

Phytoplankton and periphyton increased in our experiment when exposed to high nutrients or elevated salt concentrations (Figs. 1 and 2). The increase in phytoplankton under high-salt conditions was likely caused by a decline in the copepods and cladocerans that consume phytoplankton. This outcome has also been observed in past lake and wetland ecosystems (Van Meter et al. 2011, Hintz et al. 2017) and is similar to that seen for other contaminants that are lethal to zooplankton, including insecticides (Hua and Relyea 2014, Bendis and Relyea 2016).

While it was not surprising that phytoplankton became more abundant when nutrients were added (Conley et al. 2009, Paerl and Paul 2012), it was interesting that nutrients and sunlight had interactive effects; reduced sunlight had no effect under low-nutrient conditions but caused a large decline in phytoplankton under high-nutrient conditions. This suggests that while phytoplankton abundance is commonly nutrient-limited, it becomes light-limited when nutrients are abundant (e.g., Karlsson et al. 2009).

We hypothesized that the increases in phytoplankton caused by added nutrients or salt would shade the deeper periphyton and thereby reduce the biomass of periphyton. When we added nutrients, periphyton initially showed no change in biomass, but after 77 d, it showed an increase. The increase exhibited no interaction with light levels, suggesting that while the periphyton was nutrient-limited, it was not light-limited (unlike phytoplankton). In the case of added salt, we also observed an increase in periphyton, which was in contrast to our shading hypothesis: that the increase of phytoplankton caused by nutrient and salt additions would indirectly cause a decline in periphyton due to a shading effect. The most likely explanation for our observation of increased periphyton with salt addition is that the salt was toxic to one of the major periphyton grazers (e.g., banded mystery snails); as a result, the lower grazing pressure by snails in the high-salt treatments allowed for an increase in periphyton. Consistent with this result are other recent studies that have found periphyton increases with elevated salt (e.g., Van Meter et al. 2011, Dananay et al. 2015). However, the novel takeaway message is that increases in nutrients and salts appear to affect phytoplankton and periphyton abundance additively and not synergistically.

Macroalgae

We also found several surprising responses to our manipulations on the *Nitella* macroalgae. First, *Nitella* showed no increase in biomass when we added nutrients (Fig. 3). This suggests not only that this macroalga is not limited by nutrients, but also that it is not limited by the reduced sunlight availability that occurred as the added nutrients initiated a phytoplankton bloom. This resiliency of *Nitella* under different nutrient conditions may reflect its ability to extract and store considerable amount of nutrients from the water (Kufel and Kufel 2002).

Clear evidence that *Nitella* is not harmed by reduced sunlight availability comes from the results of our light manipulations (Fig. 3). In the absence of added salt (e.g., 15 mg Cl^-/L), large

reductions in sunlight resulted in substantial higher *Nitella* biomass. Previous studies have shown that charophytes, such as *Nitella*, can use low light intensities effectively and can therefore survive in deep water (Blindow 1992, Kufel and Kufel 2002). The fact that *Nitella* did not respond favorably to the shading effect of the phytoplankton bloom that occurred with added nutrients suggests that the reduced light availability from the phytoplankton bloom was weaker than the reduced light availability in our light manipulations, or might have caused some type of resource competition that we did not measure.

We also found, for the first time, that *Nitella* is highly sensitive to increased salt. This is surprising given that *Nitella* has been found in salinities up to 5000 mg/L (James et al. 2003). When growing well under low-light conditions, increases in salt severely reduced *Nitella* biomass in our treatments. Moreover, photosynthetic pigment concentration can indicate the physiological status of a plant (Peñuelas et al. 1995) and the lower chl *a* concentration in *Nitella* in high-salt treatments also indicates that the macrophyte was experiencing physiological stress caused by elevated salt concentration. While the impact of salt disappeared under high-light conditions, this was simply because *Nitella* grew so poorly under high-light conditions that there was very little remaining scope for a response to salt.

This high sensitivity to increased salt concentrations is particularly relevant given that many salt-polluted lakes can achieve salt concentrations of 250 to 1,000 mg Cl^-/L (Novotny et al. 2008). An additional concern arises if tributaries carry high salt concentrations into lakes and then this water sinks to lake bottoms (due to the higher density of the salty water). Under this scenario, concentrated salt water would descend to the deeper waters where *Nitella* lives and this would cause a major decline in *Nitella* abundance, with potential cascading effects on the animals that depend on the *Nitella* meadows for habitat. In summary, our results suggest that *Nitella* meadows are very susceptible to increased salt, but do not respond to increases in nutrients.

For filamentous algae, we did not find any effects of increased nutrients or light. However, we found filamentous algae to decrease with elevated salt indicating that filamentous algae have a similar salinity tolerance as *Nitella*. Hintz et al. (2017) also found that the biomass of filamentous algae decreased substantially with elevated salt levels. Thus, this may turn out to be a common observation in salt-impacted freshwater habitats.

Snails

While neither snail species performed well under low-light conditions, they had unique responses to increased salt and nutrients. The negative response to low-light conditions is likely a response to low periphyton productivity. While we measured periphyton standing crop, which did not respond to light, it appears that the productivity of periphyton growth was quite limiting to the growth of pond snails. Further support for this conclusion can be found in the pond snails, which experienced a higher abundance when nutrients were added, which increased periphyton standing crop. In contrast, banded mystery snails did not respond to the nutrient addition (Fig. 4).

Banded mystery snails are more commonly found in mesotrophic and eutrophic lakes and ponds (Browne 1978, Lee et al. 2002), although they also can be abundant in some oligotrophic lakes (e.g., Lake George, New York, USA). We therefore expected an increase in banded mystery snails with nutrient addition. The difference in sensitivity to nutrients may reflect differences in their feeding habits. Banded mystery snails are primarily detritivores, whereas pond snails are primarily periphyton grazers (Lee et al. 2002, Evans-White and Lamberti 2009). As a result, increased nutrients that cause increased periphyton productivity should favor an increased production of pond snails but have weaker effects on banded mystery snails.

A major difference between the two snail species was in their response to increased salt. Pond snails exhibited no harmful effects of increased salt, whereas banded mystery snails were nearly exterminated by high salt concentrations. However, the harmful impact of salt on banded mystery snails could only be observed under medium- and high-light conditions, since low-light conditions caused very few banded mystery snails to survive. Collectively, this suggests that the two snail species have dramatically different tolerances to salt. Moreover, as detritivores,

banded mystery snails assimilate contaminants from the sediments (which can have higher salt concentrations since saltier water has a higher density), while pond snails are grazers and would be less likely to directly assimilate contaminants from the sediments (Lee et al. 2002, Evans-White and Lamberti 2009). As a result, even if banded mystery snails and pond snail have a similar tolerance to salt, banded mystery snails may be exposed to higher levels of salt because of their habit of feeding on the detritus of sediments. Previous studies have shown pond snails to have a high tolerance to salinity (Kefford and Nugegoda 2005, Hintz et al. 2017) and that the tolerance increases with life stage (Kefford et al. 2004, 2007), while no studies on the salt tolerance of banded mystery snails were found. We clearly need much more information on the variation in salt tolerance among gastropods to better understand how salt will alter species assemblages in freshwater habitats. However, the data from our study indicate that the impacts of salt and nutrient inputs on snails are additive rather than synergistic.

Zooplankton

The zooplankton responded positively to increased sunlight and nutrients (Fig. 5). The positive response to increased sunlight and nutrients is not particularly surprising, since both of these factors combined produce a larger standing crop of phytoplankton. Increases in phytoplankton driving increases in zooplankton populations are a common observation in freshwater ecosystems (Canfield and Jones 1995, Ger et al. 2014). When more than 50% of total phytoplankton biomass are cyanobacteria, negative effects from eutrophication start to occur (Ger et al. 2014). However, zooplankton abundance did not suffer any negative effects under high-nutrient conditions; on the contrary, zooplankton populations in our mesocosms tracked the increase in phytoplankton following nutrient addition.

The more novel finding was the decline in zooplankton with increased salt and that this dynamic changed over time. We found that cladocerans and copepods experienced declines in abundance as we increased salt from 250 to 1000 mg Cl^-/L (Fig. 5). These declines are consistent with past studies of zooplankton sensitivity to salt (e.g., Petranka and Doyle 2010, Van Meter and Swan 2014, Hintz et al. 2017, Stoler et al. 2017). We also found rotifers to be less sensitive to increased salt, which is also consistent with previous studies (Sarma et al. 2006, Hintz et al. 2017). Collectively, these studies suggest that the decline in copepods that we observed in our mesocosm study was the result of direct toxicity to the added salt.

Given the direct toxicity of the high-salt treatment and given the fact that sodium and chloride do not break down or leave the system, it is quite interesting that the negative impact of salt diminished over time. A similar observation was made recently by Hintz et al. (2017) who tracked zooplankton abundance over time, and a follow-up study provided the underlying explanation. In the case of cladocerans, Coldsnow et al. (2017) found that large populations that experience high concentrations of salt are initially greatly reduced in abundance but not completely eliminated. The few that persist possess salt tolerance and, over time, these salt-tolerant cladocerans reproduce and ultimately rise to an abundance that is similar to the abundance of cladocerans that were never exposed to salt. Given this discovery, it may be the case that the copepods also evolve increased tolerance during the experiment. Many copepods experience different feeding modes during their development with some copepods changing from feeding on phytoplankton to becoming predatory (Brandl 2005). Therefore, the increase in cladocerans and rotifers in the second sampling occasion might be an indirect effect of released predation pressure as higher amount of copepods might still be in earlier developmental stages. However, even if there is always a chance of missing some patterns throughout the sampling period, our samples were taken in response to when communities were diverging among the treatments. Temperature could also influence zooplankton reproduction; however, we did not see any general drastic drop in the zooplankton community in the second sampling occasion that would indicate such a pattern (Figs. 5 and 6). In terms of our focus on the combined effects of added nutrients and road salts, our results suggest that the two anthropogenic factors have additive effects and not synergistic or antagonistic effects.

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Conclusions

Eutrophication and salinization are two ecosystem stressors that are being experienced in aquatic ecosystems around the world. While eutrophication has been studied for decades, the ecological effects of salinization are only recently receiving attention and the combined effects of the two stressors have received no attention. Our study has found that the combined effects of the two stressors—across the range of values examined—are entirely additive for all of the taxa we examined including phytoplankton, periphyton, macroalgae, snails, and zooplankton. While the impacts of anthropogenic additions of nutrients and salt are not synergistic, their combined effects on aquatic ecosystems are still of tremendous concern since they both contribute to major changes including phytoplankton and periphyton blooms (via bottom-up and top-down mechanisms, respectively). Equally important are the impacts of salinization alone, including causing a major decline in numerous taxa including zooplankton, snails, and macroalgae. One would reasonably predict that such declines would have further cascading effects on consumers that rely on the salt-sensitive prey and on species that rely on the expansive *Nitella* meadows (and perhaps other salt-sensitive macrophyte species) in freshwater lakes for habitats. Overall, the combined effects of salinization and eutrophication might fast-forward the process of lakes becoming hypertrophic, and this could potentially result in devastating algal blooms and poor water quality.

As the first study to examine the combined effects of salt and nutrients, there is clearly much more work to be done. For example, the striking negative effects of NaCl road salt on macroalgae suggest that many other macroalgae species, and perhaps many aquatic plant species that are adapted to low salinities, may be highly susceptible to road salt pollution in freshwater ecosystems. The rebounding of both cladocerans and copepods after initial declines following salt exposure suggests evolved tolerance, but our current insights into this possibility are limited to only one species of cladoceran (Coldsnow et al. 2017). There has also been growing interest in using other road salts (or mixtures of salts) for deicing roads including $MgCl_2$ and $CaCl_2$. Little research has examined the ecological impacts of these alternative salts and organic salt additives (but see Schuler et al. 2017*b*, Schuler and Relyea 2018). As we move forward on these frontiers, we will have a much more holistic idea of how anthropogenic impacts are altering aquatic ecosystems and develop management strategies for their mitigation.

Through these direct and indirect temperature effects, in combination with reduced wind speed and reduced cloudiness, summer heatwaves boost the development of harmful cyanobacterial blooms. These findings warn that climate change is likely to yield an increased threat of harmful cyanobacteria in eutrophic freshwater ecosystems.

Acknowledgments

LL, MS, WH, DJ, BM, AS, and RR conceived and designed the experiment. LL, MS, WH, BM, DJ, AS, and RR performed the experiment and collected the data. LL preformed all statistical analyses, and LL, MS, WH, DJ, BM, AS, and RR wrote the manuscript. RR also secured funding support and equipment. Funding was provided by Rensselaer Polytechnic Institute start-up funds to RR, and by The Jefferson Project at Lake George, which is a collaboration of Rensselaer Polytechnic Institute, IBM, and The FUND for Lake George. We thank James Hu, Christina Akirtava, Alex Brooks, Jeevan Narendran, Reilly Cooper, Brent Walker, Mike Kalonstian, Cody Van DeLaarschot, Kelsey Sudol, Sherese Morgan, and Alison Samsel for their help throughout the experiment and with sample processing.

Literature Cited

Anderson, D. M., P. M. Glibert, and J. M. Burkholder. 2002. Harmful algal blooms and eutrophication: nutrient sources, composition, and consequences. Estuaries 25:704–726.

Arar, E. J., and G. B. Collins. 1997. Method 445.0 in vitro determination of chlorophyll *a* and pheophytin *a* in marine and freshwater algae by fluorescence. National Exposure Research Laboratory Office of Research and Development U.S. Environmental Protection Agency, Cincinnati, Ohio, USA.

Bendis, R. J., and R. A. Relyea. 2016. Wetland defense: Naturally occurring pesticide resistance in zooplankton populations protects the stability of aquatic communities. Oecologia 181:487–498.

Blindow, I. 1992. Decline of Charophyta during eutrophication: a comparison to angiosperms. Freshwater Biology 27:9–14.

Bolen, P. W. 2013. 2013 Minerals yearbook, salt (advanced release). U.S. Geological Survey 63:1–25.

Boylen, C., L. Eichler, M. Swinton, S. Nierzwicki-Bauer, I. Hannoun, and J. Short. 2014. The state of the lake: thirty years of water quality monitoring on Lake George, New York, 1980–2009. Darrin Fresh Water Institute, Bolton Landing, New York, USA.

Brandl, Z. 2005. Freshwater copepods and rotifers: predators and their prey. Pages 475–489 *in* A. Herzig, R. D. Gulati, C. D. Jersabek, and L. May, editors. Rotifera X: Rotifer research: trends, new tools and recent advances. Hydrobiologia Volume 546. Springer, Dordrecht, The Netherlands.

Browne, R. A. 1978. Growth, mortality, fecundity biomass and productivity of four lake populations of the Prosobranch snail *Viviparus Georgianus*. Ecology 59:742–750.

Environment Canada. 2001. Canadian Environmental Protection Act, 1999: Priority Substances List Assessment Report—Road Salts. Minister of Public Works and Government Services, Toronto, Ontario, Canada.

Cañedo-Argüelles, M., M. Sala, G. Peixoto, N. Prat, M. Faria, A. M. V. M. Soares, C. Barata, and B. Kefford. 2016. Can salinity trigger cascade effects on streams? A mesocosm approach. Science of the Total Environment 540:3–10.

Canfield, T. J., and J. R. Jones. 1995. Zooplankton abundance, biomass, and size-distribution in selected Midwestern waterbodies and relation with trophic state. Journal of Freshwater Ecology 11:171–181.

Carpenter, S. R., J. F. Kitchell, and J. R. Hodgson. 1985. Cascading trophic interactions and lake productivity. BioScience 35:634–639.

Carpenter, S. R., and D. M. Lodge. 1986. Effects of submersed macrophytes on ecosystem processes. Aquatic Botany 26:341–370.

Coldsnow, K. D., B. M. Mattes, W. D. Hintz, and R. A. Relyea. 2017. Rapid evolution of tolerance to road salt in zooplankton. Environmental Pollution 222:367–373.

Conley, D. J., H. W. Paerl, R. W. Howarth, D. F. Boesch, S. P. Seitzinger, K. E. Havens, C. Lancelot, and G. E. Likens. 2009. Controlling eutrophication: nitrogen and phosphorus. Science 323:1014–1015.

Corsi, S. R., D. J. Graczyk, S. W. Geis, N. L. Booth, and K. D. Richards. 2010. A fresh look at road salt: aquatic toxicity and water-quality impacts on local, regional, and national scales. Environmental Science & Technology 44:7376–7382.

Cronin, G., and D. M. Lodge. 2003. Effects of light and nutrient availability on the growth, allocation, carbon/nitrogen balance, phenolic chemistry, and resistance to herbivory of two freshwater macrophytes. Oecologia 137:32–41.

Cushing, C. E., and J. D. Allan. 2001. Streams: their ecology and life. Academic Press, San Diego, California, USA.

Dananay, K. L., K. L. Krynak, T. J. Krynak, and M. F. Benard. 2015. Legacy of road salt: apparent positive larval effects counteracted by negative post-metamorphic effects in wood frogs. Environmental Toxicology and Chemistry 34:2417–2424.

Deegan, B., T. J. Harrington, and P. Dundon. 2005. Effects of salinity and inundation regime on growth and distribution of *Schoenoplectus triqueter*. Aquatic Botany 81:199–211.

Downing, A. L., and M. A. Leibold. 2002. Ecosystem consequences of species richness and composition in pond food webs. Nature 416:837–841.

Dugan, H. A., et al. 2017. Data Descriptor: long-term chloride concentrations in North American and European freshwater lakes. Scientific Data 4:170101.

EPA. 1988. Ambient water quality criteria for chloride. Report no. 440/5-88-001. U.S. EPA, Washington, D.C., USA.

EPA. 2016. http://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals

Evans-White, M. A., and G. A. Lamberti. 2009. Direct and indirect effects of potential aquatic contamination on grazer-algae interactions. Environmental Toxicology and Chemistry 28:418–426.

Ger, K. A., L.-A. Hansson, and M. Lurling. 2014. Understanding cyanobacteria-zooplankton interactions in a more eutrophic world. Freshwater Biology 59:1783–1798.

Gitelson, A. A., Y. Gritz, and M. N. Merzlyak. 2003. Relationships between leaf chlorophyll content and spectral reflectance and algorithms for non-destructive chlorophyll assessment in higher plant leaves. Plant Physiology 160:271–282.

Haller, W. T., D. L. Sutton, and W. C. Barlowe. 1974. Effects of salinity on growth of several aquatic macrophytes. Ecology 55:891–894.

Havens, K. E., R. T. James, T. L. East, and V. H. Smith. 2003. N: P ratios, light limitation, and cyanobacterial dominance in a subtropical lake impacted by non-point source nutrient pollution. –. Environmental Pollution 122:379–390.

Hintz, W. D., B. M. Mattes, M. S. Schuler, D. K. Jones, A. B. Stoler, L. Lind, and R. Relyea. 2017. Salinization triggers a trophic cascade in experimental freshwater communities with varying food-chain length. Ecological Applications 27:833–844.

Horrigan, N., S. Choy, J. Marchall, and F. Recknage. 2005. Response of stream macroinvertebrates to changes in salinity and the development of a salinity index. Marine and Freshwater Research 56:825–833.

Howard, K. W. F., and H. Maier. 2007. Road de-icing salt as a potential constraint on urban growth in the Greater Toronto Area, Canada. Journal of Contaminant Hydrology 9:146–170.

Howeth, J. G., and M. A. Leibold. 2010. Prey dispersal rate affects prey species composition and trait diversity in response to multiple predators in metacommunities. Journal of Animal Ecology 79:1000–1011.

Hua, J., and R. Relyea. 2014. Chemical cocktails in aquatic systems: pesticide effects on the response and recovery of >20 animal taxa. Environmental Pollution 189:18–26.

Jackson, M. C., C. J. G. Loewen, R. D. Vinebrook, and C. T. Chimimba. 2016. Net effects of multiple stressors in freshwater ecosystems: a meta-analysis. Global Change Biology 22:180–189.

James, K. R., B. Cant, and T. Ryan. 2003. Responses of freshwater biota to rising salinity levels and implications for saline water management: a review. Australian Journal of Botany 51:703–713.

Karlsson, J., P. Byström, J. Ask, P. Ask, L. Persson, and M. Jansson. 2009. Light limitation of nutrient-poor lake ecosystems. Nature 460:506–510.

Keeler, B. L., S. Polasky, K. A. Brauman, K. A. Johnson, J. C. Finlay, A. O'Neill, K. Kovacs, and B. Dalzell. 2012. Linking water quality and well-being for improved assessment and valuation of ecosystem services. Proceedings of the National Academy of Sciences USA 109:18619–18624.

Kefford, B. J., A. Dalton, C. G. Palmer, and D. Nugegoda. 2004. The salinity tolerance of eggs and hatchlings of selected aquatic macroinvertebrates in south-east Australia and South Africa. Hydrobiologia 517:179–192.

Kefford, B. J., and D. Nugegoda. 2005. No evidence for a critical salinity threshold for growth and reproduction in the freshwater snail *Physa acuta*. Environmental Pollution 134:377–383.

Kefford, B. J., D. Nugegoda, L. Metzeling, and E. J. Fields. 2006. Validating species sensitivity distributions using salinity tolerance of riverine macroinvertebrates in the southern Murray-Darling Basin (Victoria, Australia). Canadian Journal of Fisheries and Aquatic Sciences 63:1865–1877.

Kefford, B. J., D. Nugegoda, L. Zalizniak, E. J. Fields, and K. L. Hassell. 2007. The salinity tolerance of freshwater macroinvertebrate eggs and hatchlings in comparison to their older life-stages: a diversity of responses. Ecology 41:335–348.

Kovalenko, K. E., E. D. Dibble, and J. G. Slade. 2010. Community effects of invasive macrophyte control: role of invasive plant abundance and habitat complexity. Journal of Applied Ecology 47: 318–328.

Kufel, L., and I. Kufel. 2002. *Chara* beds acting as nutrient sinks in shallow lakes – a review. Aquatic Botany 72:249–260.

Lacoul, P., and B. Freedman. 2006. Environmental influences on aquatic plants in freshwater ecosystems. Environmental Reviews 14:89–136.

Lee, L. E. J., J. Stassen, A. McDonald, C. Culshaw, A. D. Venosa, and K. Lee. 2002. Snails as Biomonitors of Oil-Spill and Bioremediation Strategies. Bioremediation Journal 6:373–386.

Malmqvist, B., and S. Rundle. 2002. Threats of the running water ecosystems of the world. Environmental Conservation 29:134–153.

Naiman, R. J., S. E. Bunn, C. Nilsson, G. E. Petts, G. Pinay, and L. C. Thompson. 2002. Legitimizing fluvial ecosystems as users of water: an overview. Environmental Management 30:455–467.

Novotny, E. V., D. Murphy, and G. S. Heniz. 2008. Increase of urban lake salinity by road deicing salt. Science of the Total Environment 406:131–144.

Paerl, H. W., and V. J. Paul. 2012. Climate change: links to global expansion of harmful Cyanobacteria. Water Research 46:1349–1363.

Parida, A. K., and A. B. Das. 2005. Salt tolerance and salinity effects on plants: a review. Ecotoxicology and Environmental Safety 60:324–349.

Peñuelas, J., F. Barte, and I. Filella. 1995. Semi-empirical indices to asses carotenoids/chlorophyll from leaf spectral reflectance. Photosynthetica 31: 221–230.

Petranka, J. W., and E. J. Doyle. 2010. Effects of road salts on the composition of seasonal pond communities: Can the use of road salts enhance mosquito recruitment? Aquatic Ecology 44:155–166.

Rogora, M., et al. 2015. Recent trends in chloride and sodium concentrations in the deep subalpine lakes (Northern Italy). Environmental Science and Pollution Research 22:19013–19026.

Rout, N. P., and B. P. Shaw. 2001. Salt tolerance in aquatic macrophytes: possible involvement of the antioxidative enzymes. Plant Science 160: 415–423.

Rout, N. P., S. B. Tripathi, and B. P. Shaw. 1997. Effects of salinity on chlorophyll and proline contents in three aquatic macrophytes. Biologia Plantarum 40:453–458.

Rowe, C. L., and W. A. Dunson. 1994. The value of simulated pond communities in mesocosms for studies of amphibian ecology and ecotoxicology. Journal of Herpetology 28:346–356.

Sarma, S. S. S., S. Nandini, J. Morales-Ventura, I. Delgado-Martínez, and L. González-Valverde. 2006. Effects of NaCl salinity on the population dynamics of freshwater zooplankton (rotifers and cladocerans). Aquatic Ecology 40:349–360.

Scheffer, M., S. H. Hosper, M. L. Meijer, B. Moss, and E. Jeppesen. 1993. Alternative equilibria in shallow lakes. Trends in Ecology and Evolution 8:275–279.

Schuler, M. S., J. M. Chase, and T. M. Knight. 2017*a*. Habitat patch size alters the importance of dispersal for species diversity in an experimental freshwater community. Ecology and Evolution 7:5774–5783.

Schuler, M. S., W. D. Hintz, D. K. Jones, L. A. Lind, B. M. Mattes, A. B. Stoler, K. A. Sudol, and R. Relyea. 2017*b*. How common road salts and organic additives alter freshwater food webs: in search of safer alternatives. Journal of Applied Ecology 54:1353–1361.

Schuler, M. S., and R. A. Relyea. 2018. The effects of road salt and organic deicer additives on mosquito recruitment in experimental freshwater ponds. Oikos 127:866–874.

Stoler, A. B., B. M. Walker, W. D. Hintz, D. K. Jones, L. Lind, B. M. Mattes, M. S. Shuler, and R. Relyea. 2017. Combined effects of road salt and an insecticide on wetland communities. Environmental Toxicology and Chemistry 36:771–779.

Thunqvist, E.-L. 2004. Regional increase of mean chloride concentration in water due to the application of deicing salt. Science of the Total Environment 325:29–37.

Van Meter, R. J., and C. M. Swan. 2014. Road salts as environmental constraints in urban pond food webs. PLoS ONE 9:e90168.

Van Meter, R. J., C. M. Swan, J. Leips, and J. W. Snodgrass. 2011. Road salt stress induces novel food web structure and interactions. Wetlands 31:843–851.

Supporting Information

Additional Supporting Information may be found online at: http://onlinelibrary.wiley.com/doi/10.1002/ecs2.2383/full

Exhibit 189

EPA.PublicHearingCom

From: Jane Cogie <jane.cogie@gmail.com>
Sent: Sunday, August 11, 2019 11:25 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666, Notice No. 7516c
Attachments: NPDES Permit IL0077666-Jane Cogie.docx

Dear Mr. LeCrone,

I have attached my comments on the proposed Williamson Energy, LLC permit to discharge mine waste into the Big Muddy River (NPDES IL0077666, Notice No. 7516c).

In my comments, I request an extension of the comment period and a public hearing. I also ask that the IEPA conduct an additional study that would provide an Environmental Impact Statement.

Please include my comments in the official record for this permit application.

Sincerely,
Jane Cogie
1010 S. Oakland Avenue
Carbondale, IL 62901
jane.cogie@gmail.com
618-549-4673

Jane Cogie
1010 South Oakland
Carbondale, IL 62901
jane.cogie@gmail.com
618-549-4673

Darin LeCrone
IEPA Bureau of Water
Water Pollution Control Permit Section
1021 North Grand Ave. East
Springfield, IL 62794-9276

August 11, 2019

Re: Williamson Energy Pond Creek Mine NPDES IL0077666, Notice Number 7516c

Dear Mr. LeCrone:

I am writing to ask the Illinois Environmental Protection Agency to extend the comment period for the Pond Creek Mine's draft-renewed permit application. One month for comments is inadequate, particularly given the interlocking sets of data to be considered. I also urge the IEPA to hold a hearing to provide a public forum for citizen input.

Furthermore, I request that the IEPA study the impact of the waste water the proposed pipeline would dump into the Big Muddy—in other words, that the IEPA compile an Environmental Impact Statement. Such a study seems warranted, in particular for determining the cumulative impact of contaminants, including not just the Pond Creek Mine contaminants, which I note below, but also those contaminants already being emitted into the river from other sources, such as the Sugarcreek Mine and runoff from surrounding farm lands.

I submit these requests as a concerned citizen. From the documents I have reviewed, it is clear that concern is warranted. Available data on Pond Creek Mine waste water show that it contains high levels of chloride, sulfates, and heavy metals—dangerous to fresh water mussels and fish that inhabit the Big Muddy, not to mention other wildlife that depends on the river to survive.

Concern about the Pond Creek Mine dumping waste into this river should not be limited to the contaminants. There is also the concern over the greater flooding that would result with the addition of the millions of gallons of Pond Creek Mine waste water, particularly following heavy rain events. Such rain events have become far more frequent with climate change. Indeed one of Williamson Energy's rationales for this permit application is that steps are needed to prevent contaminants from overtopping the holding basins and harming the health of the mine's workers. Although Williamson Energy's plan includes monitoring of contaminant levels, its plan does not address the flooding potential from the sheer quantity of mine waste water to be added daily to the Big Muddy's fluctuating flow.

The company's proposed pipeline is not a solution for the handling toxic waste produced at the Pond Creek Mine. An actual solution would be for Williamson Energy to clean the waste water in an onsite water treatment plant before emitting it. A highly

Re: Williamson Energy Pond Creek Mine NPDES IL0077666, Notice Number 7516c

profitable company, Williamson can and should use some of its profits to clean up its own waste. During a time when scientists recognize that fossil fuels must be replaced by renewable energy, this kind of de facto subsidy for Williamson Energy is unacceptable. Williamson Energy doesn't own the Big Muddy River. It belongs to all of us.

Thank you for taking my comments into consideration—and for convening a hearing to review Williamson Energy's permit application and on the impacts approval of it would have on the Big Muddy.

Respectfully submitted,
Jane Cogie
1010 S. Oakland Avenue
Carbondale, IL 62901
(618) 549-4673
jane.cogie@gmail.com

Exhibit 190

EPA.PublicHearingCom

From: CaseyRhea Stout <caseyrheastout@gmail.com>
Sent: Monday, August 12, 2019 6:53 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Dear Sir,

I am writing to urge you not to approve the dumping of polluted water by Williamson Energy into the Big Muddy River. Please consider your responsibilities to protect the people and ecosystems in this state. This dumping can create mass devastation of an enormous amount of ecosystems. With the muddy bottom, pollutants could become trapped in the sediments and create toxic environments for both wildlife and humans even beyond the point of ceased dumping. And please do not forget that the Big Muddy eventually dumps into the Mississippi and we can and will be held responsible for any outstate damage that WILL happen as well. You can and should prevent this from happening. No amount of of kickbacks you might be getting should be more important than the protection of our wildlife, ecosystems, and people. No amount of jobs you might feel responsible for maintaining or creating should be more important that the protection of our wildlife, ecosystems, and people. It is your job to do nothing but protect our wildlife, ecosystems, and people from pollution - do your job, only your job, and DO NOT ALLOW THIS TO HAPPEN.

Sincerely,

Casey R. Stout

Exhibit 191

EPA.PublicHearingCom

From: jane payne <jane.payne111@gmail.com>
Sent: Monday, August 12, 2019 10:59 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice NO.7516c

My interest in the quality of water in the Big Muddy River is a personal one. My partner and I have lived in Pomona since 1978. Our property is .5 miles from Cedar Creek which flows into the Big Muddy which flows into the Mississippi River. When the water backs up, we can put our canoes and kayaks in at the bridge. There is no current; we paddle through tree tops on our way to the Big Muddy. It is a beautiful and surreal experience. We have been able to do that at least four times in the last two years.

With the scarcity of potable water being a world wide crisis, to pollute (even a bit) such a treasure as the Big Muddy makes no economic, aesthetic or rational sense. Unhealthy/toxic byproducts need to be "disarmed" if possible, but to damage a healthy ecosystem in order to dispose of the waste from a dying industry is not sane.

I also have an investment in Southern Illinois being an environmentally safe recreational area, for me, my neighbors and the people that visit. I live here because of the natural beauty of the Shawnee National Forest. George and I are the owners of the Pomona Winery, founded in 1991. We are proud of being part of the tourism industry in southern Illinois and want to help it flourish without degradation to the environment. We need to protect these resources.

Sincerely,
Jane Payne, owner of the Pomona Winery
2865 Hickory Ridge Road
Pomona, Illinois 62975
Jackson County

Exhibit 192

EPA.PublicHearingCom

From: Becky Schneider <becky_schneider1@yahoo.com>
Sent: Monday, August 12, 2019 11:18 AM
To: LeCrone, Darin
Subject: [External] NPDES IL 0077666 & notice 7516c

I am against this for many reasons. I understand finding somewhere to put toxic byproducts is difficult, but please do not use the Big Muddy to do so. We fish and get frogs out of the river. I wish you the best of luck with dealing with this, but please do not allow more pollution in this river.

Thank you,
Becky Schneider
618-697-4138

Sent from my iPhone

Exhibit 193

EPA.PublicHearingCom

From: Tom Bik <thomasjbik@gmail.com>
Sent: Monday, August 12, 2019 11:39 AM
To: LeCrone, Darin
Cc: senschimpf58@gmail.com; staterepterribryant@gmail.com
Subject: [External] NPDES IL0077666 Notice No. 7516c

darin.lecrone@illinois.gov
NPDES IL0077666
Notice No. 7516c
August 12, 2019
Public Comments Pond Creek Mine Pipeline Application
I am writing to urge that the Illinois Department of Natural Resources (IDNR) and the Illinois Environmental Protection Agency (IEPA) to deny or reverse any permits needed to facilitate the Pond Creek Mine's application to construct a pipeline that would dump millions of gallons of mine waste into the Big Muddy River.
According to newspaper accounts and government documents, this company (Williamson Energy) already has a shaky record of pollution of tributaries of the Big Muddy and groundwater mining that has severely impacted neighboring households and communities. There are numerous economic and environmental arguments against allowing this project to go forward.
This project does not make economic sense. The pipeline project would allow mine operators to externalize the cost of treating the wastewater created by its operation to the public. In a true market economy this coal mine might have to concede that dealing with the wastes that it generates in an environmentally sound way costs more than it is worth to take the coal out of the ground. So by allowing this project to proceed the IEPA and IDNR are not only facilitating the poisoning of the Big Muddy River, but also hastening global climate change. The jobs created by this mining operation are not a fair justification for the economic damage that has already been done in local communities, or that would be done downstream from its discharge, if implemented. If the State of Illinois is seriously concerned about the livelihoods of Illinois coal miners, it would do well to enact a severance tax on Illinois coal so that a fund could be establish to retrain coal miners into non-fossil fuel energy sector jobs.
This project does not make environmental sense. No environmental impact studies have been done on the long term effects of this project, including: cumulative water quality, fish and wildlife effects, bank erosion, and the social and environmental costs to the communities and individuals that live along and use the Big Muddy River. As a frequent recreational visitor to Oakwood Bottoms, Greentree Reservoir, I would echo the words of the Southern Illinoisan's 8-4-19 Editorial "The ecological importance of the lower Big Muddy River seems to be ample justification for denying the (permit) request."
I urge IDNR and IEPA to hold a public hearing be held so that citizens may be given an opportunity to publicly comment on this project, that if allowed to proceed will provide no benefits to the people of the region or the nation.
Thank you.
Thomas J. Bik
10 Pinewood Dr.
Carbondale, IL 62901
thomasjbik@gmail.com
cc: State Senator Paul Schimpf
State Representative Terry Bryant

Exhibit 194

EPA.PublicHearingCom

From: Mary Ellen <jwdmed@consolidated.net>
Sent: Monday, August 12, 2019 12:00 PM
To: LeCrone, Darin
Subject: [External] Public Hearing Request for NPDES Permit No. IL 0077666 Notice No. 7516c Williamson Energy LLC, Permit No. 456

IEPA
Agency Bureau of Water
Division of Water Pollution
Control Permit Section
1021 North Grand Avenue East
P. O. Office Box 19276
Springfield, Il 62794-9276

TO Darin LeCrone
Sent via darin.lecrone@illinois.gov

RE: Public Hearing Request for NPDES Permit No. IL 0077666 Notice No. 7516c Williamson Energy LLC, Permit No. 456

The proposed pipeline to transport coal wastewater from Pond Creek Mine in Williamson County to be discharged into the Big Muddy River in Franklin County must be denied. Pond Creek Mine must not pollute a navigable waterway with coal mine water that should be the responsibility of Williamson Energy LLC.

How did Williamson Energy LLC dispose of the high chloride /sulfate water in the past? It is known that this mine has had water accumulation problems for years. Longwall mining creates havoc for landowners' property and especially their wells, lakes, and ponds. I saw the devastation that Pond Creek mining did to Charles DuBose's home, lake, pond and well. Now this mine has the audacity to request that the taxpayer further subsidizes this mine and allow even more harm to a public waterway.

A Public Hearing would allow concerned citizens to express how approval of NPDES No. IL0077666 Notice No. 7516c would impact their lives and the quality of their environment.

Thank you for your consideration,

Mary Ellen DeClue
366 Westlake Trail

Litchfield, IL 62056

EPA.PublicHearingCom

Exhibit 195

From: Miles Maether <milesmaether89@icloud.com>
Sent: Monday, August 12, 2019 12:02 PM
To: LeCrone, Darin
Subject: [External] NPDES IL 0077666 Notice 7516C

Sent from my iPhone
I am against any additional waste being dumped into the big muddy river. Illinois public waters are polluted enough.

Exhibit 196

EPA.PublicHearingCom

From: matt borowicz <bluzbr2chicago@yahoo.com>
Sent: Monday, August 12, 2019 12:31 PM
To: LeCrone, Darin
Subject: [External] requesting a hearing on the IEPA's position on the pine creek pipeline

The IEPA should not be allowing polluted waste water into the Big Muddy River. It will pollute land, wildlife, people, and is a bad decision.
Please have a open hearing on this topic and allow our community to voice concerns over this bad proposal. We live here, we fish the waters, we hunt on the land, and your agency should not allow a company to destroy public lands and waters. PERIOD. You are the Illinois ENVIRONMENTAL PROTECTION agency. Now, PROTECT OUR ENVIRONMENT.
Thank you,
Matthew Borowicz
Jackson County Resident and Illinois Taxpayer

EPA.PublicHearingCom

From: Matt Borowicz <bluzbr2chicago@yahoo.com>
Sent: Tuesday, August 13, 2019 12:52 PM
To: LeCrone, Darin
Subject: [External] Re: requesting a hearing on the IEPA's position on the pine creek pipeline

Dear Sir,
I would like a reply to my request for a public hearing on the IEPA's poor decision on allowing polluted waste water to be dumped into the BiG Muddy River.
Thank you,
Matthew Borowicz
Jackson County Resident and Illinois Taxpayer

Sent from my iPhone

On Aug 12, 2019, at 12:31 PM, matt borowicz <bluzbr2chicago@yahoo.com> wrote:

> The IEPA should not be allowing polluted waste water into the Big Muddy River. It will pollute land, wildlife, people, and is a bad decision.
> Please have a open hearing on this topic and allow our community to voice concerns over this bad proposal. We live here, we fish the waters, we hunt on the land, and your agency should not allow a company to destroy public lands and waters. PERIOD. You are the Illinois ENVIRONMENTAL PROTECTION agency. Now, PROTECT OUR ENVIRONMENT.
> Thank you,
> Matthew Borowicz
> Jackson County Resident and Illinois Taxpayer

Exhibit 197

EPA.PublicHearingCom

From: paula whowantstoknow <erpavo@gmail.com>
Sent: Monday, August 12, 2019 12:32 PM
To: LeCrone, Darin
Subject: [External] Mine Waste Pollution of our Big Muddy River

Dear Mr. LeCrone,

I am dismayed that the state of Illinois would allow a coal mining company to pollute our waters, which goes against our state constitution and all human decency.

The very least we can expect is that the mine treat all wastewater onsite with reverse osmosis treatment to reduce the amount of pollutants entering the river. Since it appears the company is incapable of regular monitoring and reporting, we also request the installation of a SCADA system at the point of discharge so the public can monitor, in real time, the discharge and flow of treated water that enters the river. We also request a maximum volume of treated water to be discharged in any given event be less than 500,000 gallons, and only during times when the river is below flood stage. Or, if the lower limit cannot be achieved, we recommend the company treat the waste water on site AND install a pipeline to go all the way to the Mississippi River to avoid the sensitive ecological areas south of Murphysboro. Again, with a SCADA system at the outfall of the pipe.
There has been no assessment of cumulative water quality impacts from continued coal mining.
There has been no assessment of increased water volume with regard to flooding, sedimentation, and downstream impacts.
There has been no assessment for the large withdrawals of underground water resources and the impact and implications that might have on future groundwater resources.
And there has been no assessment of the full social, health, environmental, economic or climate cost of this mine to Illinois tax payers.
For these reasons, I ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c

With concern,

Paula B radshaw
1801 New Era Rd
Carbondale, IL

Exhibit 198

EPA.PublicHearingCom

From: George Majka <pomonawinery@wildblue.net>
Sent: Monday, August 12, 2019 12:39 PM
To: LeCrone, Darin
Subject: [External] NPDESIL0077666 notice #7516c

Good day:

Water and air, our two most precious resources. I find it hard to believe that anyone would even consider putting toxic pollutants into one of Illinois' rivers to support jobs in a dying industry.

George Majka
Concerned citizen

EPA.PublicHearingCom Exhibit 199

From: Matthew Blessing <blessing5150@gmail.com>
Sent: Monday, August 12, 2019 12:38 PM
To: LeCrone, Darin
Subject: [External] NPDESIL0077666 & Notice #7516C

I do not support the use of the Big Muddy for the disposal of toxins and other waste products. Please vote against this.

Sent from my iPhone

Exhibit 206

EPA.PublicHearingCom

From: David Kidd <d.kidd1@mchsi.com>
Sent: Monday, August 12, 2019 1:05 PM
To: LeCrone, Darin
Subject: [External] Pond Creek Mine

To whom it may concern,

This is regarding Williamson Energy's request to dump millions of gallons of diluted wastewater from Pond Creek Mine into the Big Muddy River. (permit number IL0077666, notice no.7516c)

I strongly oppose allowing this. Totally neutralizing all by products of mining operations is the standard that Williamson Energy should be held to. If they can't do this because they are unable to pass the cost on to their customers and make a profit, they don't deserve to be in business. Public resources such as the Big Muddy should not be used to finish the dilution their effluent. Levels of what is safe evolve over time and allowing this practice to go forward because it meets "todays standards" is short sighted. Do the right thing and deny this request!

Sincerely,

David Kidd
1 Pinewood Dr.
Carbondale, IL 62901

Exhibit 201

EPA.PublicHearingCom

From: Laurel Toussaint <laureltous@hotmail.com>
Sent: Monday, August 12, 2019 1:29 PM
To: LeCrone, Darin
Cc: GovernorsOffice; senschimpf58@gmail.com; staterepterribryant@gmail.com
Subject: [External] NPDES IL0077666 Notice No. 7516c

August 11, 2019
Pond Creek Mine Pipeline Application
darin.lecrone@illinois.gov
NPDES IL0077666
Notice No. 7516c

Dear Mr. Lecrone:
I am writing to oppose the Pond Creek Mine's application to construct a pipeline that would dump millions of gallons of mine waste into the Big Muddy River.
No environmental impact studies have been done on the long term effects of this project, including: cumulative water quality, fish and wildlife effects, bank erosion, and the social and environmental costs to the communities and individuals that live along and use the Big Muddy River.
This pipeline project would allow this corporation to externalize its costs to the public. In a true market economy this coal mine might have to concede that dealing with the wastes that it generates in an environmentally sound way costs more than it is worth to take the coal out of the ground. So by allowing this project to proceed the IEPA and IDNR and not only facilitating the poisoning of the Big Muddy River, but also hastening global climate change.
I urge the IEPA and IDNR to reject all proposals for this harmful project.
I request that a public hearing be held so that citizens may be given an opportunity to publicly comment on a project that if allowed to proceed will provide no benefits to the people of the region or the nation.
Thank you,

Laurel Toussaint
10 Pinewood Dr.
Carbondale, IL 62901
laureltous@hotmail.com

cc: Governor J.B. Pritzer
Senator Paul Schimpt
Representative Terri Bryant

Exhibit 202

EPA.PublicHearingCom

From: Carla Womack <crusso1957@yahoo.com>
Sent: Monday, August 12, 2019 2:00 PM
To: LeCrone, Darin
Subject: [External] NPDESIL0077666 Notice No.7516c

Dear Mr. Lecrone,

As a citizen in Jackson County and near the Big Muddy River, I am asking you to please reconsider giving the Pond Creek Mine final permission to discharge mine waste water with high levels of sulfates and chlorides in the Big Muddy. I have canoed/kayaked on this body of water and do not want to see the damage this act will do. The sheer volume of water to be discharged alone is frightening as the maximum amount of wastewater allowed would have over 7 million gallons of wastewater and this is terrible. I know during heavy rain periods and during the spring, the river already floods many areas of Murphysboro and points upstream and downstream of us. My area where I live was impacted this May into June by flooding that subsequently flooded the creek near my home. It flooded the low-lying area of the Shawnee Forest (on the way to my house) that there was over 4 feet of floodwater over the road for more than a month. The "natural" river water alone was devastating to the wildlife and plant life in our area. I can NOT imagine what having cancer causing products in this water would do to the wildlife, plants and humans that would come in contact with these agents. Many of my neighbors do fish the river and these contaminates would have an awful impact on fish, other aquatic creatures and PEOPLE. Please do not give permission for this action. The mine should be building a water treatment plant onsite to take care of their water to ensure the discharges meet environmental regulations and not count on the Big Muddy River to "dilute" this contaminated water.

I also urge you to hold public hearings in the Jackson County (or Murphusboro) area. Many of the area residents would be interested in hearing the details for this action. The fact that the Big Muddy also dumps into the Mississippi River is a concern. The Gulf has had way too much damage from pesticide runoff (agriculture), floods, pollution. The impact of all of this in the Mississippi and Gulf has already taken a toll on coral and aquatic life. The extra sulfates and chloride would not be a good addition to the water.

Thank you for your consideration
Carla Womack
2010 Hickory Ridge Road
Pomona, IL 62975

Exhibit 203

EPA.PublicHearingCom

From: Jon Womack <dulce55@yahoo.com>
Sent: Monday, August 12, 2019 2:26 PM
To: LeCrone, Darin
Subject: [External] Pond Creek Mine

Dear Mr. Lecrone,

As a citizen in Jackson County and near the Big Muddy River, I am asking you to please reconsider giving the Pond Creek Mine final permission to discharge mine waste water with high levels of sulfates and chlorides in the Big Muddy. I have canoed/kayaked on this body of water and do not want to see the damage this act will do. The sheer volume of water to be discharged alone is frightening as the maximum amount of wastewater allowed would have over 7 million gallons of wastewater and this is terrible. I know during heavy rain periods and during the spring, the river already floods many areas of Murphysboro and points upstream and downstream of us. My area where I live was impacted this May into June by flooding that subsequently flooded the creek near my home. It flooded the low-lying area of the Shawnee Forest (on the way to my house) that there was over 4 feet of floodwater over the road for more than a month. The "natural" river water alone was devastating to the wildlife and plant life in our area. I can NOT imagine what having cancer causing products in this water would do to the wildlife, plants and humans that would come in contact with these agents. Many of my neighbors do fish the river and these contaminates would have an awful impact on fish, other aquatic creatures and PEOPLE. Please do not give permission for this action. The mine should be building a water treatment plant onsite to take care of their water to ensure the discharges meet environmental regulations and not count on the Big Muddy River to "dilute" this contaminated water.

I also urge you to hold public hearings in the Jackson County (or Murphysboro) area. Many of the area residents would be interested in hearing the details for this action. The fact that the Big Muddy also dumps into the Mississippi River is a concern. The Gulf has had way too much damage from pesticide runoff (agriculture), floods, pollution. The impact of all of this in the Mississippi and Gulf has already taken a toll on coral and aquatic life. The extra sulfates and chloride would not be a good addition to the water.

Thank you,
Jon Womack
2010 Hickory Ridge Road
Pomona, IL 62975

Exhibit 204

EPA.PublicHearingCom

From: Jan thomas <jan@artapult.com>
Sent: Monday, August 12, 2019 2:30 PM
To: LeCrone, Darin
Subject: [External] Regarding: NPDES IL0077666 and notice No. 7516c
Attachments: Pond Creek objection letter - 12 August 2019.pdf

Dear Mr. LeCrone,
Please find attached my Objection Letter to the Pond Creek Mine NPDES IL0077666 and notice No. 7516c
Thank you for your consideration.
Jan Thomas
433 N. 7th St.
Murphysboro, IL 62966
Jan@artapult.com

Virus-free. www.avast.com

12 August 2019

Mr. Darin LeCrone
Illinois Environmental Protection Agency
Water Pollution Control Permit Section
1021 North Grand Ave. East
Springfield, IL 62794-9276

Regarding: NPDES IL0077666 and notice No. 7516c

Dear Mr. LeCrone,

I am writing to request that the IEPA hold a public hearing on the above permit application by Williamson Energy's Pond Creek Mine, and to deny the permit altogether as being not in the best interests of the southern Illinois Environment.

I am a co-owner of the Douglass School Art Place in Murphysboro, Illinois. My partner Cameron Smith has written to you about our problems with the Big Muddy flooding our historic building, Murphysboro's former segregated elementary school, the Frederic Douglass School. Further problems can be anticipated if 3.5 million gallons of water are added to the river's volume on a daily basis. This is a one-hundred year old building with porous foundation bricks extending down to two feet below the 2011 flood level. Continued saturation by Big Muddy water would eventually undermine the entire building.

There are many areas of concern with this permit: No environmental assessments have ever been done on the cumulative effects of this discharge on riparian life—fish, mussels, crustaceans, amphibians, birds and mammals, or humans. Since the opening of this mine in 2006 permits have been issued piecemeal for their various initiatives, but the TOTAL effect has never been assessed. Many Compliance and Discharge Monitoring Records are incomplete or missing from the public record. There is reason to believe that the Mine has substantially exceeded their permitted levels in the past. There seems to be little or no monitoring of their activities.

I am also concerned that the proposed diffuser outlet is to be sited **downstream** from the Plumfield Gauging Station. This means that the measurements taken by this gauging station, which include not only volume but also flow rates, pH, turbidity, conductance, temperature, nitrate and nitrite levels, etc. will be inaccurate with regards to downstream effects. And also will not accurately reflect whether the Mine has adhered to the requirements of **this** permit. At the very least, if this permit is to go forward, the Mine should be required to re-route their pipeline to a diffuser upstream from the Plumfield station.

Williamson Energy and Foresight Energy are extremely rich corporations. Foresight brags on its website that the Pond Creek Mine "was the most productive underground coal mine in the United States during the first five years of its history based on clean tons produced per man hour worked." They also continually refer to their "low operating costs." Part of this is secured by their transportation assets which include locomotives, coal cars, extensive rail lines and contractual access to others, and a 20 million ton per year Sitran loading facility on the Ohio River. Most of this coal will be shipped abroad, so it is no benefit to the people of Illinois. And there is no coal Severance Tax in Illinois, so we get no tax

Regarding: NPDES IL0077666 and notice No. 7516c

benefit from them either. It is just outrageous that the people of Illinois should pay for Foresight's garbage treatment in the form of added degradation to a Water of the State. They should be required to appropriately treat this water on site before being allowed to dump it into the river. And their systems should be properly monitored and controlled with an appropriate SCADA system.

This is high sulfur, high Btu coal—the most polluting in the world. The climate crisis is upon us. The burning of coal must stop if we are to survive. It is not the time to be building out more infrastructures to tie us to more fossil fuel use when we must now learn how to use less.

For all these reasons I urge the IEPA to fulfill their legal mandate to protect our environment and hold a well publicized, timely and accessible public hearing so the people can make their concerns known. This permit should be denied.

Thank you for your consideration.

Jan Thomas
433 N. 7th St.
Murphysboro, IL 62966
Jan@artapult.com

Exhibit 205

EPA.PublicHearingCom

From: James Plumley <james.plumley@foresight.com>
Sent: Wednesday, July 17, 2019 4:45 PM
To: 7666 Notice No 7516c
Subject: IEPA Public Notice request on IL0077666 Notice No 7516c
Attachments: IEPA Public Notice Request on 7-17-19 IL0077666 Notice 7516c.pdf

Darin,
Attached is a pdf of the request for a public hearing on IL0077666 Notice 7516c that will be sent via FedEx for tomorrow delivery. We would request that the public hearing be held at the first available date.

If you have any question or comment please contact me at 618-694-3739.

James P

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020 Fax: 618-983-3017

July 17, 2019

Illinois Environmental Protection Agency
Bureau of Water, Division of Water Pollution Control Permit Section
1021 North Grand Avenue East
Springfield, IL 62794-9276

Re: Williamson Energy, LLC's Pond Creek No. 1 Mine, Permit IL0077666 (Notice No. 7516c)

ATTN Bureau of Water, Division of Water Pollution Control Permit Section

Williamson Energy would like to request a public hearing be held on Permit IL0077666. Williamson Energy request this hearing be held at the first available date so that any public comments can be addressed prior to the issuance of this permit renewal.

If you need any additional information, or have any questions, please let me know.

Sincerely,

James Plumley

James Plumley
Authorized Person

Exhibit 206

EPA.PublicHearingCom

From: Steve eberhart <eberpsy@icloud.com>
Sent: Monday, August 12, 2019 2:52 PM
To: LeCrone, Darin
Subject: [External] Hearing

Please hold a hearing on the iepa's position on the pine creek mine pipeline before August 12. Steve Eberhart and Lilly Boruszkowski

Sent from my iPhone

Exhibit 207

EPA.PublicHearingCom

From: SAFE Org <saveilwater@gmail.com>
Sent: Monday, August 12, 2019 3:21 PM
To: LeCrone, Darin
Subject: [External] Regarding: NPDES IL0077666 and notice No. 7516c
Attachments: Pond Creek Request for Hearing Letter.pdf

Please see our attached letter requesting a public hearing for NPDES IL0077666 and notice No. 7516c

SAFE
Southern Illinoisans Against Fracturing Our Environment
PO Box 1325
Vienna, IL 62995

Mr. Darin LeCrone
Illinois Environmental Protection Agency
Water Pollution Control Permit Section
1021 North Grand Ave. East
Springfield, IL 62794-9276

Regarding: NPDES IL0077666 and notice No. 7516c

Dear Mr. LeCrone,

On behalf of all members of Southern Illinoisans Against Fracturing Our Environment, many of whom live in Williamson, Jackson and Union County, we respectfully request a public hearing for the Pond Creek application which seeks to allow upwards of 3.5 million gallons of mine waste water to be discharged into the Big Muddy River north of Murphysboro.

Our concerns are based on the results of information obtained from Freedom of Information Act, and public records.

The Permit IL0077666 for Williams Energy LLC expired in 2010 and the mine has been in non compliance for several years, releasing effluents containing excessive amounts of sulfates and chlorides, and unsafe pH levels. Only one informal enforcement action has been recorded (https://echo.epa.gov/detailed-facility-report?fid=110023026884#summary) Many reports are incomplete.

In 2018 alone, sulfite and chloride exceeded expired permit levels with 102,455 lb/yr dumped into Pond Creek Tributary. (https://echo.epa.gov/trends/loading-tool/reports/dmr-pollutant-loading?permit_id=IL0077666&year=2018) In 2017, sulfate exceeded 413,320 lb/yr and chlorides exceeded 409,744 lb/yr dumped into Pond Creek Tributary. (https://echo.epa.gov/trends/loading-tool/reports/dmr-pollutant-loading?permit_id=IL0077666&year=2017) All these bi-products eventually flow downstream into the Big Muddy River. The concentrated mining waste includes dangerous levels of chlorides and sulfates which are harmful to all aquatic life downstream, beyond the discharge point. The Big Muddy River is already impacted by permitted and pre-regulation mine pollution. The cumulative impact is not good for Southern Illinois or the Big Muddy River.

The NPDES permit expired nearly a decade ago and the Discharge Monitoring report is incomplete. Given the lack of governmental oversight and enforcement, and the lack of consequences for expired permits, neither the agency nor the affected communities have any good reason to suppose that the company is in compliance with local, state and federal regulations now, or in the future.

According to the EPA EJscreen mapper, (https://ejscreen.epa.gov/mapper/) those who live downstream of the discharge point along the Big Muddy River near Murphysboro, Illinois and to the south where the river empties into the Mississippi, are considered low income, over 65 and have less than a highschool education, which means that the impacted community that will receive the discharge waste is an Environmental Justice Community. Multiple public housing locations are in low lying areas that are prone to flooding by the Big Muddy River, and in 2019 there have been more than 145 days of water levels above flood stage due to extreme precipitation events. We think it's worth noting that the communities most impacted by additional volumes of mining waste discharge are those with the least ability to relocate to higher, safer ground.

We understand the safety of the miners is important, as are all the people and nature downstream. We request that the mine treat all wastewater onsite with reverse osmosis treatment to reduce the amount of pollutants entering the river. Since it appears the company is incapable of regular monitoring and reporting, we also request the installation of a SCADA system at the point of discharge so the public can monitor, in real time, the discharge and flow of treated water that enters the river. We also request a maximum volume of treated water to be discharged in any given event be less than 500,000 gallons, and only during times when the river is below flood stage. Or, if the lower limit cannot be achieved, we recommend the company treat the waste water on site AND install a pipeline to go all the way to the Mississippi River to avoid the sensitive ecological areas south of Murphysboro. Again, with a SCADA system at the outfall of the pipe.

There has been no assessment of cumulative water quality impacts from continued coal mining.

There has been no assessment of increased water volume with regard to flooding, sedimentation, and downstream impacts.

There has been no assessment for the large withdrawals of underground water resources and the impact and implications that might have on future groundwater resources.

And there has been no assessment of the full social, health, environmental, economic or climate cost of this mine to Illinois tax payers.

For these reasons, we ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c

Sincerely,

SAFE, PO Box 1325, Vienna, IL 62995

Steering Committee:
Mark Coats
Vito Mastrangelo
Cameron Smith
Jan Thomas
Tabitha Tripp
Patti Walker
Rich Whitney

EPA.PublicHearingCom

From: SAFE Org <saveilwater@gmail.com>
Sent: Monday, August 12, 2019 4:02 PM
To: sonjay.sofat@illinois.gov; Keller, Al
Cc: LeCrone, Darin
Subject: [External] Fwd: Regarding: NPDES IL0077666 and notice No. 7516c
Attachments: Pond Creek Request for Hearing Letter.pdf

Due to receiving an out-of-office response from Mr. LeCrone we are also sending cc Mr. Sofat and Mr. Keller to insure your comments are considered
by the deadline closing today.

---------- Forwarded message ---------
From: **SAFE Org** <saveilwater@gmail.com>
Date: Mon, Aug 12, 2019 at 3:20 PM
Subject: Regarding: NPDES IL0077666 and notice No. 7516c
To: <darin.lecrone@illinois.gov>

Please see our attached letter requesting a public hearing for NPDES IL0077666 and notice No. 7516c

SAFE
Southern Illinoisans Against Fracturing Our Environment
PO Box 1325
Vienna, IL 62995

EPA.PublicHearingCom

From:	Keller, Al
Sent:	Monday, August 12, 2019 4:10 PM
To:	Ward, Iwona
Cc:	LeCrone, Darin
Subject:	FW: [External] Fwd: Regarding: NPDES IL0077666 and notice No. 7516c
Attachments:	Pond Creek Request for Hearing Letter.pdf

Another hearing request.

From: SAFE Org <saveilwater@gmail.com>
Sent: Monday, August 12, 2019 4:02 PM
To: sonjay.sofat@illinois.gov; Keller, Al <Al.Keller@Illinois.gov>
Cc: LeCrone, Darin <Darin.LeCrone@Illinois.gov>
Subject: [External] Fwd: Regarding: NPDES IL0077666 and notice No. 7516c

Due to receiving an out-of-office response from Mr. LeCrone we are also sending cc Mr. Sofat and Mr. Keller to insure your comments are considered
by the deadline closing today.

---------- Forwarded message ---------
From: SAFE Org <saveilwater@gmail.com>
Date: Mon, Aug 12, 2019 at 3:20 PM
Subject: Regarding: NPDES IL0077666 and notice No. 7516c
To: <darin.lecrone@illinois.gov>

Please see our attached letter requesting a public hearing for NPDES IL0077666 and notice No. 7516c

SAFE
Southern Illinoisans Against Fracturing Our Environment
PO Box 1325
Vienna, IL 62995

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EPA.PublicHearingCom

From: Sofat, Sanjay
Sent: Monday, August 12, 2019 4:12 PM
To: LeCrone, Darin; Dragovich, Amy; Ward, Iwona
Subject: FW: [External] Fwd: Regarding: NPDES IL0077666 and notice No. 7516c
Attachments: Pond Creek Request for Hearing Letter.pdf

fyi

From: SAFE Org <saveilwater@gmail.com>
Sent: Monday, August 12, 2019 4:10 PM
To: Sofat, Sanjay <Sanjay.Sofat@Illinois.gov>
Subject: [External] Fwd: Regarding: NPDES IL0077666 and notice No. 7516c

---------- Forwarded message ---------
From: SAFE Org <saveilwater@gmail.com>
Date: Mon, Aug 12, 2019 at 4:02 PM
Subject: Fwd: Regarding: NPDES IL0077666 and notice No. 7516c
<al.keller@illinois.gov>
Cc: <darin.lecrone@illinois.gov>

Due to receiving an out-of-office response from Mr. LeCrone we are also sending cc Mr. Sofat and Mr. Keller to insure your comments are considered
by the deadline closing today.

---------- Forwarded message ---------
From: SAFE Org <saveilwater@gmail.com>
Date: Mon, Aug 12, 2019 at 3:20 PM
Subject: Regarding: NPDES IL0077666 and notice No. 7516c
To: <darin.lecrone@illinois.gov>

Please see our attached letter requesting a public hearing for NPDES IL0077666 and notice No. 7516c

SAFE
Southern Illinoisans Against Fracturing Our Environment
PO Box 1325
Vienna, IL 62995

State of Illinois - CONFIDENTIALITY NOTICE: The information contained in this communication is confidential, may be attorney-client privileged or attorney work product, may constitute inside information or internal deliberative staff communication, and is intended only for the use of the addressee. Unauthorized use, disclosure or copying of this communication or any part thereof is strictly prohibited and may be unlawful. If you have received this communication in error, please notify the sender immediately by return e-mail and destroy this communication and all copies thereof, including all attachments. Receipt by an unintended recipient does not waive attorney-client privilege, attorney work product privilege, or any other exemption from disclosure.

Mr. Darin LeCrone
Illinois Environmental Protection Agency
Water Pollution Control Permit Section
1021 North Grand Ave. East
Springfield, IL 62794-9276

Regarding: NPDES IL0077666 and notice No. 7516c

Dear Mr. LeCrone,

On behalf of all members of Southern Illinoisans Against Fracturing Our Environment, many of whom live in Williamson, Jackson and Union County, we respectfully request a public hearing for the Pond Creek application which seeks to allow upwards of 3.5 million gallons of mine waste water to be discharged into the Big Muddy River north of Murphysboro.

Our concerns are based on the results of information obtained from Freedom of Information Act, and public records.

The Permit IL0077666 for Williams Energy LLC expired in 2010 and the mine has been in non compliance for several years, releasing effluents containing excessive amounts of sulfates and chlorides, and unsafe pH levels. Only one informal enforcement action has been recorded (https://echo.epa.gov/detailed-facility-report?fid=110023026884#summary) Many reports are incomplete.

In 2018 alone, sulfite and chloride exceeded expired permit levels with 102,455 lb/yr dumped into Pond Creek Tributary. (https://echo.epa.gov/trends/loading-tool/reports/dmr-pollutant-loading?permit_id=IL0077666&year=2018) In 2017, sulfate exceeded 413,320 lb/yr and chlorides exceeded 409,744 lb/yr dumped into Pond Creek Tributary. (https://echo.epa.gov/trends/loading-tool/reports/dmr-pollutant-loading?permit_id=IL0077666&year=2017) All these bi-products eventually flow downstream into the Big Muddy River. The concentrated mining waste includes dangerous levels of chlorides and sulfates which are harmful to all aquatic life downstream, beyond the discharge point. The Big Muddy River is already impacted by permitted and pre-regulation mine pollution. The cumulative impact is not good for Southern Illinois or the Big Muddy River.

The NPDES permit expired nearly a decade ago and the Discharge Monitoring report is incomplete. Given the lack of governmental oversight and enforcement, and the lack of consequences for expired permits, neither the agency nor the affected communities have any good reason to suppose that the company is in compliance with local, state and federal regulations now, or in the future.

According to the EPA EJscreen mapper, (https://ejscreen.epa.gov/mapper/) those who live downstream of the discharge point along the Big Muddy River near Murphysboro, Illinois and to the south where the river empties into the Mississippi, are considered low income, over 65 and have less than a highschool education, which means that the impacted community that will receive the discharge waste is an Environmental Justice Community. Multiple public housing locations are in low lying areas that are prone to flooding by the Big Muddy River, and in 2019 there have been more than 145 days of water levels above flood stage due to extreme precipitation events. We think it's worth noting that the communities most impacted by additional volumes of mining waste discharge are those with the least ability to relocate to higher, safer ground.

We understand the safety of the miners is important, as are all the people and nature downstream. We request that the mine treat all wastewater onsite with reverse osmosis treatment to reduce the amount of pollutants entering the river. Since it appears the company is incapable of regular monitoring and reporting, we also request the installation of a SCADA system at the point of discharge so the public can monitor, in real time, the discharge and flow of treated water that enters the river. We also request a maximum volume of treated water to be discharged in any given event be less than 500,000 gallons, and only during times when the river is below flood stage. Or, if the lower limit cannot be achieved, we recommend the company treat the waste water on site AND install a pipeline to go all the way to the Mississippi River to avoid the sensitive ecological areas south of Murphysboro. Again, with a SCADA system at the outfall of the pipe.

There has been no assessment of cumulative water quality impacts from continued coal mining.

There has been no assessment of increased water volume with regard to flooding, sedimentation, and downstream impacts.

There has been no assessment for the large withdrawals of underground water resources and the impact and implications that might have on future groundwater resources.

And there has been no assessment of the full social, health, environmental, economic or climate cost of this mine to Illinois tax payers.

For these reasons, we ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c

Sincerely,

SAFE, PO Box 1325, Vienna, IL 62995

Steering Committee:
Mark Coats
Vito Mastrangelo
Cameron Smith
Jan Thomas
Tabitha Tripp
Patti Walker
Rich Whitney

Exhibit 208

EPA.PublicHearingCom

From: Colleen Flanagan <colleencarole@gmail.com>
Sent: Monday, August 12, 2019 3:50 PM
To: LeCrone, Darin
Subject: [External] Pond Creek Mine Pipeline

I am requesting a public a hearing on IEAP's position on on the proposed Pine Creek Mine dumping its waste into the Big Muddy River.

I live in Murphysboro, Il by the Big Muddy and am proud of the work done in our community's to keep area free of ongoing contamination of the land and waterways.

Colleen Flanagan
416 North Street
Murphysboro, IL 62966
618-581-5425

Exhibit 209

EPA.PublicHearingCom

From: Jennifer Reiman <jreiman618@gmail.com>
Sent: Monday, August 12, 2019 3:58 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Mr. LeCrone,

Please schedule a public hearing for the Pond Creek Mine permit application. The Big Muddy River is a precious resource for Southern Illinois. It flows through some of the most scenic and unique landscapes of the Shawnee National Forest. Aquatic life in the Big Muddy and in the wetlands along it's banks should not be subjected to pollutants in the discharged water. The river should not be sacrificed for the benefit of a coal mining corporation. The people of Illinois deserve to have a public hearing to gather all evidence and comments before any action is taken on the permit application. Please schedule the hearing and let the voices of the people be heard.

Thank you,
Jennifer Reiman
215 Garden Blvd, Belleville, IL 62220
618-334-1371

Exhibit 210

EPA.PublicHearingCom

From: Sarah Heyer <heysar41@yahoo.com>
Sent: Monday, August 12, 2019 3:34 PM
To: LeCrone, Darin
Cc: GovernorsOffice; Patrick Windhorst; Dale Fowler
Subject: [External] NPDES IL0077666 Notice No. 7516c

August 12, 2019
Pond Creek Mine Pipeline Application
darin.lecrone@illinois.gov
NPDES IL0077666
Notice No. 7516c

Dear Mr. Lecrone:
I oppose the Pond Creek Mine's application to construct a pipeline that would dump millions of gallons of mine waste into the Big Muddy River and request a public hearing to allow public comments on a project that provides no benefits but damages the environment and people of this area.
Several years ago I put up sandbags at a friend's house that was being flooded by the Big Muddy. The first floor of her house was inundated. I can't imagine how much worse it would have been if that water were more polluted.
No environmental impact studies have been done on the long term effects of this project, including: cumulative water quality, fish and wildlife effects, bank erosion, and the social and environmental costs to the communities and individuals that live along and use the Big Muddy River.
This pipeline project would allow this corporation to externalize its costs to the public. In a true market economy this coal mine might have to concede that dealing with the wastes that it generates in an environmentally sound way costs more than it is worth to take the coal out of the ground. So by allowing this project to proceed the IEPA and IDNR and not only facilitating the poisoning of the Big Muddy River, but also hastening global climate change.
I urge the IEPA and IDNR to reject all proposals for this harmful project.

Thank you,

Sarah Heyer
1442 E Gary Dr
Carbondale, IL 62902
heysar41@yahoo.com

cc: Governor J.B. Pritzer
Senator Dale Fowler
Representative Patrick Windhorst

EPA.PublicHearingCom

Exhibit 21

From: Robert Morwell <robertmorwell@gmail.com>
Sent: Monday, August 12, 2019 4:35 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 and notice No. 7516c

From: Robert C Morwell
612 S. Surrey Ln.
Carbondale, 62901

Darin.lecrone@illinois.gov
Subject: NPDES IL0077666 and notice No. 7516c

Mr LeCrone,

Regarding: NPDES IL0077666 and notice No. 7516c

I am calling for a public hearing on the proposed release of toxic mine waste which would make its way into the Big Muddy River and to all other water systems into which it feeds. I believe this constitutes an unacceptable pollution of the local water systems.

The long ter effects of this release have been insufficiently studied and once it is done, there is no way to alleviate the damage it could do to both wildlife and humans.

An insufficiently studied release of these toxins is simply irresponsible.

Therefore, I ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c before actions are taken which cannot be reversed or remedied

Sincerely,
Robert Morwell

Exhibit 212

EPA.PublicHearingCom

From:	Joyce Blumenshine <joblumen@yahoo.com>
Sent:	Monday, August 12, 2019 4:49 PM
To:	LeCrone, Darin; Sanjay Sofat; Keller, Al
Subject:	[External] NPDES IL0077666 Public Notice 7516c Request for Public Hearing and Comment Letter
Attachments:	NPDES IL0077666 Notice 7516c IEPA Request for Public Hearing and Comments.pdf

Good Day,
Because of being informed that Mr. LeCrone is out of office this week and Ms. Ward was on vacation, I am copying Mr. Sofat and Mr. Keller on these comments to insure they are received by the deadline of today.

Thank you.

Sincerely,
Joyce Blumenshine

TO: Illinois Environmental Protection Agency Bureau of Water

Division of Water Pollution Control Permit Section

1021 North Grand Ave., East

Springfield, IL 62794-9276

RE: NPDES Permit No. IL0077666 Notice No. 7516c

Request for Public Hearing and Preliminary Comments

August 9, 2019

This letter is to request the IEPA hold a public hearing regarding your proposed NPDES Permit No. IL0077666 regarding the Williamson Energy, LLC, Pond Creek coal mine located east of Johnston City, Williamson County. The proposal of permitting 2.7 to 3.5 million gallons per day, or more, of mine water discharge containing high levels of chlorides and sulfates to the river is a concern to the entire region and the future of the Big Muddy river ecosystem.

It is my opinion that the proposed permit does not give adequate consideration of downstream impacts, including toxicity levels to invertebrates and fish on which migrating waterfowl, resident wildlife and human fishing, including commercial fishing and other activities depend. I do not see that IEPA is taking into any kind of adequate consideration the already significant levels of pollutants being discharged into the Big Muddy River watershed from currently operating and closed coal mines, agricultural run-off and other pollution along the river.

As an Illinois citizen and taxpayer, I have direct concerns in this issue. It looks to me that this coal mine is taking advantage of public resources, impacting wetlands without mitigation and in other ways putting what should rightfully be their due costs of operating onto the public and environmental resources. This mine is causing the excess contaminated water problem and should be required to pay the costs of dealing with it as due costs of doing business. This mine could change to a different area for their coal extraction, change mining techniques including doing room and pillar instead of longwall, or build a water treatment plant on their property instead of planning to use the Big Muddy River for diluting their pollution to insure their own profits. That is not right in my opinion and such practices should be ended.

I am very concerned that IEPA appears to be allowing use of an out-dated Antidegradation Assessment, found on page 11 of your Public Notice/Fact Sheet. It appears that the information lacks any specifics regarding the proposed NPDES discharge 011 at the Big Muddy River. In paragraph 7 on page 11 it has: "No adverse impacts to the receiving streams will occur as all water quality standards will be met." In a brief review of the federal EPA ECHO database it does not appear that this mine is meeting water quality standards and that is has had repeated problems in doing so for some time.

Comments and Questions:

1. Does IEPA take into consideration the history of permit compliance before approving new NDPES permits? If not, why is that?

2. The Antidegradation Statement does not have any information on the social and economic benefits of the Big Muddy River; the wetlands this proposal will impact; the values of the fishing, hunting and other recreation along and in the river; anything regarding potential costs of additional erosion or flooding or the harm to the ecosystem the addition of mine discharges could exacerbate. Can you require a new Antidegradation Statement that includes the current commercial, recreational, environmental and ecosystem social and economic benefits and has more of a total assessment instead of only what is of benefit to the mine?

3. Can IEPA require an Environmental Impact Statement for this permit? This mine should be required to provide a full EIS because of the plans to discharge directly to the Big Muddy River.

There is a large range of concerns beyond just the NPDES discharge points, including the impacts of the pipeline that will be built for discharge point 011. Pond Creek is already used for numerous discharge points and it is difficult to understand how the addition of more discharge locations will not cause problems downstream. Mine statements that no adverse impacts will occur are not reliable and cannot be accepted based on their history of permit compliance. As recently as this year, this mine was the subject of Illinois Pollution Control Board Case PCB-2019-085 filed by the Office of the Illinois Attorney General who was pursuing pollution at this mine on behalf of the IEPA.

I am very concerned about pollution loading to area surface and groundwater resources and the increasingly alarming impacts downstream affecting the Mississippi River. The catastrophic levels of pollution throughout much of the Mississippi River Basin are expanding the dead zone in the Gulf of Mexico. In addition, coal pollutants, including from mining, are a significant part of the global climate crisis which humans have caused and which is currently happening. In an October, 2018, report, the United Nations Intergovernmental Panel on Climate Change stated that if global greenhouse gas emissions continue at the current rate, our atmosphere is predicted to warm 2.7 degrees Fahrenheit above pre-industrial levels by 2040. This rise is seen as irreversible and catastrophic. I respect IEPA has specific regulations for these permit reviews, but I would like to ask: when is your agency water division going to face the issues of our time to be part of the emergency solutions needed to face climate crisis on behalf of the state of Illinois? Thank you for the opportunity to comment.

Joyce Blumenshine

2419 East Reservoir, Peoria, IL 61614-8029

joblumen@yahoo.com

Exhibit 2/3

EPA.PublicHearingCom

From: Gary Kolb <gpkolb@gmail.com>
Sent: Monday, August 12, 2019 4:54 PM
To: LeCrone, Darin
Subject: [External] NPDS IL0077666 Notice No. 7516

I am writing to request a **public hearing** on IEPA's positions on the proposed **Pine Creek Mine pipeline**.

Thank you,

Gary Kolb

Exhibit 3/4

EPA.PublicHearingCom

From: Jaime Snyder <jsnyder@explorecarbondale.com>
Sent: Monday, August 12, 2019 6:35 PM
To: LeCrone, Darin
Cc: 'Gary Williams'; 'Kathy Renfro'; mrtwomey@btbhh.com
Subject: [External] NPDES IL0077666 & Notice 7516c
Attachments: City of Carbondale Joint Resolution on Williamson Energy 2019-08-12.pdf; CPKD Joint Resolution on Willamson Energy 2019-08-12.pdf

Mr. Lecrone:

Please find attached two copies of the joint resolutions from the Carbondale Park District and the City of Carbondale as it relates to the Williamson Energy's request to dump waste water into the Big Muddy River.

Lenoard "Jamie" Snyder
City Attorney
City of Carbondale
200 S. Illinois Ave.
Carbondale, IL 62901
(618) 457-3215
Fax (618) 549-1402

This page added by Illinois EPA as a place holder for the following attached document(s)

Attachment 1

RESOLUTION 2019-R-43

A JOINT RESOLUTION OF THE CARBONDALE CITY COUNCIL AND THE CARBONDALE PARK DISTRICT BOARD OPPOSING THE WILLIAMSON ENERGY APPLICATION TO DISPOSE OF WASTE WATER INTO THE BIG MUDDY RIVER FROM THE POND CREEK MINE

WHEREAS, the City of Carbondale, Illinois, is a home rule unit of local government under the Illinois Constitution, 1970, Article VII, Section 6; and

WHEREAS, the Carbondale Park District is a public taxing authority in Jackson County, in the City of Carbondale, and has a vested interest in the health of citizens, plants, and wildlife; and

WHEREAS, Williamson Energy, a subsidiary of Murray Energy, operates the Pond Creek Mine in Franklin County, Illinois and is proposing to construct a 12-mile pipeline to discharge 3 million gallons of waste water daily into the Big Muddy River; and

WHEREAS, the waste water that Williamson Energy proposes to dump into the Big Muddy River, a public waterway, will be high in sulfates and chlorides which threaten all kinds of plants and wildlife; and

WHEREAS, the Carbondale Park District has irrigation waters and public open space which are affected by the waters of the Big Muddy River; and

WHEREAS, the Big Muddy River runs through the zoning jurisdiction of the City of Carbondale affecting Carbondale residents; and

WHEREAS, Carbondale, Jackson County, and southern Illinois are home to diverse wildlife, fauna, and natural resources; and

WHEREAS, Murray Energy has a history of violating environmental and labor standards and has paid more than $30 million in penalties associated with health, environmental, and labor violations; and

WHEREAS, Murray Energy realized over $525 million in corporate profits in 2019 alone; and

WHEREAS, in consideration of Murray Energy's regulatory track record and their ample financial resources, the Carbondale City Council and the Carbondale Park District request that the Illinois Environmental Protection Agency (IEPA) prioritize the water quality, natural resources, and public health of our residents over the financial interests of Murray Energy; and

WHEREAS, the IEPA can demonstrate its commitment to the environment and public health of the residents served by the City of Carbondale and the Carbondale Park District by denying Williamson Energy's proposal to pump polluted water into the Big Muddy River.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF CARBONDALE, ILLINOIS AS FOLLOWS:

SECTION 1. That the Carbondale City Council and the Carbondale Park District oppose Williamson Energy's application to dispose of any waste water into the Big Muddy River.

SECTION 2. That this Resolution be spread at length upon the minute records of the City Council and Carbondale Park District.

SECTION 3. That this Resolution shall take effect upon its passage, approval, recording, and publication in pamphlet form in accordance with law.

This Resolution is adopted at a Special Joint Meeting of the Carbondale Park District and the Carbondale City Council of Carbondale, Illinois on the 12th day of August, 2019.

Carl Flowers, Park Board President

Attest: Kathy Renfro, Secretary

John M. Henry, Mayor

Attest: Jennifer R. Sorrell, City Clerk

Jessica Sergeev, Vice President

Carmen Suarez, Treasurer

Jane Adams, Commissioner

Kirsten Trimble, Commissioner

Councilwoman Jessica Bradshaw

Councilman Jeffrey W. Doherty

Councilman Lee M. Fronabarger

Councilman Tom Grant

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Councilman Adam Loos

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Councilwoman Carolin Harvey

Councilman Adam Loos

This page added by Illinois EPA as a place holder for the following attached document(s)

Attachment 2

A JOINT RESOLUTION OF THE CARBONDALE CITY COUNCIL AND THE CARBONDALE PARK DISTRICT BOARD OPPOSING THE WILLIAMSON ENERGY APPLICATION TO DISPOSE OF WASTE WATER INTO THE BIG MUDDY RIVER FROM THE POND CREEK MINE

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Councilwoman Jessica Bradshaw

Councilman Jeffrey W. Doherty

Councilman Lee M. Fronabarger

Councilman Tom Grant

Councilwoman Carolin Harvey

Councilman Adam Loos

Exhibit 215

EPA.PublicHearingCom

From: Isabel Zimmerman <isabelzimmerman@icloud.com>
Sent: Monday, August 12, 2019 7:37 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 Notice No. 7516c

Dear Sir:

I understand that the Illinois EPA is considering a request from Williams Energy to be allowed to dump 3.5 million gallons of toxic waste water each day into the Big Muddy River.

As a citizen of Illinois and a resident of southern Illinois I go on record as being strongly opposed to the granting of such permission.

The Big Muddy, a tributary of the Mississippi River, is the largest stream in the central and western parts our region and is one of the major rivers in the State. It is a recreational asset that flows through or near towns, villages, and environmentally sensitive areas. It is an important element of the natural and scenic landscape that citizens of this region require to promote a growing and badly needed tourist economy. What better way to undercut and ultimately destroy the very basis of such a developing industry than to allow steady pollution of one of its main attractions? Owing to the increasing difficulty of coal mining and sales to compete against natural gas, wind power, solar energy, and public opposition it will not be long before the number of tourist-related jobs in this region must exceed those of a dying coal industry.

In the final analysis, there is no moral, ethical, or economic reason why the population of this region can be expected to permit the degradation of its waters, fields, and forests to increase the profits of a single company or a class of similar corporations. It would be a tragic error to risk southern Illinois, or any other part of our great State of the damage that resulted from the Kingston (TN) or the Dan River (VA) toxic coal waste pollution, just to mention two recent examples.

Please listen to the many of the citizens of this region and refuse permission for Williams Energy to pollute and degrade the quality of the Bug Muddy River.

Thank you for your consideration.

Sincerely,

Jay Zimmerman

306 S Plover Dr
Carbondale, IL 62901

Exhibit 2/6

EPA.PublicHearingCom

From: Maryann Stout <mastout10@gmail.com>
Sent: Monday, August 12, 2019 8:45 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Dear sir,
It's your job to protect people, wildlife, and the environment. Nobody should dump wastes into a river. That's a no-brainer. Review the cancer rate in southern Illinois.....it's way above the rest of the state. Would you be responsible for possibly adding to that with wastes in our water and environment? Certainly, it's your job to protect us. So, do it.
Sincerely,
Mary Ann Stout
Anna, IL

Exhibit 217

EPA.PublicHearingCom

From: ann.f.12@gmail.com
Sent: Monday, August 12, 2019 9:17 PM
To: LeCrone, Darin
Subject: [External] Opposing Pond Creek Mine discharge into Big Muddy River, NPDES IL0077666, Notice No. 7516c

Hello.

I would like to register my extreme concern about allowing the Pond Creek Mine to dump polluted water into the Big Muddy River (NPDES IL0077666, Notice No. 7516c). This would be disastrous for a number of reasons.

I urge you to hold a public hearing on this matter. Thank you very much.

Ann Fischer
149 Bernice Cochran Ct.
Pomona IL 62975

Exhibit 218

EPA.PublicHearingCom

From: Linda Webb <mcwebb3.lw@gmail.com>
Sent: Monday, August 12, 2019 9:57 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

From: Linda Webb
315 N. Sims Street
Royalton, IL 62983

I am writing to request a public hearing on the IEPA's tentative determination approving Williamson Energy's request to dump waste water into the Big Muddy River. I am against the IEPA approval and do not feel they should grant Williamson Energy the approval to discharge polluted water into the Big Muddy River.

Please grant our request for a public hearing before you allow this to happen.

Thank you
Linda Webb

EPA.PublicHearingCom

From: Linda Webb <mcwebb3@icloud.com>
Sent: Monday, August 12, 2019 10:05 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No.7516c

From: Linda Webb
315 N. Sims Street
Royalton, IL 62983

Regarding NPDES IL0077666 & Notice No.7516c

I am writing to request a public hearing on the IEPA's tentative determination approving Williamson Energy's request to dump waste water into the Big Muddy River. I am against the IEPA approval and do not feel they should grant Williamson Energy the approval to discharge polluted water into the Big Muddy River.

Please grant our request for a public hearing before you allow this to happen.

Thank you
Linda Webb

Exhibit 219

EPA.PublicHearingCom

From: Priscilla Pimentel <ppimentel71@gmail.com>
Sent: Monday, August 12, 2019 9:57 PM
To: LeCrone, Darin
Subject: [External] I oppose Pond Creek mine dumping wastewater into big muddy

If the water is so safe, why can't it just be poured on the ground on site? Why is a 12 mile pipe line more economical than disposing of "safe" water? This company has a history of being unsafe. I strongly oppose allowing A permit to dump waste water from Pond creek mine or any mining operation into the big muddy river.--
Priscilla R. Pimentel
Digital Imaging Specialist
Southern Illinois Region, Carbondale

"The "little things" we all do are not futile. In fact, little things add up fast. Especially if you do them, and then talk to your friends and family so that they start doing them too."
-Umbra Fisk

Exhibit 220

EPA.PublicHearingCom

From: mcwebb3 <mcwebb3@frontier.com>
Sent: Monday, August 12, 2019 10:01 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No.7516c

From: Paul Webb
315 N. Sims Street
Royalton, IL 62983

Regarding NPDES IL0077666 7 Notice No.7516c

I am writing to request a public hearing on the IEPA's tentative determination approving Williamson Energy's request to dump waste water into the Big Muddy River. I am against the IEPA approval and do not feel they should grant Williamson Energy the approval to discharge polluted water into the Big Muddy River.

Please grant our request for a public hearing before you allow this to happen.

Thank you
Paul Webb

EPA.PublicHearingCom

From: mcwebb3 <mcwebb3@frontier.com>
Sent: Monday, August 12, 2019 10:07 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No.7516c

From: Paul Webb
315 N. Sims Street
Royalton, IL 62983

Regarding NPDES IL0077666 & Notice No.7516c

I am writing to request a public hearing on the IEPA's tentative determination approving Williamson Energy's request to dump waste water into the Big Muddy River. I am against the IEPA approval and do not feel they should grant Williamson Energy the approval to discharge polluted water into the Big Muddy River.

Please grant our request for a public hearing before you allow this to happen.

Thank you
Paul Webb

Exhibit 221

EPA.PublicHearingCom

From: Rebecca S <rebeccaschlosser6@gmail.com>
Sent: Monday, August 12, 2019 10:35 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

NPDES IL0077666 & Notice No. 7516c

Mr LeCrone,

Regarding: NPDES IL0077666 and notice No. 7516c

We the People of Illinois respectfully request a public hearing for the Pond Creek application which seeks to allow upwards of 3.5 millions gallons of mine waste water to be discharged into the Big Muddy River north of Murphysboro. This discharge includes mine process water and ground water seeping into the mine during normal operations. The mining waste will have concentrations of dangerous levels of chlorides and sulfates that will be harmful to all aquatic life downstream of the discharge point.
Big Muddy River is already impacted by permitted and pre-regulation mine pollution. The cumulative impact will not be good for Southern IL or the Big Muddy River.

There has been no assessment of cumulative water quality impacts from continued coal mining.
There has been no assessment of increased water volume with regard to flooding, sedimentation, and downstream impacts.
There has been no assessment for the large withdrawals of underground water resources and the impact and implications that might have on future groundwater resources.
And there has been no assessment of the full social, health, environmental, economic or climate cost this mine will cost IL tax payers.

For these reasons, we ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c

Sincerely,
Rebecca Schlosser
502 W. Sycamore St.
Carbondale, Illinois 62901

Exhibit 222

EPA.PublicHearingCom

From: Dawn Hoyden <hoyden@razorgirls.org>
Sent: Monday, August 12, 2019 10:36 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 and notice No. 7516c

Mr LeCrone,

Regarding: NPDES IL0077666 and notice No. 7516c
We the People of Illinois respectfully request a public hearing for the Pond Creek application which seeks to allow upwards of 3.5 millions gallons of mine waste water to be discharged into the Big Muddy River north of Murphysboro. This discharge includes mine process water and ground water seeping into the mine during normal operations. The mining waste will have concentrations of dangerous levels of chlorides and sulfates that will be harmful to all aquatic life downstream of the discharge point.

Big Muddy River is already impacted by permitted and pre-regulation mine pollution. The cumulative impact will not be good for Southern IL or the Big Muddy River.
There has been no assessment of cumulative water quality impacts from continued coal mining.

There has been no assessment of increased water volume with regard to flooding, sedimentation, and downstream impacts.
There has been no assessment for the large withdrawals of underground water resources and the impact and implications that might have on future groundwater resources.
And there has been no assessment of the full social, health, environmental, economic or climate cost this mine will cost IL tax payers.

For these reasons, we ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c

Sincerely,
Dawn Roberts
405 N Allyn St
Carbondale, IL
62901

Exhibit 223

EPA.PublicHearingCom

From: Molly Groom Alter <mollygroom@icloud.com>
Sent: Monday, August 12, 2019 10:38 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 /Notice No. 7516c

Dear Mr. Lecrone,
I am writing to demand a public hearing on the Pond Creek Mine plan to discharge millions of gallons daily of toxic waste into the Big Muddy River.
This dumping of mine waste will have catastrophic impacts in several areas and communities along the Big Muddy River- and subsequently The Mississippi River, down to the Gulf of Mexico.
First I would like to state the impact of the amount of water that would be discharged daily would double the flow of the Big Muddy River, and that River is already taxed with high levels from rainfall. It will wipe out private properties along the River, it will make our bridges and infrastructure more vulnerable.
Second, and most importantly, our water ways can not be used as toxic dumping sites! We cannot put more pressure and chemicals into our eco systems and diverse biological growth systems. This is an absolute abomination that it would be considered. Our fish, turtles, snake, birds, will die! Our plants and vegetation will die! Our other wildlife that use the Big Muddy River as drinking source will die!
I am not ok with any of those things! As the head of the IEPA, you shouldn't be either.
Third, the increase in River flow will devastate our River communities. We are already seeing the flooding from rainfall that has destroyed families livlihoods. Flooding for miles and miles. This is not what I want for my communities.

I strongly OPPOSE the approval of Pond Creek Mine discharged waste water into the Big Muddy River.

I am resident of Murphysboro Illinois, the River is in my community and we don't want this!
We are trying to be good stewards of our planet, not the continuous destruction of our ecological and biological resources.

I DEMAND A PUBLIC HEARING

Molly Alter
2136 Spruce Street
Murphysboro, Illinois
62966
618-401-3433

Sent from my iPad

Sent from my iPad

Exhibit 224

EPA.PublicHearingCom

From: Karen Fiorino <claylickcreek@gmail.com>
Sent: Monday, August 12, 2019 10:39 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 and notice No. 7516c

Mr LeCrone,

Regarding: NPDES IL0077666 and notice No. 7516c

We the People of Illinois respectfully request a public hearing for the Pond Creek application which seeks to allow upwards of 3.5 millions gallons of mine waste water to be discharged into the Big Muddy River north of Murphysboro. This discharge includes mine process water and ground water seeping into the mine during normal operations. The mining waste will have concentrations of dangerous levels of chlorides and sulfates that will be harmful to all aquatic life downstream of the discharge point.
Big Muddy River is already impacted by permitted and pre-regulation mine pollution. The cumulative impact will not be good for Southern IL or the Big Muddy River.

There has been no assessment of cumulative water quality impacts from continued coal mining.
There has been no assessment of increased water volume with regard to flooding, sedimentation, and downstream impacts.
There has been no assessment for the large withdrawals of underground water resources and the impact and implications that might have on future groundwater resources.
And there has been no assessment of the full social, health, environmental, economic or climate cost this mine will cost IL tax payers.

For these reasons, we ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c

Sincerely,
Karen Fiorino
45 Old US Hwy 51
Makanda, IL 62958

Exhibit 225

EPA.PublicHearingCom

From: C.R. W. <crdoubleu99@ymail.com>
Sent: Monday, August 12, 2019 10:40 PM
To: LeCrone, Darin
Subject: [External] Regarding NPDES IL0077666 and notice No. 7516c

Hello, I wrote last week but since I did not specifically mention the Pond Creek Mine by name I thought I would send another more consistent email in this regard.

Mr LeCrone,

Regarding: NPDES IL0077666 and notice No. 7516c

We the People of Illinois respectfully request a public hearing for the Pond Creek application which seeks to allow upwards of 3.5 millions gallons of mine waste water to be discharged into the Big Muddy River north of Murphysboro. This discharge includes mine process water and ground water seeping into the mine during normal operations. The mining waste will have concentrations of dangerous levels of chlorides and sulfates that will be harmful to all aquatic life downstream of the discharge point.
Big Muddy River is already impacted by permitted and pre-regulation mine pollution. The cumulative impact will not be good for Southern IL or the Big Muddy River.

There has been no assessment of cumulative water quality impacts from continued coal mining.
There has been no assessment of increased water volume with regard to flooding, sedimentation, and downstream impacts.
There has been no assessment for the large withdrawals of underground water resources and the impact and implications that might have on future groundwater resources.
And there has been no assessment of the full social, health, environmental, economic or climate cost this mine will cost IL tax payers.

For these reasons, we ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c

Sincerely,

Craig Wilson
Carbondale IL 62901

Exhibit 226

EPA.PublicHearingCom

From: beau henson <beau.henson@myself.com>
Sent: Monday, August 12, 2019 10:46 PM
To: LeCrone, Darin
Subject: [External] Big muddy

Hello sir.

Please stop ruining the environment.

Very best,
Beau Henson
--
Sent from my Android phone with mail.com Mail. Please excuse my brevity.

Exhibit 227

EPA.PublicHearingCom

From: John Wallace <forestally1@gmail.com>
Sent: Monday, August 12, 2019 10:45 PM
To: LeCrone, Darin
Subject: [External] NPDES Permit No. IL0077666 Comments
Attachments: 8.12.19 Pond Creek Comments, Shawnee Chap IAS.pdf

Madame/Sir,

Please find the attached comments regarding NPDES Permit No. IL0077666, Notice No. 7516c Pond Creek Mine for the Shawnee Chapter of Illinois Audubon Society.

Should you have any problems opening the file, accessing all the information, or questions about these comments, please do not hesitate to contact me at forestally1@gamil.com or call at 618.534.0939.
Thank you,
John B. Wallace

Shawnee Chapter
Illinois Audubon Society
P.O. Box 73
Carbondale, IL 62903
Stewards of War Bluff Valley Sanctuary

August 12, 2019

Mr. Darin LeCrone
Illinois Environmental Protection Agency
Bureau of Water, Water Pollution Control Permit Section
1021 North Grand Ave. East
Springfield, IL 62794-9276
Email: darin.lecrone@illinois.gov

RE: NPDES Permit No. IL0077666 Notice No. 7516c Pond Creek Mine

Dear Mr. LeCrone,

I have been authorized by the Shawnee Chapter of Illinois Audubon Society's Board of Directors to submit the following on behalf of the organization and its membership. Please consider this as the Shawnee Chapter's official comments on the Illinois Environmental Protection Agency (IEPA) National Pollutant Discharge Elimination System (NPDES) tentative determination (draft) to issue Permit No. IL0077666 Notice No. 7516c to Williamson Energy, LLC, for the Pond Creek Mine Facility in Williamson and Franklin Counties for a total of 11 different outfalls and discharges of alkaline and acid mine discharges into Pond Creek, into unnamed tributaries of Pond Creek and into the Big Muddy River.

Founded in 1995, the purpose of the Shawnee Chapter of Illinois Audubon Society (SCIAS) is to actively promote the perpetuation of our native flora and fauna and their habitats. Our organization is the southernmost chapter of the Illinois Audubon Society, the oldest non-governmental conservation organization in the state. The majority of SCIAS members reside in southern Illinois.

Of primary concern to SCIAS are the three new designated outfalls/discharge locations of mine drainage for Pond Creek, for an unnamed tributary of Pond Creek and for the Big Muddy River (Outfall Nos. 009, 009ES and 011), especially in light of the current eight outfall/discharge locations (Outfall Nos. 001 - 008) already found on unnamed tributaries of Pond Creek. The discharges consist of alkaline and acid mine drainage from groundwater that infiltrates the mine, which averages approximately 2.7 million gallons per day, but may be as much as 3.5 million gallons. The discharged water is also known to be high in chloride and in sulfates, in concentrations above IEPA limits that are toxic to humans, to fish and other aquatic life.

Pond Creek is a tributary of the Big Muddy River, which provides habitat to a number of aquatic organisms including macro-invertebrates, fish, amphibians, reptiles and mammals. Numerous avian species also use the river for feeding, and its floodplain for feeding, roosting and nesting. The vegetation in and around the flood plain of the Big

Muddy provides important food and shelter for both aquatic organisms and terrestrial wildlife. Areas of importance for wildlife include Riverside Park in Murphysboro and the Shawnee National Forest, including Oakwood Bottoms, Little Grand Canyon and LaRue Pine Hills, all located in Jackson County.

Since the concentrations of chlorides and sulfates in this discharge are too toxic, Williamson Energy proposes mixing or diluting them for discharging into the Big Muddy River, an important public waterway of the state. While important habitat for wildlife, both the Big Muddy River and Pond Creek are already considered impaired by IEPA at the sites in questions due to sedimentation, total suspended solids, dissolved oxygen levels, chlorides and other toxins. Even though the concentrations of toxins may be more diluted, the addition of more chlorides and sulfates in waters that are already impaired, simply impair this waterway, further. The further degradation puts more stress on aquatic organisms and all others, both humans and wildlife that feed on them.

State listed, endangered and threatened animal species are known to occur in the Big Muddy River and more are known to feed on aquatic organisms found in the river. Federal and state listed, endangered and threatened plants and animals are found within the Big Muddy River floodplain. What will be the impacts from the additional volume of water, and from the additional wastewater toxins contained in the floodwaters on the rare floodplain flora and fauna?

It is not clear to us if the additional daily average of 2.7 million gallons of wastewater discharge will go directly into outfall no. 011 on the Big Muddy River, or if it will be dispersed into all three of the newly proposed outfalls (009 and 009ES). Since Pond Creek is a tributary of the Big Muddy, has IEPA considered the cumulative impacts from the newly proposed discharge along with the other eight existing outfall/discharge locations? If so what will those cumulative impacts be? What is the total volume of water and total overall pollutants?

Have studies been undertaken to consider the impacts on shoreline erosion that the additional 2.7 million gallons of water per day on river flow may have on the shoreline of the Big Muddy River? Will it create more suspended solids in the river? Total suspended solids are a pollutant already identified as causing impairment to the Big Muddy River.

Considering the overall impacts from this proposal, we believe further studies should be conducted. The project would significantly increase the volume of water in the river the impacts from the additional toxins that would be introduced into the Big Muddy River, a significant waterway that passes through and inundates important habitats during flood times at Riverside Park in the City of Murphysboro and on the Shawnee National Forest, will be far reaching. As such, we believe a project of this magnitude and of national significance should trigger a full blown Environmental Impact Statement (EIS) study under the National Environmental Policy Act (NEPA) of 1970.

It seems that some of us just have not learned the lesson that, "dilution is not the solution to water pollution!"

With consideration to the aforementioned concerns, SCIAS also respectfully asks that the public notice period ending today be extended and does formally request that IEPA conduct a public hearing on this draft NPDDES Permit No. IL0077666.

Thank you for considering these comments. Please keep SCIAS apprised as to any developments regarding this draft permit.

Sincerely,

John B. Wallace
President, Shawnee Chapter
Illinois Audubon Society
Email: forestally1@gmail.com
618/534-0939

Exhibit 228

EPA.PublicHearingCom

From: JoAnn Pillatsch <jpillatsch@frontier.com>
Sent: Monday, August 12, 2019 11:08 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 &Notice No. 7516c

To whom it may concern:
It is the EPA's fiduciary responsibility to protect our environment! I don't even understand it was given a second thought!!! NO! Should have been the first and final answer to allowing Williamson Energy's request to dump poison into the Big Muddy River! If water accumulating in the mine is a problem, why are they just now dealing with the problem!?!? Surely, their engineers have given thought ahead of time, don't you think? Why allow them to poison the water, land, kill animal life...then pull up stakes and move on??? Oh well...what's done is done...No, stop it NOW!!! Coal is no longer king...it's not long before it's a "thing" of the past! Just look around to all the closures in So IL. Do the right thing!!! Say NO, save the BIG MUDDY!
JoAnn Pillatsch
Marion, IL

Sent from my iPhone

Exhibit 229

EPA.PublicHearingCom

From: Jill Adams <jeadamspol@gmail.com>
Sent: Monday, August 12, 2019 11:28 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 and notice No. 7516c

I am writing to urge you to hold public hearings on the proposed discharge by Pond Creek of mine waste water into the Big Muddy River north of Murphysboro. There is insufficient assessment of many of the effects of this proposed discharge. There is strong community opposition to this permit and significant interest as evidenced by The Southern Illinoisan's editorial of 6/23 and again on 8/4. In addition letters to the editor have strongly opposed this permit. The mayor of Murphysboro has also expressed opposition and a resolution opposing the permit was passed unanimously tonight by a joint meeting of the Carbondale City Council and the Carbondale Park Board.

The significant potential effects and the deep community concern are ample grounds to hold a public hearing before any action is taken on this permit application.

Jill Adams
816 Hartline Rd
Makanda IL 62958
618 549 1250

Exhibit 330

EPA.PublicHearingCom

From: Brian Ritzel <brian.ritzel@gmail.com>
Sent: Monday, August 12, 2019 11:33 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 and notice No. 7516c

Mr LeCrone,

Regarding: NPDES IL0077666 and notice No. 7516c

We the People of Illinois respectfully request a public hearing for the Pond Creek application which seeks to allow upwards of 3.5 millions gallons of mine waste water to be discharged into the Big Muddy River north of Murphysboro. This discharge includes mine process water and ground water seeping into the mine during normal operations. The mining waste will have concentrations of dangerous levels of chlorides and sulfates that will be harmful to all aquatic life downstream of the discharge point.
Big Muddy River is already impacted by permitted and pre-regulation mine pollution. The cumulative impact will not be good for Southern IL or the Big Muddy River.

There has been no assessment of cumulative water quality impacts from continued coal mining.
There has been no assessment of increased water volume with regard to flooding, sedimentation, and downstream impacts.
There has been no assessment for the large withdrawals of underground water resources and the impact and implications that might have on future groundwater resources.
And there has been no assessment of the full social, health, environmental, economic or climate cost this mine will cost IL tax payers.

For these reasons, we ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c

Sincerely,
Brian Ritzel
747 Clarence #2
Oak Park, IL 60304

Exhibit 231

EPA.PublicHearingCom

From: John Wallace <forestally1@gmail.com>
Sent: Monday, August 12, 2019 11:42 PM
To: LeCrone, Darin
Subject: [External] NPDES Permit No. IL0077666 Comments
Attachments: Pond Creek Mine EPA discharge letter.pdf

Ladies/Gentlemen,
Please find the attached comments for the proposed Pond Mine NPDES Permit No. IL0077666 Notice No. 7516c.

Should you have any questions or problems opening the pdf version, please do not hesitate to contact us.

Thank you,
John Wallace & Karen Frailey

Karen J. Frailey & John B. Wallace
37 State Highway 147
Simpson, Illinois 62985
forestally1@gmail.com

August 12, 2019

Mr. Darin LeCrone
Illinois Environmental Protection Agency
Bureau of Water, Water Pollution Control Permit Section
1021 North Grand Ave. East
Springfield, IL 62794-9276
Email: darin.lecrone@illinois.gov

RE: NPDES Permit No. IL0077666 Notice No. 7516c Pond Creek Mine

Dear Mr. LeCrone,

Please consider the following as our official comments on the Illinois Environmental Protection Agency (IEPA) National Pollutant Discharge Elimination System (NPDES) tentative determination (draft) to issue Permit No. IL0077666 Notice No. 7516c to Williamson Energy, LLC, for the Pond Creek Mine Facility in Williamson and Franklin Counties for a total of 11 different outfalls and discharges of alkaline and acid mine discharges into Pond Creek, into unnamed tributaries of Pond Creek and into the Big Muddy River.

While we have concerns about the eight existing permitted outfalls and discharges, of most concern to us are the three new designated outfalls/discharges for Pond Creek, for an unnamed tributary of Pond Creek and for the Big Muddy River (Outfall Nos. 009, 009ES and 011). We ask that the public notice period ending today be extended and we request a public hearing on this draft NPDDES permit.

Have any biological assessments been undertaken to evaluate the plan's proposed discharge of polluted water and overall increase in water volume for this river? Even though it comes from ground water, we understand that the wastewater to be discharged contains chloride and sulfate in excess of state water quality standards for such a discharge and that the wastewater discharged into the Big Muddy River is expected to average 2.7 million gallons, daily.

We are recreational users of the Big Muddy River that boat and fish on the river in Jackson County. We also bird watch, wildlife watch, botanize, hike, and camp, within the floodplain of the Big Muddy and on the nearby uplands on public land in Jackson County, downstream of the existing and proposed mine drainage discharges. We cannot imagine that our use of and appreciation for this natural resource will not be negatively impacted by this proposed upstream discharge of polluted water into the river.

What kind of impacts will this discharge have on nearby residents and communities near the Big Muddy River, downstream of the discharge? What effect will this discharge have on the floodplain? Will the increase in volume affect its flooding? How will this floodwater affect agricultural lands located in the floodplain? How will this discharge affect some of the unique areas such as Oakwood Bottoms, Little Grand Canyon, LaRue Swamp Ecological Area and other Shawnee National Forest floodplain ecosystems?

Do you know the full impacts from pumping out this quantity of polluted ground water into an above ground waterway? If pumping out this water is so important for the operation of the privately owned mine, why should the responsibility of dealing with (treating and containing) this contaminated water not fall to the mine owners/operators? Why should that responsibility of dealing with the consequences of dumping these wastes and this volume of water then also fall to the public, (i.e. taxpayers of Illinois)?

The Big Muddy River provides habitat to a number of aquatic organisms including macro-invertebrates, fish, amphibians, reptiles and mammals. Numerous avian species also use the river for feeding, and its floodplain for feeding, roosting and nesting. The vegetation in and around the flood plain of the Big Muddy provides important food and shelter for both aquatic organisms and terrestrial wildlife. Areas of importance for wildlife include Riverside Park in Murphysboro and the Shawnee National Forest, including Oakwood Bottoms, Little Grand Canyon and LaRue Pine Hills, all located in Jackson County.

What will the impacts of the discharge be on the macro-invertebrates, fish, amphibians and reptiles that inhabit the river downstream from the discharge? How about the impact on migratory waterfowl that inhabit the river and floodplain or the impact on other birds that eat the macro-invertebrates, fish or amphibians in the river that absorb or consume higher amounts of sulfates and chloride from the discharge? The concentrations of chlorides and sulfates in this discharge are too toxic. As such, Williamson Energy proposes mixing or diluting them for discharging into the Big Muddy River, an important public waterway of the state. While the Big Muddy River is important habitat for wildlife, it is already considered impaired at the proposed discharge site. According to IEPA this is due to sedimentation, total suspended solids, dissolved oxygen levels and other toxins. Even though the concentrations of toxins may be more diluted, the addition of more chlorides and sulfates in waters that are already impaired, simply impair this waterway, further. The further degradation puts more stress on aquatic organisms and all others, both humans and wildlife that use the area and feed on them.

State listed, endangered and threatened animal species are known to occur in the Big Muddy River and more are known to feed on aquatic organisms found in the river. Federal and state listed, endangered and threatened plants and animals (including golden eagle and Indiana bat) are found within the Big Muddy River floodplain. What will be the impacts from the additional volume of water, and from the additional wastewater toxins contained in the floodwaters on the rare floodplain flora and fauna?

It is not clear to us if the additional daily average of 2.7 million gallons of wastewater discharge will go directly into outfall no. 011 on the Big Muddy River, or if it will be dispersed into all three of the newly proposed outfalls (009 and 009ES). Since Pond Creek is a tributary of the Big Muddy, has IEPA considered the cumulative impacts from the newly proposed discharge along with the other eight existing outfall/discharge locations? If so what is the total volume of water and total overall pollutants and what will those impacts be?

Have studies been undertaken to consider the impacts on shoreline erosion that the additional 2.7 million gallons of water per day on river flow may have on the shoreline of the Big Muddy River? Will it create more suspended solids in the river? Total suspended solids are a pollutant already identified as causing impairment to the Big Muddy River.

Considering the overall impacts from this proposal, we believe further studies should be conducted. The project would significantly increase the volume of water in the river and would negatively impact the water quality, from the additional toxins that would be introduced into the Big Muddy River. Since the Big Muddy is a significant waterway that passes through and inundates important habitats during flood times at Riverside Park in the City of Murphysboro and on the Shawnee National Forest, the negative

impacts will be far reaching. As such, we also believe a project of this magnitude and of such significance would likely trigger an Environmental Impact Statement (EIS) study under the National Environmental Policy Act (NEPA) of 1970. Has an EIS for this project been considered?

We reiterate our request that the public notice period ending today be extended and our request for a public hearing on this draft NPDDES permit.

Please keep us informed about the status of this application and other such proposed projects that may impact the Big Muddy River. Thank you for your consideration in processing these comments.

Sincerely,

Karen J. Frailey
featherfoil1@gmail.com

John B. Wallace
forestally1@gmail.com

37 State Highway 147
Simpson, IL 62985
618/534-0939

Exhibit 232

EPA.PublicHearingCom

From: Rachel Cristaudo <cristaudork@gmail.com>
Sent: Tuesday, August 13, 2019 1:00 AM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 & Notice No. 7516c

Hi,

Please consider this article to be my comment against dumping in the Big Muddy. In addition, I'd like to request a public hearing,

Thank you,
Rachel Cristaudo

"Voice of The Southern: The state should not turn Big Muddy River into wastewater

- Aug 4, 2019 Updated Aug 9, 2019
-

Save

EPA.

The "P" stands for protection. Not Pond Creek. And not permission.

That's our viewpoint concerning the Illinois Environmental Protection Agency making a tentative determination approving Williamson Energy's request to dump millions of gallons of wastewater into the Big Muddy River.

The proposal states that up to 3.5 million gallons of water per day could be dumped into the river. During the summer months, that figure would represent about one-tenth of the river's daily flow.

The IEPA's approval is apparently part one of a two-part process. The final ruling will come at the end of a public comment period that closes Aug. 12.

We're hoping this indicates that the "P" in EPA may stand for procedural and that the agency isn't actually considering giving the agency the green light to turn the Big Muddy River into its own private sewer.

The coal company has been required to amend its proposal more than a dozen times. At one point, it had asked to pump water with high concentrations of chlorides and sulfates, both of which are toxic to aquatic organisms, into the river.

The latest proposal apparently calls for water to be diluted through a system of tanks prior to being discharged. Frankly, this isn't any more palatable.

We understand jobs are critical to Southern Illinois. We understand much of Southern Illinois is impoverished, but what price are we willing to pay for the state to subsidize one employer?

Virtually every manufacturing operation generates waste material that needs to be disposed. This newspaper certainly does. However, it isn't the state's job to see that our waste is disposed of properly. We're not asking the people of Illinois to bury old newspapers at Giant City State Park or at Lake Murphysboro.

Nor, should we think it is acceptable for the state to grant permission to turn the Big Muddy into a Williamson Energy subsidiary. The Big Muddy River belongs to the people of Illinois. The state should not have the authority to sublet an entire river.

It's not just the newspaper opposing the project.

Recently, Murphysboro mayor Will Stephens spoke out against the request, noting that Williamson Energy had amended its request 24 times. Stephens said, correctly in our estimation, that the company lacks foresight, or at worst, isn't acting in good faith.

Which brings us to a vital point.

Who is going to make sure the discharge meets water quality standards and who is going to make sure the discharge doesn't exceed the allowable volume?

Is anyone willing to take the coal company at it's word.

The Illinois Department of Natural Resources is woefully understaffed. And, even if a violation is detected, it could be too late to prevent an environmental disaster. The Big Muddy flows through agricultural lands downstream as well as some of the most unique and sensitive biological areas in the state.

The ecological importance of the lower Big Muddy River seems to be ample justification for denying the request.

In the name of environmental protection, the use of farm chemicals is regulated to keep harmful materials from flowing into ditches, which empty into creeks, which empty into rivers. Yet, it seems the IEPA may approve the discharge of 3.5 million gallons of polluted water into one of the state's major rivers.

Finally, public sentiment, at least what we've been able to gauge, is adamantly opposed to the mine's proposal. Granted, making decisions based on group think isn't necessarily the proper course of action, but in this case, it certainly merits consideration.

It is "We the people" who will have to live with the consequences of this decision."

Exhibit 233

EPA.PublicHearingCom

From: Alex Trujillo <alexdtrujillo@gmail.com>
Sent: Thursday, August 15, 2019 3:11 PM
To: LeCrone, Darin
Subject: [External] NPDES IL0077666 and notice No. 7516c

Mr Lecrone,

Regarding: NPDES IL0077666 and notice No. 7516c

We the People of Illinois respectfully request a public hearing for the Pond Creek application which seeks to allow upwards of 3.5 millions gallons of mine waste water to be discharged into the Big Muddy River north of Murphysboro. This discharge includes mine process water and ground water seeping into the mine during normal operations. The mining waste will have concentrations of dangerous levels of chlorides and sulfates that will be harmful to all aquatic life downstream of the discharge point.
Big Muddy River is already impacted by permitted and pre-regulation mine pollution. The cumulative impact will not be good for Southern IL or the Big Muddy River.

There has been no assessment of cumulative water quality impacts from continued coal mining.
There has been no assessment of increased water volume with regard to flooding, sedimentation, and downstream impacts.
There has been no assessment for the large withdrawals of underground water resources and the impact and implications that might have on future groundwater resources.
And there has been no assessment of the full social, health, environmental, economic or climate cost this mine will cost IL tax payers.

For these reasons, we ask for a public hearing for Pond Creek Mine: NPDES IL0077666 and notice No. 7516c

Sincerely,
Alex Trujillo

Studer, Dean

From: Biggs, Kim
Sent: Monday, August 12, 2019 4:41 PM
To: Lieberoff, Barb; Studer, Dean
Subject: FW: [External] SAVE THE BIG MUDDY RIVER

Exhibit 234

From: M. A. Smith <christopherareanews@gmail.com>
Sent: Monday, August 12, 2019 4:37 PM
To: Biggs, Kim <Kim.Biggs@Illinois.gov>
Subject: [External] SAVE THE BIG MUDDY RIVER

I am 100% opposed to the Pond Creek M8ne #1 being allowed to dump 3.5 million gallons of mine waste into the Big Muddy. Anyone who works for the Illinois Environmental Protection Act should be smart enough to know this is WRONG. It is dangerous to our air, water, land and wildlife. Also why doesnt Illinois get a coal severance tax from the coal companies like West Virginia and Kentucky do? Please have a public hearing. Put that public hearing notice in our LICAL newspapers and LOCAL radio stations and share the date and time with those of us who have emailed.
Use your common sense. I am 100% sure that NONE of you who work at the iepa and even the epa are part of the 1%. You and your family will suffer along with the rest of us when our land air and water is ruined!
Marian Smith Furlow
611 S. Thomas
Christopher Il 62822

State of Illinois - CONFIDENTIALITY NOTICE: The information contained in this communication is confidential, may be attorney-client privileged or attorney work product, may constitute inside information or internal deliberative staff communication, and is intended only for the use of the addressee. Unauthorized use, disclosure or copying of this communication or any part thereof is strictly prohibited and may be unlawful. If you have received this communication in error, please notify the sender immediately by return e-mail and destroy this communication and all copies thereof, including all attachments. Receipt by an unintended recipient does not waive attorney-client privilege, attorney work product privilege, or any other exemption from disclosure.

Exhibit 235

EPA.PublicHearingCom

From: Tony Graham <tonygracing@gmail.com>
Sent: Wednesday, October 30, 2019 2:47 PM
To: EPA.PublicHearingCom
Subject: [External] Fwd: Pond Creek Mine IL0077666

To whom it may concern,

This is in response to the proposal that states that up to 3.5 million gallons of water per day could be released into the big muddy river by Williamson Energy. My family lives on a creek that feeds the big muddy river, when the river floods it moves this water well up into my back yard. This is the backyard in which my dog and family visit often when not under water. I am deeply concerned about the proposal not just from my prospective but the impact that it will have on the water way and the natural world that depends on the river. Please do not allow this proposal to proceed. This is not in the best interest of the people of southern Illinois or the natural habitats that we greatly treasure.

Tony Graham

DeSoto Illinois

EPA.PublicHearingCom

From: Josh Crouch <joshuacay@gmail.com>
Sent: Thursday, October 31, 2019 4:31 PM
To: EPA.PublicHearingCom
Subject: [External] IL0077666

Exhibit 236

I opposed this permit, my family has used the big muddy river for recreational fishing and kayaking for quite a few years, this project is sure to affect the quality of the wildlife living there, cost is not a justifiable means to destroy a habitat, make the facility handle the waste in a way that will not pollute the surrounding environment -Joshua Crouch

Exhibit 237

From: Earth Water
To: EPA.PublicHearingCom
Subject: [External] NPDES Permit IL0077666
Date: Thursday, December 12, 2019 1:13:48 PM
Attachments: EPACommentNPDESPermitNo.IL0077666.docx

Hello. I have attached my written comments for the Pond Creek Mine NPDEs Permit No. IL0077666. I will also be presenting some of the information provided at the public hearing next week and will submit a paper copy.
Lucia Amorelli

12/11/2019

Written Comments for Pond Creek Mine NPDES Permit No. IL0077666

To:
Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES
Illinois Environmental Protection Agency
1021 N. Grand Ave. East
P.O. Box 19276
Springfield, IL 62794-9276
epa.publichearingcom@illinois.gov

From:
Lucia Amorelli
315 N. Westridge Dr. Apt. 12
Carbondale, IL 62901
618-771-0154
Earthwater365@gmail.com

I am submitting comments for Pond Creek Mine NPDES Permit No. IL0077666, specifically regarding the portion of the permit concerning Outfall #011 which would allow significant amounts of mine wastewater to be pumped into the Big Muddy River. I am a teacher, unpaid environmental advocate, and long-term resident of southern Illinois. I am an avid hiker, kayaker, swimmer, and bicyclist. I remain in this area specifically because of the unique beauty of our area, and I frequently (at least once a week) utilize our state parks and national forest areas. I live only a few miles from the Big Muddy River and only a couple of blocks from Little Crab Orchard Creek, one of the tributaries in the Big Muddy Watershed.

I am adamantly opposed to this permit as is. At minimum, there needs to be a proper filtration system for wastewater; using a dilution method with the river's own water is not going to be able to filter millions of gallons of toxic water that is going to be discharged. The following pages list some of the concerns and questions I have after reading through the draft permit and related materials concerning this issue. I believe, they all have a direct relation to the Clean Water Act and antidegradation analysis. This is by no means an exhaustive account of my concerns.

Williamson Energy History of Violations

The Attorney General (on behalf of the people of Illinois) sued Williamson Energy February, 2019 on eight counts of violations that occurred in 2016 due to a pump failure which dumped approximately 90,000 gallons of coal slurry/acid mine discharge into an unnamed tributary of Pond Creek. An example of some of the counts include: discharging contaminants into the water; depositing contaminants onto the land; violating water quality standards for chloride and iron; and INTENTIONAL diversion of a waste stream from sediment pond to and outflow into a tributary of Pond creek. There was only one announcement in the *Marion Repu*blican regarding this case; no one requested a hearing. Williamson Energy did not admit to the violations, and the case was settled without a hearing. They only had to pay a civil penalty for $80,000 even though five of the eight counts had a $50,000 penalty (the other three had $10,000 each).

According to information provided in the Pond Creek Watershed Inventory (2019) created by Greater Egypt Regional Planning and Development Commission, Williamson Energy had over 45 outfall effluent violations between 2015 and 2017 (Source of violation history is from EPA-ECHO). Some of the pollutants include: chloride, sulfate, nitrogen, pH, manganese, and total dissolved oxygen (TSS).

Question: How many more violations have occurred since 2017? How many violations in total does Williamson Energy have? Have the impacts of these violations on aquatic life been assessed?

Question: Are there any IEPA regulations or stipulations under the Clean Water Act regarding granting new permits or additions to existing permits when the company requesting them have an extensive history of violations? Citizens do not get to keep violating law without increasing consequences (e.g. prison time, permanently losing a driving license, losing child custody, etc.). If there are not rules/regulations which can prohibit granting companies new permits and/or terminating a permit due to continued and repeated violations which cause harm to the environment and its inhabitants, then the IEPA needs to create them. Companies should not be allowed to violate laws endlessly with only monetary fines as their penalty.

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Question: Can the IEPA be held accountable by law for allowing a pipeline to discharge acid mine drainage with elevated concentrations of numerous pollutants into a river that is currently listed as impaired and is also a candidate for wild and scenic river designation?

There were 11 violations related to sulfates and ten to chloride in Pond Creek, a tributary of Big Muddy River (Pond Creek Watershed Inventory, Greater Egypt Regional Planning and Development Commission, 2019, p.85). In addition, the report states the following:

- "...chloride is listed as an impairment to aquatic life in the waterbody." (p.74)
- "The mine also had a number of single event violations including: improper operation and maintenance, numeric effluent, unapproved bypass, and an unauthorized discharge." (p.85)
- "Pond Creek has been listed for chloride and sedimentation/siltation impairments since 2010, and dissolved oxygen since 2012. In 2008, the stream was listed for iron, manganese, pH, total suspended solids (TSS), and fecal coliform." (p.74)
- The Illinois Integrated Water Quality Report categorizes Pond Creek as having three designated uses; aquatic life, which is not supported... (p. 72)

Water Quality

In the IEPA Big Muddy River TDML 2004 report it states that the Big Muddy River is a compromised and impaired river and is due in part because of mining operations. It states that "abandoned coal mines should be identified **in addition to other mining activity** which could contribute to manganese and sulfate concentrations..." According to the Antidegradation Analysis report (2016), the Big Muddy River is listed in the 2014 Section 303 (d) list for sedimentation/ siltation, sulfates, total suspended solids (TSS), mercury, and polychlorinated biphenyl (PCBs). The site is on the 2016 Section 303(d) list for impaired waters due to sedimentation/ siltation, TSS, mercury, PCBs, iron, dissolved oxygen, pH, and fecal coliform.

And just recently, the Upper Big Muddy River TDML Report (IEPA 2019) was released which stated that elevated concentrations of Iron and Manganese were

found in Big Muddy Watershed and according to IEPA have negative impacts on aquatic life.

> Iron TMDL: IEPA identified one segment, Andy Creek (IL_NZN-13), with elevated concentrations of dissolved iron. Elevated concentrations of dissolved iron can negatively impact aquatic species by disturbing normal metabolic and osmoregulatory functions. Aquaculture studies have also demonstrated that increased dissolved iron concentrations in the water column may negatively impact gill functionality in certain fish species and thus reduce biodiversity in certain stream environments. 4 Excessive iron within the water column may harm aquatic species such as fish and macroinvertebrates. Certain metals species dissolve in water and may be absorbed by fish and other aquatic organisms. Small concentrations of certain dissolved metals may be, in the short term, toxic to fish and aquatic species and, in the long term, may bioaccumulate in certain aquatic species.

Question: Why is the water quality standard for Iron listed on the draft permit for the Pond Creek Pipeline as 3mg/6mgL when the standard on the IEPA Water Quality Standard Report 2019 states that the acceptable level is 1mg/L?

> Manganese TMDL: IEPA identified one segment, Beaver Creek (IL_NGAZ-JC-D1), with elevated concentrations of dissolved manganese. Elevated dissolved manganese concentrations in the water column have many of the same negative effects of dissolved iron on fish species and biodiversity of the water column and benthic environments. Excessive manganese within the water column may harm aquatic species such as fish and macroinvertebrates. Certain metals species dissolve in water and may be absorbed by fish and other aquatic organisms. Small concentrations of certain dissolved metals may be, in the short term, toxic to fish and aquatic species and, in the long term, may bioaccumulate in certain aquatic species. (Upper Big Muddy River TDML Report, IEPA, 2019).

The Union of Concerned Scientists state that

> "mining operations can negatively impact water supplies, often with long-lasting effects. The fundamental issue involves contamination of nearby

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> rivers, lakes, and aquifers by what comes *out* of a coal mine—usually highly acidic water containing heavy metals like arsenic, copper, and lead. The process is known as **acid mine drainage**. It happens when certain substances (typically iron sulfide, FeS2, or fool's gold) is oxidized after being exposed to air and water. Runoff can change the pH of nearby streams to the same level as *vinegar* (Coal and Water Pollution, Union of Concerned Scientists,https://www.ucsusa.org/clean-energy/coal-and-other-fossil-fuels/coal-water-pollution, Accessed 7.22.2019.)

According to U.S. Fish and Wildlife, "Because acid mine drainage can destroy a stream's aquatic community for miles, many of the old mining sites are being reclaimed (Acid Mine Drainage, U.S. Fish and Wildlife, https://www.fws.gov/mountain-prairie/contaminants/acidMineDrainage.php, accessed 7.2019)

Question: Does this mean then that the IEPA is going against its own implementation plans (2004/2019) by considering granting a permit for a pipeline which will infuse the river more with elevated levels of chlorides, sulfates, manganese and other pollutants? Does this not go against the Clean Water Act?

Interestingly, there is no mention of the Pond Creek in the TDML IEPA 2019 Upper Big Muddy Watershed report, even though other tributaries are discussed.

Question: Why is Pond Creek not included in this report since according to the Greater Egypt Regional Planning and Development Commission just released a watershed-based plan (2019) which was created because of the creek being polluted? It is already polluted with some of the very pollutants the mine will be discharging such as chloride, iron, manganese, and TSS.

In 2018 and 2019, The Big Muddy River had a fish advisory for mercury by the Illinois Health Department. Mercury is one of the pollutants which is to be monitored in the acid mine discharge. The advisory for Mercury has recently been removed from the website.

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Question: Why has the mercury advisory suddenly been lifted?

Question: Has the fact that elevated sulfates can cause Mercury to undergo methylation into its most toxic form methylmercury according to Orem, W. in "Sulfate as a Contaminant in Freshwater Ecosystems: Sources, Impacts and Mitigation" (U.S. Geological Survey, assessed 10.2019)

Chlorides

IEPA has listed the acceptable levels for chloride concentrations in waterways as 500mg/L. According to the Pine Creek Pond Permit Application No. 456, samples taken of the mine wastewater showed high levels of both chlorides and sulfates that far exceed the acceptable level for water quality standards. The average chloride concentration of the samples taken was 2, 237 mg/L.

- The national standard for sustaining aquatic life is 230mg/L for chronic (long-term) levels and 860 mg/L for acute (short-term). (https://www.epa.gov/wqc/national-recommended-water-quality-criteria)
- Missouri revised their chloride levels in 2012 to 178mg/L for chronic and as low as 288mg/L for acute. (EPA Region 7, 2015)
- Indiana adopted new criterion in 2012 for chloride levels for Lake Michigan to be 250 mg/L. (Indiana Preliminary Adopts Revised Chloride and Sulfate Water Quality Criteria, BDlegal.com, 2019).
- According to Kentucky state website (2019), acute chloride levels ranging from 2500 to 8400 mg/L can be toxic to aquatic life such as snails, minnows, catfish, and trout.
- Another study by University of Rhode Island has much lower long-term exposure rates of 250mg/L and 860 mg/L for short-term exposure. (Hunt, Herron, & Green. *Chlorides in Fresh Water*. University of Rhode Island. March 2012)

Question: Why does Illinois EPA have much higher accepted levels of chloride than surrounding states especially since what is considered to be safe levels for aquatic life is much lower than the Illinois accepted level of 500mg/L? Why does IEPA not have both an acute and a chronic level like other states and the national standard?

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Question: According to the draft permit for the pipeline samples taken from the acid mine discharge showed chloride levels greater than 2,000 mg/ and levels of up to 12,000mg/L are permissible from the discharge point into the Big Muddy River. This grossly exceeds both the national and state accepted levels. How can the IEPA allow such a gross violation of its own and national regulation? 12,000mg/L would be 48x the national standard and 24x the state standard. Is it truly be diluted "immediately" and rapidly" which is what is stated in the In Section 302.102 12(e) Allowed Mixing, Mixing Zones and ZIDs (TITLE 35: ENVIRONMENTAL PROTECTION SUBTITLE C: WATER POLLUTION CHAPTER I: POLLUTION CONTROL BOARD PART 302 WATER QUALITY STANDARDS SUBPART A: GENERAL WATER QUALITY PROVISIONS, 2019)

Sulfates:

The accepted sulfate level is listed as 1250 mg/l on the draft permit; however, the average sulfate concentration taken from the Pond Creek mine wastewater was 1,940 mg/L and the IEPA antidegradation assessment states that the levels to be discharged to the Big Muddy River could be as high as 2,120 mg/L sulfate. This would be the equivalent of 476,000 pounds per day of sulfate.

According to Kentucky State website (2019). "Problems caused by sulfates are most often related to their ability to form strong acids which change the pH. Sulfate ions also are involved in complexing and precipitation reactions which affect solubility of metals and other substances."

In addition to the afore mentioned pollutants in the Big Muddy River, the IEPA has recently listed four sections (IL0029165, IL0031704, IL0027871, IL0027898) of the Big Muddy River under the Nutrient Assessment Reduction Plan/Illinois Nutrient Loss Reduction Strategy Implementation (2019). These sections of the river are all downstream from the proposed pipeline.

According to a study by Kaushal in 2005, many of our waterways are becoming victims of 'freshwater salinization syndrome', where "high levels of chloride and other salt ions can kill freshwater animals, from zooplankton at the base of the food web to insects and fish, because they make it hard for the creatures to osmotically regulate their cell's ion concentrations." Furthermore, the study

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states that high levels of chlorides and other salts can cause more algal blooms due to dying off of algae-eating zooplankton which in turn can cause the releasing of toxins and deplete oxygen. In addition, higher salt levels can "favor invasive species that better survive in brackish water," and "at nonlethal levels, salt can stunt the reproduction and growth of freshwater organisms, lowering biodiversity and shifting the structure of the food webs." (*For Healthier Lakes, Rivers, and Drinking Water Hold the Salt*, Lockwood, D., Chemical and Engineering News, 2019).

Question: Has the IEPA considered the impact of discharging millions of gallons of unfiltered mine wastewater with elevated levels of chlorides, sulfates and other contaminants on the already elevated nutrient load of the Big Muddy River which is supposed to be being mitigated?

Question: Has the EPA taken into consideration current studies regarding effects of salination on aquatic animals?

<u>Mixing Zones</u>

There are numerous issues with the granting of this permit which could possibly violate the water quality standards as listed by the IEPA Pollution Control Board (2019):

In Section 302.102 Allowed Mixing, Mixing Zones and ZIDs.

> 4) Mixing is not allowed in waters containing mussel beds, endangered species habitat, fish spawning areas, areas of important aquatic life habitat, or any other natural features vital to the well-being of aquatic life in such a manner that the maintenance of aquatic life in the body of water as a whole would be adversely affected.

Question: Has this been determined by the IEPA/IDNR? There was no mention of this in the draft permit.

> 6) Mixing must allow for a zone of passage for aquatic life in which water quality standards are met.

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Question: Has this been determined? Again, there was no mention of this in the permit.

> 7) The area and volume in which mixing occurs, alone or in combination with other areas and volumes of mixing, must not intersect any area of any body of water in such a manner that the maintenance of aquatic life in the body of water as a whole would be adversely affected.

Question: Has the current state of the river (i.e. known pollutants) as well as the Sugar Creek Mine discharge pipeline been considered in determining this?

> 9) No mixing is allowed when the water quality standard for the constituent in question is already violated in the receiving water.

Question: Given that the Big Muddy River already has elevated levels of sulfates and manganese, mixing would be violating this regulation. How then can a permit be granted for a mixing zone?

> 12) The area and volume in which mixing occurs must be as small as is practicable under the limitations prescribed in this subsection (b), and in no circumstances may the mixing encompass a surface area larger than 26 acres. c) All water quality standards of this Part must be met at every point outside of the area and volume of the receiving water within which mixing is allowed. The acute toxicity standards of this Part must be met within the area and volume within which mixing is allowed, except as provided in subsection (e).
>
> e) Pursuant to the procedures of Section 39 of the Act and 35 Ill. Adm. Code 309, a person may apply to the Agency to include as a condition in an NPDES permit a ZID as a component portion of a mixing zone. The ZID shall, at a minimum, be limited to waters within which effluent dispersion is immediate and rapid. For the purposes of this subsection, "immediate" dispersion means an effluent's merging with receiving waters without delay in time after its discharge and within close proximity of the end of the discharge pipe, so as to minimize the length of exposure time of aquatic life to undiluted effluent, and "rapid" dispersion means an effluent's merging with receiving waters so as to minimize the length of exposure time of

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> aquatic life to undiluted effluent. Upon proof by the applicant that a proposed ZID conforms with the requirements of Section 39 of the Act and this Section, the Agency shall, pursuant to Section 39(b) of the Act, include within the NPDES permit a condition defining the ZID.
>
> (TITLE 35: ENVIRONMENTAL PROTECTION SUBTITLE C: WATER POLLUTION CHAPTER I: POLLUTION CONTROL BOARD PART 302 WATER QUALITY STANDARDS SUBPART A: GENERAL WATER QUALITY PROVISIONS, 2019)

Question: With up to 5,000gals/minute or 300,000gals/hr. of mine waster discharge being permissible, how can there be an "immediate" or "rapid" dispersion to avoid having to adhere to Section 302.102, 12, (c), which states that acute toxicity standards must be met within the mixing zone. How can up to 12,000mg/l chlorides be rapidly dispersed in a small river?

Endangered Species

I am still trying to find out what species specific to Big Muddy River are Endangered or Threatened. I have contacted numerous government agencies, including: U.S. Fish and Wildlife, IDNR, IEPA, Illinois Endangered Species Protection Board, and Shawnee National Forest. No one has been able to give me any information. I have been trying since Fall 2018 after the initial hearing at IDNR.

Question 8: How can this permit be granted if none of these agencies seem to know exactly what species are endangered and threatened in the Big Muddy River Watershed as well as Pond Creek watershed?

Freshwater Mussels

Since 2018, US Fish and Wildlife Service has been under litigation for not protecting critical habitat for certain endangered mussels in 18 states, including three that occur in Illinois-Spectaclecase, Sheepnose, and Snuffbox. These and many more are protected under the 2019 Endangered Species Act. Anyone requiring federally funded or permitted projects in mussel's habitats must consult the US Fish and Wildlife Service to ensure habitat would not be damaged. There are more mussel species in the eastern U.S. than anywhere in the world;

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however, 70% of species are either endangered, threatened or extinct already. (Center for Biological Diversity)

According to a study conducted by the Illinois Natural History Survey, "Freshwater Mussels of the Big Muddy River" (2012), six species of mussels previously detected in the Big Muddy River were not found; although five of these are commonly found in other rivers in Illinois. These include: pink heelsplitter, pimpleback (listed as federally endangered), deertoe, creeper, fawnsfoot, plain pocketbook. 19 others were detected. "In Illinois, 25 of the 62 extant species (44%) are listed as threatened or endangered. Some of the species listed in the study that were documented in the Big Muddy River are: Lilliput, paper pondshell, pondhorn, white heelsplitter, giant floater, maple leaf, pink papershell.

The study lists the abandoned coal mines, specifically in the Murphsyboro area of the Big Muddy River, as a source of pollution. The study goes on to state that

mussels are more sensitive to sodium chloride and potassium chloride and that the current USEPA AWQC may not be protective of freshwater mussels (2013 Science Inventory). In addition, the study states that sedimentation and siltation might be causing a lack of species.

Question: Are any of the mussel species that exist in the Big Muddy watershed listed as threatened or endangered or rare? If this is not known, then it is pertinent to find out given the fact that most mussel species are now listed as threatened or endangered or already extinct and that they have been found to be sensitive to chloride levels as well as sedimentation/siltation both of which will be inflated due to the discharge of up to millions of gallons a day of acid mine discharge with extremely high levels of chloride and sulfates.

Fish Species

According to "Fishes of the Big Muddy" (1999), at least ten native fish species within a 100 year period are no longer found due to pollution, cultivation, and habitat lost. The study suggests the need for "continual vigorous reclamation of abandoned mines lands and treatment of acid mine drainage." The study goes on to say that "Big Muddy River drainage...has been subjected to an array of enviro

stresses that have permanently disrupted its hydrological cycle, and ultimately altered its fish fauna."

The following are list of fish species that were recorded at time of study: bluegill, channel catfish, largemouth bass, sauger, striped bass, white bass, white crappie, yellow bullhead.

Question: What is the current state of the fish population in the Big Muddy and how will these elevated levels of chlorides/sulfates affect them as well as possible other toxins such as manganese and iron? Are any of these species listed as endangered or threatened?

Other Endangered/Threatened Species

The alligator snapping turtle is listed as a threatened species in Illinois.

Question: Has it been determined if their habitat includes the Big Muddy Watershed?

Ecologically Sensitive Areas

The Big Muddy flows adjacent to two very ecologically diverse areas, Little Grand Canyon and La Rue Pine Hills, both of which are National Natural Registered Landmarks with many rare, threatened, and endangered plant and animal species. "LaRue-Pine Hills Ecological Area, located within the Shawnee National Forest, contains one of the finest assemblages of diverse vegetation in the Midwest. The site represents species of northern, southern, eastern, and western affinities, including 40 species rare in Illinois." (Prairie Research Institute). Some threatened and endangered animal species include the Indian Bat, Illinois chorus frog, eastern woodrat which is only located in the La Rue Pine hills area, several fish species, and many plant species. La Rue Pine Hills/Otter Pond is also a national Research Natural Area which is protected federally.

Question: Are any of these species being considered? In the draft permit, it states that there will be no adverse effects on species because water quality standards will be met. However, in the case of Williamson Energy, this is obviously not the case. Water quality standards are not met. How then can species be protected? Under the Clean Water Act, section. 101(a)2, water quality provides for the protection and propagation of fish, shellfish, and

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wildlife. In addition, the Big Muddy River is already polluted with elevated levels of manganese, sulfates, phosphorus, mercury and has a fish advisory for PCBs. How the does adding elevated levels of chloride, sulfate and other toxins known to have adverse effects on animal and plant species permissible under this section of the Clean Water Act?

There is also a large area in southwestern Illinois listed as a Conservation Opportunity Area for La Rue Pine Hills under IDNR which includes sections of the Big Muddy River in both Jackson and Union County (IDNR, accessed 2019).

Fifty-two miles of the Big Muddy River, from S.R. 14 south of Rend Lake to Southern Illinois Airport (U.S. 51), is a candidate for the Wild and Scenic River Designation (National Rivers Inventory, 2019) and is listed as having "Outstanding Remarkable Value", exactly the area where the proposed pipeline is supposed to discharge. Due to this fact, special considerations need to be considered.

> The Council on Environmental Quality (CEQ), under 5(d)(1) Wild and Scenic River Act authority, provides guidance to federal agencies with permitting and/or granting authority for projects on or near rivers listed on the NRI. In accordance with executive memorandum, all agencies must "take care to avoid or mitigate adverse effects" to rivers identified in the Nationwide Rivers Inventory.

The following information is listed on the National Park Services website regarding rivers listed on the National Rivers Inventory:

1. Determine whether the proposed action could affect an NRI river.

- Check the current regional/state NRI list to determine whether the proposed action could affect an NRI river (i.e., is the proposed action location in the vicinity of the NRI segment).
- If an NRI river segment could be affected by the proposed action, an environmental assessment or and environmental impact statement may be required depending on the significance of the effects.

2. Determine whether the proposed action could have an adverse effect on the natural, cultural, and recreational values of the NRI segment. These values are listed as "outstandingly remarkable values" (ORVs) on the state NRI list.

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Adverse effects on NRI rivers may occur under conditions which include, but are not limited to:

- Destruction or alteration of all or part of the free flowing nature of the river;
- Deterioration of water quality; or

3. Determine whether the proposed action could foreclose options to classify any portion of the NRI segment as wild, scenic, or recreational river areas.

- In some cases, impacts of a proposed action could be severe enough to preclude inclusion in the Wild and Scenic River System, or lower quality of the classification (e.g., from wild to recreational). If the proposed undertaking could effectively downgrade any portion of the NRI segment, you should consult with NPS.
- Proposed actions (whether uses or physical changes), which are theoretically reversible, but which are not likely to be reversed in the short term, should be considered to have the effect of foreclosing for all practical purposes Wild and Scenic River status. This is because a river segment, when studied for possible inclusion in the Wild and Scenic River System, must be judged as it is found to exist at the time of the study, rather than as it may exist at some future time.
- If a proposal, including one or more alternatives, could have an adverse effect on an NRI river, an EA, or if the effects are significant, an EIS must be prepared.

4. Incorporate mitigation/avoidance measures in the proposed action to the maximum extent feasible within the agency's authority.

Question: Has the IEPA taken into consideration that numerous sections of the Big Muddy River downstream from the pipeline are listed not only on the National Rivers Inventory but also in several state and federally listed special environmental zones and therefore has special protections?

<u>IEPA Exhibiting Conflict of Interest</u>

1) The IEPA included in the draft permit a section on social/economic benefits of the proposed activity (pipeline). Goes on to list statistics about jobs and

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revenue for state. My argument is that an agency that was supposedly created for the purpose of protecting our environment should not take economic nor social factors into account.

2) The IEPA also goes on to favor the mine company by stating that "filtration is a technology that is not feasible for the proposed facility because: filtration is much more expensive than sediment ponds...a large area of land would be required for such a facility, and maintenance and supervision of the filtration and sludge operation would be burdensome and would increase production costs."

Question: Is the EPA supposed to be taking into consideration financial aspects of a company in lieu of protecting the environment? Is it supposed to weigh economic benefit over protecting the environment? And why has not the IEPA commented on the economic cost to the citizens of Illinois due to pollution already caused by the mine and the pollution that will be caused by the mine? The Big Muddy River is already polluted and there are now two implementation plans that have been created by the IEPA (2004, 2019) costing hundreds of millions of dollars to implement. The mines, which are listed as one of the causes of pollution, are not held accountable for paying for these costly plans, rather the "stakeholders" and concerned citizens are told they must try to find monies to clean up the rivers. To date, no watershed-based plan group has been formed based on the 2004 findings.

<u>Illinois Constitution</u>

The Illinois Constitution in Article XI states that we have a right to a healthy environment. Since Williamson Energy has numerous and frequent violations which can have and have had adverse impacts on the watersheds and its inhabitants and the IEPA has already listed the Big Muddy River as well as some of its tributaries such as Pond Creek as being impaired for numerous pollutants some as a direct result of both past and current mining activities. It seems that IEPA would be violating the constitution for granting a permit to a company that has a history of polluting public waters and the fact that the nature of the permit would allow even more pollutants to enter the watershed.

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Question: Has the IEPA fully considered whether granting this permit for dumping more pollutants into the already impaired Big Muddy River will violate the law as stated in Article XI of our state constitution?

River Rights

Question: Has the IEPA considered that the river itself should have its own rights. It is already dammed and polluted? How much more should the Big Muddy River endure? The IEPA has already granted another similar permit for a discharge pipeline into the Big Muddy River with even higher expected levels of chlorides form the Sugar Camp Mine only 12.5 miles above stream from the proposed Pond Creek Mine pipeline.

And I end this with one final question to each of the IEPA staff.

Question: If this river was flowing through your backyard/property/town/county would you want millions of gallons of mine wastewater dumped into it without being filtered of all contaminants?

Exhibit 238

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 · (217) 782-3397
JB PRITZKER, GOVERNOR JOHN J. KIM, DIRECTOR

INTERNAL MEMORANDUM

TO: **John J. Kim, Director**
Christine Zeivel, Hearing Officer

FROM: Sanjay Sofat, BOW Bureau Chief SKS

DATE: December 11, 2019

RE: **Williamson Energy Pond Creek Mine NPDES Permit Hearing Board**
NPDES Permit No. IL0077666

Pursuant to the Director's delegation of authority to appoint an NPDES Permit Hearing Board as prescribed by 35 Ill. Adm. Code 309.115, I designate the following individuals to serve as the Hearing Board for the Pond Creek Mine NPDES Permit Hearing:

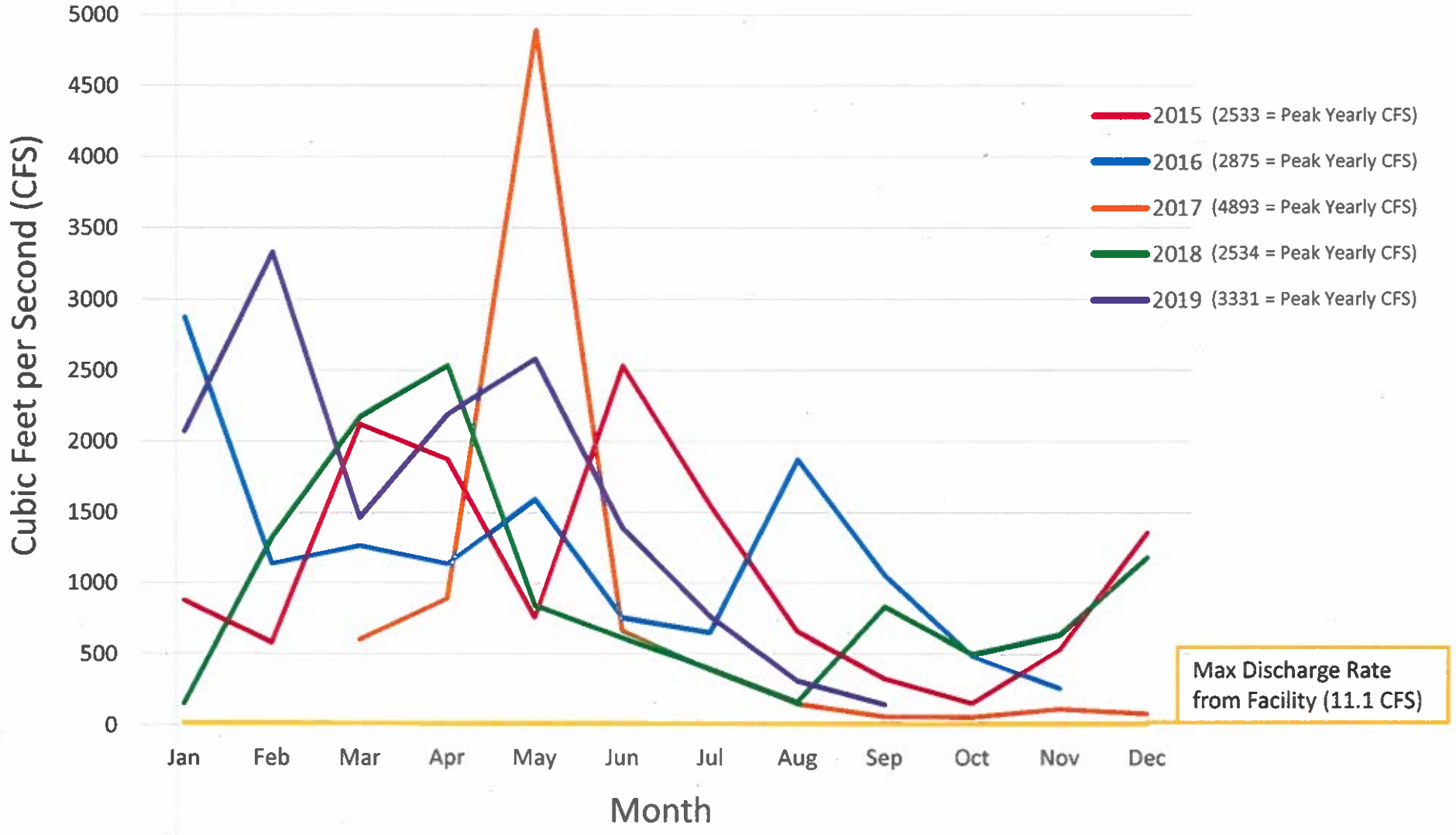
1. Christine Zeivel, Hearing Officer and Board Chairperson
2. Iwona Ward, Permit Engineer, Mine Pollution Control Program
3. Darin LeCrone, Industrial Permit Section Manager
4. Scott Twait, Water Quality Standards Section
5. Amy Zimmer, Groundwater Division
6. Stefanie Diers, Division of Legal Counsel

The designated members of the Hearing Board will sit on the Illinois EPA panel at the Public Hearing to be held on Wednesday, December 18, 2019, in Marion, Illinois. The Hearing Officer will render a recommendation required by 35 Ill. Adm. Code 309.118 based upon the technical and legal advice provided by the other designated members of the Hearing Board.

R03300

Ex a 54

Big Muddy River
Monthly Mean Flow by Year

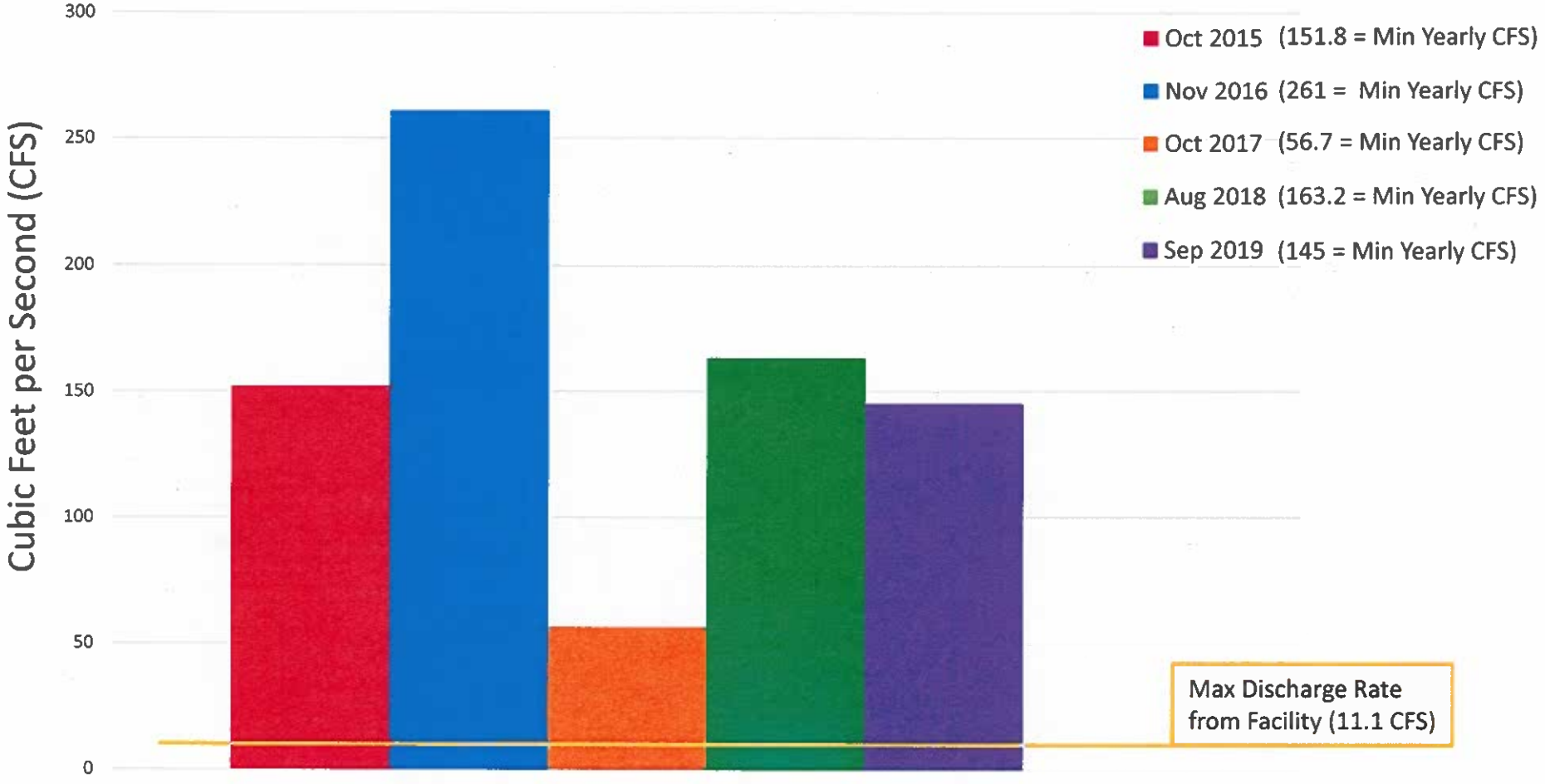


Source: USGS Data from Big Muddy River at Plumfield Station

R03301

Ex 240

Big Muddy River
Minimum Monthly Mean Flow in Each Year



Source: USGS Data from Big Muddy River at Plumfield Station

Williamson Energy NPDES Renewal Public Hearing
December 18, 2019

Clayton Cross

Good Evening. My name is Clayton Cross, and I am the Director of Engineering at Foresight and Williamson Energy. Williamson Energy operates one of the safest and most productive coal mines in the entire world.

This is no mistake. Williamson Energy has invested in the best people, best systems, and best equipment to build this coal mine. In all, over $600 million has been invested into this property. We are responsible for employing 194 coal miners directly. Another 283 contractors work supplying, servicing, or performing some other activity for our operation. That means almost 500 families in this area directly depend upon the success of this mine for their livelihood – to pay their mortgages, educate their children, and buy Christmas gifts. Furthermore, every year this mine directly or indirectly generates $78 million in state, county, and local revenues. The economic boost that this mining operation provides to southern Illinois is very significant.

Given the extensive coal reserve that we have the rights to mine, this mine could be operating for another 50 years at current production levels. We need this permit renewed to keep this mine open long term and operating in an environmentally responsible manner, while ensuring that our coal miners are not exposed to the unnecessary dangers of excessive water. This mine has operated since 2006, and the purpose of this hearing is to take comments on IEPA's decision to renew and modify our NPDES permit. Generally, the NPDES permit allows us to discharge water at our mining operation under certain conditions.

Exhibit 241

When we first started this mine in 2006, the mine was very dry, meaning we had to import almost all of our water for various uses. In other words, the mine didn't "make" much water. Now, as our mine has expanded for 13 years, we have had to handle an increasing amount of groundwater that is seeping into our mine.

This groundwater infiltrating into our underground coal mine presents two main problems for us. First, we have to get it out of the mine because the water has the ability to block our critical ventilation systems or flood escapeways out of the mine, any of which leads to serious risks to our miners. We HAVE to get the water out of the mine. We do this with pumps that bring the water to the surface, and pipelines to convey it to our main facilities.

That brings me to the second problem: the groundwater that is infiltrating our mine has naturally occurring sulfates and chlorides in it. So, one non-technical way to look at it: it's a little bit salty or what you might call "brackish" water.

Again, this little bit of "saltiness" is naturally occurring in the water. It is not caused by anything we add to the water or because the water comes into contact with our coal. But, because it is relatively "salty," we have to deal with it differently than normal water. Historically, we have stored the water in surface ponds or impoundments, but they have limited capacities. We recirculate and use as much of the brackish water as we can on site through various processes, but we still have an excess.

So, as many of you know, the plan to deal with this problem long term involves Williamson Energy building a twelve and one-half mile buried pipeline to the Big Muddy River, installing a multi-port diffuser, and tying the diffuser to real-time continuous monitors. All of these elements will work together to strategically discharge the water through a mixing zone into a water body that can easily assimilate it WITHOUT violating the water quality standard. We evaluated other alternatives – Reverse Osmosis, Evaporation, and Crystallization to name a few, but these methods consume a tremendous amount of energy and require the disposal of the concentrated cake to a separate landfill. It is not as simple as filtering the water. The salt is dissolved.

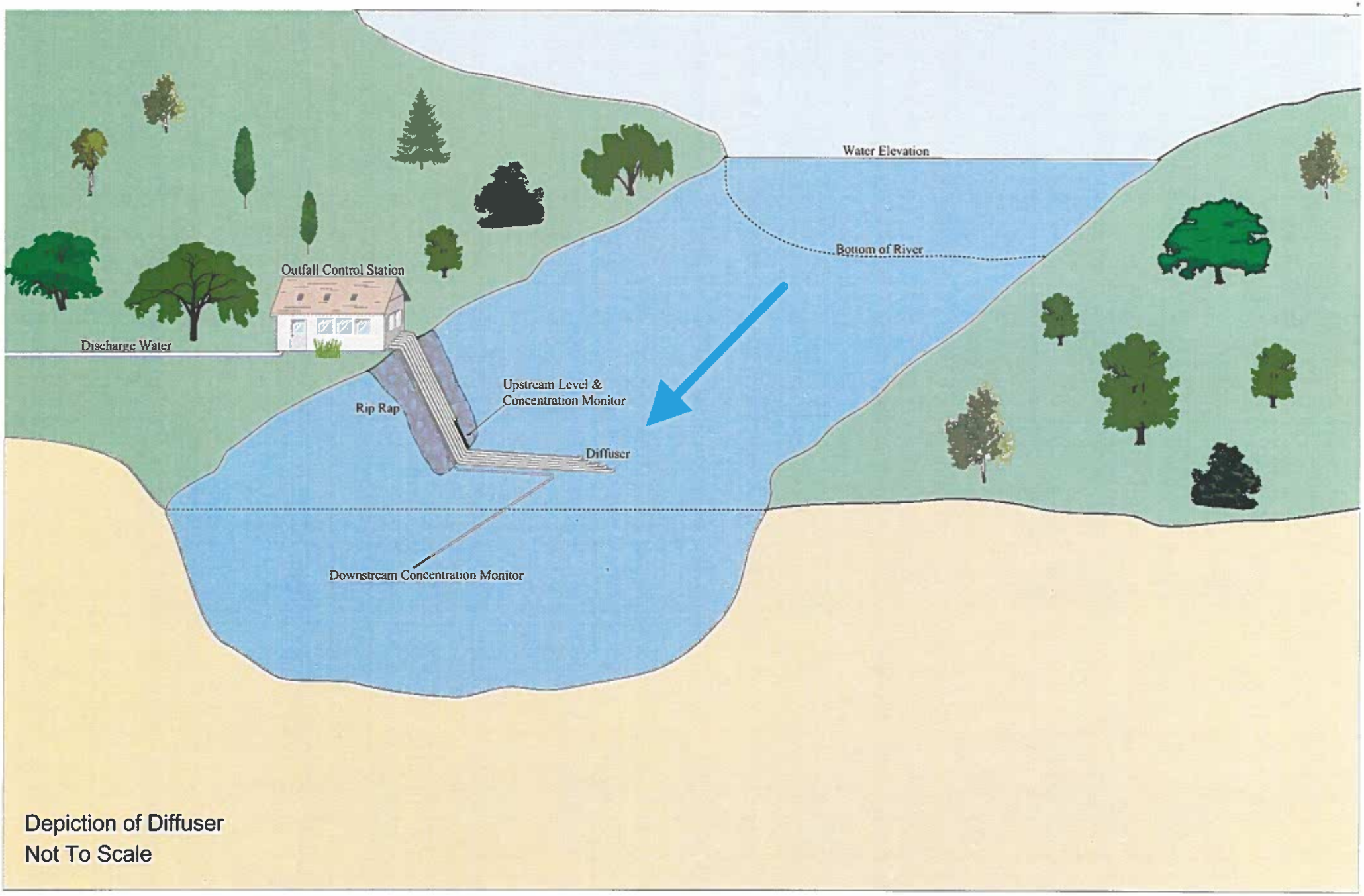
This mixing zone is not going to be just an open pipe dumping continuously into the river. There are very specific controls to make sure the discharges are compliant with water quality standards. Water quality standards are adopted and approved by both the US and Illinois EPA based on a rigorous scientific process that result in standards that are conservatively protective of aquatic life. In addition, we have reviewed the aquatic life present in the Big Muddy River in conjunction with academic experts and they have concluded that our discharges will not adversely impact aquatic life in the Big Muddy River.

We will install continuous water quality monitors upstream and downstream of the diffuser (or outfall structure). This will give us virtually continuous data on the chloride levels in the receiving water, the Big Muddy River. If we see on these monitors that the Big Muddy is not capable of accepting our water without violating a water quality standard, then we will not discharge. Instead, we will hold the water until the river can

receive it without violating the standard. This provides the ability to control the flow so that water quality standards will be met on a continuous basis.

Lastly, I wish to address the concern for increasing the flood risk. Our discharge will not have any practically measureable impact to the surface water elevation and to the flood extent. For example, we had a large rain event in this area on October 26 of this past year. It produced nearly 3.5-inches of rain. This is almost equivalent to a two year, 24-hour rain event for this area. The Big Muddy River at the Plumfield Bridge monitoring station eventually crested at a height of almost 10 feet, flowing 834 cubic feet per second – which is 374,326 gallons per minute. Again, almost 375,000 gallons per minute. If we were to pump our max capacity of just under 5,000 gallons per minute, our contribution would increase the water elevation at the Route 13 Bridge in Murphysboro by about 1.8 mm. This is equivalent to the thickness of a quarter. Not practically measurable.

Approving the requested mixing zone is the safest, most environmentally sound, and most effective way for Williamson Energy to manage its excess water to ensure miners safety and enhance our ability to meet the mandated water quality standards. We are fully committed to operating this system within the legal limits of the permit. This long-term solution will allow our first class operation to continue and support about 500 local families. Thank you.



Depiction of Diffuser
Not To Scale

R03306

Big Muddy River at Plumfield Monitoring Station
Flood Categories

River Elevation [feet]	River Flow [gpm]	Mine Flow [gpm]	Percentage Mine Adding [%]	Flood Categories
2	8,528	0	0.00%	Low Stage
9	289,048	4,982	1.69%	In-between stage
16	835,277	4,982	0.59%	Bankful stage is reached
18	1,166,067	4,982	0.43%	Action Stage
20	1,567,323	4,982	0.32%	Minor Flood Stage
27	4,205,112	4,982	0.12%	Moderate Flood Stage
34	19,254,917*	4,982	0.03%	Major Flood Stage

*estimated
May 10, 1961 reported flow

National Oceanic and Atmospheric Administration (NOAA) information
www.water.weather.gov

R03307

Exhibit 242

My name is Cameron Smith, I live Murphysboro, IL and I am a member of SAFE.

I am here to protect my property and I am not here to take anyone's job away from them.

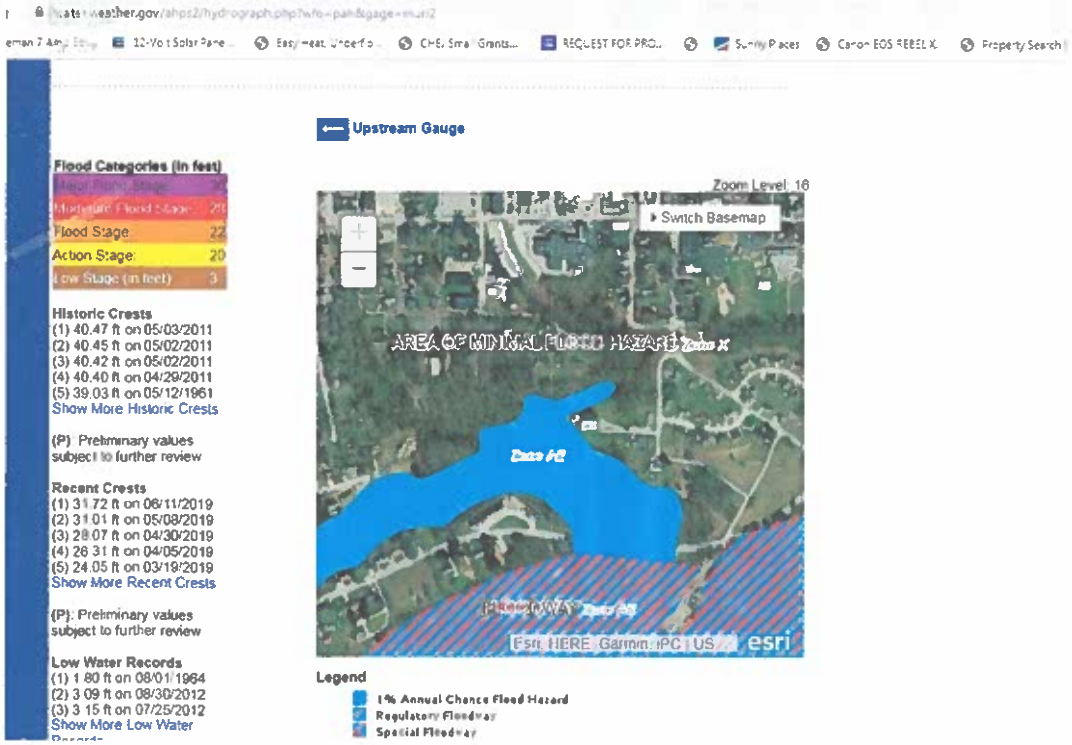
My wife and I co-own the Historic Douglass School in Murphysboro.

The Frederick Douglass School was first built in 1897, way before the building of the Rend Lake Dam; it was Murphysboro's segregated school and they built it next to the Big Muddy River, back in the day when the Big Muddy was a navigable river.

Today FEMA has classified our building as being in an AE Flood Zone. So it is not a matter of **if** it will flood, it is **when** it will flood.

On May 3, 2011 the Big Muddy River reached a record high of 40.47 feet at the Murphysboro gauge station on the Route 127 Bridge. At that time the 127 Bridge was closed and under water. The river water was so high you could no longer see the guard rails on either the side of the bridge. The Route 13 Bridge was being threatened too, but remained open and was closely monitored by IDOT. During that time the flood water was so high and strong that the water was vibrating the bridge, so it was decided by IDOT to rebuild and raise the level of the Route 13 Bridge. I have to wonder if IDOT calculated for this increase of water flow.

This spring we had standing water on our property for 148 day. Most of the time the flood water goes out as fast as it comes in. But this spring the water was standing in our yard so long, that we could see hundreds if not thousands of minnows and tadpoles along the water edge. I have to wonder what the extra chlorides and sulfates will do the wildlife population?



On 11/8/2019, 8:59 am, the USGS report from the gauging station at Plumfield the river was discharging 236 cubic feet per second and at Murphysboro it was discharging 992 cubic feet per second.
https://waterdata.usgs.gov/nwis/uv?site_no=05597000%2C05350490%2C05599490&format=gif_mult_sites&PARAmeter_cd=00060&period=7

At Murphysboro the 3.5 million gallons per day ~~or 40.5 per second~~ would only be .5% to 1% increase, which doesn't sound like much. But my understanding is that the **mine** will be allowed to increase they water discharge when the Big Muddy is high. **I have to wonder what would that 1% increase of salty water will do our historic building.**

How much longer will we continue to pollute our waters and not care? I ask the IEPA to deny or delay this permit to allow further study of what the impact will have on all the people of Southern Illinois.

Exhibit 243

Public Comment: Pond Creek Mine
Permit: #IL0077666 and 7516C
Date: 12/18/2019
Marion IL

My name is Connie Schmidt. I serve as the Chairperson of the Executive Committee of the Sierra Club IL Chapter. We are a BIG Group. I represent 100,000 members and supporters across the state who are concerned that we have a clean healthy environment for all residents of IL. This includes clean water, which is what brings me here today.

The request by the Pond Creek mine owners for discharge of dirty wastewater carrying high concentrations of chloride and sulfate into the Big Muddy River is ludicrous at best. These pollutants impact aquatic life both plants and organisms by altering their ability to reproduce and killing many of them off, thus drastically impacting the ecosystem and other species who depend on those life forms.

Dumping waste into a natural resource like the Big Muddy is harmful to southern Illinois and beyond. The Big Muddy carries water to the Mississippi and on to the Gulf of Mexico. This is already an area in serious peril. In addition, the Big Muddy is important to humans. It provides tourism and recreational options to visitors and local residents, not to mention safe haven to countless fish and aquatic species. This area is also prone to flooding so the polluted waters would harm the riparian areas of the watershed as well. Endangering these factors is like shooting a healthy resource in the foot.

The plan to monitor this discharge is flawed at best. The discharge would enter the river at its bed where contaminants are more difficult to detect and the entry point is strategically placed just downstream of a monitoring system. This river does not have a rock bottom that naturally acts as a filtration. By it's very name; we know that mud lines the river basin trapping pollution within its banks. Even if the pollutants could seep through the river they would enter an aquifer that no doubt connects to human drinking water at some point. It is just not a good idea to allow pollution into a water source.

In conclusion, please deny the request to dump dirty wastewater from this mine into any water system sustaining life for recreation or creatures of our environment.

Connie Sue Schmidt
Chair - Il Chapter Sierra Club
35. 501 Landon, Warrenville IL 60555
630 234 3029
TWNSTR111@msn.com
(ones)

Exhibit 244

305 Campers Lane

Creal Springs, IL 62922

December 18, 2019

Comments prepared for the IEPA Public Hearing regarding:

NPDES Permit No. IL0077666 No. 7516c, Williamson Energy, LLC, Pond Creek Mine

On behalf of the Southern Illinois Kayak and Canoe Club, I appreciate the opportunity to submit some concerns regarding the proposed pipeline from Pond Creek Mine No. 1 and the Big Muddy River. The key issues include:

1. Although we have been assured that the discharge of 2,700,000 to 3,500,000 gallons per day of mine water into the Big Muddy will not pose a hazard to individuals using the river for kayaking and canoeing, it is difficult to believe that this will not create enough **turbulence** to pose a danger to some individuals less experienced with maneuvering around water hazards. I realize the diffusers are proposed to be placed near the bottom of the river and directed downstream, but when the water level is low, there seems to be some potential danger.
2. In addition to the turbulence issue, there is concern that the high concentrations of sulfates, chlorides, and other **pollutants** pose a danger to individuals using the Big Muddy for recreation, especially if they fall into the river in the region of the

diffusers. Will this area be clearly marked to warn people to stay away from the side of the stream where the mine water effluent is most concentrated?

3. The **Anti-degradation Assessment** is deficient because:
   a. It totally is focused on the water quality issues without giving any assessment of the impact on recreational use of the Big Muddy and the potential economic impact on reducing the Big Muddy's contribution to the region as a tourism destination
   b. The assessment identifies that the Big Muddy is already impaired due to sulfates, chlorides, and several other factors, but ignores the fact that the plan will inevitably result in MORE contamination of the river. The reality is that the proposed dumping will result in some increase in the TMDL (Total Maximum Daily Load). Just because the diffusers are located near the bottom of the river out of sight does not change the dumping impact. At best it minimizes the portion of the river that is immediately impacted and the "plume" may not be evident to observers. **We would hope that the IEPA is not saying that the pollution is acceptable, as long as the water quality limits are not exceeded.** That would be like saying that "The Big Muddy is already impaired, so what is a little more contamination?" Rather than a diffuser hidden underwater and out of sight, it would be preferable for the pipeline to dump directly and visibly into the Big Muddy for all to see the issue and be able to visibly monitor when discharge is occurring. Then folks could see the potential hazards.
4. How will the monitoring equipment be installed to ensure that it is secured when the water levels vary so drastically in that region? There are no bridges or other sturdy structures to shield the

instruments from trees and other large floating debris during flood conditions.

5. How will the diffuser vents be protected from people continuing to use the location as a dump site for large objects? (People historically have used the site to discard items into the river so the next flood will dispose of objects.)

Thank you for receiving these concerns.

Galen Thomas

Exhibit 245

DATE: August 1, 2019

TO: IEPA Bureau of Water
Water Pollution Control Permit Section
1021 North Grand Ave. East
Springfield, IL. 62794-0276

FROM: Jerry and Carolyn Worthen
3974 Watt Hill Road
Murphysboro, IL. 62966

PERMIT: NPDES IL0077666 NOTICE NO. 7516C

We are responding to the Pond Creek Mine dumping waste in to The Big Muddy River.

The Worthen farm has been in the family since 1836. We raise grain and have cattle. It is registered with The state of Illinois as a "Centennial Farm". This farm is located 5 miles southwest of Murphysboro on The Big Muddy River. The farm is prime bottom ground and is susceptible to flooding. This year our whole farm was flooded and prevented us from planting. Our son does the planting as I am disabled. We have hopes of the farm being carried through for generations. This farm is our living. So is the mine going to compensate us for that?

We find the dumping of waste water, will contaminate our ground, kill fish, and wildlife, cause erosion, and high water. Not only is that our concern, but those who have farm wells will have contaminated drinking water. The Big Muddy runs into the Mississippi - more land and water contamination. No end to it!

There are many farms and towns up and down the river. What kind of an effect would that cause them?

Since when did the IEPA, not protect all ground and waterways, at our cost? If this goes through it will be a disaster and cause hardship for those of us just trying to make an honest living. The mine is taking advantage of a lot of people's lives. We request a meeting with the Illinois EPA in our area, Southern Illinois!

Concerned Citizens
Of Southern Illinois

Cc: Terri Bryant
Mike Bost

Il, Sand Ridge River Gage
Corp of eng - ST, Louis

3 Month Summary for 2019

Gage Location: Sand Ridge T MI. E.

January	2019		February	2019		March	2019	
1	345.98	RHy	1	349.67	C	1	351.26	C
2	350.11	C	2	348.36	C	2	351.86	C
3	352.32	C	3	347.19	C	3	350.20	SNOW FT
4	353.48	R .23"	4	346.07	F	4	348.68	C
5	354.15	C	5	345.01	C	5	346.65	F
6	353.73	C	6	345.62	RHy 1.00"	6	344.94	F
7	353.13	F	7	349.06	RHy .9[illegible]"	7	342.95	F
8	352.39	RLT	8	353.80	RLT .35"	8	342.14	RLT
9	351.36	C	9	355.80	C	9	342.01	RLT
10	350.25	C	10	357.39	RLT	10	346.26	RHy 1.10"
11	349.14	C	11	358.56	RHy .94"	11	347.92	C
12	348.51	SNow 3"	12	359.39	RHy .97"	12	349.86	C
13	348.68	RLT	13	359.58	C	13	351.89	RLT
14	349.13	C	14	359.29	F	14	354.10	RHy 1.9
15	348.53	C	15	359.29	C	15	355.51	C
16	347.70	C	16	359.03	SNOW	16	356.14	F
17	347.41	RLT	17	358.83	C	17	356.68	F
18	347.62	C	18	357.05	C	18	357.29	F
19	348.63	RHy .76	19	357.04	C	19	357.47	F
20	349.48	SNOW HY,	20	356.46	RH .0[illegible]	20	357.55	RLT
21	350.35	SNOW	21	355.56	C	21	357.50	RLT
22	350.83	C	22	354.98	C	22	357.38	F
23	352.05	RHy .77"	23	354.26	RLT	23	357.35	F
24	352.94	C	24	353.77	C	24	357.35	RLT
25	353.60	F	25	353.20	F	25	357.37	RLT 0.16
26	354.05	F	26	353.83	F	26	357.64	C
27	354.24	F	27	352.72	F	27	357.88	F
28	354.05	C	28	352.65	RLT	28	358.14	RLT
29	353.45	C	29	352.23	R	29	358.44	RLT
30	352.46	F				30	358.75	RLT .07"
31	351.02	SNOW FT				31	359.33	RHy .7[illegible]

3 Month Summary for 2019

Gage Location:

	April		May		June
1	360.08 F	1	359.48 RHy .71"	1	364.72 RLT
2	360.71 F	2	359.61 RHy 1.50"	2	364.97 RHy .64"
3	361.23 F	3	359.87 RHy .71"	3	364.02 F
4	361.47 F	4	361.02 RHy .79"	4	365.25 RLT
5	361.46 RLT	5	362.77 RLT	5	365.83 RH .73"
6	361.37 C	6	363.95 F	6	366.22 RLT
7	361.08 RLT	7	364.57 C	7	366.45 RLT
8	360.62 F	8	364.72 C	8	366.76 RLT
9	360.10 F	9	364.53 RLT	9	367.05 RLT
10	359.49 F	10	364.14 RLT	10	367.20 C
11	359.46 F	11	363.35 C	11	367.21 F
12	358.65 RLT	12	363.42 RLT .34"	12	367.15 F
13	358.35 F	13	363.14 F	13	366.86 RLT
14	358.48 RHy 1.02"	14	362.79 RLT .37"	14	366.53 F
15	358.64 C	15	362.50 F	15	366.14 F
16	358.64 F	16	362.11 F	16	365.74 F
17	358.64 F	17	362.09 F	17	365.42 RH .70"
18	358.83 RLT	18	361.63 F	18	365.05 RLT
19	359.05 RHy .82"	19	361.46 RLT	19	364.62 F
20	359.08 C	20	360.46 F	20	364.24 RLT
21	359.03 F	21	359.86 RLT .48"	21	363.96 F
22	358.85 F	22	359.76 RHy 1.70"	22	363.45 RHy 1.15"
23	358.59 F	23	360.10 C	23	363.45 RHy .80"
24	358.26 RLT	24	360.68 F	24	363.30 RLT
25	358.06 RHy .74"	25	361.63 F	25	363.08 F
26	358.96 RHy 1.70"	26	362.62 F	26	362.97 F
27	359.80 RLT	27	363.44 F	27	362.82 RHy .70"
28	359.44 C	28	363.99 F	28	362.63 F
29	359.56 F	29	364.25 F	29	362.37 F
30	359.57 F	30	364.46 RLT	30	362.13 F
~~31~~	~~XXXX~~	31	364.55 RLT	~~31~~	~~XXXXX~~

Temp Gage

RLT

3 Month Summary for 2019

Gage Location:

30 June 362.13 F

	July		August		September
1	361.83 F	1	351.25 F	1	346.23 F
2	361.32 RLT	2	351.02 F	2	346.09 F
3	361.28 F	3	350.65 F	3	346.05 F
4	360.91 F	4	350.22 F	4	345.78 F
5	360.54 F	5	349.74 F	5	344.96 F
6	360.08 RLT	6	349.21 F	6	344.48 F
7	359.55 F	7	348.49 F	7	343.84 F
8	358.94 F	8	347.53 F	8	343.13 F
9	358.47 F	9	346.50 F	9	342.89 RLT, 08"
10	357.96 F	10	345.11 F	10	342.82 F
11	357.49 F	11	345.09 F	11	342.59 F
12	357.01 F	12	344.44 RLT. 05"	12	342.53 F
13	356.65 F	13	345.09 RHy .54"	13	342.51 F
14	356.33 F	14	345.34 F	14	342.25 F
15	356.00 RLT.	15	344.90 F	15	342.63 F
16	355.79 RHy .80"	16	344.70 F	16	342.25 F
17	355.61 RHy 1.31"	17	344.12 F	17	343.73 F
18	355.26 RHy 1.04"	18	343.44 F	18	344.44 F
19	354.94 F	19	343.49 RLT, 21	19	345.34 F
20	354.64 F	20	343.59 F	20	345.54 F
21	354.31 F	21	343.34 RHy .60"	21	345.15 RHy .5"
22	353.96 F	22	344.94 RHy 1.20"	22	345.79 F
23	353.71 C	23	346.03 RLT, 42"	23	345.94 RLT, 15"
24	353.54 F	24	345.72 RLT	24	345.86 F
25	353.25 F	25	345.53 F	25	345.99 RLT
26	352.92 F	26	345.29 RLT	26	347.05 RLT
27	352.58 F	27	345.79 RLT	27	348.34 F
28	352.25 F	28	347.37 F	28	348.88 F
29	351.87 F	29	346.73 F	29	348.99 F
30	351.59 RLT	30	345.90 F	30	348.88 F
31	351.42 F	31	345.53 RLT	31	XXXXXXX

3 Month Summary for 2019

Gage Location:

	October	November	December
1	349.08 F	351.48 C	350.08 RLT .14"
2	350.12 F Back in Creek	351.75 F	351.37 C
3	351.32 F "	351.94 F	352.33 C
4	352.29 F "	351.71 F	352.78 F
5	352.86 F "	351.49 RLT	352.74 F
6	353.18 F	351.21 RLT	352.35 F
7	353.45 RLT	350.88 RLT .42"	351.60 C
8	353.59 F	350.39 RLT .05"	350.51 F
9	353.68 F	349.81 F	349.22 RLT
10	353.86 F " "	349.47 F	348.03 C
11	354.43 RHY	349.18 F	346.78 F
12	354.45 RLT	348.76 Snow Lite	345.73 C
13	354.72 F	348.47 C	345.02 C
14	354.94 F	348.20 C	344.21 C
15	354.89 F	348.06 F	343.24 RLT
16	354.56 F	347.67 F	341.52 RLSNOW
17	354.15 F	347.17 F	340.68 C
18	353.75 F	346.71 C	
19	353.55 F	346.14 RLT	
20	353.47 F	345.48 F	
21	353.41 F	344.78 RLT	
22	353.32 F	344.81 RHY .75"	
23	353.16 F	344.82 RLT	
24	352.93 F	344.58 C	
25	352.54 F	344.34 C	
26	352.30 RHY 1.65"	343.97 F	
27	353.40 RHY 1.77"	344.23 RLT .45"	
28	353.04 RLT	344.58 RLT	
29	352.50 RLT	344.95 RLT	
30	351.76 RLT	347.35 RHY 1.94"	
31	351.42 RLT .48"		

Exhibit 246

Barbara McKasson
2 Hillcrest Drive
Carbondale, IL 62901
babitaji@aol.com

Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P. O. Box 19276
Springfield, IL 62794-9276

Below are my comments on the proposed revised NPDES permit No. IL0077666 for Pond Creek Mine for the hearing on December 18, 2019. I reserve the right to add written comments during the comment period ending on January 17, ~~2019~~ 2020

I live near the Big Muddy River and often visit natural areas that are impacted by the Big Muddy River, such as LaRue - Pine Hills National Natural Landmark and Little Grand Canyon. LaRue-Pine Hills is currently one of the most biologically diverse areas in the United States – in competition with Smoky Mountain National Park. I have spent many hours in efforts to combat invasive species in the area, especially in the area next to LaRue Swamp, which is commonly referred to as the area along Snake Road, in order to help preserve the many native plants in that area. I am very active in Shawnee Group Sierra Club, which has sponsored many nature walks at LaRue-Pine Hills. I have also participated in hikes through Little Grand Canyon, sponsored by Shawnee Group. Both of those places are highly impacted whenever the Big Muddy River floods.

I have hiked, gone wildlife viewing, enjoyed the wildflowers and just enjoyed the beautiful views of these areas. I would hate to see them damaged by the proposed increased pollution from the mine discharge. Considering the increased pollution, I certainly hope that Shawnee Group Sierra Club will be able to be confident in sponsoring canoe outings on the Big Muddy River with the proposed increased pollution.

The record of violations – past and present – by Williamson Energy at the Pond Creek Mine does not give me confidence, especially with such a complicated proposal For outfall 011 that will vary with the volume of water from the mine, the volume of water in the Big Muddy River and the variation in the amount of chlorides, sulfates and heavy metals concentrations. How will IEPA verify that all these calibrations will work so that the effluent will stay within the limits of the regulations? Is that why IEPA is allowing huge fluctuations of the sulfates and chlorides – sometimes far above the standards set by the regulations? Even with a diffuser, what gives IEPA any confidence that there will not be acutely high concentrations that can gravely harm the fish, macroinvertebrates, mussels, plants and other wildlife that depend on the Big Muddy River, especially near the #011 outflow location? Science has shown that organisms have trouble regulating osmosis through their tissues with such high concentrations of chlorides. How current are surveys of fish and macroinvertibrates in Pond Creek and the Big Muddy River? Shouldn't IEPA conduct these surveys before granting this permit so that you will be better prepared to know how much the aquatic life is being affected by the effuluent from Pond Creek Mine?

The fact that the bond required for the discharge pipe into the Big Muddy does not cover harm caused by the effluent does not give me confidence. It also is another instance of a corporation taking profits

by polluting the environment and then leaving the cost of the clean-up to the public. The people and environment of Illinois are already continuing to pay the price of acid mine drainage from abandoned mines. Why is Williamson Energy not required to put up a bond for repairing damage that may be caused by their operations - that is - damage to the Big Muddy River wildlife and the people who depend on the Big Muddy for recreation? What if there is a big fish kill – can IEPA hold Williamson Energy responsible and charge them reparations for the damage? Can Williamson Energy be held responsible for restoring fish populations? Murray Energy, the parent company, filed for bankruptcy in October of this year, and the stock of Foresight Energy, and affiliate of Williamson Energy, has dropped to around eight cents per share. So we must ask: what is the financial status of Williamson Energy? Would they be able to ameliorate or mitigate any harmful events? Does the corporation and IEPA expect public funds and the environment to absorb the costs?

I am concerned that the proposed location of the Downstream Monitoring Probe is too far downstream to measure and evaluate the level of pollutants at the outfall. The permit specifies that "This downstream monitoring shall be performed a sufficient distance downstream of the associated outfall to ensure that complete mixing has occurred." If the mine places the probe further downstream, they gain additional mixing. Why are they not required to monitor as close as possible to the edge of the designated mixing zone, which is the point of compliance? Is IEPA encouraging Williamson Energy to cheat?

I am also concerned about the Outfall 009, which goes into Pond Creek, which has been designated in the past as impaired by chloride in TMDL evaluation. Pond Creek is listed in the public notice and appears to be impaired for chlorides. Why are you proposing to grant the mine a

mixing zone for chlorides at the Pond Creek outfall if the Big Muddy River is already impaired? Why was the level of chlorides in Pond Creek found by IEPA to no longer be of concern by the recent TMDL assessment when it already has been measured at or near the maximum of 500mg/L? According to the Pond Creek Watershed Inventory (2019) created by Greater Egypt Regional Planning and Development Commission (p. 74), "Pond Creek has been listed for chloride and sedimentation/siltation impairments since 2010, and dissolved oxygen since 2012. In 2008, the stream was listed for iron, manganese, pH, total suspended solids (TSS), and fecal coliform."

Methyl mercury is known to cause serious nerve and organ problems in humans. Will the increased chloride and total dissolved solids levels in the Big Muddy River cause higher methyl mercury levels? Will the acid mine drainage allowed in this permit also increase the conversion of mercury to methyl mercury? Can IEPA assure us that it will not? We know that there is commercial fishing and recreational fishing in the Big Muddy River. Because of bioaccumulation of heavy metals up the food chain, we are concerned that anyone eating catfish, bass or other predatory fish will be harmed. Has IEPA evaluated the possible harm to humans from increased methyl mercury that could be caused by granting this permit? According to <science direct.com> "Mercury speciation, which is affected by chloride, will impact mercury bioavailability to methylating bacteria, affecting subsequent MeHg production and bioaccumulation in these systems." Also, the Illinois Department of Public Health has issued a methyl mercury advisory for predator fish in all the waters of the state.
<http://www.idph.state.il.us/envhealth/factsheet/fishadv.htm>

In summary, considering these concerns, I am opposed to IEPA granting this permit number IL0077666 to Williamson Energy, LLC or Foresight Energy or Mach Mine or whatever they are going to call themselves tomorrow.

Sugar Camp mine, with the same owner, will be discharging into this same stream, with high amounts of chlorides and sulfates and heavy metals. These permits should not be considered in isolation. . Assuming that they operate their discharge correctly, they plan to put enough chloride into the river to raise a quarter of the river to 500 mg/l. By the time that water reaches the downstream Pond Creek mine discharge, the entire river will have a chloride concentration of 147 mg/l. If Pond Creek is also discharging at its limit, the river downstream of Pond Creek will now be around 240 mg/l - the entire stream. This isn't just worst case. This is the likely result because the mines are expanding and judging from the Williamson Energy statement that they will have to discharge continuously in order to try to stay under the limits, it is very likely that there will be times when there are huge spikes of the pollutants.

PETITION TO PROTECT BIG MUDDY RIVER

Exhibit 247

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to en pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallo when the Big Muddy River is below flood level.

Printed Name RONALD ELLIS Address 2036 TESKE ROAD City, State, Zip MARION, IL 62959 Email WILCOMRE@YAHOO.COM If you wish to be added to our email list	Printed Name Candace Stanton Address 312 S. Locust City, State, Zip Jonesboro, Il. 62952 Email If you wish to be added to our email list
Printed Name Tay Rich Address 114 Achler St City, State, Zip Jonesboro, IL, 62952 Email If you wish to be added to our email list	Printed Name Brittney Hill Address City, State, Zip Anna, IL 62906 Email If you wish to be added to our email list
Printed Name Allison Rich Address 114 Achler St City, State, Zip Jonesboro, IL 62952 Email If you wish to be added to our email list	Printed Name Dallas McGhee Address City, State, Zip Anna, IL 62906 Email If you wish to be added to our email list

R03324

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system online, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Beverly Tanner Address 400 Berryville RD City, State, Zip Goreville IL 62939 Email If you wish to be added to our email list	Printed Name GREGORY MGlhott Address 95 Eagle drive City, State, Zip Goreville, FL 62939 Email If you wish to be added to our email list
Printed Name Samantha Ciesielski Address 1080 Tom Rd City, State, Zip Carbondale IL 62902 Email If you wish to be added to our email list	Printed Name Jaette Fox Address 124 Housing Circle City, State, Zip Donepla, Ill. 62926 Email If you wish to be added to our email list
Printed Name Jamie Vinson Address 95 eagle drive City, State, Zip goreville IL 62939 Email jme-vinson@marmail.com If you wish to be added to our email list	Printed Name DANNY FOX Address 124 Housing Circle City, State, Zip Donepla Ill. 62926 Email If you wish to be added to our email list

R03325

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to en pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallo when the Big Muddy River is below flood level.

Printed Name JAMES A. WRIGHT Address 130 Follis Drive City, State, Zip Jonesboro, Il. 62952 Email If you wish to be added to our email list	Printed Name ROSE HOGAN Address P O BOX 268 / 414 W. POPLAR City, State, Zip COBDEN, IL 62920 Email If you wish to be added to our email list
Printed Name Marsha Griffin Address 1570 Airport Rd City, State, Zip Jonesboro, IL 62952 Email mglittleg@aol.com If you wish to be added to our email list	Printed Name Kirsten Schaper Address 445 Blueberry Hill Rd City, State, Zip Cobden IL 62920 Email If you wish to be added to our email list
Printed Name Gregory Harris Address 134 Hillside Terrace City, State, Zip Anna, IL 62906 Email gharris@meridian.net If you wish to be added to our email list	Printed Name Emily C. Hartsock Address 805 Brady Mill Rd City, State, Zip Anna IL 62906 Email If you wish to be added to our email list

R03326

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to en pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallo when the Big Muddy River is below flood level.

Printed Name DAVID TELLOR Address 204 PEACH DR. City, State, Zip ANNA, IL. 62906 Email If you wish to be added to our email list	Printed Name Jeremy Sparks Address 51 Youngman Rd Apt 2 City, State, Zip Murphysboro IL 62966 Email If you wish to be added to our email list
Printed Name ASA BUSBY Address P.O. Box 309 City, State, Zip Jonesboro IL 62952 Email buzzbba@yahoo.com If you wish to be added to our email list	Printed Name ERIN POIRIER Address 1870 OLD HWY 51 N City, State, Zip ANNA, IL 62906 Email If you wish to be added to our email list
Printed Name Janet Smith Address 325 State Route City, State, Zip Jonesboro 62952 Email If you wish to be added to our email list	Printed Name Deborah Nash Address 1500 Jamestown Rd City, State, Zip Cobden, IL 62920 Email If you wish to be added to our email list

R03327

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to en pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallo when the Big Muddy River is below flood level.

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Printed Name Tom Sadowsk. Address 365 Neely City, State, Zip Anna IL 62906 Email If you wish to be added to our email list	Printed Name Jennifer Jones Address 86 Lucas Hap Rd City, State, Zip Anna IL 62906 Email jenn8jones@gmail.com If you wish to be added to our email list
Printed Name Gwen Hall Grosshennich Address 2315 Old US Hwy 51 N. City, State, Zip Corden IL 62920 Email If you wish to be added to our email list	Printed Name Melissa Keck Address 156 Lucas Hap Rd City, State, Zip Anna IL 62906 Email If you wish to be added to our email list

R03328

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to en pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallo when the Big Muddy River is below flood level.

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Printed Name Lico Wells Address 300 Plum City, State, Zip Anna IL 62906 Email If you wish to be added to our email list	Printed Name Megan Brown Address 301 E. Hickory St. City, State, Zip Anna IL 62906 Email If you wish to be added to our email list
Printed Name John O. Hudgins Address 150 white tail Rd City, State, Zip Murphysboro IL 62966 Email If you wish to be added to our email list	Printed Name ED EARNHART Address 105 WARREN ST City, State, Zip ANNA IL 62906 Email If you wish to be added to our email list

R03329

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to en pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallo when the Big Muddy River is below flood level.

Printed Name Kenneth D Rosson Address 530 Hidden Hills Lane City, State, Zip Jonesboro IL 62952 Email If you wish to be added to our email list	Printed Name Tim Casper Address 305 E 8th St. City, State, Zip Cobden IL 62920 Email If you wish to be added to our email list
Printed Name Bob Dover Address 2838 STATE Rt 146 E. City, State, Zip Anna IL 62906 Email If you wish to be added to our email list	Printed Name Jim Harris Address 102 Magnolia Dr. City, State, Zip Anna IL 62906 Email J73Harris@Gmail.Com If you wish to be added to our email list
Printed Name Terri Dover Address 2838 St. Rt. 146E City, State, Zip Anna, IL 62906 Email If you wish to be added to our email list	Printed Name Randy Edmonds Address 1465 U.S. Hwy. 51 S. City, State, Zip Anna, IL, 62906 Email r.edmonds49@gmail.com. If you wish to be added to our email list

R03330

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to en pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallo when the Big Muddy River is below flood level.

Printed Name GREG MADURA Address 345 FOSTER RD City, State, Zip ANNA, IL. 62906 Email smad55@AOL.com If you wish to be added to our email list	Printed Name Shannon Cook Address 105 nile St City, State, Zip Anna IL 629016 Email If you wish to be added to our email list
Printed Name Angela Madura Address 345 Foster City, State, Zip Anna, IL 62906 Email Annsmile@AOL.com If you wish to be added to our email list	Printed Name Robert Cook Address 105 nile St City, State, Zip Anna IL 629016 Email If you wish to be added to our email list
Printed Name Bonnie Cissell Address 772 Kaolin City, State, Zip Golden IL 62920 Email Thecissells@hotmail.com If you wish to be added to our email list	Printed Name Linda Bates Address 509 S Main City, State, Zip Anna IL Email AJwildcats62@gmail.com If you wish to be added to our email list

R03331

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzger to Protect Big Muddy River from further degradation. We ask Governor Pritzger to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Rich Whitney Address 1801 New Era Road City, State, Zip Carbondale, IL 62901 Email richwhitney@frontier.com If you wish to be added to our email list	Printed Name JAN THOMAS Address 433 N 7th ST. City, State, Zip MURPHYSBORO IL 62966 Email JAN@ARTAPULT.COM If you wish to be added to our email list
Printed Name Kristy Nickless-Jones Address 20 Alaska. Rd. City, State, Zip Makanda, IL 62958 Email If you wish to be added to our email list	Printed Name Cameron Smith Address 433 N 7th M-Boro City, State, Zip IL 62962 Email CJS@artapult.com If you wish to be added to our email list
Printed Name Jeffrey R. Jones Address 20 Alaska Rd City, State, Zip Makanda, IL 62958 Email If you wish to be added to our email list	Printed Name Curt Carter Address 1060 Morgan School City, State, Zip Jonesboro IL 62952 Email Land 4 Learn [illegible] If you wish to be added to our email list

R03332

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to en pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallo when the Big Muddy River is below flood level.

Printed Name Vonda Benefield Address 205 Holly Terrace City, State, Zip Anna IL 62906 Email If you wish to be added to our email list	Printed Name Jerry L Rapert Address 205 Pine City, State, Zip Anna IL 62906 Email If you wish to be added to our email list
Printed Name Robert L. Hausman Address 118 Ashlar St City, State, Zip Jonesboro IL 62952 Email midrivermans.1@gmail.com If you wish to be added to our email list	Printed Name Sandra Baez Address Lick Creek Rd. City, State, Zip Anna 62906 Email If you wish to be added to our email list
Printed Name Kelli Watson Address 4845 Lick Creek City, State, Zip Buncombe IL 62912 Email kelliwatson13@yahoo.com If you wish to be added to our email list	Printed Name Kelly Keller Address 312 Mississippi St City, State, Zip Jonesboro IL 62952 Email kdallasr@hotmail.com If you wish to be added to our email list

R03333

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to en pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallo when the Big Muddy River is below flood level.

Printed Name JoAn Dallas Address 312 W. Mississippi City, State, Zip Jonesboro, IL 62952 Email If you wish to be added to our email list	Printed Name Peggy Deat Address 750 Toledo Cem Rd City, State, Zip Cobden, IL 62920 Email pldent1@frontier.com If you wish to be added to our email list
Printed Name Jeanine Schaefer Address 419 E. Jefferson St. City, State, Zip Anna, IL 62906 Email If you wish to be added to our email list	Printed Name AUSTIN DENT Address 750 TOLEDO CEMETERY RD. City, State, Zip COBDEN, IL 62920 Email If you wish to be added to our email list
Printed Name Mary Nash Swink Address PO Box 502 City, State, Zip Dongola IL 62926 Email If you wish to be added to our email list	Printed Name Linda L. Grant-e Address 108 Grand Ave City, State, Zip Anna IL. 62906 Email If you wish to be added to our email list

R03334

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzger to Protect Big Muddy River from further degradation. We ask Governor Pritzger to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Lucia Amorelli Address 315 N. Westridge #12 City, State, Zip Carbondale, IL 62901 Email earthwater365@gmail.com If you wish to be added to our email list	Printed Name Karen Frailey Address 37 State Highway 147 City, State, Zip Simpson IL 62985 Email featherfoil1@gmail.com If you wish to be added to our email list
Printed Name April Bartnick Address PO Box 94 City, State, Zip Mt. to Pass, IL 62965 Email lifthewings615@gmail.com If you wish to be added to our email list	Printed Name Rachel Forsyth Address 215 Arizona Rd City, State, Zip Carbondale IL 62903 Email raelulehof62901@yahoo.com If you wish to be added to our email list
Printed Name Charlotte Salmon Address 1448 Giant City Rd. City, State, Zip Carbondale 62902 Email If you wish to be added to our email list	Printed Name Candace A. Davis Address 1001 N. Bridge St. City, State, Zip Carbondale, IL 62901 Email roundapes@yahoo.com If you wish to be added to our email list

R03335

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzger to Protect Big Muddy River from further degradation. We ask Governor Pritzger to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Matthew Borowicz Address 905 S Skyline Drive City, State, Zip Carbondale, IL 62901 Email If you wish to be added to our email list	Printed Name Sage Banks Address 905 S. Taylor Dr. City, State, Zip Carbondale, IL 62901 Email sagebanks@yahoo.com If you wish to be added to our email list
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Printed Name Amber Loos Address 1217 W. Freeman St. City, State, Zip Carbondale, IL 62901 Email If you wish to be added to our email list	Printed Name Address City, State, Zip Email If you wish to be added to our email list

R03336

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzger to Protect Big Muddy River from further degradation. We ask Governor Pritzger to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Henry Hexmoor Address 282 High Forest Dr. City, State, Zip Carbondale, IL 62903 Email henryworking@yahoo.com If you wish to be added to our email list	Printed Name Megan Robin-Abbott Address 905 S Skyline Dr. City, State, Zip Carbondale, IL 62901 Email mrobinabbotts@msn.com If you wish to be added to our email list
Printed Name Dona Reese Address 282 High Forest Dr. City, State, Zip Carbondale, IL 62903 Email dona.reese@gmail.com If you wish to be added to our email list	Printed Name KATHY LIVINGSTON Address 709 W CHERRY City, State, Zip CARBONDALE IL 62901 Email If you wish to be added to our email list
Printed Name Patti Walker Address 465 Karbers Ridge Rd City, State, Zip Elizabethtown, IL 62931 Email If you wish to be added to our email list	Printed Name William Peterson Address 210 S Hewitt St City, State, Zip Carbondale, IL 62901 Email If you wish to be added to our email list

R03337

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzger to Protect Big Muddy River from further degradation. We ask Governor Pritzger to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Katie Murdock Address City, State, Zip Carterville, IL Email Katiem_90@hotmail.com If you wish to be added to our email list	Printed Name Address City, State, Zip Email If you wish to be added to our email list
Printed Name Christina Steglich Address City, State, Zip Murphysboro, IL Email cdpenrod@hotmail.com If you wish to be added to our email list	Printed Name Address City, State, Zip Email If you wish to be added to our email list
Printed Name Amber Futch Address 513 W College St City, State, Zip Carbondale IL 62901 Email 431 996 1913 If you wish to be added to our email list	Printed Name Address City, State, Zip Email If you wish to be added to our email list

R03338

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to en pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallo when the Big Muddy River is below flood level.

Printed Name DANA S GRIFFITH Address 480 NEW SARATOGA RD. City, State, Zip ANNA IL 62906 Email If you wish to be added to our email list	Printed Name Address City, State, Zip Email If you wish to be added to our email list
Printed Name Randy Griffith Address 480 New Saratoga Rd. City, State, Zip Anna IL 62906 Email If you wish to be added to our email list	Printed Name Address City, State, Zip Email If you wish to be added to our email list
Printed Name Address City, State, Zip Email If you wish to be added to our email list	Printed Name Address City, State, Zip Email If you wish to be added to our email list

R03339

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Stephen Constantine Address 1106 W. Saint Louis St. City, State, Zip West Frankfort, IL 62896 Email stephen_constantine@yahoo.com If you wish to be added to our email list	Printed Name Timothy A. Smith Address 1120 E Davis St City, State, Zip Anna, IL 62906 Email jsja1967@gmail.com If you wish to be added to our email list
Printed Name RON TIPPITT Address 68851 APPLE RIDGE ROAD City, State, Zip ILLIKA IL. 62849 Email If you wish to be added to our email list	Printed Name Alison Smith Address 219 Brady Mill Rd City, State, Zip Anna, IL 62906 Email Alwishing07@gmail.com If you wish to be added to our email list
Printed Name JAMES CARL Address 88 WHIPPOORWILL LN City, State, Zip MARION IL 62958 Email JIMMYCARL@ILUMAIL.COM If you wish to be added to our email list	Printed Name Hilary Chandler Address 606 West Oak St City, State, Zip Carbondale IL 62901 Email hlychandler@gmail If you wish to be added to our email list

R03340

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Faylin Jihan Address 604 S. Oakland Ave City, State, Zip Carbondale, IL 62901 Email If you wish to be added to our email list	Printed Name Zoe Smith Address 34440 Annapolis Rd. City, State, Zip Annapolis, CA 95412 Email If you wish to be added to our email list
Printed Name Sarah L Melton Address 390 N. Beadle Lane City, State, Zip Carbondle, IL 62901 Email If you wish to be added to our email list	Printed Name Gordon Smith Address 34440 Annapolis Rd City, State, Zip Annapolis ca 95412 Email — If you wish to be added to our email list
Printed Name Tara Rdnk Address 5144 Grant City Rd City, State, Zip Carbondale, IL 62902 Email If you wish to be added to our email list	Printed Name Address City, State, Zip Email If you wish to be added to our email list

R03341

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Nancy Cottom Address 1000 N. Springer St. City, State, Zip Carbondale, IL 62901 Email njcmt13@gmail.com If you wish to be added to our email list ✓	Printed Name JAN THOMAS Address 433 N 7th ST. City, State, Zip MURPHYSBORO IL 62966 Email JAN@ARTAPULT.COM If you wish to be added to our email list
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R03342

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Gloria A. Smiley Address 3397 Hwy 4 City, State, Zip Vergennes, IL 62994 Email smileyspins@yahoo.com If you wish to be added to our email list	Printed Name SAUNDRA L. KAYNE Address 113 Archelle Drive City, State, Zip Carbondale, IL 62901 Email KAYNE52@msn.com If you wish to be added to our email list
Printed Name WALTER DRAGON Address 3397 HWY 4 City, State, Zip VERGENNES, IL 60094 Email If you wish to be added to our email list	Printed Name Maya Kayne Address 113 Archelle Drive City, State, Zip Carbondale, IL 62901 Email ViperphoenixC@MSN.COM If you wish to be added to our email list
Printed Name Steven Martin Address 1311 Charles Ave. City, State, Zip Carterville, IL 62918 Email SMMbox1@msn.com If you wish to be added to our email list	Printed Name Tim Faye Address 19746 N 1660th St City, State, Zip Shumway IL 62461 Email fryepotterygirl@yahoo.com If you wish to be added to our email list

R03343

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Catlin Langellier Address 65 Holder Rd City, State, Zip Carbondale, IL 62903 Email Ctln@email.com If you wish to be added to our email list	Printed Name Heather Smith Address 3698 Boskydell Rd City, State, Zip Carbondale IL 62903 Email mailboxcandy@yahoo.com If you wish to be added to our email list
Printed Name Ingrid Thomas Address 3269 N Reed Station Rd City, State, Zip De Soto, IL 62924 Email img3thomas@yahoo.com If you wish to be added to our email list	Printed Name SUE BOWERMAN Address 861 OLD US HWY 51 City, State, Zip MAKANDA IL 62958 Email SUSANMARYB333@GMAIL.COM If you wish to be added to our email list
Printed Name CAROLYN TSCHOMAKOFF Address 177 LAKE DRIVE City, State, Zip MURPHYSBORO, IL 62966 Email cwtegalaxycable.net If you wish to be added to our email list	Printed Name ALLAN STUCK Address 897 OLD US HWY 51 City, State, Zip MAKANDA IL 62958 Email If you wish to be added to our email list

R03344

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Lisa Schmidt Address 2027 S. US Hwy 51 City, State, Zip Makanda IL 62958 Email ShutterbugLS@aol.com If you wish to be added to our email list	Printed Name Morgan Stevenson Address 1335 Hall Church Road City, State, Zip Makanda IL 62958 Email mizmo86@yahoo.com If you wish to be added to our email list
Printed Name Judy Hoepker Address 1335 Hall Church Rd. City, State, Zip Makanda, IL 62958 Email If you wish to be added to our email list	Printed Name Joyce Shepherd Address 401 S. Dixon City, State, Zip carbondale, IL 62901 Email If you wish to be added to our email list
Printed Name Hugh Devenl Address PO Box 3 City, State, Zip Makanda, IL 62958 Email hdevenl77@gmail.com If you wish to be added to our email list	Printed Name Amelia Naas Address 287 Naas Road City, State, Zip Carbondale, IL 62903 Email Lunasilks@gmail.com If you wish to be added to our email list

R03345

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Jennifer Bearden Address 4202 Gladson Rd City, State, Zip Tamaroa IL 62888 Email jennibear-23@yahoo.com If you wish to be added to our email list	Printed Name Catherine Schmidt Address 7530 Hickory Ridge Rd City, State, Zip Pomona IL 62975 Email wheee01@gmail.com If you wish to be added to our email list
Printed Name Karen Fiorino Address 45 OLD US HWY 51 City, State, Zip Makanda, IL 62958 Email If you wish to be added to our email list	Printed Name CHELSEA GRIFFITH Address 1386 ORCHARD HILL ROAD. City, State, Zip MURPHYSBORO IL 62966 Email If you wish to be added to our email list
Printed Name SAIKO LANIER Address 514 WEST OWENS ST. City, State, Zip Carbondale IL 62901 Email If you wish to be added to our email list	Printed Name TERESA FIX Address 412 DURY RD. City, State, Zip C'dale IL. 62902 Email teresafix@frontier.com If you wish to be added to our email list

R03346

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Jane Adams Address 606 W. Elm City, State, Zip Carbondale, IL 62901 Email jadams.cdale@gmail.com If you wish to be added to our email list	Printed Name Neth Hass Address 3215 Nash Rd City, State, Zip Anna IL 62906 Email If you wish to be added to our email list
Printed Name Elizabeth Donoghue Address 1902 W. Freeman City, State, Zip Carbondale, IL 62901 Email elizabeth.donoghue@siu.edu If you wish to be added to our email list	Printed Name Erin Palmer Address 306 N. Springer St. City, State, Zip Carbondale, IL 62901 Email If you wish to be added to our email list
Printed Name CYNTHIA DUDEK Address 3215 NASH Ave City, State, Zip Anna IL 62906 Email If you wish to be added to our email list	Printed Name Adriane Koontz Address 1116 Country Club Rd City, State, Zip Carbondale, IL 62903 Email If you wish to be added to our email list

R03347

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Joyce Schulz Address 413 Chautauqua City, State, Zip Carbondale IL 62901 Email joycekarlene@hotmail.com If you wish to be added to our email list	Printed Name Lakesha Graham Address 428 S 15st City, State, Zip M'boro IL 629646 Email Keshcapesh@gmail.com If you wish to be added to our email list
Printed Name Timothy Meier Address 416 N Washington St City, State, Zip DuQuoin, IL, 62832 Email mr.meier98@gmail.com If you wish to be added to our email list	Printed Name Cheryl Ellis Address 1505 Business Hwy 13 City, State, Zip Murphysboro IL 62966 Email If you wish to be added to our email list
Printed Name Marjorie Pelvin Address 19 West Lane City, State, Zip Elkville, IL 62932 Email marjoriepelvin@aol.com If you wish to be added to our email list	Printed Name Kathy Bower Address 14 Buena Vista Dr City, State, Zip Murphysboro IL 62966 Email agathathreadneedle@gmail.com If you wish to be added to our email list

R03348

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name JOAN DAVIS Address 2350 DOGWOOD City, State, Zip CARBONDALE, IL 62902 Email If you wish to be added to our email list	Printed Name Thomas Bik Address 10 PINEWOOD City, State, Zip CARBONDALE IL 62901 Email If you wish to be added to our email list
Printed Name Pam Jacobini Address 900 S. Skyline City, State, Zip Carbondale, Il 62901 Email If you wish to be added to our email list	Printed Name Betsy Bishop Address 106 S. Dixon Ave City, State, Zip Carbondale, IL 62901 Email imbjb@hotmail.com If you wish to be added to our email list
Printed Name Carla Wimack Address 2010 Hickory Ridge Rd City, State, Zip Pomona IL 62975 Email crusso1957@yahoo.com If you wish to be added to our email list	Printed Name Carl Bailey Address 245 Potters Rd. City, State, Zip Makanda, IL 62958 Email If you wish to be added to our email list

R03349

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Joann N. Nelson Address 2116 N. Almond City, State, Zip Carbondale IL 62901 Email joannnelson1928@gmail.com If you wish to be added to our email list	Printed Name YOLAN PRESLEY Address 1020 Ghev City, State, Zip Carbondale, IL Email yp@astrosleuth.com If you wish to be added to our email list
Printed Name Mike Ryan Address 1828 Edith St. City, State, Zip Murphysboro, IL 62966 Email If you wish to be added to our email list	Printed Name Jane Perr Address 705 E. 8th St. City, State, Zip W. Frankfort IL 62896 Email If you wish to be added to our email list
Printed Name Harry Randolph Hughes Address 2002 W Sunset Dr City, State, Zip Carbondale IL 62901 Email If you wish to be added to our email list	Printed Name Mark Coats Address 4301 Valley Forge RD Apt D City, State, Zip Mt Vernon, IL 62864 Email markscoats@yahoo.com If you wish to be added to our email list

R03350

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name John S. Rendleman Address 3108 W. Kent Dr. City, State, Zip C'dale, Ic 62901 Email If you wish to be added to our email list	Printed Name Thomas Finkenkeller Address 1941 S. Illinois Ave. Apt. A City, State, Zip Carbondale, IL 62903 Email If you wish to be added to our email list
Printed Name Gregory Wendt Address 110 South Maple St. City, State, Zip Carbondale, IL 62901 Email If you wish to be added to our email list	Printed Name SHARON SMAGA Address 599 LAMB RD City, State, Zip CARBONDALE, IL 62902 Email If you wish to be added to our email list
Printed Name Sally Elms Address 1838 S. IL Ave City, State, Zip Carbondale, IL 62903 Email If you wish to be added to our email list	Printed Name Sarah Richards Address 1828 Edith St City, State, Zip Murphysboro, IL 62966 Email If you wish to be added to our email list

R03351

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Gail Odonnell Address 911 N. Norwest City, State, Zip Carbondale IL 62901 Email If you wish to be added to our email list	Printed Name NILA TANNER Address 73 POKER RUN City, State, Zip CARBONdale IL Email If you wish to be added to our email list
Printed Name Sharmon Frantz Address C/o Wanya Trace City, State, Zip Carbondale, IL 62902 Email If you wish to be added to our email list	Printed Name John Cox Address 1920 Hardy City, State, Zip Mboro, IL. Email JohnRCox48@Gmail.com If you wish to be added to our email list
Printed Name Harriet Simon Address 805 Glenview City, State, Zip Carbondale IL 62901 Email hesimon1@gmail.com If you wish to be added to our email list	Printed Name Sarah Lewison Address 56 Hansen Way City, State, Zip Murphys-boro IL 62966 Email If you wish to be added to our email list

R03352

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Ivy Graham Address 511 W Walnut St City, State, Zip Carbondale, IL, 62901 Email anivycoveredlayne@gmail.com If you wish to be added to our email list	Printed Name Nina Martin Address 800 N Springer St City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list
Printed Name Chelsea Housden Address 102 N Violet Ln (apt. A) City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Wileta Brown-Martin Address 800 N Springer St City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list
Printed Name Michael Everly Address 102 N Violet Ln (apt A) City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Thomas Sronkoski Address 910 W Pecan St City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list

R03353

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Tim Skidmore Address 202 E Main St City, State, Zip Ava , IL , 62907 Email If you wish to be added to our email list	Printed Name Josie Pimentel Address 79 Roosevelt Rd City, State, Zip Carbondale , IL , 62901 Email If you wish to be added to our email list
Printed Name Dave Skidmore Address 202 E Main St City, State, Zip Ava , IL , 62907 Email If you wish to be added to our email list	Printed Name Jon Emery Address 290 Warren Rd #20 City, State, Zip Carbondale , IL , 62901 Email If you wish to be added to our email list
Printed Name Shalla McBride Address 202 E Main St City, State, Zip Ava , IL , 62907 Email If you wish to be added to our email list	Printed Name Susan Walch-Pimentel Address 79 Roosevelt Rd City, State, Zip Carbondale , IL , 62901 Email If you wish to be added to our email list

R03354

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Rowen Skye Address 290 Warren Rd #71 City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Zachary Sapienza Address 726 S 20th St City, State, Zip Murphysboro, IL, 62966 Email If you wish to be added to our email list
Printed Name Eileen Troutt-Ervin Address 130 N Rod Ln City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Amanda Peppers Address Johnston City, IL, 62951 City, State, Zip Email amandacy.1994@gmail.com If you wish to be added to our email list
Printed Name Gage Glisson Address 307 N Hickory City, State, Zip DeSoto, IL, 62901 Email If you wish to be added to our email list	Printed Name Austin Peppers Address Johnston City, IL, 62951 City, State, Zip Email austinpeppers94@gmail.com If you wish to be added to our email list

R03355

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Vladimir Valchev Address 800 E Grand Ave #46C City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Phoenix John Address 1115 Jamestown Rd City, State, Zip Cobden, IL, 62920 Email If you wish to be added to our email list
Printed Name Kayla Valchev Address 800 E Grand Ave #46C City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Robin Thompson Address 143 Ridge Rd City, State, Zip Makanda, IL, 62958 Email If you wish to be added to our email list
Printed Name Ashley Bryant Address 1320 Boskydell Rd City, State, Zip Carbondale, IL, 62902 Email If you wish to be added to our email list	Printed Name Jordan Duke Address 1200 E Grand AVE City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list

R03356

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Carmella Cesario Address 3698 Boskeydell Rd City, State, Zip Carbondale, IL, 62903 Email If you wish to be added to our email list	Printed Name Richard Brannon Address 500 S Forest Ave City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list
Printed Name Caleb Bonney Address 500 S Forest Ave City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Isaiah Shepherd Address 290 Warren Rd #71 City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list
Printed Name Sarah Brannon Address 500 S Forest Ave City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Czaria Bonney Address 500 S Forest Ave City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list

R03357

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Susan Benson Address 5 Hillcrest Dr City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Megan Bates Address 96 Wyoming Rd City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list
Printed Name Avalon Wheetley Address 810 W Mill St City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Aaron Greyman Address 96 Wyoming Rd City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list
Printed Name AP Benson Address 5 Hillcrest Dr City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Grant Greyman Address 96 Wyoming Rd City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list

R03358

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Orion Fiorino-Matthews Address 1207 S Wall St #309 City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Gabriel Ebel Address 215 Arizona Rd City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list
Printed Name Steven J Bozarth Address 215 Arizona Rd City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Aleister Hale Address 215 Arizona Rd City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list
Printed Name Rachel Ebel-Bozarth Address 215 Arizona Rd City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Drake Hale Address 215 Arizona Rd City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list

R03359

PETITION TO PROTECT BIG MUDDY RIVER

The People of IL call on Governor Pritzker to Protect Big Muddy River from further degradation. We ask Governor Pritzker to ensure that Williamson Energy LLC pre- treat the mining waste water with reverse osmosis treatment to remove salts, chlorides and heavy metals , install a SCADA monitoring system (public on-line, real time water monitoring) at the point of discharge and to reduce the volume of treated water to less than 500,000 gallons per discharge event and only when the Big Muddy River is below flood level.

Printed Name Andrew Troutt Address 130 N Rod Ln City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Benjamin J Puffer Address 613 W Lincoln St City, State, Zip DeSoto, IL, 62924 Email If you wish to be added to our email list
Printed Name Alyssa Causert Address 111 N Rod Ln City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Cheyenne Braswell Address 109 Outdoorsman Dr City, State, Zip Makanda, IL, 62958 Email If you wish to be added to our email list
Printed Name Sydney E. Rather Address 2800 Old W Main St #203 City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Ryan Steele Address 191 ~~Hiffels Rd~~ Wides Rd City, State, Zip Murphysboro, IL, 62966 Email If you wish to be added to our email list

R03360

PETITION TO PROTECT BIG MUDDY RIVER

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Printed Name Erika Riley Address 1200 E Grand Ave City, State, Zip Carbondale, IL, 62901 Email If you wish to be added to our email list	Printed Name Madison Engelston Address 1301 Crossing Place University Village #1035 City, State, Zip Austin, TX, 78741 Email If you wish to be added to our email list
Printed Name Joe Matthews Address 45 OLD US HWY 51 City, State, Zip Makanda, IL, 62958 Email If you wish to be added to our email list	Printed Name Artemis Address 1104 N Pierce City, State, Zip Carbondale, IL, 62901 Email talentedwithmusic743@gmail.com If you wish to be added to our email list
Printed Name Karen Fiorino Address 45 OLD US HWY 51 City, State, Zip Makanda, IL, 62958 Email If you wish to be added to our email list	Printed Name Address City, State, Zip Email If you wish to be added to our email list

R03361

Foresight Energy LP Financial Statements 2011-2019 | FELP

Exhibit 248

Prices | Financials | Revenue & Profit | Assets & Liabilities | Margins | Price Ratios | Other Ratios | Other Metrics

Income Statement | Balance Sheet | Cash Flow Statement | Key Financial Ratios

Format: Annual

Search for ticker or company name...

Annual Data | Millions of US $ except per share data	2018-12-31	2017-12-31	2016-12-31	2015-12-31	2014-12-31	2013-12-31	2012-12-31	2011-12-31
Revenue	$1,104.991	$954.538	$875.832	$984.853	$1,109.404	$957.412	$845.886	$500.791
Cost Of Goods Sold	$771.608	$657.077	$577.195	$698.347	$689.315	$559.662	$481.48	$272.577
Gross Profit	$333.383	$297.461	$298.637	$286.506	$420.089	$397.75	$364.406	$228.214
Research And Development Expenses	-	-	-	-	-	-	-	-
SG&A Expenses	$39.568	$30.109	$25.265	$31.357	$33.683	$32.295	$41.528	$38.894
Other Operating Income Or Expenses	$-83.133	$-36.569	$-86.431	$22.823	$42.846	$1.165	$9.925	$1.481
Operating Expenses	$1,020.468	$932.255	$853.103	$902.296	$849.919	$752.969	$637.635	$380.401
Operating Income	$84.523	$22.283	$22.729	$82.557	$259.485	$204.443	$208.251	$120.39
Total Non-Operating Income/Expense	$-146.136	$-237.516	$-201.349	$-121.241	$-118.009	$-193.67	$-82.58	$-38.193
Pre-Tax Income	$-61.613	$-215.233	$-178.62	$-38.684	$141.476	$10.773	$125.671	$82.197
Income Taxes	-	-	-	-	-	-	-	-
Income After Taxes	$-61.613	$-215.233	$-178.62	$-38.684	$141.476	$10.773	$125.671	$82.197
Other Income	-	-	-	-	-	-	-	-
Income From Continuous Operations	$-61.613	$-215.233	$-178.62	$-38.684	$141.476	$10.773	$125.671	$82.197
Income From Discontinued Operations	-	-	-	-	-	-	-	-
Net Income	$-61.613	$-215.233	$-178.789	$-39.477	$70.192	$8.517	$125.831	$82.093
EBITDA	$213.398	$239.075	$199.521	$284.85	$436.274	$374.194	$341.038	$196.857
EBIT	$84.523	$22.283	$22.729	$82.557	$259.485	$204.443	$208.251	$120.39
Basic Shares Outstanding	145	142	131	130	130	-	-	-
Shares Outstanding	145	142	131	130	130	-	-	-
Basic EPS	$-0.43	$-1.51	$-1.37	$-0.30	$0.54	-	-	-
EPS - Earnings Per Share	$-0.43	$-1.51	$-1.37	$-0.30	$0.54	-	-	-

Source: https://www.macrotrends.net/stocks/charts/FELP/foresight-energy-lp/financial-statements

Annual Financials for Foresight Energy LP

View Ratios

Operating Activities

Fiscal year is January-December. All values USD millions.	2014	2015	2016	2017	2018	5-year trend
Net Income before Extraordinaries	139.05M	(38.68M)	(178.62M)	(215.23M)	(61.61M)	
Depreciation, Depletion & Amortization	167.04M	195.42M	164.21M	208.5M	117.64M	
Depreciation and Depletion	167.04M	195.42M	164.21M	-	-	
Amortization of Intangible Assets	-	-	-	-	-	
Deferred Taxes & Investment Tax Credit	-	-	-	-	-	
Deferred Taxes	-	-	-	-	-	
Investment Tax Credit	-	-	-	-	-	
Other Funds	(11.22M)	44.87M	195.62M	152.65M	71.19M	
Funds from Operations	294.86M	201.6M	181.21M	145.92M	127.22M	
Extraordinaries	-	-	-	-	-	
Changes in Working Capital	(58.82M)	(1.19M)	44.01M	(1.47M)	6.15M	
Receivables	(15.66M)	(5.76M)	19.36M	(7.73M)	(3.66M)	
Accounts Payable	9.63M	(5.01M)	5.78M	15.69M	23.08M	
Other Assets/Liabilities	(37.56M)	(18.73M)	(17.43M)	2.55M	1.82M	
Net Operating Cash Flow	**236.04M**	**200.41M**	**225.22M**	**144.45M**	**133.37M**	

Source: https://www.marketwatch.com/investing/stock/felpu/financials/cash-flow

Exhibit 249 R03364

U.S. Environmental Protection Agency

Mark Malkovich
mmalk55@hotmail.com

What is Acid Mine Drainage



Sources of Non-point Source Pollution

Acid Mine Drainage (AMD) is currently the main pollutant of surface water in the mid-Atlantic region. AMD is caused when water flows over or through sulfur-bearing materials forming solutions of net acidity. AMD comes mainly from abandoned coal mines and currently active mining. AMD degrades more than 4,500 stream miles in the mid-Atlantic region with the loss of aquatic life, and restricts stream use for recreation, public drinking water and industrial water supplies.

What is Mine Drainage?

- Mine drainage is metal-rich water formed from chemical reaction between water and rocks containing sulfur-bearing minerals.
- The runoff formed is usually acidic and frequently comes from areas where ore or coal mining activities have exposed rocks containing pyrite, a sulfur bearing mineral.
- Metal-rich drainage can also occur in mineralized areas that have not been mined.

How does Mine Drainage Occur?

- Mine drainage is formed when pyrite, an iron sulfide, is exposed and reacts with air and water to form sulfuric acid and dissolved iron.
- Some or all of this iron can precipitate to form the red, orange, or yellow sediments in the bottom of streams containing mine drainage
- The acid runoff further dissolves heavy metals such as copper, lead, mercury into ground or surface water
- The rate and degree by which acid-mine drainage proceeds can be increased by the action of certain bacteria.

Problems Associated with Mine Drainage

- Contaminated drinking water
- Disrupted growth and reproduction of aquatic plants and animals
- Corroding effects of acid on parts of infrastructure such as bridges

Acid Mine Drainage

- Mines built as early as the 1800's were developed in a manner which utilized gravity drainage, to avoid excessive water accumulation in the mines
- As a result, water polluted by acid, iron, sulfur and aluminum drained away from the mines and into streams



Results of Acid Mine Drainage

- Acid mine drainage is one of Region 3 most serious water pollution problems
- It is not only an ecological concern to the states but an economic concern as well

Economic Concerns Resulting from Acid Mine Drainage

- A region impacted by acid mine drainage often has a decline in valued recreational fish species such as trout as well as a general decline in outdoor recreation and tourism along with contamination of groundwater drinking supplies

Additional Information

- For additional information regarding information on this page contact Dan Sweeney at 215-814-5731
- US EPA Region 3 Water Protection Division Nonpoint Source Pollution Program
- Public Information Hotline - 800-438-2474

Exhibit 250

Big Muddy River threatened

My name is Karl Finley. I am 72 years old and have lived on the river all my life in Murphysboro. I have been a commercial fisherman since I was 15. I am currently the president of the so. Ill. waterfowl assoc. which represents the southern 9 counties in Ill.

This river is the lifeblood of the region from Rend Lake to the Mississipi. The entire ecological system is being threatened by this proposal.

All the fish, waterfowl, wildlife, trees and adjoining lands will be decimated by this waste water. The good lord made this river for us and I'm sure he didn't intend for it to be turned into a sewer from any coal mines.

This poison water will kill fish. Bald Eagles nesting along the river will feed these fish to their young and wipe out generations of eagles. All species of waterfowl use this river year around. Especially in the spring they feed on invertebrates in the water to get the protein to sustain their northward migration.

Extended periods of high water will kill trees and ruin farmland.

The coal mines need to build their own wastewater plants and not be

allowed to ruin our beautiful river. I pray that government agencies will not allow this to happen. In God we trust.

Karl Staley
15 Oakwood Ln
Murphysboro, IL.
62966
618-776-5566

Exhibit 251

December 18, 2019
IEPA Pond Creek Mine Hearing
IL0077666
Marion, IL

My name is Christina Krost. I am the Southern Illinois Outreach Coordinator for Faith in Place, an interfaith creation care and environmental justice organization. I live near Harrisburg and do outreach and organizing all over southern IL. I'm a person of faith, a mother, and a concerned citizen.

Thank you for holding this hearing today. I appreciate the chance to explain why I am **opposed to the approval of the Pond Creek Mine permit,** because I feel the activities at the mine threaten human health and the environment for all Illinoisans, and the plants and animals living in the Big Muddy River watershed.

Water is life. Without it we cannot survive. This truth echoes through the generations and across all faiths and cultural backgrounds. People have also long known that everyone is downstream or downwind of someone, so it's important to steward the land, air, and water where you live, so you don't adversely affect your neighbors.

This permit includes a 12.5 mile pipeline for discharge of millions of gallons of high chloride and sulfate water to dump directly into the Big Muddy River near West Frankfort. As a parent and concerned citizen, I did some research about the public health impacts of chloride and sulfate in water. It turns out that these pollutants can cause gastrointestinal tract problems such as diarrhea, nausea, inflammatory bowel disease, and consequent dehydration from these conditions. This is a threat to public health.

I also learned that chloride increases the corrosivity of water and reacts with metal ions, increasing levels of metals in drinking water. I am acutely aware of the dangers of heavy metals poisoning, as I grew up not far from Flint, MI. But we don't have to go very far to see the effects of this in Illinois. In 2016, one in five Chicago homes tested had high levels of lead, even after running the water for 3-5 minutes before using the water. What we've learned from Flint is that when the public is kept in the dark about water issues, like this mine permit, terrible things can happen and then be covered up.

My research also led to a better understanding of how water travels from the Big Muddy River. The Big Muddy basin includes Kinkaid Lake, Rend Lake, Crab Orchard Lake, Devil's Kitchen Lake, Little Grassy Lake and Cedar Lake. Of particular concern to me is Little Grassy Lake.

My husband is a United Methodist pastor, and my family has been attending camp at Little Grassy United Methodist Camp for many years. To learn that this mine discharge could affect my family's beloved camp was deeply concerning. I've watched countless families and young adults deepen their spiritual relationship with their Creator through

their time at Little Grassy. This place changes lives. I cannot stand by and let this place be harmed because of a company's pursuit of profit at the expense of a beautiful natural resource.

As a mother and a person of faith, I must speak out about potential harm to my children and my neighbor's children. As a southern Illinois resident, I must ask you to consider the impact of this mine discharge on our shared land, air and water, and the people and wildlife sustained by it. And as an environmental justice advocate, I urge you to assure that communities are not abandoned by polluters who refuse responsibility for their pollution should a disaster occur. Please consider cumulative impacts of pollution on vulnerable communities and on the plants and animals that call the Big Muddy River their home.

IEPA, you have a chance to assure safe drinking water for my children, your children, and the next generation to come. Please do not approve this permit.

Thank you again for hosting this hearing. And thank you for working to protect the environment and Illinois residents.

Christina Krost
christina@faithinplace.org
217-343-4899

Exhibit 252

December 18, 2019
IEPA Pond Creek Mine Hearing
IL0077666
Marion, IL

My name is Madeline Krost. I am a high school freshman and I live in Harrisburg.

I've been going to Little Grassy United Methodist Camp since I was in 4th grade. I've experienced swimming in Little Grassy Lake and hiking its shores. The lake is so clear you can see the fish moving under you. I've made clam shell sand castles on the beach. There are more butterflies there than I've ever seen anywhere else.

My mom told me about how water travels from the Big Muddy River and then to Little Grassy Lake. And she said that there's a mine that wants to dump waste water into the Big Muddy River.

To learn that this mine discharge could affect my family's favorite camp was upsetting. What would happen to the plants and animals that live in Little Grassy Lake? Will it still be safe for us to swim in? It makes me sad to think that it might not always be there and be safe for us to enjoy.

IEPA, I am asking you to not approve this permit for the Pond Creek Mine.

Thank you for hosting this hearing. And thank you for working to protect the environment and Illinois residents.

Madeline Krost
Madeline.krost@gmail.com
217-663-4112

Exhibit 253

12/11/2019

Written Comments for Pond Creek Mine NPDES Permit No. IL0077666

To:
Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES
Illinois Environmental Protection Agency
1021 N. Grand Ave. East
P.O. Box 19276
Springfield, IL 62794-9276
epa.publichearingcom@illinois.gov

From:
Lucia Amorelli
315 N. Westridge Dr. Apt. 12
Carbondale, IL 62901
618-771-0154
Earthwater365@gmail.com

I am submitting comments for Pond Creek Mine NPDES Permit No. IL0077666, specifically regarding the portion of the permit concerning Outfall #011 which would allow significant amounts of mine wastewater to be pumped into the Big Muddy River. I am a teacher, unpaid environmental advocate, and long-term resident of southern Illinois. I am an avid hiker, kayaker, swimmer, and bicyclist. I remain in this area specifically because of the unique beauty of our area, and I frequently (at least once a week) utilize our state parks and national forest areas. I live only a few miles from the Big Muddy River and only a couple of blocks from Little Crab Orchard Creek, one of the tributaries in the Big Muddy Watershed.

I am adamantly opposed to this permit as is. At minimum, there needs to be a proper filtration system for wastewater; using a dilution method with the river's own water is not going to be able to filter millions of gallons of toxic water that is going to be discharged. The following pages list some of the concerns and questions I have after reading through the draft permit and related materials concerning this issue. I believe, they all have a direct relation to the Clean Water Act and antidegradation analysis. This is by no means an exhaustive account of my concerns.

Williamson Energy History of Violations

The Attorney General (on behalf of the people of Illinois) sued Williamson Energy February, 2019 on eight counts of violations that occurred in 2016 due to a pump failure which dumped approximately 90,000 gallons of coal slurry/acid mine discharge into an unnamed tributary of Pond Creek. An example of some of the counts include: discharging contaminants into the water; depositing contaminants onto the land; violating water quality standards for chloride and iron; and INTENTIONAL diversion of a waste stream from sediment pond to and outflow into a tributary of Pond creek. There was only one announcement in the *Marion Repu*blican regarding this case; no one requested a hearing. Williamson Energy did not admit to the violations, and the case was settled without a hearing. They only had to pay a civil penalty for $80,000 even though five of the eight counts had a $50,000 penalty (the other three had $10,000 each).

According to information provided in the Pond Creek Watershed Inventory (2019) created by Greater Egypt Regional Planning and Development Commission, Williamson Energy had over 45 outfall effluent violations between 2015 and 2017 (Source of violation history is from EPA-ECHO). Some of the pollutants include: chloride, sulfate, nitrogen, pH, manganese, and total dissolved oxygen (TSS).

Question: How many more violations have occurred since 2017? How many violations in total does Williamson Energy have? Have the impacts of these violations on aquatic life been assessed?

Question: Are there any IEPA regulations or stipulations under the Clean Water Act regarding granting new permits or additions to existing permits when the company requesting them have an extensive history of violations? Citizens do not get to keep violating law without increasing consequences (e.g. prison time, permanently losing a driving license, losing child custody, etc.). If there are not rules/regulations which can prohibit granting companies new permits and/or terminating a permit due to continued and repeated violations which cause harm to the environment and its inhabitants, then the IEPA needs to create them. Companies should not be allowed to violate laws endlessly with only monetary fines as their penalty.

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Question: Can the IEPA be held accountable by law for allowing a pipeline to discharge acid mine drainage with elevated concentrations of numerous pollutants into a river that is currently listed as impaired and is also a candidate for wild and scenic river designation?

There were 11 violations related to sulfates and ten to chloride in Pond Creek, a tributary of Big Muddy River (Pond Creek Watershed Inventory, Greater Egypt Regional Planning and Development Commission, 2019, p.85). In addition, the report states the following:

- "...chloride is listed as an impairment to aquatic life in the waterbody." (p.74)
- "The mine also had a number of single event violations including: improper operation and maintenance, numeric effluent, unapproved bypass, and an unauthorized discharge." (p.85)
- "Pond Creek has been listed for chloride and sedimentation/siltation impairments since 2010, and dissolved oxygen since 2012. In 2008, the stream was listed for iron, manganese, pH, total suspended solids (TSS), and fecal coliform." (p.74)
- The Illinois Integrated Water Quality Report categorizes Pond Creek as having three designated uses; aquatic life, which is not supported... (p. 72)

Water Quality

In the IEPA Big Muddy River TDML 2004 report it states that the Big Muddy River is a compromised and impaired river and is due in part because of mining operations. It states that "abandoned coal mines should be identified **in addition to other mining activity** which could contribute to manganese and sulfate concentrations..." According to the Antidegradation Analysis report (2016), the Big Muddy River is listed in the 2014 Section 303 (d) list for sedimentation/ siltation, sulfates, total suspended solids (TSS), mercury, and polychlorinated biphenyl (PCBs). The site is on the 2016 Section 303(d) list for impaired waters due to sedimentation/ siltation, TSS, mercury, PCBs, iron, dissolved oxygen, pH, and fecal coliform.

And just recently, the Upper Big Muddy River TDML Report (IEPA 2019) was released which stated that elevated concentrations of Iron and Manganese were

found in Big Muddy Watershed and according to IEPA have negative impacts on aquatic life.

> Iron TMDL: IEPA identified one segment, Andy Creek (IL_NZN-13), with elevated concentrations of dissolved iron. Elevated concentrations of dissolved iron can negatively impact aquatic species by disturbing normal metabolic and osmoregulatory functions. Aquaculture studies have also demonstrated that increased dissolved iron concentrations in the water column may negatively impact gill functionality in certain fish species and thus reduce biodiversity in certain stream environments. 4 Excessive iron within the water column may harm aquatic species such as fish and macroinvertebrates. Certain metals species dissolve in water and may be absorbed by fish and other aquatic organisms. Small concentrations of certain dissolved metals may be, in the short term, toxic to fish and aquatic species and, in the long term, may bioaccumulate in certain aquatic species.

Question: Why is the water quality standard for Iron listed on the draft permit for the Pond Creek Pipeline as 3mg/6mgL when the standard on the IEPA Water Quality Standard Report 2019 states that the acceptable level is 1mg/L?

> Manganese TMDL: IEPA identified one segment, Beaver Creek (IL_NGAZ-JC-D1), with elevated concentrations of dissolved manganese. Elevated dissolved manganese concentrations in the water column have many of the same negative effects of dissolved iron on fish species and biodiversity of the water column and benthic environments. Excessive manganese within the water column may harm aquatic species such as fish and macroinvertebrates. Certain metals species dissolve in water and may be absorbed by fish and other aquatic organisms. Small concentrations of certain dissolved metals may be, in the short term, toxic to fish and aquatic species and, in the long term, may bioaccumulate in certain aquatic species. (Upper Big Muddy River TDML Report, IEPA, 2019).

The Union of Concerned Scientists state that

> "mining operations can negatively impact water supplies, often with long-lasting effects. The fundamental issue involves contamination of nearby

> rivers, lakes, and aquifers by what comes *out* of a coal mine—usually highly acidic water containing heavy metals like arsenic, copper, and lead. The process is known as **acid mine drainage**. It happens when certain substances (typically iron sulfide, FeS2, or fool's gold) is oxidized after being exposed to air and water. Runoff can change the pH of nearby streams to the same level as *vinegar* (Coal and Water Pollution, Union of Concerned Scientists,https://www.ucsusa.org/clean-energy/coal-and-other-fossil-fuels/coal-water-pollution, Accessed 7.22.2019.)

According to U.S. Fish and Wildlife, "Because acid mine drainage can destroy a stream's aquatic community for miles, many of the old mining sites are being reclaimed (Acid Mine Drainage, U.S. Fish and Wildlife, https://www.fws.gov/mountain-prairie/contaminants/acidMineDrainage.php, accessed 7.2019)

Question: Does this mean then that the IEPA is going against its own implementation plans (2004/2019) by considering granting a permit for a pipeline which will infuse the river more with elevated levels of chlorides, sulfates, manganese and other pollutants? Does this not go against the Clean Water Act?

Interestingly, there is no mention of the Pond Creek in the TDML IEPA 2019 Upper Big Muddy Watershed report, even though other tributaries are discussed.

Question: Why is Pond Creek not included in this report since according to the Greater Egypt Regional Planning and Development Commission just released a watershed-based plan (2019) which was created because of the creek being polluted? It is already polluted with some of the very pollutants the mine will be discharging such as chloride, iron, manganese, and TSS.

In 2018 and 2019, The Big Muddy River had a fish advisory for mercury by the Illinois Health Department. Mercury is one of the pollutants which is to be monitored in the acid mine discharge. The advisory for Mercury has recently been removed from the website.

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Question: Why has the mercury advisory suddenly been lifted?

Question: Has the fact that elevated sulfates can cause Mercury to undergo methylation into its most toxic form methylmercury according to Orem, W. in "Sulfate as a Contaminant in Freshwater Ecosystems: Sources, Impacts and Mitigation" (U.S. Geological Survey, assessed 10.2019) been considered in the granting of this permit?

Chlorides

IEPA has listed the acceptable levels for chloride concentrations in waterways as 500mg/L. According to the Pine Creek Pond Permit Application No. 456, samples taken of the mine wastewater showed high levels of both chlorides and sulfates that far exceed the acceptable level for water quality standards. The average chloride concentration of the samples taken was 2, 237 mg/L.

- The national standard for sustaining aquatic life is 230mg/L for chronic (long-term) levels and 860 mg/L for acute (short-term). (https://www.epa.gov/wqc/national-recommended-water-quality-criteria)
- Missouri revised their chloride levels in 2012 to 178mg/L for chronic and as low as 288mg/L for acute. (EPA Region 7, 2015)
- Indiana adopted new criterion in 2012 for chloride levels for Lake Michigan to be 250 mg/L. (Indiana Preliminary Adopts Revised Chloride and Sulfate Water Quality Criteria, BDlegal.com, 2019).
- According to Kentucky state website (2019), acute chloride levels ranging from 2500 to 8400 mg/L can be toxic to aquatic life such as snails, minnows, catfish, and trout.
- Another study by University of Rhode Island has much lower long-term exposure rates of 250mg/L and 860 mg/L for short-term exposure. (Hunt, Herron, & Green. *Chlorides in Fresh Water*. University of Rhode Island. March 2012)

Question: Why does Illinois EPA have much higher accepted levels of chloride than surrounding states especially since what is considered to be safe levels for aquatic life is much lower than the Illinois accepted level of 500mg/L? Why does IEPA not have both an acute and a chronic level like other states and the national standard?

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Question: According to the draft permit for the pipeline samples taken from the acid mine discharge showed chloride levels greater than 2,000 mg/ and levels of up to 12,000mg/L are permissible from the discharge point into the Big Muddy River. This grossly exceeds both the national and state accepted levels. How can the IEPA allow such a gross violation of its own and national regulation? 12,000mg/L would be 48x the national standard and 24x the state standard. Is it truly be diluted "immediately" and rapidly" which is what is stated in the In Section 302.102 12(e) Allowed Mixing, Mixing Zones and ZIDs (TITLE 35: ENVIRONMENTAL PROTECTION SUBTITLE C: WATER POLLUTION CHAPTER I: POLLUTION CONTROL BOARD PART 302 WATER QUALITY STANDARDS SUBPART A: GENERAL WATER QUALITY PROVISIONS, 2019)

Sulfates:

The accepted sulfate level is listed as 1250 mg/l on the draft permit; however, the average sulfate concentration taken from the Pond Creek mine wastewater was 1,940 mg/L and the IEPA antidegradation assessment states that the levels to be discharged to the Big Muddy River could be as high as 2,120 mg/L sulfate. This would be the equivalent of 476,000 pounds per day of sulfate.

According to Kentucky State website (2019). "Problems caused by sulfates are most often related to their ability to form strong acids which change the pH. Sulfate ions also are involved in complexing and precipitation reactions which affect solubility of metals and other substances."

In addition to the afore mentioned pollutants in the Big Muddy River, the IEPA has recently listed four sections (IL0029165, IL0031704, IL0027871, IL0027898) of the Big Muddy River under the Nutrient Assessment Reduction Plan/Illinois Nutrient Loss Reduction Strategy Implementation (2019). These sections of the river are all downstream from the proposed pipeline.

According to a study by Kaushal in 2005, many of our waterways are becoming victims of 'freshwater salinization syndrome', where "high levels of chloride and other salt ions can kill freshwater animals, from zooplankton at the base of the food web to insects and fish, because they make it hard for the creatures to osmotically regulate their cell's ion concentrations." Furthermore, the study

states that high levels of chlorides and other salts can cause more algal blooms due to dying off of algae-eating zooplankton which in turn can cause the releasing of toxins and deplete oxygen. In addition, higher salt levels can "favor invasive species that better survive in brackish water," and "at nonlethal levels, salt can stunt the reproduction and growth of freshwater organisms, lowering biodiversity and shifting the structure of the food webs." (*For Healthier Lakes, Rivers, and Drinking Water Hold the Salt*, Lockwood, D., Chemical and Engineering News, 2019).

Question: Has the IEPA considered the impact of discharging millions of gallons of unfiltered mine wastewater with elevated levels of chlorides, sulfates and other contaminants on the already elevated nutrient load of the Big Muddy River which is supposed to be being mitigated?

Question: Has the EPA taken into consideration current studies regarding effects of salination on aquatic animals?

<u>Mixing Zones</u>

There are numerous issues with the granting of this permit which could possibly violate the water quality standards as listed by the IEPA Pollution Control Board (2019):

In Section 302.102 Allowed Mixing, Mixing Zones and ZIDs.

> 4) Mixing is not allowed in waters containing mussel beds, endangered species habitat, fish spawning areas, areas of important aquatic life habitat, or any other natural features vital to the well-being of aquatic life in such a manner that the maintenance of aquatic life in the body of water as a whole would be adversely affected.

Question: Has this been determined by the IEPA/IDNR? There was no mention of this in the draft permit.

> 6) Mixing must allow for a zone of passage for aquatic life in which water quality standards are met.

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Question: Has this been determined? Again, there was no mention of this in the permit.

> 7) The area and volume in which mixing occurs, alone or in combination with other areas and volumes of mixing, must not intersect any area of any body of water in such a manner that the maintenance of aquatic life in the body of water as a whole would be adversely affected.

Question: Has the current state of the river (i.e. known pollutants) as well as the Sugar Creek Mine discharge pipeline been considered in determining this?

> 9) No mixing is allowed when the water quality standard for the constituent in question is already violated in the receiving water.

Question: Given that the Big Muddy River already has elevated levels of sulfates and manganese, mixing would be violating this regulation. How then can a permit be granted for a mixing zone?

> 12) The area and volume in which mixing occurs must be as small as is practicable under the limitations prescribed in this subsection (b), and in no circumstances may the mixing encompass a surface area larger than 26 acres. c) All water quality standards of this Part must be met at every point outside of the area and volume of the receiving water within which mixing is allowed. The acute toxicity standards of this Part must be met within the area and volume within which mixing is allowed, except as provided in subsection (e).
>
> e) Pursuant to the procedures of Section 39 of the Act and 35 Ill. Adm. Code 309, a person may apply to the Agency to include as a condition in an NPDES permit a ZID as a component portion of a mixing zone. The ZID shall, at a minimum, be limited to waters within which effluent dispersion is immediate and rapid. For the purposes of this subsection, "immediate" dispersion means an effluent's merging with receiving waters without delay in time after its discharge and within close proximity of the end of the discharge pipe, so as to minimize the length of exposure time of aquatic life to undiluted effluent, and "rapid" dispersion means an effluent's merging with receiving waters so as to minimize the length of exposure time of

> aquatic life to undiluted effluent. Upon proof by the applicant that a proposed ZID conforms with the requirements of Section 39 of the Act and this Section, the Agency shall, pursuant to Section 39(b) of the Act, include within the NPDES permit a condition defining the ZID.
>
> (TITLE 35: ENVIRONMENTAL PROTECTION SUBTITLE C: WATER POLLUTION CHAPTER I: POLLUTION CONTROL BOARD PART 302 WATER QUALITY STANDARDS SUBPART A: GENERAL WATER QUALITY PROVISIONS, 2019)

Question: With up to 5,000gals/minute or 300,000gals/hr. of mine waster discharge being permissible, how can there be an "immediate" or "rapid" dispersion to avoid having to adhere to Section 302.102, 12, (c), which states that acute toxicity standards must be met within the mixing zone. How can up to 12,000mg/l chlorides be rapidly dispersed in a small river?

Endangered Species

I am still trying to find out what species specific to Big Muddy River are Endangered or Threatened. I have contacted numerous government agencies, including: U.S. Fish and Wildlife, IDNR, IEPA, Illinois Endangered Species Protection Board, and Shawnee National Forest. No one has been able to give me any information. I have been trying since Fall 2018 after the initial hearing at IDNR.

Question 8: How can this permit be granted if none of these agencies seem to know exactly what species are endangered and threatened in the Big Muddy River Watershed as well as Pond Creek watershed?

Freshwater Mussels

Since 2018, US Fish and Wildlife Service has been under litigation for not protecting critical habitat for certain endangered mussels in 18 states, including three that occur in Illinois-Spectaclecase, Sheepnose, and Snuffbox. These and many more are protected under the 2019 Endangered Species Act. Anyone requiring federally funded or permitted projects in mussel's habitats must consult the US Fish and Wildlife Service to ensure habitat would not be damaged. There are more mussel species in the eastern U.S. than anywhere in the world;

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however, 70% of species are either endangered, threatened or extinct already. (Center for Biological Diversity)

According to a study conducted by the Illinois Natural History Survey, "Freshwater Mussels of the Big Muddy River" (2012), six species of mussels previously detected in the Big Muddy River were not found; although five of these are commonly found in other rivers in Illinois. These include: pink heelsplitter, pimpleback (listed as federally endangered), deertoe, creeper, fawnsfoot, plain pocketbook. 19 others were detected. "In Illinois, 25 of the 62 extant species (44%) are listed as threatened or endangered. Some of the species listed in the study that were documented in the Big Muddy River are: Lilliput, paper pondshell, pondhorn, white heelsplitter, giant floater, maple leaf, pink papershell.

The study lists the abandoned coal mines, specifically in the Murphsyboro area of the Big Muddy River, as a source of pollution. The study goes on to state that

mussels are more sensitive to sodium chloride and potassium chloride and that the current USEPA AWQC may not be protective of freshwater mussels (2013 Science Inventory). In addition, the study states that sedimentation and siltation might be causing a lack of species.

Question: Are any of the mussel species that exist in the Big Muddy watershed listed as threatened or endangered or rare? If this is not known, then it is pertinent to find out given the fact that most mussel species are now listed as threatened or endangered or already extinct and that they have been found to be sensitive to chloride levels as well as sedimentation/siltation both of which will be inflated due to the discharge of up to millions of gallons a day of acid mine discharge with extremely high levels of chloride and sulfates.

Fish Species

According to "Fishes of the Big Muddy" (1999), at least ten native fish species within a 100 year period are no longer found due to pollution, cultivation, and habitat lost. The study suggests the need for "continual vigorous reclamation of abandoned mines lands and treatment of acid mine drainage." The study goes on to say that "Big Muddy River drainage...has been subjected to an array of enviro

stresses that have permanently disrupted its hydrological cycle, and ultimately altered its fish fauna."

The following are list of fish species that were recorded at time of study: bluegill, channel catfish, largemouth bass, sauger, striped bass, white bass, white crappie, yellow bullhead.

Question: What is the current state of the fish population in the Big Muddy and how will these elevated levels of chlorides/sulfates affect them as well as possible other toxins such as manganese and iron? Are any of these species listed as endangered or threatened?

Other Endangered/Threatened Species

The alligator snapping turtle is listed as a threatened species in Illinois.

Question: Has it been determined if their habitat includes the Big Muddy Watershed?

Ecologically Sensitive Areas

The Big Muddy flows adjacent to two very ecologically diverse areas, Little Grand Canyon and La Rue Pine Hills, both of which are National Natural Registered Landmarks with many rare, threatened, and endangered plant and animal species. "LaRue-Pine Hills Ecological Area, located within the Shawnee National Forest, contains one of the finest assemblages of diverse vegetation in the Midwest. The site represents species of northern, southern, eastern, and western affinities, including 40 species rare in Illinois." (Prairie Research Institute). Some threatened and endangered animal species include the Indian Bat, Illinois chorus frog, eastern woodrat which is only located in the La Rue Pine hills area, several fish species, and many plant species. La Rue Pine Hills/Otter Pond is also a national Research Natural Area which is protected federally.

Question: Are any of these species being considered? In the draft permit, it states that there will be no adverse effects on species because water quality standards will be met. However, in the case of Williamson Energy, this is obviously not the case. Water quality standards are not met. How then can species be protected? Under the Clean Water Act, section. 101(a)2, water quality provides for the protection and propagation of fish, shellfish, and

wildlife. In addition, the Big Muddy River is already polluted with elevated levels of manganese, sulfates, phosphorus, mercury and has a fish advisory for PCBs. How the does adding elevated levels of chloride, sulfate and other toxins known to have adverse effects on animal and plant species permissible under this section of the Clean Water Act?

There is also a large area in southwestern Illinois listed as a Conservation Opportunity Area for La Rue Pine Hills under IDNR which includes sections of the Big Muddy River in both Jackson and Union County (IDNR, accessed 2019).

Fifty-two miles of the Big Muddy River, from S.R. 14 south of Rend Lake to Southern Illinois Airport (U.S. 51), is a candidate for the Wild and Scenic River Designation (National Rivers Inventory, 2019) and is listed as having "Outstanding Remarkable Value", exactly the area where the proposed pipeline is supposed to discharge. Due to this fact, special considerations need to be considered.

> The **Council on Environmental Quality (CEQ)**, under 5(d)(1) Wild and Scenic River Act authority, provides guidance to federal agencies with permitting and/or granting authority for projects on or near rivers listed on the NRI. In accordance with **executive memorandum**, all agencies must "take care to avoid or mitigate adverse effects" to rivers identified in the Nationwide Rivers Inventory.

The following information is listed on the National Park Services website regarding rivers listed on the National Rivers Inventory:

1. Determine whether the proposed action could affect an NRI river.

- Check the current regional/state NRI list to determine whether the proposed action could affect an NRI river (i.e., is the proposed action location in the vicinity of the NRI segment).
- If an NRI river segment could be affected by the proposed action, an environmental assessment or and environmental impact statement may be required depending on the significance of the effects.

2. Determine whether the proposed action could have an adverse effect on the natural, cultural, and recreational values of the NRI segment. These values are listed as "outstandingly remarkable values" (ORVs) on the state NRI list.

p.14 Amorelli

Adverse effects on NRI rivers may occur under conditions which include, but are not limited to:

- Destruction or alteration of all or part of the free flowing nature of the river;
- Deterioration of water quality; or

3. Determine whether the proposed action could foreclose options to classify any portion of the NRI segment as wild, scenic, or recreational river areas.

- In some cases, impacts of a proposed action could be severe enough to preclude inclusion in the Wild and Scenic River System, or lower quality of the classification (e.g., from wild to recreational). If the proposed undertaking could effectively downgrade any portion of the NRI segment, you should consult with NPS.
- Proposed actions (whether uses or physical changes), which are theoretically reversible, but which are not likely to be reversed in the short term, should be considered to have the effect of foreclosing for all practical purposes Wild and Scenic River status. This is because a river segment, when studied for possible inclusion in the Wild and Scenic River System, must be judged as it is found to exist at the time of the study, rather than as it may exist at some future time.
- If a proposal, including one or more alternatives, could have an adverse effect on an NRI river, an EA, or if the effects are significant, an EIS must be prepared.

4. Incorporate mitigation/avoidance measures in the proposed action to the maximum extent feasible within the agency's authority.

Question: Has the IEPA taken into consideration that numerous sections of the Big Muddy River downstream from the pipeline are listed not only on the National Rivers Inventory but also in several state and federally listed special environmental zones and therefore has special protections?

<u>IEPA Exhibiting Conflict of Interest</u>

1) The IEPA included in the draft permit a section on social/economic benefits of the proposed activity (pipeline). Goes on to list statistics about jobs and

revenue for state. My argument is that an agency that was supposedly created for the purpose of protecting our environment should not take economic nor social factors into account.

2) The IEPA also goes on to favor the mine company by stating that "filtration is a technology that is not feasible for the proposed facility because: filtration is much more expensive than sediment ponds...a large area of land would be required for such a facility, and maintenance and supervision of the filtration and sludge operation would be burdensome and would increase production costs."

Question: Is the EPA supposed to be taking into consideration financial aspects of a company in lieu of protecting the environment? Is it supposed to weigh economic benefit over protecting the environment? And why has not the IEPA commented on the economic cost to the citizens of Illinois due to pollution already caused by the mine and the pollution that will be caused by the mine? The Big Muddy River is already polluted and there are now two implementation plans that have been created by the IEPA (2004, 2019) costing hundreds of millions of dollars to implement. The mines, which are listed as one of the causes of pollution, are not held accountable for paying for these costly plans, rather the "stakeholders" and concerned citizens are told they must try to find monies to clean up the rivers. To date, no watershed-based plan group has been formed based on the 2004 findings.

<u>Illinois Constitution</u>

The Illinois Constitution in Article XI states that we have a right to a healthy environment. Since Williamson Energy has numerous and frequent violations which can have and have had adverse impacts on the watersheds and its inhabitants and the IEPA has already listed the Big Muddy River as well as some of its tributaries such as Pond Creek as being impaired for numerous pollutants some as a direct result of both past and current mining activities. It seems that IEPA would be violating the constitution for granting a permit to a company that has a history of polluting public waters and the fact that the nature of the permit would allow even more pollutants to enter the watershed.

p. 16 Amorelli

Question: Has the IEPA fully considered whether granting this permit for dumping more pollutants into the already impaired Big Muddy River will violate the law as stated in Article XI of our state constitution?

River Rights

Question: Has the IEPA considered that the river itself should have its own rights. It is already dammed and polluted? How much more should the Big Muddy River endure? The IEPA has already granted another similar permit for a discharge pipeline into the Big Muddy River with even higher expected levels of chlorides form the Sugar Camp Mine only 12.5 miles above stream from the proposed Pond Creek Mine pipeline.

And I end this with one final question to each of the IEPA staff.

Question: If this river was flowing through your backyard/property/town/county would you want millions of gallons of mine wastewater dumped into it without being filtered of all contaminants?

Exhibit 254

Jane Logie
jane.logie@gmail.com

R03388

As a resident of Jackson County living near the Big Muddy and a volunteer advocating for this river's use by all residents and all economic entities, large and small, I am here to oppose Pond Creek Mine permit No. IL0077666. In particular, my comment relates to the permit section concerning Outfall #011. This provision would, if approved, allow the Pond Creek Mine to pump millions of gallons of toxic mine waste water into the Big Muddy River, a body of water that should remain a resource for everyone who lives and works and gains their livelihood in and around the Big Muddy.

I will review in brief some of the facts that led to my decision to oppose this permit—facts that have not yet, to my knowledge, been adequately addressed ~~by the mine's owner, Williamson Energy, LLC~~.

(1.) The Pond Creek Mine facility has been found to violate its NPDES permit, and those violations have not been fully addressed.

(2.) Given these violations and also the harm that would be done to aquatic and wild life by the chloride and sulphate in the PCM's discharge, residents depending on the Big Muddy for their own economic livelihood and recreation, have a right, should this permit be approved, to demand ~~constant~~ frequent monitoring of toxicity of the mine's discharge at a number of locations. To my knowledge, how, how often, and by whom this testing should be carried out has not been specified.

As a taxpayer and resident of Jackson County, I would see it as ~~unacceptable~~ a conflict of interest to have Williamson Energy LLC designate the entity that would do the testing. Indeed, for the testing to achieve its purpose—to avoid harm to the Big Muddy's eco-system ~~and maintain the delicate balance of the life that depends on the river and that the river depends on~~—the US Geological Survey would be ~~the most~~ a credible entity to do the monitoring, both because of the frequency of their testing—as I understand it, they test daily—and their status as a neutral governmental agency.

(3.) Another concern ~~among many~~ I have is that the PCM permit should ~~definitely~~ not be approved until the permitted Sugar Camp Mine waste discharge has already been assessed for toxicity levels—assessed not just as those levels have been projected but as they have been determined once the Sugar Camp discharge has begun. Surely, determining of the impact of the Sugar Camp Mine discharge would be essential to assessing whether the Pond Creek Mine's permit should be approved.

(4.) Before closing, I want to make a more general point: Safe, clean water is now understood to be a ~~highly valuable~~, irreplaceable resource for sustaining life and the variety of livelihoods and activities people pursue that depend on clean, safe water. Thus waiting and seeing whether and how often the Pond Creek Mine's discharge would exceed the permitted level, should not be acceptable. Companies ~~such as the Williamson Energy, LLC~~ that increase toxins in our waters and ~~rob the larger public of~~ our shared resources, must be made to take full responsibility for the waste they produce. Jeopardizing a public resource for the benefit of one industry is more and more clearly unacceptable.

Comments on NPDES Permit No. IL0077666 Pond Creek Mine No. 1
Public Hearing: Wednesday, December 18, 2019
Submitted by William Sasso, 9 Pinewood Drive, Carbondale, IL 62901

Thank you for the opportunity to speak on this topic.

I speak against granting the requested permit, on the grounds that the increased release of contaminants into the Big Muddy River and its tributaries may not be adequately controlled and therefore may put the residents of Williamson, Franklin, and Jackson Counties at risk. Those risks include contamination of groundwater aquifers as well as risks from contact with the water itself, especially when the Big Muddy and its tributaries overflow their banks. Since the Big Muddy is itself a tributary of the Mississippi River, increased contamination of the Big Muddy clearly leads to increased contamination of the Mississippi, threatening additional residents of Union and Alexander Counties as well as those of of Missouri, Arkansas, Louisiana, Kentucky, Tennessee, and Mississippi.

My concern that the proposed contaminant discharges may not be adequately controlled is based on the sampling plans described in the Special Conditions section (pages 36 – 40) of NPDES Permit No. IL0077666, Notice No. 7516c (the Draft Renewed NPDES Permit to Discharge into Waters of the State Public Notice/Fact Sheet Issued By: Illinois Environmental Protection Agency Bureau of Water, Division of Water Pollution Control, Permit Section).

Here are my specific concerns.

First, the conditions specify ongoing monitoring of the discharge flows as well as monitoring of the rivers and creeks, both upstream and downstream of the proposed points of discharge. However, in Special Conditions 13 (see 13.b.ii and 13.b.iii), 14 (see 114.b.ii and 14.b.iii), 15 (see 15.b.ii and 15.b.iii), 16 (see 16.b.ii and 16.b.iii), and 18, sampling is required on an infrequent basis such as quarterly, semi-annually, or annually. In "Water Sampling: Traditional Methods and New Approaches in Water Sampling Strategy," published in Trends in Analytical Chemistry, Yolanda Madrid and Zoyne Pedrero Zayas state that "Sampling frequency is … an important factor …. Low sampling frequency could underestimate the occasional presence of samples with high analyte concentration." In other words, given that the mine wastewater will have varying levels of contamination over time, and that the creeks and rivers will flow at different rates within the normal range of river behavior, infrequent sampling may well fail to identify problematic levels of contaminants.

This issue is aggravated by the fact that even these minimal sampling schedules may be reduced or eliminated upon request by the Mine. That would mean that intermittent additional contamination of the river and its tributaries might not be detected at all. And while sampling downstream from the point of wastewater discharge is important, at best it enables us to close the barn door after the horse is gone.

A second issue is that the sampling is conducted by Pond Creek Mine, rather than by a disinterested third party organization. This assignment of responsibility creates potential for a significant conflict of interest, which could jeopardize the timeliness and accuracy of the water sampling and reporting process.

Finally, I am concerned about the reporting requirements specified in the Special Conditions. In many cases, the monitoring observations are reported to IEPA on a quarterly basis, meaning that a violation of the conditions under which the permit is requested might come to IEPA's attention as much as three

months after the violation occurred. In order to minimize risk to the public and the environment, I suggest that at minimum, 24-hour exception reporting standards be incorporated.

Let's remember that the Big Muddy River is part of our natural heritage, something that should be restored to its natural state rather than contaminated further. Even if humans don't use its waters for bathing or for drinking, many species of animals and migrating waterfowl do. Let's reject this permit as proposed, in order to respect and honor the interdependent web of nature.

The McCann Family and the Big Muddy River since 1871

My great grandfather James McCann was born in Ireland in 1831, he came to America and settled on the eastern bank of the river, south of Rattlesnake Ferry in 1871 at a spot called Kings Ferry. The USDA Forest Service has a picnic area in that general location named for my family, McCann Springs. My great grandfather and grandfather were loggers; they started a log yard at Kings Ferry.

My grandfather Charles McCann was born in 1872, my dad James was born in 1911, and I, Charles D. McCann was born in 1947. We (as a family) continue to own the property that was settled by my great-grandfather, the farm is on the county line with 40 acres in Jackson County and 259 acres in Union County.

As a child I was always attracted to the river, nothing was more fun than going to the Pine Hills Farm, we fished, hunted and trapped the river. We picked up pecans from the trees that our farmer, farmed around. Our farmer in my youth was an outdoors person named Howard Clover, he instilled in me a love for all things that were associated with the river.

I annually and have for years purchased a commercial fishing license my 2019 license # is 020370725 and my trapping license # is 020066686.

The river is full of fish. Catfish and buffalo (of various species) plus game fish are available to those that are willing to work for them. Otter, beaver, coons, mink and muskrats can all be taken along the banks of the river. Unfortunately right now wild fur is not in great demand but all these creatures can be found in good numbers along the river. I often see deer and wild turkey just west and north of the old Rt. 13 Bridge in Murphysboro.

For every big creature like an eagle, mallard duck, otter, beaver, turkey, deer, flathead catfish or buffalo fish that call the river and the surrounding area home, there are literally millions of lesser creatures that form the base of the food pyramid. These lesser creatures salamanders and crawfish for example are the first to be influenced by pollution; a slight change in the ph of the water for example, can spell disaster in the food chain. Without the food source at the base

of pyramid the creatures at the top won't last for long. Very few people come home saying, "You won't believe what I saw today, a newt."

How do you measure the economic valve of certain experiences? Gigging a bull frog at 2 am on the 4th of July, lifting a hoop net at dawn in the heat of the summer on my birthday in late August, picking up pecans on the afternoon of Veterans Day, shooting a fat coon from a oak tree a little after sunset on Christmas Eve, are all experiences that are associated with the river.

I also remember some negative experiences associated with the river. **In the 50's and early 60's the river would sometimes be full of dead fish from accidents at the tie plant in the Carbondale area.**

Others have different experiences that are river related, more people are into kayaking for example, the biggest challenged to river goers is access. Murphysboro Park has a boat ramp that was constructed in 1971, it is often muddied over, and while monies were appropriated for the construction no money was awarded for regular maintenance. The more river access points that are available, the more the public will take advance of the river. (that is another issue)

Coal and coal production is old school technology. I can remember when no one wanted their child/son to be a miner. Now for some strange reason the life (income) of a miner has become something that is positive. Let's focus on the new technologies that make life better for all and leave our streams, river and lands unpolluted. By allowing these companies the right to pollute, we are giving away what we have worked hard to achieve in quality over the past several decades.

Feel free to call (I have a conflict with another meeting that evening).

Charles D. McCann (mccan314@frontier.com) phone 618-457-6969

Charles D. McCann
618-457-6969 or 618-303-5079
2603 Highway 127
Carbondale, IL 62903

Exhibit 257

Barb Lieberoff, Mail Code #5

Re: Pond Creek Mine NPDES

Illinois Environmental Protection Agency

1021 North Grand Avenue East

P. O. Box 19276

Springfield, IL 62794-9276

Dec 19, 2019
Marion IL 62959

Dear Barb Lieberoff,

I attempted to send the following message to the address listed on the Pond Creek Hearing flyer, but it was not deliverable. Hence, I am sending it snail mail. Is the address listed in the flyer not correct?

From: Susan VanDyk <grandmavandyk@gmail.com>

Subject: **Pond Creek Mine**

Date: December 18, 2019 at 3:51:52 PM CST
To: epa.publichearingcom.illinois.gov@gmail.com

I am very concerned to hear about the potential dumping of wastewater from the Pond Creek Mine into the Big Muddy River. Please do NOT allow that. The mine should be required to treat and neutralize all contaminants on site, and not expect to use our public waters as their company sewer. I like to fish with my grandchildren and am very concerned that the IDNR, instead of protecting the environment for the people, may be placing a mining company's profits ahead of our ability to enjoy southern Illinois' natural beauty.

Thank you for considering my comment.

Susan Van Dyk
12565 Sarilda Ln
Marion, IL 62959

Susan VanDyk

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DEC 24 2019
THE OFFICE OF THE DIRECTOR

RECEIVED IN
OFFICE OF THE DIRECTOR

Van Dyk
12565 Sarilda Lane
Marion IL 62959

SAINT LOUIS MO 630
20 DEC 2019 PM 3 L



Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES
IL Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield IL 62794-9276

62794-927676

Exhibit 258

Barb Lieveroff
Mail Code #5:
Illinois Environmental Protection Agency,
1021 N. Grand Ave. East,
P.O. Box 19276,
Springfield, IL 62794-9276.

Re: Pond Creek Mine NPDES,

Please do not allow companies to discharge chloride, sulfate or other chemicals into the Big Muddy River. I am a taxpayer and do not want our waters polluted for the financial benefit of a company. In Southern Illinois, we depend on outdoor activities for our economic well being, such as tourist for the wineries or hunters coming here. Allowing these wastes into the public waterway will harm our economy.

Thank you

Barb Elam

Mrs. Barb Elam, MS
789 Boskydell Rd
Carbondale IL
62902

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DEC 2 4 2019
THE OFFICE OF THE DIRECTOR

David & Barbara Elam
789 Boskydell Rd.
Carbondale, IL 62902

SAINT LOUIS MO 630
13 DEC 2019 PM 7 L



Barb Lieveroff
Mail Code #5
ILL. E.P.A.
1021 N. Grand Ave East
PO Box 19276
Springfield IL 62794-9276

62794-9276

R03399

Exhibit 259

Karen Fiorino
45 Old US Hwy 51
Makanda, IL 62958
claylickcreek@gmail.com

RECEIVED IN
DEC 2 4 2019
THE OFFICE OF THE DIRECTOR

20th December, 2019

Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES Illinois Environmental Protection Agency
1021 North Grand Avenue East
P. O. Box 19276
Springfield, IL 62794-9276

Re: Pond Creek Mine IL0077666

Dear Madam,
I attended the public hearing for the Pond Creek Mine on 12-18-19 and I want to enter into the record comments questioning the validity to issue a permit for this mine to dump pollutants into the Big Muddy River.

1. Several documents have said the pipeline is only for 10 years and then it will be removed. Is this the projected end of the date of the coal seam and mine closure? On page APP B-1 the IL DOA of the Results of Review, Permanent Program Permit Application No 456, says the pipeline is only for 10 years. Is this the projected end of the mine and its closure? Especially in the light that the first commenter of the night and mine booster said the mine had enough coal for the next 50 years. The citation (https address) given is grossly inaccurate as there are spelling errors within the link itself. Plus, who is going to pay for the removal of this pipeline as Foresight energy stocks which Williamson Energy, LLC is a subsidiary are tanking, and Foresight as of 12-20-19 Files An 8-K Entry into a Material Definitive Agreement https://t.co/xrHayH1eAG .

Why would the IEPA issue a permit to a company when the company is going into bankruptcy? Because Williamson Energy is a LLC, in a chapter 7 business bankruptcy, the LLCs assets are sold and used to pay the LLC's creditors. After the bankruptcy, the LLC's remaining debts are wiped and and the LLC is no longer in business. The LLC's owners are generally not responsible for the LLCs debts like retirement, ESOPs and 401K's and the 500 or so employees of Williamson Energy will have more problems besides losing just their jobs. They will lose their retirement pensions as well.

2. To address the issue of oversight of discharge from the mine, How many Marion water pollution control and mine staff are there now versus 20 years

ago? There are 10 on staff 20 years ago and now 4. How will a staff of 4 people monitor the discharge from this mine along with all the other places in the region. Mines are to be inspected by the IEPA 2-4 times as a federal requirement. How many mine have between routinely inspected in the past 12 years? How many times has The Pond Creek Mine been inspected since the mine began?

How does a staff of 4 manage to do this while writing mining permits for mining companies? As per,

https://www.chicagotribune.com/news/environment/ct-met-illinois-epa-budget-cuts-20191205-pkwnmzzvuvgk3fgbplvxhbji6q-story.html Illinois also cut its environmental agency's workforce by 38% during the same period — more than any other state.

With a smaller staff and less money, the state agency has failed repeatedly to identify hazards to public health and hold polluters accountable, said Eric Schaeffer, a former top U.S. EPA enforcement official who directs the nonprofit Environmental Integrity Project and compiled one of the reports.

In conclusion, these comments along with the multitude of comments against issuing of a permit for Pond Creek Mine a private company to dump pollutants into a public waterway from my fellow citizens of the area implore you to not approve the permit referenced above to the Pond Creek Mine.

Sincerely,

Karen Fiorino

Karen Fiorino

Karen Fiorino
45 Old Us Highway 51
Makanda, IL 62958



SAINT LOUIS MO 630
20 DEC 2019 PM 3 L



Barb Lieberoff, mail code #5
RE: Pond Creek Mine NPDES Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276

62794-927676

R03402

Exhibit 240 R03403

To Whom it may concern,

As a southern Illinois coal miner, I just want to say that I am shocked and in a total state of disbelief that the EPA would sit back and let a coal mine dump millions of gallons of water into one of our rivers.

It is embarrasing to call myself a coal miner at this point. The track record of Bob Murray and the mines that he operates is proof alone that none of these people actually care about the coal miner.

It is up to you to defend our environment. By letting this happen, you are proving that the EPA is a pointless, farce. You are proving that the environment is not what you are protecting, it is the wallets of billionaire coal mine owners and the lobbyist groups at their feet.

Jason Stephenson
Knighthawk Coal

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To whomever it may concern:

I would like to state the reasons as to why allowing mine waste to be dumped into the big muddy river is a bad idea + why I do not support it.

The Big Muddy river is a water source for many people around here. Having mine waste dumped into the river would cause the people to have to drink contaminated water. The waste has many different chemicals in it, + none of which are healthy to ingest. No one can be sure of the long time effects this has on a person, or the sicknesses that could be caused by the mine waste. [redacted] animals, including fish + birds, would also be negatively affected. Since the fish digest the water, they could become sick, which would then cause the animals that ate the fish, including humans, to become sick. There is literally nothing good that would come out of this. It's not worth the possible damage that could happen.

Thank you, for your Consideration,

Bella Stephenson

age 15

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DEC 24 2019
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To whom it may concern:

I want to publicly state that I do not support the possibility of polluted mine water waste being dumped into the Big Muddy. Nobody can be sure of the long term outcome as far as wildlife or the effect on humans. I'm sure Bob Murray wouldn't want his family swimming in it. Why should we have to. Water is Sacred. Water is life. Take Care of it.

Sincerely,
Alycia Snyder

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To Whom it may concern,

I am worried on mine waster could cause fish and kids to get sick.

Sincerely,
Sofia Stephenson

age 9

RECEIVED IN
DEC 2 4 2019
THE OFFICE OF THE DIRECTOR

Stephenson
704 Clark School Rd.
De Soto, IL
6*2*9*2*4

ST LOUIS
MO 630
20 DEC '19
PM 6 L

FOREVER 834891123114335



Barb Lieberoff
Mail code #5,
Re: Pond Creek mine NPDES
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276

R03407

Exhibit 201

From: Margaret Shaklee
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 5:08:51 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Margaret Shaklee
1212 Croft Lane
Evanston IL 60202
847-328-7954

Exhibit 242

From: Dianne Ansari-Winn, MD
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 5:11:41 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 203

From: Vince Unger
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 5:12:40 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

THANKS.

Peace and Solidarity,

vince
847.224.3202

"I side with Love, hate is too much a burden."
- Dr. Martin Luther King Jr.
Sent with AquaMail for Android
https://www.mobisystems.com/aqua-mail

Exhibit 204

From: Karen Kortsch
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 5:13:35 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Karen Kortsch
13279 W Heiden Cir, Lake Bluff, IL 60044

Exhibit 205

From: Nancy Irons
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 5:14:32 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Nancy Irons
156 Dogwood Street
Park Forest, IL 60466
708-712-3228

Exhibit 206

From: Adair Small
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 5:15:47 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Adair B. Small
1721 W 104th PL
Chicago, IL 60643
773-238-2803

Exhibit 247

From: Pamela Rumancik
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 5:17:50 PM

Greetings -
DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.
We are connected to this earth and destroying ourselves through greed and lack of care for our earth home. Please prioritize human life over monetary gain.

blessings,
Pam Rumancik

Rev Pamela Rumancik
She/Her/Hers
Unitarian Church of Hinsdale
C. 440-570-9812

We are undone by each other. And if we're not, we're missing something. ~Judith Butler

Don't ask what the world needs. Ask what makes you come alive, and go do it. Because what the world needs is people who have come alive. ~Howard Thurm

Exhibit 208

From: Karen Fort
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 5:20:21 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.
Karen O Fort

Exhibit 209

From: Marcia Bernstein
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 5:25:17 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Marcia Bernstein

Sent from my iPad

Exhibit 270

From: Terry Kinsey
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 5:27:00 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 271

From: Beth Dowell
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 5:29:16 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Dr. Elizabeth Dowell, MD

Exhibit 272

From: Renee Hoff
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 5:48:01 PM

Please DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Thank you for allowing me to voice my concern!
Renee Hoff
1600 Thelin Court
Evanston, IL 60201

Exhibit 273

From: Julie Prandi
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 5:58:19 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 274

From: bmerbe@gmail.com
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 6:00:35 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to the highest standard of environmental protection.

Brigitte Erbe
433 W Roslyn Place
Chicago, IL 60614

Sent from Mail for Windows 10

Exhibit 275

From: MaryAnne O"Toole
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 6:02:13 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River.

As a citizen of Illinois AND THE EARTH, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Mary Anne OToole
2246363162

Exhibit 274

From: Mary Corazza Parks
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 6:05:10 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Mary Parks

Exhibit 277

From: Diana Heizer
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 6:22:38 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Diana Heizer

Sent from my iPhone

Exhibit 278

From: Ruth Reagel
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 6:32:14 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Sincerely, Ruth Reagel.

Exhibit 279

From: James Hobart
To: EPA.PublicHearingCom
Subject: [External] Big Muddy dumping
Date: Tuesday, December 17, 2019 6:47:58 PM

In this age, when we have learned the damage and cost of industrial pollution dumping toxic wastes into our public waterways, it is unconscionable to allow these practices to continue. Show the way toward a revived climate and a Fair Earth Home by rejecting this proposal to dump toxic wastes into the Big Muddy and the Mississippi River further downstream.

The Rev. James A. Hobart
Chicago
Retired Unitarian Universalist Minister

Exhibit 280

From:	Jennifer Livingston
To:	EPA.PublicHearingCom
Subject:	[External] Pond Creek Mine, IL0077666
Date:	Tuesday, December 17, 2019 6:48:30 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

We need to hold corporations responsible for the environmental damage that their practices cause, reflecting the true cost. Don't allow this pollution of our water.

Sincerely,
Jennifer Livingston
1212 Oak Creek Rd, Mahomet, IL 61853

Exhibit 281

From: Debbie Montgomery
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 6:51:58 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 282

From: Kathleen O"Laughlin
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 7:09:26 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.
Kathleen O'Laughlin
Carbondale, IL

Sent from my iPad

Exhibit 283

From: Sunny and Tom Hall
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 7:23:36 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 284

From: Donna Schiller
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 7:29:51 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Sent from my iPhone

Exhibit 285

From: Robert D B
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 7:37:08 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Thank you,
Robert Bulanda
60429

Exhibit 286

From: Barbara Ghoshal
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 7:41:00 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Sincerely,
Barbara Ghoshal
Des Plaines, IL 60016

Exhibit 287

From: Craig & Glenda Shaver
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 7:47:01 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Sent from my iPhone

Exhibit 288

From: Carden, Jerry A
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 7:54:09 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection. I grew up 10 miles from the Mississippi, and discharging such waste water into a river heading for the Mississippi is just the epitome of an asinine proposal.
Jerry Carden
Urbana, IL, and also an owner of farmland near the Mississippi at Burlington, Iowa.

Exhibit 289

From: Linda Groetzinger
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 8:11:56 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.
Linda Groetzinger
Chicago, IL

Exhibit 290

From: Kristin Lems
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 8:19:10 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Thank you ~~ Dr. Kristin Lems

Exhibit 291

From: Mike Pabian
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 8:29:12 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.
Michael Pabian

Exhibit 292

From: Eleanor Hall
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 8:41:57 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc. to a higher standard of environmental protection.

This waste water is not something that should be discharged into the Big Muddy River. It would seriously contaminate the Big Muddy.

Sincerely,

Eleanor Hall
1400 E. 55th Pl., #711-S
Chicago, IL 60637

773-324-2304

Exhibit 293

From: John Malan
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 9:28:51 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.
We are the United States of America. This kind of thing must not be allowed to happen here!
Sincerely,
John Malan
(formerly of Du Quoin)

Exhibit 294

From: Martha Holman
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 9:43:20 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Thank you for considering this!

Exhibit 295

From: Mary Ellen McGoey
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 9:59:48 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Thank you.

Mary Ellen McGoey
5 Oxford Road
Lake Forest, IL 60045

Exhibit 296

From: Parr, Jim
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 10:03:30 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 297

From: Olson Potthoff
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 10:52:44 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

I'm concerned about the water going into in the Mississippi River, polluting water for those nearby and downstream.

Tracey Olson
4053 Woodland
Western Springs, IL 60558

Exhibit 298

From:	Nancy Sidman
To:	EPA.PublicHearingCom
Subject:	[External] Pond Creek Mine, IL0077666
Date:	Tuesday, December 17, 2019 10:59:30 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 299

From: Jennifer Evans
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, December 17, 2019 11:18:27 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Sent from my iPhone

Exhibit 300

From: Allen Harden
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 12:09:33 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 301

From: Wanda Hoover
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 6:23:59 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 302

From: Anne White
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 6:46:03 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Sent from my iPhone

Exhibit 303

From: Parry Stevens
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 6:48:37 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine, Inc. to a higher standard of environmental protection.

It is so obvious that this is a total disregard for the environment, now and going forward. Will the responsible folks please search their souls and think of the planet we someday bequeath to our loved ones and descendants ?

Thank you.

Exhibit 304

From: Susan Frances
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 7:38:29 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Sincerely,
Susan Frances

Exhibit 305

From: Andrea Schmidlin
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 7:41:50 AM

As a Unitarian Universalist, my faith calls me to respect the interdependent web of all existence of which we are a part.

I am writing to ask that you NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Andrea Schmidlin
Elgin, IL

Exhibit 306

From: William Koehl
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 8:16:46 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate wastewater into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

William Koehl
UUSG - UU Geneva
2280 Bloomfield Circle
Geneva, IL 60134

Exhibit 307

From: webdurkin@comcast.net
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 8:18:55 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection
Ruth Durkin

Sent from my Sprint Phone.

Exhibit 308

From: Rosemary Maziarz
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 8:37:01 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate wastewater into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection. Since our current POTUS is doing everything he can to undermine a clean environment states need to step in and prevent polluters to clean up their act.

Sincerely,
Rosemary Maziarz

Exhibit 309

From: Joyce Haeckel
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 8:53:30 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Joyce Haeckel

Exhibit 310

From: Michael Moutrie
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 9:03:41 AM

Regarding today's public hearing,

Please DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Mike Moutrie

Exhibit 311

From: andreabudasi
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 9:08:12 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Sent from my Samsung Galaxy smartphone.

Exhibit 312

From: Lisa Solomon
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 9:19:29 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Sincerely,

Lisa Solomon

Exhibit 313

From: VOHNY MOEHLING
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 9:25:50 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

DON'T ALLOW THIS TRAVISTY! sincerely, vohny moehling

Exhibit 314

From: Lydia Larrabee
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 9:45:54 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Lydia E. Larrabee

Exhibit 315

From: Madeleine Van Hecke
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 9:47:50 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 310

From: Judy Medina
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 10:14:48 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Sent from my iPhone

Exhibit 317

From: Bill Scown
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 10:50:21 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.
Sent from Mail for Windows 10

Exhibit 318

From: Pam Richart
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 10:50:28 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Pam

Exhibit 319

From:	jeanpierce@aol.com
To:	EPA.PublicHearingCom
Subject:	[External] Pond Creek Mine, IL0077666
Date:	Wednesday, December 18, 2019 10:53:23 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River.

As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Jean Pierce

Exhibit 320

From:	Lisa Gades
To:	EPA.PublicHearingCom
Subject:	[External] Pond Creek Mine, IL0077666
Date:	Wednesday, December 18, 2019 10:56:43 AM

Dear EPA Staff,

Please do not allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection. Our water resources are some of our most important to protect, especially as we watch other parts of the country struggle with water shortage. It would be short-sighted to allow extra pollution into one of Illinois' rivers.

Thank you for your consideration,

Lisa Gades

Exhibit 321

From: Rachel McManus
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 11:25:19 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 322

From: janeellen2820
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 11:51:47 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.
Jane kimball Dundee,Il

Sent from Samsung tablet

Exhibit 323

From: Jen Packheiser
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 11:55:58 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Let's keep our waterways clean.

Thank you-

Jen Packheiser

Exhibit 324

From: Mary Alice Masonick
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 12:27:34 PM

I am a citizen of Illinois and am strongly opposed to the dumping of toxic chemicals into the Big Muddy River. DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Look forward to your response.

Mary Alice Masonick
38W668 Ridgewood Lane
Elgin IL 60124
847-931-4363

Exhibit 325

From: Joe Masonick
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 12:32:17 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection. Do not dump toxins in rivers! - Thank you.

Joe Masonick 38W668 Ridgewood Elgin, IL 60124 847-931-4363

Sent from my iPhone

Exhibit 326

From: Carol Ovelmen
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 12:48:02 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Sent from Yahoo Mail on Android

Exhibit 327

From: Kathie Wachholder
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 12:58:06 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection
Kathie Wachholder
100 Summit Dr
Gilberts, IL

Exhibit 328

From: SUSAN COLEMAN
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 1:42:58 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Susan Coleman
Bloomingdale, IL

Exhibit 329

From: Shirley Adams
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 3:32:07 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

--

Sent from Gmail Mobile

Exhibit 330

From: Trilby Evans
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine
Date: Wednesday, December 18, 2019 3:34:39 PM

Dear DNR,
I don't think it's a good idea to pollute the Big Muddy. Please stop the Pond creek mine people from doing it. It will travel all the way to the gulf of mexico, probably. Pollution is very bad for the ecosystem and all the animals and fish. Please think about that when you make your decision.

Trilby Evans
2114 market Rd.
Marion, IL 62959

Exhibit 331

From: Lida Burns
To: EPA.PublicHearingCom
Subject: [External] Pond creek mine
Date: Wednesday, December 18, 2019 3:39:07 PM

To whom it may concern,

I am against this pipeline due to several concerns regarding water levels of the river, wildlife/human safety among others.
I agree that no company should dump their waste and essentially, "problems" into public water ways. The risk is too great regarding safety for many reasons.

I am one of the ones against this pipeline.
I was not able to attend the public meeting but wanted to express my opinion on the matter.

Thank you for your time,
Lida E. Burns

Lidaburns@yahoo.com

Exhibit 332

From: Marsha Borders
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 3:40:42 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 333

From: Alex Matthews
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 4:25:08 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Alex Matthews

Exhibit 334

From: Beth Cralley
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine
Date: Wednesday, December 18, 2019 4:48:24 PM

I am writing to formally note my strong opposition to Pond Creek Mine dumping mine waste into our waterways. My family hunts and fishes in and near the Big Muddy River and we have seen first hand some of the runoff issues from mines in other areas. There are too many unknowns and several issues with this deal are suspicious. It is NOT worth the risks. I am at St. Jude Children's Research Hospital at this moment with my son with brain cancer. When waste is poured into unnatural places like this, we have no idea the possible outcomes. How many times must we learn these lessons? Come look these bald and sick children in the eyes and tell them you're going to allow this. Again these risks are NOT worth it. I doubt the powers that be would be willing to live near and eat from this river with no concerns. If they say they are okay with it, they are either lying or ignorant. Please don't allow this to happen.

Sincerely,
Elizabeth McKinney
14 Meininger Rd Vergennes, IL 62994

Exhibit 335

From: Jacquelyn Seaman
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 4:55:22 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Jacquelyn Seaman
Sent from my iPhone

Exhibit 336

From: David Foulser
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 4:57:37 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection. Thanks

Exhibit 337

From: Ronald Campbell
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine
Date: Wednesday, December 18, 2019 5:22:30 PM

It is my opinion that the dumping of waste water from Williamson Energy's mine into the Big Muddy River is not in the best interest of the public, and is an environmentally poor use of our waterways. I am against the dumping of polluted water into our public rivers for the benefit of a private enterprise.

Exhibit 338

From: Debra Singleton
To: EPA.PublicHearingCom
Subject: [External] DENY W.E. pipeline permit
Date: Wednesday, December 18, 2019 6:39:47 PM

To the Illinois EPA:
I am writing to express my STRONG OBJECTION to Williamson Energy's permit for the Pond Creek Mine that would allow them to build a 12.5-mile discharge pipeline into the Big Muddy River. It is irresponsible to allow the discharge of millions of gallons of highly toxic high-chloride and sulfate water into the Big Muddy - or any waterway. Given that the Big Muddy is a major public waterway and a principal tributary of the MIssissippi River, any toxins released into the Big Muddy would not only contaminate the environment of the Big Muddy, they would also flow downstream into the Mississippi, affecting a large number of communities downstream from the discharge. Furthermore, when the Mississippi backflows into the Big Muddy, toxins intended to flow downstream would flow back into the big Muddy watershed, adversely affecting agricultural areas and communities for 40 miles along the Big Muddy.

This is an issue that affects public health, the health of ecosystems and agriculture, and environmental justice. Any company that operates in our state must be held accountable for the toxicity of its byproducts and for handling them in a fashion that protects public and environmental health - not forcing the public and the ecosystem to suffer the consequences and costs of dumping them into public tributaries.

I urge you to DENY the Williamson Energy request for this discharge pipeline permit.

Sincerely,
Debra Singleton
1135 Warrington Rd
Deerfield, IL 60015

Exhibit 339

From: Greg Clark
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Wednesday, December 18, 2019 7:19:59 PM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Sent from my iPhone

Exhibit 340

From: Zeivel, Christine on behalf of EPA.PublicHearingCom
To: "Sam Stearns"
Subject: RE: Pond Creek Mine NPDES, Permit No. IL0077666
Date: Sunday, January 12, 2020 1:10:00 PM

Sam,

Your comments will be entered into the public hearing record for NPDES Permit No. IL0077666 as Exhibit 340. We are unable to open the document attached to the original email. If you have comments that are not provided in the body of the e-mail below, please provide them in a follow-up e-mail to EPA.PublicHearingCom@illinois.gov. The Agency appreciates your comments and would like to ensure that we have received all of them.

Your email address will be added to the list of contacts receiving notice of final agency action in this matter and the availability of the Responsiveness Summary that addresses comments received during the public comment period.

Thank you,

Christine Zeivel
Hearing Officer, Illinois EPA
Office of Community Relations
217.524.1628

From: Sam Stearns <bellsmithsprings@hotmail.com>
Sent: Wednesday, December 18, 2019 7:35 PM
To: EPA.PublicHearingCom <EPA.PublicHearingCom@Illinois.gov>; EPA.PublicHearingCom <EPA.PublicHearingCom@Illinois.gov>
Subject: [External] Pond Creek Mine NPDES, Permit No. IL0077666

Attached and below please find AND RESPOND TO my comments:

794 Ozark Road

Stonefort, Illinois 62987

December 17, 2019

Attention: Barb Lieberoff, Mail Code #5

Illinois Environmental Protection Agency

1021 N. Grand Ave. East

P.O. Box 19276

Springfield, IL 62794-9276

epa.publichearingcom@illinois.gov

Re: Pond Creek Mine NPDES, Permit No. IL0077666

Dear Barb Lieberoff---

My name is Sam Stearns. I am the third generation of my family which has worked in coal mines: both my grandfathers came to Southern Illinois from Europe to mine coal. My father retired from Sahara Coal Company; many of my male relatives worked in the mines; and I myself worked underground for Zeigler Coal Company.

I grew up in Two Patch, a suburb of the old coal mining community of Ledford, just outside of Harrisburg. Two Patch was named for the Old Number Two Mine which had operated there long before I was born. I grew up playing on the old mine spoils and swimming in the mine pits in that area. My parents loved me. Had they known what we now know about the poison soil which is brought to the surface by mining; had they known about the chemicals leaching into those pits; they would never have let me play in those places. But they did, out of honest ignorance---they simply did not know any better.

We can no longer plead ignorance.

There are already too many acres of blighted mined land in Williamson and surrounding counties. Thousands of acres of land in this area are already spoiled and poisoned for innumerable years to come---FOREVER in terms of human existence.

Once the topography and the hydrology of the land is changed, it is changed forever. The notion of mine reclamation is a fraud. It is simply putting makeup on a corpse.

I realize that periodically extractive industries like coal and government bureaucracies like the IEPA and IDNR will hold ceremonies where they slap each other on the backs and give each other plaques & awards and congratulate each other on how well they have "reclaimed" some small piece of land in those thousands of mined acres or "mitigated" some environmental degradation; but I repeat, mitigation efforts and reclamation are a fraud; it is putting makeup on a corpse.

Diluting mine discharge water or putting a few inches of top soil back on top of many feet of poison substrate can produce some shallow-rooted crops for a few years as long as that layer of topsoil is treated with probiotics and fed fertilizers. But the soil structure and hydrology are changed forever and that land will never be able to support deep-rooted native trees and plants again.

Citizens like me who have watched these coal wastelands for decades have little confidence in the state agencies which are charged with protecting us and our streams from the discharges of these polluting sacrifice zones. We know that agencies such as the IEPA operate at the whim of politicians who are in the pocket of industry and are many times staffed with corporate shills who put the interests of industry over the health of our citizens.

My parents let me play in poisoned soil and swim in poisoned water out of benign, honest ignorance of the situation. But we no longer have the luxury of ignorance: now we know better.

That is why I ask you to deny this proposed permit for a discharge of mine water into the watershed of the Big Muddy River. We now know that there is no way that the pollutants from the water and soil of a coal mine can be safely discharged into the watershed of the Big Muddy without harming citizens of this State.

I would like to ask

Has the IEPA ever rejected a mine discharge permit, even to a company which has a record of serial violations of their mining permits?

Does the IEPA have the authority to refer a case to the Illinois Attorney General when permit violations are found; and if so, how many times has the IEPA done so?

These are comments for Pond Creek Mine NPDES Permit No. IL0077666, specifically regarding the portion of the permit concerning Outfall #011 which would allow significant amounts of mine wastewater to be pumped into the Big Muddy River. I have visited the Big Muddy River and various places in its watershed for most of my 65 years.

I am adamantly opposed to this permit as is. At minimum, there needs to be a proper filtration system for wastewater; using a dilution method with the river's own water is not going to be able to filter millions of gallons of toxic water that is going to be discharged. We should be long past the pathetic rhetoric that dilution is the solution for pollution. The following pages list some of the concerns and questions I have after reading through the draft permit and related materials concerning this issue. I believe, they all have a direct relation to the Clean Water Act and antidegradation analysis. This is by no means an exhaustive account of my concerns.

Williamson Energy History of Violations

The Attorney General (on behalf of the people of Illinois) sued Williamson Energy February, 2019 on eight counts of violations that occurred in 2016 due to a pump failure which dumped approximately 90,000 gallons of coal slurry/acid mine discharge into an unnamed tributary of Pond Creek. An example of some of the counts include: discharging contaminants into the water; depositing contaminants onto the land; violating water quality standards for chloride and iron; and INTENTIONAL diversion of a waste stream from sediment pond to and outflow into a tributary of Pond creek. There was only one announcement in the Marion Republican regarding this case; no one requested a hearing. Williamson Energy did not admit to the violations, and the case was settled without a hearing. They only had to pay a civil penalty for $80,000 even though five of the eight counts had a $50,000 penalty (the other three had $10,000 each).

According to information provided in the Pond Creek Watershed Inventory (2019) created by Greater Egypt Regional Planning and Development Commission, Williamson Energy had over 45 outfall effluent violations between 2015 and 2017 (Source of violation history is from EPA-ECHO). Some of the pollutants include: chloride, sulfate, nitrogen, pH, manganese, and total dissolved oxygen (TSS).

Question: How many more violations have occurred since 2017? How many violations in total does Williamson Energy have? Have the impacts of these violations on aquatic life been assessed?

Question: Are there any IEPA regulations or stipulations under the Clean Water Act regarding granting new permits or additions to existing permits when the company requesting them have an extensive history of violations? Citizens do not get to keep violating law without increasing consequences (e.g. prison time, permanently losing a driving license, losing child custody, etc.). If there are not rules/regulations which can prohibit granting companies new permits and/or terminating a permit due to continued and repeated violations which cause harm to the environment and its inhabitants, then the IEPA needs to create them. Companies should not be allowed to violate laws endlessly with only monetary fines as their penalty.

Question: Can the IEPA be held accountable by law for allowing a pipeline to discharge acid mine drainage with elevated concentrations of numerous pollutants into a river that is currently listed as impaired and is also a candidate for wild and scenic river designation?

There were 11 violations related to sulfates and ten to chloride in Pond Creek, a tributary of Big Muddy River (Pond Creek Watershed Inventory, Greater Egypt Regional Planning and Development Commission, 2019, p.85). In addition, the report states the following:

• "…chloride is listed as an impairment to aquatic life in the waterbody." (p.74)

• "The mine also had a number of single event violations including: improper operation and maintenance, numeric effluent, unapproved bypass, and an unauthorized discharge." (p.85)

• "Pond Creek has been listed for chloride and sedimentation/siltation impairments since 2010, and dissolved oxygen since 2012. In 2008, the stream was listed for iron, manganese, pH, total suspended solids (TSS), and fecal coliform." (p.74)

• The Illinois Integrated Water Quality Report categorizes Pond Creek as having three designated uses; aquatic life, which is not supported… (p. 72)

Water Quality

In the IEPA Big Muddy River TDML 2004 report it states that the Big Muddy River is a compromised and impaired river and is due in part because of mining operations. It states that "abandoned coal mines should be identified in addition to other mining activity which could contribute to manganese and sulfate concentrations…" According to the Antidegradation Analysis report (2016), the Big Muddy River is listed in the 2014 Section 303 (d) list for sedimentation/ siltation, sulfates, total suspended solids (TSS), mercury, and polychlorinated biphenyl (PCBs). The site is on the 2016 Section 303(d) list for impaired waters due to sedimentation/ siltation, TSS, mercury, PCBs, iron, dissolved oxygen, pH, and fecal coliform.

And just recently, the Upper Big Muddy River TDML Report (IEPA 2019) was released which stated that elevated concentrations of Iron and Manganese were found in Big Muddy Watershed and according to IEPA have negative impacts on aquatic life.

Iron TMDL: IEPA identified one segment, Andy Creek (IL_NZN-13), with elevated concentrations of dissolved iron. Elevated concentrations of dissolved iron can negatively impact aquatic species by disturbing normal metabolic and osmoregulatory functions. Aquaculture studies have also demonstrated that increased dissolved iron concentrations in the water column may negatively impact gill functionality in certain fish species and thus reduce biodiversity in certain stream environments. 4 Excessive iron within the water column may harm aquatic species such as fish and macroinvertebrates. Certain metals species dissolve in water and may be absorbed by fish and other aquatic organisms. Small concentrations of certain dissolved metals may be, in the short term, toxic to fish and aquatic species and, in the long term, may bioaccumulate in certain aquatic species.

Question: Why is the water quality standard for Iron listed on the draft permit for the Pond Creek Pipeline as 3mg/6mgL when the standard on the IEPA Water Quality Standard Report 2019 states that the acceptable level is 1mg/L?

Manganese TMDL: IEPA identified one segment, Beaver Creek (IL_NGAZ-JC-D1), with elevated concentrations of dissolved manganese. Elevated dissolved manganese concentrations in the water column have many of the same negative effects of dissolved iron on fish species and biodiversity of the water column and benthic environments. Excessive manganese within the water column may harm aquatic species such as fish and macroinvertebrates. Certain metals species dissolve in water and may be absorbed by fish and other aquatic organisms. Small concentrations of certain dissolved metals may be, in the short term, toxic to fish and aquatic species and, in the long term, may bioaccumulate in certain aquatic species. (Upper Big Muddy River TDML Report, IEPA, 2019).

The Union of Concerned Scientists state that

"mining operations can negatively impact water supplies, often with long-lasting effects. The fundamental issue involves contamination of nearby rivers, lakes, and aquifers by what comes out of a coal mine—usually highly acidic water containing heavy metals like arsenic, copper, and lead. The process is known as acid mine drainage. It happens when certain substances (typically iron sulfide, FeS2, or fool's gold) is oxidized after being exposed to air and water. Runoff can change the pH of nearby streams to the same level as vinegar (Coal and Water Pollution, Union of Concerned Scientists,https://www.ucsusa.org/clean-energy/coal-and-other-fossil-fuels/coal-water-pollution, Accessed 7.22.2019.)

According to U.S. Fish and Wildlife, "Because acid mine drainage can destroy a stream's aquatic community for miles, many of the old mining sites are being reclaimed (Acid Mine Drainage, U.S. Fish and Wildlife, https://www.fws.gov/mountain-prairie/contaminants/acidMineDrainage.php, accessed 7.2019)

Question: Does this mean then that the IEPA is going against its own implementation plans (2004/2019) by considering granting a permit for a pipeline which will infuse the river more with elevated levels of chlorides, sulfates, manganese and other pollutants? Does this not go against the Clean Water Act?

Interestingly, there is no mention of the Pond Creek in the TDML IEPA 2019 Upper Big Muddy Watershed report, even though other tributaries are discussed.

Question: Why is Pond Creek not included in this report since according to the Greater Egypt Regional Planning and Development Commission just released a watershed-based plan (2019) which was created because of the creek being polluted? It is already polluted with some of the very pollutants the mine will be discharging such as chloride, iron, manganese, and TSS.

In 2018 and 2019, The Big Muddy River had a fish advisory for mercury by the Illinois Health Department. Mercury is one of the pollutants which is to be monitored in the acid mine discharge. The advisory for Mercury has recently been removed from the website.

Question: Why has the mercury advisory suddenly been lifted?

Question: Has the fact that elevated sulfates can cause Mercury to undergo methylation into its most toxic form methylmercury according to Orem, W. in "Sulfate as a Contaminant in Freshwater Ecosystems: Sources, Impacts and Mitigation" (U.S. Geological Survey, assessed 10.2019)

Chlorides

IEPA has listed the acceptable levels for chloride concentrations in waterways as 500mg/L. According to the Pine Creek Pond Permit Application No. 456, samples taken of the mine wastewater showed high levels of both chlorides and sulfates that far exceed the acceptable level for water quality standards. The average chloride concentration of the samples taken was 2, 237 mg/L.

• The national standard for sustaining aquatic life is 230mg/L for chronic (long-term) levels and 860 mg/L for acute (short-term). (https://www.epa.gov/wqc/national-recommended-water-quality-criteria)

• Missouri revised their chloride levels in 2012 to 178mg/L for chronic and as low as 288mg/L for acute. (EPA Region 7, 2015)

• Indiana adopted new criterion in 2012 for chloride levels for Lake Michigan to be 250 mg/L. (Indiana Preliminary Adopts Revised Chloride and Sulfate Water Quality Criteria, BDlegal.com, 2019).

• According to Kentucky state website (2019), acute chloride levels ranging from 2500 to 8400 mg/L can be toxic to aquatic life such as snails, minnows, catfish, and trout.

• Another study by University of Rhode Island has much lower long-term exposure rates of 250mg/L and 860 mg/L for short-term exposure. (Hunt, Herron, & Green. Chlorides in Fresh Water. University of Rhode Island. March 2012)

Question: Why does Illinois EPA have much higher accepted levels of chloride than surrounding states especially since what is considered to be safe levels for aquatic life is much lower than the Illinois accepted level of 500mg/L? Why does IEPA not have both an acute and a chronic level like other states and the national standard?

Question: According to the draft permit for the pipeline samples taken from the acid mine discharge showed chloride levels greater than 2,000 mg/ and levels of up to 12,000mg/L are permissible from the discharge point into the Big Muddy River. This grossly exceeds both the national and state accepted levels. How can the IEPA allow such a gross violation of its own and national regulation? 12,000mg/L would be 48x the national standard and 24x the state standard. Is it truly be diluted "immediately" and rapidly" which is what is stated in the In Section 302.102 12(e) Allowed Mixing, Mixing Zones and ZIDs (TITLE 35: ENVIRONMENTAL PROTECTION SUBTITLE C: WATER POLLUTION CHAPTER I: POLLUTION CONTROL BOARD PART 302 WATER QUALITY STANDARDS SUBPART A: GENERAL WATER QUALITY PROVISIONS, 2019)

Sulfates:

The accepted sulfate level is listed as 1250 mg/l on the draft permit; however, the average sulfate concentration taken from the Pond Creek mine wastewater was 1,940 mg/L and the IEPA antidegradation assessment states that the levels to be discharged to the Big Muddy River could be as high as 2,120 mg/L sulfate. This would be the equivalent of 476,000 pounds per day of sulfate.

According to Kentucky State website (2019). "Problems caused by sulfates are most often related to their ability to form strong acids which change the pH. Sulfate ions also are involved in complexing and precipitation reactions which affect solubility of metals and other substances."

In addition to the afore mentioned pollutants in the Big Muddy River, the IEPA has recently listed four sections (IL0029165, IL0031704, IL0027871, IL0027898) of the Big Muddy River under the Nutrient Assessment Reduction Plan/Illinois Nutrient Loss Reduction Strategy Implementation (2019). These sections of the river are all downstream from the proposed pipeline.

According to a study by Kaushal in 2005, many of our waterways are becoming victims of 'freshwater salinization syndrome', where "high levels of chloride and other salt ions can kill freshwater animals, from zooplankton at the base of the food web to insects and fish, because they make it hard for the creatures to osmotically regulate their cell's ion concentrations." Furthermore, the study states that high levels of chlorides and other salts can cause more algal blooms due to dying off of algae-eating zooplankton which in turn can cause the releasing of toxins and deplete oxygen. In addition, higher salt levels can "favor invasive species that better survive in brackish water," and "at nonlethal levels, salt can stunt the reproduction and growth of freshwater organisms, lowering biodiversity and shifting the structure of the food webs." (For Healthier Lakes, Rivers, and Drinking Water Hold the Salt, Lockwood, D., Chemical and Engineering News, 2019).

Question: Has the IEPA considered the impact of discharging millions of gallons of unfiltered mine wastewater with elevated levels of chlorides, sulfates and other contaminants on the already elevated nutrient load of the Big Muddy River which is supposed to be being mitigated?

Question: Has the EPA taken into consideration current studies regarding effects of salination on aquatic animals?

Mixing Zones

There are numerous issues with the granting of this permit which could possibly violate the water quality standards as listed by the IEPA Pollution Control Board (2019):

In Section 302.102 Allowed Mixing, Mixing Zones and ZIDs.

4) Mixing is not allowed in waters containing mussel beds, endangered species habitat, fish spawning areas, areas of important aquatic life habitat, or any other natural features vital to the well-being of aquatic life in such a manner that the maintenance of aquatic life in the body of water as a whole would be adversely affected.

Question: Has this been determined by the IEPA/IDNR? There was no mention of this in the draft permit.

6) Mixing must allow for a zone of passage for aquatic life in which water quality standards are met.

Question: Has this been determined? Again, there was no mention of this in the permit.

7) The area and volume in which mixing occurs, alone or in combination with other areas and volumes of mixing, must not

intersect any area of any body of water in such a manner that the maintenance of aquatic life in the body of water as a whole would be adversely affected.

Question: Has the current state of the river (i.e. known pollutants) as well as the Sugar Creek Mine discharge pipeline been considered in determining this?

9) No mixing is allowed when the water quality standard for the constituent in question is already violated in the receiving water.

Question: Given that the Big Muddy River already has elevated levels of sulfates and manganese, mixing would be violating this regulation. How then can a permit be granted for a mixing zone?

12) The area and volume in which mixing occurs must be as small as is practicable under the limitations prescribed in this subsection (b), and in no circumstances may the mixing encompass a surface area larger than 26 acres. c) All water quality standards of this Part must be met at every point outside of the area and volume of the receiving water within which mixing is allowed. The acute toxicity standards of this Part must be met within the area and volume within which mixing is allowed, except as provided in subsection (e).

e) Pursuant to the procedures of Section 39 of the Act and 35 Ill. Adm. Code 309, a person may apply to the Agency to include as a condition in an NPDES permit a ZID as a component portion of a mixing zone. The ZID shall, at a minimum, be limited to waters within which effluent dispersion is immediate and rapid. For the purposes of this subsection, "immediate" dispersion means an effluent's merging with receiving waters without delay in time after its discharge and within close proximity of the end of the discharge pipe, so as to minimize the length of exposure time of aquatic life to undiluted effluent, and "rapid" dispersion means an effluent's merging with receiving waters so as to minimize the length of exposure time of aquatic life to undiluted effluent. Upon proof by the applicant that a proposed ZID conforms with the requirements of Section 39 of the Act and this Section, the Agency shall, pursuant to Section 39(b) of the Act, include within the NPDES permit a condition defining the ZID.

(TITLE 35: ENVIRONMENTAL PROTECTION SUBTITLE C: WATER POLLUTION CHAPTER I: POLLUTION CONTROL BOARD PART 302 WATER QUALITY STANDARDS SUBPART A: GENERAL WATER QUALITY PROVISIONS, 2019)

Question: With up to 5,000gals/minute or 300,000gals/hr. of mine waster discharge being permissible, how can there be an "immediate" or "rapid" dispersion to avoid having to adhere to Section 302.102, 12, (c), which states that acute toxicity standards must be met within the mixing zone. How can up to 12,000mg/l chlorides be rapidly dispersed in a small river?

Endangered Species

I am still trying to find out what species specific to Big Muddy River are Endangered or Threatened. I have contacted numerous government agencies, including: U.S. Fish and Wildlife, IDNR, IEPA, Illinois Endangered Species Protection Board, and Shawnee National Forest. No one has been able to give me any information. I have been trying since Fall 2018 after the initial hearing at IDNR.

Question 8: How can this permit be granted if none of these agencies seem to know exactly what species are endangered and threatened in the Big Muddy River Watershed as well as Pond Creek watershed?

Freshwater Mussels

Since 2018, US Fish and Wildlife Service has been under litigation for not protecting critical habitat for certain endangered mussels in 18 states, including three that occur in Illinois-Spectaclecase, Sheepnose, and Snuffbox. These and many more are protected under the 2019 Endangered Species Act. Anyone requiring federally funded or permitted projects in mussel's habitats must consult the US Fish and Wildlife Service to ensure habitat would not be damaged. There are more mussel species in the eastern U.S. than anywhere in the world;

however, 70% of species are either endangered, threatened or extinct already. (Center for Biological Diversity)

According to a study conducted by the Illinois Natural History Survey, "Freshwater Mussels of the Big Muddy River" (2012),

six species of mussels previously detected in the Big Muddy River were not found; although five of these are commonly found in other rivers in Illinois. These include: pink heelsplitter, pimpleback (listed as federally endangered), deertoe, creeper, fawnsfoot, plain pocketbook. 19 others were detected. "In Illinois, 25 of the 62 extant species (44%) are listed as threatened or endangered. Some of the species listed in the study that were documented in the Big Muddy River are: Lilliput, paper pondshell, pondhorn, white heelsplitter, giant floater, maple leaf, pink papershell.

The study lists the abandoned coal mines, specifically in the Murphsyboro area of the Big Muddy River, as a source of pollution. The study goes on to state that

mussels are more sensitive to sodium chloride and potassium chloride and that the current USEPA AWQC may not be protective of freshwater mussels (2013 Science Inventory). In addition, the study states that sedimentation and siltation might be causing a lack of species.

Question: Are any of the mussel species that exist in the Big Muddy watershed listed as threatened or endangered or rare? If this is not known, then it is pertinent to find out given the fact that most mussel species are now listed as threatened or endangered or already extinct and that they have been found to be sensitive to chloride levels as well as sedimentation/siltation both of which will be inflated due to the discharge of up to millions of gallons a day of acid mine discharge with extremely high levels of chloride and sulfates.

Fish Species

According to "Fishes of the Big Muddy" (1999), at least ten native fish species within a 100 year period are no longer found due to pollution, cultivation, and habitat lost. The study suggests the need for "continual vigorous reclamation of abandoned mines lands and treatment of acid mine drainage." The study goes on to say that "Big Muddy River drainage…has been subjected to an array of environmental stresses that have permanently disrupted its hydrological cycle, and ultimately altered its fish fauna."

The following are list of fish species that were recorded at time of study: bluegill, channel catfish, largemouth bass, sauger, striped bass, white bass, white crappie, yellow bullhead.

Question: What is the current state of the fish population in the Big Muddy and how will these elevated levels of chlorides/sulfates affect them as well as possible other toxins such as manganese and iron? Are any of these species listed as endangered or threatened?

Other Endangered/Threatened Species

The alligator snapping turtle is listed as a threatened species in Illinois.

Question: Has it been determined if their habitat includes the Big Muddy Watershed?

Ecologically Sensitive Areas

The Big Muddy flows adjacent to two very ecologically diverse areas, Little Grand Canyon and La Rue Pine Hills, both of which are National Natural Registered Landmarks with many rare, threatened, and endangered plant and animal species. "LaRue-Pine Hills Ecological Area, located within the Shawnee National Forest, contains one of the finest assemblages of diverse vegetation in the Midwest. The site represents species of northern, southern, eastern, and western affinities, including 40 species rare in Illinois." (Prairie Research Institute). Some threatened and endangered animal species include the Indian Bat, Illinois chorus frog, eastern woodrat which is only located in the La Rue Pine hills area, several fish species, and many plant species. La Rue Pine Hills/Otter Pond is also a national Research Natural Area which is protected federally.

Question: Are any of these species being considered? In the draft permit, it states that there will be no adverse effects on species because water quality standards will be met. However, in the case of Williamson Energy, this is obviously not the case. Water quality standards are not met. How then can species be protected? Under the Clean Water Act, section. 101(a)2, water quality provides for the protection and propagation of fish, shellfish, and wildlife. In addition, the Big Muddy River is already polluted with elevated levels of manganese, sulfates, phosphorus, mercury and has a fish advisory for PCBs. How the does adding elevated levels of chloride, sulfate and other toxins known to have adverse effects on animal and plant species permissible under this section of the Clean Water Act?

There is also a large area in southwestern Illinois listed as a Conservation Opportunity Area for La Rue Pine Hills under

IDNR which includes sections of the Big Muddy River in both Jackson and Union County (IDNR, accessed 2019).

Fifty-two miles of the Big Muddy River, from S.R. 14 south of Rend Lake to Southern Illinois Airport (U.S. 51), is a candidate for the Wild and Scenic River Designation (National Rivers Inventory, 2019) and is listed as having "Outstanding Remarkable Value", exactly the area where the proposed pipeline is supposed to discharge. Due to this fact, special considerations need to be considered.

The Council on Environmental Quality (CEQ), under 5(d)(1) Wild and Scenic River Act authority, provides guidance to federal agencies with permitting and/or granting authority for projects on or near rivers listed on the NRI. In accordance with executive memorandum, all agencies must "take care to avoid or mitigate adverse effects" to rivers identified in the Nationwide Rivers Inventory.

The following information is listed on the National Park Services website regarding rivers listed on the National Rivers Inventory:

1. Determine whether the proposed action could affect an NRI river.

• Check the current regional/state NRI list to determine whether the proposed action could affect an NRI river (i.e., is the proposed action location in the vicinity of the NRI segment).

• If an NRI river segment could be affected by the proposed action, an environmental assessment or and environmental impact statement may be required depending on the significance of the effects.

2. Determine whether the proposed action could have an adverse effect on the natural, cultural, and recreational values of the NRI segment. These values are listed as "outstandingly remarkable values" (ORVs) on the state NRI list.

Adverse effects on NRI rivers may occur under conditions which include, but are not limited to:

• Destruction or alteration of all or part of the free flowing nature of the river;

• Deterioration of water quality; or

3. Determine whether the proposed action could foreclose options to classify any portion of the NRI segment as wild, scenic, or recreational river areas.

• In some cases, impacts of a proposed action could be severe enough to preclude inclusion in the Wild and Scenic River System, or lower quality of the classification (e.g., from wild to recreational). If the proposed undertaking could effectively downgrade any portion of the NRI segment, you should consult with NPS.

• Proposed actions (whether uses or physical changes), which are theoretically reversible, but which are not likely to be reversed in the short term, should be considered to have the effect of foreclosing for all practical purposes Wild and Scenic River status. This is because a river segment, when studied for possible inclusion in the Wild and Scenic River System, must be judged as it is found to exist at the time of the study, rather than as it may exist at some future time.

• If a proposal, including one or more alternatives, could have an adverse effect on an NRI river, an EA, or if the effects are significant, an EIS must be prepared.

4. Incorporate mitigation/avoidance measures in the proposed action to the maximum extent feasible within the agency's authority.

Question: Has the IEPA taken into consideration that numerous sections of the Big Muddy River downstream from the pipeline are listed not only on the National Rivers Inventory but also in several state and federally listed special environmental zones and therefore has special protections?

IEPA Exhibiting Conflict of Interest

1) The IEPA included in the draft permit a section on social/economic benefits of the proposed activity (pipeline). Goes on to

list statistics about jobs and revenue for state. My argument is that an agency that was supposedly created for the purpose of protecting our environment should not take economic nor social factors into account.

2) The IEPA also goes on to favor the mine company by stating that "filtration is a technology that is not feasible for the proposed facility because: filtration is much more expensive than sediment ponds…a large area of land would be required for such a facility, and maintenance and supervision of the filtration and sludge operation would be burdensome and would increase production costs."

Question: Is the EPA supposed to be taking into consideration financial aspects of a company in lieu of protecting the environment? Is it supposed to weigh economic benefit over protecting the environment? And why has not the IEPA commented on the economic cost to the citizens of Illinois due to pollution already caused by the mine and the pollution that will be caused by the mine? The Big Muddy River is already polluted and there are now two implementation plans that have been created by the IEPA (2004, 2019) costing hundreds of millions of dollars to implement. The mines, which are listed as one of the causes of pollution, are not held accountable for paying for these costly plans, rather the "stakeholders" and concerned citizens are told they must try to find monies to clean up the rivers. To date, no watershed-based plan group has been formed based on the 2004 findings.

Illinois Constitution

The Illinois Constitution in Article XI states that we have a right to a healthy environment. Since Williamson Energy has numerous and frequent violations which can have and have had adverse impacts on the watersheds and its inhabitants and the IEPA has already listed the Big Muddy River as well as some of its tributaries such as Pond Creek as being impaired for numerous pollutants some as a direct result of both past and current mining activities. It seems that IEPA would be violating the constitution for granting a permit to a company that has a history of polluting public waters and the fact that the nature of the permit would allow even more pollutants to enter the watershed.

Question: Has the IEPA fully considered whether granting this permit for dumping more pollutants into the already impaired Big Muddy River will violate the law as stated in Article XI of our state constitution?

River Rights

Question: Has the IEPA considered that the river itself should have its own rights. It is already dammed and polluted? How much more should the Big Muddy River endure? The IEPA has already granted another similar permit for a discharge pipeline into the Big Muddy River with even higher expected levels of chlorides form the Sugar Camp Mine only 12.5 miles above stream from the proposed Pond Creek Mine pipeline.

Listen to the many, not to the money: health over wealth.

Sincerely submitted…

—-Sam Stearns

Friends of Bell Smith Springs

794 Ozark Road

Stonefort, Illinois 62987

bellsmithsprings@hotmail.com

Exhibit 341

From: Alycia Stephenson
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine
Date: Wednesday, December 18, 2019 10:37:07 PM

I am writing to you today to ask that you do your jobs, and reject a permit to let the mine dump their waste into our river. This is a no brainer. Nobody wants to eat contaminated fish, or swim in polluted water. Please do the jobs you all were hired to do and protect our water.

Sent from Yahoo Mail for iPhone

Exhibit 342A

From: Marilyn Avery
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine
Date: Wednesday, December 18, 2019 11:09:12 PM

I do not want you to give the mine the permit to dump their disgusting waste in our river.

Exhibit 342B

From: Marilyn Avery
To: EPA.PublicHearingCom
Subject: [External] Fwd: Pond Creek Mine
Date: Wednesday, December 18, 2019 11:17:39 PM

I do not want you to give the mine the permit to dump their disgusting waste in our river

---------- Forwarded message ---------
From: **Marilyn Avery** <marilynsavery56@gmail.com>
Date: Wed, Dec 18, 2019, 11:08 PM
Subject: Pond Creek Mine
To: <epa.publichearingcom@illinois.gov>

I do not want you to give the mine the permit to dump their disgusting waste in our river.

Exhibit 342 C

From: Marilyn Avery
To: EPA.PublicHearingCom
Subject: [External] Fwd: Pond Creek Mine
Date: Wednesday, December 18, 2019 11:21:43 PM

I do not you to give the mine the permit to dump their disgusting waste in our river

---------- Forwarded message ---------
From: **Marilyn Avery** <marilynsavery56@gmail.com>
Date: Wed, Dec 18, 2019, 11:17 PM
Subject: Fwd: Pond Creek Mine
To: <epa.publichearingcom@illinois.gov>

I do not want you to give the mine the permit to dump their disgusting waste in our river

---------- Forwarded message ---------
From: **Marilyn Avery** <marilynsavery56@gmail.com>
Date: Wed, Dec 18, 2019, 11:08 PM
Subject: Pond Creek Mine
To: <epa.publichearingcom@illinois.gov>

I do not want you to give the mine the permit to dump their disgusting waste in our river.

Exhibit 343

From: rachel ebel
To: EPA.PublicHearingCom
Subject: [External] Big muddy and the energy plant
Date: Thursday, December 19, 2019 5:42:41 AM

You don't have a right to let them poison our water. You need to do your job and protect the water from these people. We're working on getting solar up everywhere and we don't need this company anyway. E do need our wildlife and our clean water.
Thank you,
Rachel Bozarth

Sent from my iPhone

Exhibit 344

From: Howard Hansen
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Thursday, December 19, 2019 9:41:13 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 345

From: ROBERT E. JACKSON
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Thursday, December 19, 2019 10:10:00 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.

Exhibit 340

From: Danielle O"Connell
To: EPA.PublicHearingCom
Subject: [External] Big muddy river
Date: Thursday, December 19, 2019 1:07:37 PM

My family and I do not want mine waste dumped into the big muddy river. We are concerned for the health of the animals, drinking water, farm land and ecosystem at large.

Please do not allow this to happen.

Danielle O'Connell

Exhibit 347

From: Josselyn O"Connell
To: EPA.PublicHearingCom
Subject: [External] big muddy river
Date: Thursday, December 19, 2019 1:11:19 PM

I do not want mine waste dumped in the big muddy river!!!!!

All the animals, think of them, would you like it if someone dumped mine waste in your home?

Do not!

From josselyn o'connell
age 8

Exhibit 348

From: linda linsin
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Thursday, December 19, 2019 2:55:17 PM

To Barb Lieberoff, Illinois Environmental Protection Agency

It is with grave concern that I write this letter in objection to Williamson Energy's permit for the Pond Creek Mine to discharge millions of gallons of high chloride and sulfate water into the Big Muddy River. This highly toxic discharge will impact everything downstream including wildlife, property, and the environmental health and public uses of the river.

As a member of the Carbondale Unitarian Fellowship, I have respect for the interdependent web of all existence of which we are a part. The proposed discharge of these toxic substances and the environmental impact it will have, moves me to speak out for those who cannot speak for themselves; our shared land, air, and water, as well as our neighbors that will be negatively impacted.

In addition, allowing a corporation to benefit financially from harm done to our common home is an offense to our community.

Hoping this action is stopped, I am

Linda Linsin
1905 Westminster Dr.
Marion, IL 62959

Exhibit 349

From: Dave and Barb Elam
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine IL0077666
Date: Thursday, December 19, 2019 4:02:03 PM

To Whom It May Concern

The Illinois EPA is paid by us-taxpayers-to PROTECT our environment.

Please deny the application to permit dumping into the Big Muddy river here in southern Illinois.

Thank you

Dr. Elam
139 Pine Shore Dr. #37
Carbondale IL 62901

Exhibit 350

From: laura basanta
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Thursday, December 19, 2019 10:24:47 PM

NO, No, No,DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection. This is not right.
Laura Basanta

Sent from my iPad

Exhibit 351

From: Patty W
To: EPA.PublicHearing.Com
Subject: [External] Pond Creek Mine comments IL0077666
Date: Friday, December 20, 2019 10:34:01 AM

Dear IEPA staff—Thank you for hosting the Pond Creek mine hearing. The testimonies by participants were very moving and I hope provided convincing content to support protecting the Big Muddy River from being used as a toxic dumping medium. Two comments I would like to contribute:

1. Rivers are among the highest echelon of nature's creations. Rivers and waterways are the most diverse biosystems for natural habitat and need to receive the of the utmost level of protection. As Rachael Carson wrote in *Silent Spring*, nature is supremely adapted to closing the loop of recycling natural waste, however, when chemicals and manmade toxins are dumped into the system in astronomical quantities (such as mine waste and agricultural run off) nature is oversaturated and overstressed, and becomes sick and dies. Please, for the sake of our present life (fish, mammals, in/vertebrates, and plants that live in riparian areas) and future generations, do not allow rivers to be used as sewers.
2. There are precedents for agency decisions being repealed, as the following lawsuit where in Seattle, WA—on Oct 15 2019, a Federal Court for the Western District of Washington ruled the Army Corps' commercial shellfish aquaculture general permit, which is used to permit the vast majority of the shellfish aquaculture in Washington, to be unlawful. In response to a lawsuit brought by Center for Food Safety (CFS), the court found that Army Corps failed to adequately consider impacts of commercial shellfish aquaculture to Washington shorelines and wildlife habitat. The court also ruled that Army Corps' conclusory findings of minimal cumulative impact were not supported by the evidence before the agency, which shows harm to the environment, including damage to crucial fish habitat.

Sincerely, Patty Weyhich, concerned citizen, landowner, Carbondale, IL

CENTER FOR FOOD SAFETY PROTECTS WASHINGTON'S ICONIC COASTLINES AND WILDLIFE FROM EXPANDING INDUSTRIAL SHELLFISH AQUACULTURE

OCTOBER 15, 2019

SHARE THIS:



Center for Food Safety Protects Washington's Iconic Coastlines and Wildlife from Expanding Industrial Shellfish Aquaculture

Court Rules Army Corps Failed to Protect Clean Water and Assess Cumulative Environmental Impacts

Seattle, WA—On Friday, a Federal Court for the Western District of Washington ruled the Army Corps' commercial shellfish aquaculture general permit, which is used to permit the vast majority of the shellfish aquaculture in Washington, to be unlawful. In response to a lawsuit brought by Center for Food Safety (CFS), the court found that Army Corps failed to adequately consider impacts of commercial shellfish aquaculture to Washington shorelines and wildlife habitat. The court also ruled that Army Corps' conclusory findings of minimal cumulative impact were not supported by the evidence before the agency, which shows harm to the environment, including damage to crucial fish habitat that support iconic species like salmon and orcas.

Army Corps' permit, Nationwide Permit 48 (NWP 48) issued by the Trump administration in 2017, would have allowed an enormous expansion of an over $100 million dollar-a-year industry without sufficient marine wildlife or water quality protections for these unique and sensitive ecosystems. After reviewing the information before the Corps, the court found that the evidence of environmental impacts from shellfish aquaculture (such as harm to eelgrass, a crucial seagrass, and all the species that rely on it) could not support the agency's conclusion that allowing thousands of these operations would only have minimal impact.

"Army Corps has failed to protect public waters from the harmful environmental impacts of industrial shellfish aquaculture for years, but now the agency must finally accept that this type of aquaculture is not benign and follow federal law," **said Amy van Saun, senior attorney at CFS**, based out of its Pacific Northwest office. "We're relieved that the court did the right thing and prevented this unbridled expansion of industrial aquaculture at the expense of Washington's wildlife and residents."

Industrial aquaculture already threatens Washington's iconic, invaluable shorelines and bays, which are home to numerous marine species including endangered salmon. The expansion would have allowed shellfish aquaculture acreage to double to an estimated 72,300 acres—or a third of all Washington shorelines—including critical spawning and feeding grounds for forage fish, birds, invertebrates like Dungeness crab, and finfish like salmon and green sturgeon.

As the evidence before the Army Corps showed, many of these species rely on eelgrass and other aquatic vegetation. Eelgrass also helps to mitigate the effects of climate change on oceans. Industrial shellfish aquaculture is known to reduce or eliminate eelgrass, including through the industry's intentional the use of pesticides. Yet the new permit did not place any restrictions on impacts to eelgrass, through pesticide use or otherwise.

"As a business owner and lover of Willapa Bay, and someone personally impacted by the spraying of toxic pesticides on shellfish beds, I am thrilled that the Corps will no longer be able to shirk its responsibility to evaluate pesticide impacts to our Bay, as well as the massive expansion of industrial-scale clam and oyster aquaculture over so much of the Bay," **said Fritzi Cohen, Pacific County resident, owner and proprietor of the Moby Dick Hotel on Willapa Bay.** "The science shows that pesticides harm both the wildlife that are exposed to them, and can show up in the very oysters that are being grown for people to eat, and the Corps must address this danger in its shellfish permitting."

The permit also failed to restrict the enormous use of plastics by the industry, like the 42,000 PVC tubes per acre that are covered in plastic netting and used to grow geoducks (a type of clam grown almost exclusively for the luxury export market). Netting can trap and entangle wildlife, and the plastics break down into microplastics that are hazardous to marine organisms, including the very shellfish being grown for human consumption.

The court found that "the Corps acknowledged that reissuance of NWP 48 would have foreseeable environmental impacts on the biotic and abiotic components of coastal waters, the intertidal and subtidal habitats of fish, eelgrass, and birds, the marine substrate, the balance between native and non-native species, pollution, and water quality, chemistry, and structure, but failed to describe, much less quantify, these consequences."

As a result of the Corps' refusal to evaluate these various impacts, and their cumulative impact, at the outset, as well as its reliance on cherry-picked data, its adoption of NWP 48 in Washington was unlawful under the National Environmental Policy Act and the Clean Water Act. The court set aside NWP 48 in Washington, but is allowing limited additional briefing on how to revoke the general permit.

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

THE COALITION TO PROTECT PUGET SOUND HABITAT,

Plaintiff,

v.

U.S. ARMY CORPS. OF ENGINEERS, *et al.*,

Defendants,

and

TAYLOR SHELLFISH COMPANY, INC.,

Intervenor - Defendant.

Case No. C16-0950RSL

CENTER FOR FOOD SAFETY,

Plaintiff,

v.

U.S. ARMY CORPS OF ENGINEERS, *et al.*,

Defendants,

and

PACIFIC COAST SHELLFISH GROWERS ASSOCIATION,

Intervenor - Defendant.

Case No. 17-1209RSL

ORDER HOLDING NWP 48 UNLAWFUL IN THE STATE OF WASHINGTON AND REQUESTING ADDITIONAL BRIEFING

This matter comes before the Court on cross-motions for summary judgment filed by the parties and intervenors in the above-captioned matters. Dkt. # 36, # 44, and # 45 in C16-

0950RSL; Dkt. # 31, # 43, and # 44 in C17-1209RSL. The Court has also considered the Swinomish Indian Tribal Community's submission in a related case, C18-0598RSL (Dkt. # 28). Plaintiffs challenge the U.S. Army Corps of Engineers' issuance of Nationwide Permit 48 ("NWP 48") authorizing discharges, structures, and work in the waters of the United States related to commercial shellfish aquaculture activities. Plaintiffs argue that the Corps failed to comply with the Clean Water Act ("CWA"), the National Environmental Policy Act ("NEPA"), and the Endangered Species Act ("ESA") when it reissued NWP 48 in 2017. They request that the decision to adopt NWP 48 in Washington[1] be vacated under the Administrative Procedures Act ("APA") and that the Corps be required to comply with the environmental statutes before issuing any new permits or verifications for commercial shellfish aquaculture in this State.[2]

BACKGROUND

The CWA authorizes the Army Corps of Engineers to issue permits for the discharge of dredged or fill material into the navigable waters of the United States. 33 U.S.C. § 1344(a). If the Corps determines that activities involving discharges of dredged or fill material "are similar in nature, will cause only minimal adverse environmental effects when performed separately, and will have only minimal cumulative adverse effect on the environment," it may issue general permits on a state, regional or nationwide basis permitting the activities for a five year period. 33

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[1] The Coalition to Protect Puget Sound Habitat seeks to bar the use of NWP 48 only in Puget Sound.

[2] The Court finds that one or more members of plaintiff Center for Food Safety has/have standing to pursue the CWA, NEPA, and ESA claims based on their concrete, particularized, and imminent injuries arising from activities in Washington that are permitted under the 2017 version of NWP 48.

U.S.C. § 1344(e). "[T]he CWA imposes substantive restrictions on agency action" (Greater Yellowstone Coalition v. Flowers, 359 F.3d 1257, 1273 (10th Cir. 2004)): if "the effect of a general permit will be more than minimal, either individually or cumulatively, the Corps cannot issue the permit" (Wyoming Outdoor Council v. U.S. Army Corps of Eng'rs, 351 F. Supp. 2d 1232, 1255-57 (D. Wyo. 2005)). General permits often impose requirements and standards that govern the activities undertaken pursuant to the permit, but they relieve operators from the more burdensome process of obtaining an individual, project-based permit.

In 2017, the Corps reissued NWP 48, thereby authorizing "the installation of buoys, floats, racks, trays, nets, lines, tubes, containers, and other structures into navigable waters of the United States. This NWP also authorizes discharges of dredged or fill material into waters of the United States necessary for shellfish seeding, rearing, cultivating, transplanting, and harvesting activities." NWP003034. The nationwide permit authorizes(a) the cultivation of nonindigenous shellfish species as long as the species has previously been cultivated in the body of water at issue, (b) all shellfish operations affecting ½ acre or less of submerged aquatic vegetation, and (c) theall operations affecting more than ½ acre of submerged aquatic vegetation if the area had been used for commercial shellfish aquaculture activities at any point in the past 100 years. NWP003034-35.[3]

In addition to the CWA's requirement that the Corps make "minimal adverse effect" findings before issuing a general permit, "NEPA imposes procedural requirements on federal agencies to analyze the environmental impact of their proposals and actions." O'Reilly v. U.S.

[3] The 100-year look back provision was not in the 2012 version of NWP 48.

Army Corps of Engr's, 477 F.3d 225, 228 (5th Cir. 2007). Federal agencies are required to do an environmental assessment ("EA") of their proposed action, providing a brief discussion of the anticipated environmental impacts and enough evidence and analysis to justify a no-significant-impact determination. 40 C.F.R. § 1508.9. If the agency, after conducting an EA, is unable to state that the proposed action "will not have a significant effect on the human environment," a more detailed and comprehensive environmental impact statement ("EIS") must be prepared. 40 C.F.R. § 1508.11 and § 1508.13.[4]

The Corps' EA regarding the 2017 reissuance of NWP 48 is presented in a Decision Document dated December 21, 2016. NWP003034-3116. An additional condition was later imposed by the Seattle District through its Supplemental Decision Document dated March 19, 2017. COE 127485-611. The Court has considered both Decision Documents to the extent they reflect the Corps' analysis of the anticipated environmental impacts of issuing the nationwide permit and imposing the additional regional condition. The Decision Documents set forth the Corps' discussion of anticipated environmental impacts and the evidence and analysis justifying its determination "that the issuance of [NWP 48] will not have a significant impact on the quality of the human environment," making an EIS unnecessary under NEPA. NWP003106. The Decision Documents also reflect the Corps' determination that the "activities authorized by [NWP 48] will result in no more than minimal individual and cumulative adverse effects on the aquatic environment" for purposes of the CWA. NWP003107. The Seattle District, for its part, concluded that if it added a regional condition preventing the commercial harvest of clams by

[4] "Impact" and "effect" are used interchangeably in the regulations and are deemed synonymous. 40 C.F.R. § 1508.8.

means of hydraulic escalator equipment and evaluated proposed activities as they were verified under the reissued permit, the effects of the permitted activities would be individually and cumulatively minimal. COE 127592-93.

Plaintiffs argue that these conclusions must be invalidated under the APA because the record does not support the Corps' conclusions regarding the environmental effects of individual shellfish aquaculture activities or their cumulative impacts and the EA does not accurately describe the anticipated environmental impacts of NWP 48 or otherwise justify a no-significant-impact determination. Under the APA, a reviewing court must set aside agency actions, findings, or conclusions that are "arbitrary, capricious, an abuse of discretion, [] otherwise not in accordance with law" or "without observance of procedure required by law." 5 U.S.C. § 706(2)(A) and (D). Agency action is arbitrary and capricious "if the agency has relied on factors which Congress has not intended it to consider, entirely failed to consider an important aspect of the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise." Motor Vehicle Mfrs. Ass'n v. State Farm Mut. Auto. Ins. Co., 463 U.S. 29, 43 (1983). Although agency predictions within the agency's area of expertise are entitled to the highest deference, they must nevertheless have a substantial basis in fact. Ctr. for Biological Diversity v. Zinke, 900 F.3d 1053, 1067 (9th Cir. 2018). In determining whether a decision is supported by substantial evidence in the record, the Court will not substitute its own judgment for that of the agency but rather considers whether the decision is based on relevant evidence that a reasonable mind might accept as adequate to support the agency's conclusion.

San Luis & Delta-Mendota Water Auth. v. Jewell, 747 F.3d 581, 601 (9th Cir. 2014).[5]

DISCUSSION

Having reviewed the submissions of the parties and the administrative record, and having heard the arguments of counsel, the Court finds that there is insufficient evidence in the record to support the agency's conclusion that the reissuance of NWP 48 in 2017 would have minimal individual and cumulative adverse impacts on the aquatic environment for purposes of the CWA and that the Corps' environmental assessment does not satisfy NEPA's requirements. Although the minimal impacts finding is repeated throughout the Corps' Decision Document (see NWP003038, NWP003045-46, NWP003049, NWP003051, NWP003091, NWP003107), it is based on little more than (1) selectively chosen statements from the scientific literature, (2) the imposition of general conditions with which all activities under nationwide permits must comply, and (3) the hope that regional Corps districts will impose additional conditions and/or require applicants to obtain individual permits if necessary to ensure that the adverse impacts will be minimal. Each of these considerations is discussed below.

(1) Effects Analysis

At various points in its analysis, the Corps acknowledges that commercial shellfish aquaculture activities can have adverse environmental impacts. See NWP003040 (commercial

[5] Plaintiffs also argue that the agency action should be invalidated because the Corps (a) failed to analyze a reasonable range of alternative actions in the EA, (b) failed to allow for meaningful public participation, and (c) failed to re-initiate consultation with expert wildlife agencies under the ESA when the 2017 version of NWP 48 was modified to increase the acreage on which commercial shellfish production was authorized, failed to incorporate assumed conservation measures and conditions, and failed to analyze the impacts of pesticides on endangered species. Because the Court finds that the Corps violated the CWA and NEPA, it has not considered these alternative theories for why NWP 48 should be invalidated.

shellfish aquaculture activities "have some adverse effects on the biotic and abiotic components of coastal waters, including intertidal and subtidal areas"); Id. (noting that "at a small spacial scale (e.g., the site directly impacted by a specific aquaculture activity) there will be an adverse effect."); NWP003041 (acknowledging "some impacts on intertidal and subtidal habitats, fish, eelgrass, and birds"); NWP003042 (recognizing that "commercial shellfish aquaculture activities do have some adverse effects on eelgrass and other species that inhabit coastal waters"); COE 127559 (stating that "marine debris is a serious impact on the marine environment"); COE 127570 (acknowledging "potential adverse impacts" to riffle and pool complexes); COE 127584 (noting that "[c]ommercial shellfish aquaculture activities can result in conversion of substrates (e.g. mudflats to gravel bars), impacts to submerged aquatic vegetation, alteration in aquatic communities from native to non-native shellfish species, and water quality impacts from harvest activities"). It concludes that these impacts are no more than minimal, however, (a) when considered on a landscape rather than a site-by-site scale, (b) because the relevant ecosystems are resilient, and (c) because the impacts are "relatively mild" in comparison "to the disturbances and degradation caused by coastal development, pollution, and other human activities in coastal areas." NWP003040 and NWP003044.

(a) Scale of Impacts Evaluation

In determining the potential effects of a proposed discharge of dredged or fill material in an aquatic environment, the Corps is required to determine the nature and degree of the environmental impact the discharge will have, both individually and cumulatively. "Consideration shall be given to the effect at the proposed disposal site of potential changes in substrate characteristics and elevation, water or substrate chemistry, nutrients, currents,

circulation, fluctuation, and salinity, on the recolonization and existence of indigenous aquatic organisms or communities." 40 C.F.R. § 230.11(e) (emphasis added). Ignoring or diluting site-specific, individual impacts by focusing solely on a cumulative, landscape-scale analysis is not consistent with the governing regulations.

(b) Resilient Ecosystems

The Decision Document issued by Corps Headquarters acknowledges that "[t]he effects of commercial shellfish aquaculture activities on the structure, dynamics, and functions of marine and estuarine waters are complicated, and there has been much discussion in the scientific literature on whether those effects are beneficial or adverse." NWP003040. Relying in large part on a paper published by Dumbauld and McCoy for the U.S. Department of Agriculture in 2015, the Corps concluded that the individual and cumulative impacts of the activities authorized by NWP 48 would be minimal "because the disturbances caused by these activities on intertidal and subtidal ecosystems are temporary and those ecosystems have demonstrated their ability to recover from those temporary disturbances." NWP003045-46.[6]

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[6] The Corps also cites a 2009 paper co-written by Dumbauld, which it describes as "a review of empirical evidence of the resilience of estuarine ecosystems and their recovery (including the recovery of eelgrass) after disturbances caused by shellfish aquaculture activities." NWP003044. The Corps relies on the 2009 Dumbauld paper to support its conclusion that commercial shellfish production can have beneficial impacts on some aspects of the aquatic environment. See NWP003406 ("Many species co-exist with commercial shellfish aquaculture activities and many species benefit from these activities."); NWP003086 (noting improved water and habitat quality at moderate shellfish population densities); NWP003087 ("Activities authorized by this NWP may alter habitat characteristics of tidal waters. Some species of aquatic organisms will benefit from those changes, while others will be adversely affected."); NWP003104 ("Sessile or slow-moving animals in the path of discharges of dredged or fill material and aquaculture equipment may be destroyed. Some aquatic animals may be smothered by the placement of fill materials. Some aquatic organisms will inhabit the physical structure created by equipment used for commercial shellfish aquaculture activities."). The fact that there are environmental winners and losers when activities authorized under NWP 48 are undertaken does not resolve the issue of whether the

Dumbauld and McCoy's research cannot justify such a broad, sweeping conclusion regarding the resilience of entire ecosystems in both the intertidal and subtidal zones. According to the Corps' own summary of the paper, the authors evaluated only the effects of oyster aquaculture activities on submerged aquatic vegetation. NWP003044. The paper itself shows that Dumbauld and McCoy were studying the effects of intertidal oyster aquaculture on the seagrass *Zostera marina*. There is no discussion of the impacts on other types of aquatic vegetation, on the benthic community, on fish, on birds, on water quality/chemistry/structures, or on substrate characteristics. There is no discussion of the subtidal zone. There is no discussion regarding the impacts of plastic use in shellfish aquaculture and only a passing reference to a possible side effect of pesticide use. The Corps itself does not remedy these deficiencies: although it identifies various resources that will be adversely impacted by issuance of the national permit (along with resources that may benefit from shellfish production), it makes virtually no effort to characterize the nature or degree of those impacts. The Decision Document's "Impact Analysis" consists of little more than an assurance that district engineers will consider the direct and indirect effects caused by the permitted activity on a regional or case-by-case basis. NWP003073-74.

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proposed agency action has more than minimal impacts or obviate the need for a "hard look" at all impacts, beneficial and adverse. Native Ecosys. Council v. U.S. Forest Serv., 428 F.3d 1233, 1238-39 (9th Cir. 2005). The 2009 review clearly shows, and the Corps acknowledges, that at least some aquatic species and characteristics are adversely affected by commercial shellfish aquaculture. The Ninth Circuit, faced with a similar situation under NEPA, noted that "even if we had some basis for assuming that [the agency's] implementation of the BiOp would have exclusively beneficial impacts on the environment, we would still lack a firm foundation for holding that [the agency] need not prepare an EA and, if necessary, an EIS." San Luis & Delta-Mendota Water Auth. v. Jewell, 747 F.3d 581, 652 n.52 (9th Cir. 2014).

Under the CWA, the Corps must find that the proposed activity "will cause only minimal adverse environmental effects when performed separately, and will have only minimal cumulative adverse effect on the environment" before it issues a general permit. 33 U.S.C. § 1344(e). Under NEPA, the Corps is required to "[b]riefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact." 40 C.F.R. § 1508.9(a)(1). The agency is required to take a "hard look" at the likely environmental impacts of the proposed action and prepare an EA to determine whether the impacts are significant enough to necessitate the preparation of an EIS. Native Ecosys. Council, 428 F.3d at 1238-39. The analysis, though brief, "must be more than perfunctory" and must be based on "some quantified or detailed information; . . . [g]eneral statements about possible effects and some risk do not constitute a hard look absent a justification regarding why more definitive information could not be provided." Klamath-Siskiyou Wildlands Ctr. v. Bureau of Land Mgmt., 387 F.3d 989, 993-94 (9th Cir. 2004) (alteration in original, citations omitted).

In this case, the Corps acknowledged that reissuance of NWP 48 would have foreseeable environmental impacts on the biotic and abiotic components of coastal waters, the intertidal and subtidal habitats of fish, eelgass, and birds, the marine substrate, the balance between native and non-native species, pollution, and water quality, chemistry, and structure, but failed to describe, much less quantify, these consequences. The Corps cites the two Dumbauld papers for general statements regarding the positive or negative effects of shellfish aquaculture on certain aquatic resources or characteristics (focusing on seagrass), but it makes no attempt to quantify the effects or to support its conclusion that the effects are no more than minimal.

Even if the health and resilience of seagrass were the only concern - and, as discussed

above, it is not - the 2015 Dumbauld and McCoy paper cannot reasonably be interpreted as evidence that seagrass is only minimally impacted by commercial shellfish aquaculture. As noted above, the paper evaluated only the effect of oyster aquaculture. In that context, it recognized the research suggesting that oyster aquaculture has direct impacts on native seagrasses at the site of the activity and in short temporal spans. These impacts are then ignored by both Dumbauld and the Corps in favor of a landscape, cumulative analysis which, as discussed above, is inadequate. Just as importantly, NWP 48 authorizes the discharge of dredged and fill material from not only oyster operations, but also from mussel, clam, and geoduck operations carried out on bottom substrate, in containers, and/or on rafts or floats. Thus, Dumbauld and McCoy did not evaluate, and drew no conclusions regarding, the impact that many of the activities authorized by NWP 48 would have on seagrass (much less other aquatic resources). The Seattle District, for its part, acknowledged the breadth of species and cultivation techniques that are encompassed in the phrase "commercial shellfish aquaculture." A draft cumulative impact assessment generated in February 2017 dedicated twenty-five pages to discussing the wide range of work and activities covered by NWP 48 and noting the species-dependent variability in cultivation techniques, gear, and timing. COE 125591-616.[7] These variations gave rise to a wide array of effects on the aquatic habitat (COE 125635-36), none of which is acknowledged or evaluated in the national Decision Document. In its Supplement, the Seattle District noted:

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[7] The Corps acknowledges that the draft regional impact assessment "was a NEPA-level analysis," but faulted the author because that level of analysis should be performed by Headquarters for a nationwide permit. COE 125856. No comparable analysis is included in the national Decision Document, however.

> The impacts to eelgrass from aquaculture can be temporary, depending on the activity, because the habitat conditions themselves (elevation, water quality, etc.) are not permanently altered which allows eelgrass to eventually recover given sufficient time. In Washington State, the timeframe for recovery has been documented to be about 5 years depending on the activity and other factors. For example, when a geoduck farm is seeded it is covered with tubes and nets for 2 or more years and then the tubes and nets are removed until harvest, 3-5 years later. The eelgrass would have died back under the nets, had a chance to return when nets were removed, and then eelgrass is disturbed/removed again when harvest occurs. While this process allows for eelgrass return at the site, the frequency of disturbance and relatively long recovery times result in a local habitat condition where eelgrass more often than not is either not present or present at a much reduced functional state. This effect would persist as long as aquaculture is occurring at the site. In some cases, such as when nets are placed over planted clam beds, any eelgrass is likely to be permanently smothered and not recover. This is because of the permanence of the nets, which are only removed between harvest and the next planting cycle. The time between harvest and planting may only be a matter of weeks or months. Other impacts are discussed in the national decision document. This existing cycle of impacts to eelgrass represents the existing environment from aquaculture activities authorized under NWP [48] 2012; and these or similar effects may continue if verification under NWP 48 2017 is requested and received.

COE 127587-88.

Agency predictions within their areas of expertise are entitled to the highest deference, but they must have a substantial basis in fact. The Corps recognized that certain shellfish operations would displace eelgrass entirely for extended periods of time. In some cases, nets are used to smother the vegetation, precluding any chance of recovery. Where smothering nets are not in use, the eelgrass may recover to some extent, but was not likely to return to is full functional state before being disturbed and/or removed again for the next harvest or seeding

activity. The impacts of commercial shellfish aquaculture on eelgrass (and presumably on all species that rely on eelgrass) would continue as long as the permitted activity continued. Under the 2017 version of NWP 48, a significant number of additional acres that were not cultivated under the 2012 NWP could be put into shellfish aquaculture if the area had been commercially productive during the past 100 years. See COE 118145-49; COE 127584. Any such "reopened" beds could result in additional losses of seagrass and the benefits it provides. COE 127589 ("[F]or many current operations, verification under NWP 2017 will create no appreciable change to the baseline environmental conditions, and the impacts will be minimal both individually and cumulatively.[8] For other operations, however, activities may create a change in current conditions, for example if activities are proposed on land populated with recovered eelgrass."). The national Decision Document does not quantify the periodic and permanent losses of seagrass[9] or the impact on the wider aquatic environment. A reasonable mind reviewing the

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[8] By quoting this portion of the Seattle District Supplement, the Court is not adopting its reasoning. National, regional, and state permits issued under the authority of the CWA last for only five years. When a NWP is reissued, the environmental impacts of the agency action logically include all activities conducted under the auspices of the permit, regardless of whether those operations are brand new or are simply "verified" as covered by the reissued NWP. The governing regulations expressly impose upon the Corps the obligation to consider the ongoing effects of past actions when conducting a cumulative impacts analysis. 40 C.F.R. § 1508.7. See Ohio Valley Envtl. Coalition v. Hurst, 604 F. Supp. 2d 860, 886-87 (S.D. W. Va. 2009) (rejecting the Corps' *post hoc* rationalization that past authorizations of moutaintop mining had no continuing effects and noting that, in the court's "common sense judgment," "[t]hese losses and impacts do not exist in a vacuum; they are not corrected or cured every five years with the renewal of a new nationwide permit. Nor do these accumulated harms become the baseline from which future impacts are measured. Before authorizing future activities with such tremendous impacts, the Corps must at least consider the present effects of past activities . . . .").

[9] The cumulative impacts of reissuing NWP 48 are to be analyzed in accordance with 40 C.F.R. § 230.7(b)(3), pursuant to which the Corps must predict "the number of activities expected to occur until the general permit expires." NWP003043. The Corps' estimates of how many acres are likely to be cultivated under the reissued national permit vary widely, however. The estimate provided in Section

record as a whole would not accept Dumbauld and McCoy's limited findings regarding the landscape-level impact of oyster cultivation on a species of seagrass in the intertidal zone as support for the conclusion that entire ecosystems are resilient to the disturbances caused by shellfish aquaculture or that the impacts of those operations were either individually or cumulatively minimal.

(c) Impacts of Other Human Activity

Although the Corps does not rely on this line of reasoning in opposing plaintiffs' motions for summary judgment, its Decision Document is replete with various forms of the following statement: "[c]ommercial shellfish aquaculture activities are a minor subset of human activities that affect coastal intertidal and subtidal habitats and contribute to cumulative effects to those coastal habitats." NWP003041. See also NWP003040; NWP003042-44; NWP003061; NWP003068; NWP003075-76; NWP003081; NWP003083-85. To the extent the Corps' minimal impacts determination is based on some sort of comparison between the environmental impacts of shellfish aquaculture and the environmental impacts of the rest of human activity (see

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7.2.2 of the Decision Document states that NWP 48 will be utilized 1,625 times over the five-year period, resulting in impacts to approximately 56,250 acres of water. NWP003098. Those numbers are reportedly based on past uses of the NWP plus an estimate of the number of activities that did not require pre-construction notification and were not voluntarily reported to the Corps district. Id. According to the Seattle District, however, over 56,000 acres of marine tidelands were permitted under the 2012 version of NWP 48 in Washington State alone, and that number was only going to increase under the 2017 version. COE 127590. Recognizing the long history of commercial shellfish operations in the State's waters and the 100-year look back for identifying "existing" operations, the Seattle District estimated that 72,300 acres of Washington tidelands could be authorized for commercial shellfish production under the 2017 NWP 48. COE 127590-92. Thus, even if Headquarters had attempted to quantify the proposed action's impacts on seagrass (or any other aquatic resource) before reissuing NWP 48, its data regarding past uses of the permit was incorrect and its estimates of future uses are suspect.

NWP003046 (commercial shellfish aquaculture activities "cause far less change to the environmental baseline than the adverse effects caused by development activities, pollution, and changing hydrology that results from the people living and working in the watersheds that drain to coastal waters . . ."); NWP003078 ("[T]here are many categories of activities that contribute to cumulative effects to the human environment. The activities authorized by this NWP during the 5-year period it will be in effect will result in no more than minimal incremental contributions to the cumulative effects to these resource categories."); NWP003081 ("The activities authorized by this NWP will result in a minor incremental contribution to the cumulative effects to wetlands, streams, and other aquatic resources in the United States because, as discussed in this section, they are one category of many categories of activities that affect those aquatic resources.")), the analysis is inadequate. NEPA and the CWA were enacted because humans were adversely affecting the environment to a noticeable and detrimental extent. See 42 U.S.C. § 4331(a) (Congressional recognition of "the profound impact of man's activity on the interrelations of all components of the natural environment"); 33 U.S.C. § 1251(a) ("The objective of [the CWA] is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."). Noting that a particular environmental resource is degraded is not an excuse or justification for further degradation. The Corps must analyze the individual and cumulative impacts of the proposed activity against the environmental baseline, not as a percentage of the decades or centuries of degrading activities that came before.

The Corps makes a similarly untenable argument whenever the use of pesticides in a shellfish operation permitted under NWP 48 is discussed. While acknowledging that these substances are used and released into the environment during permitted activities, the Corps

declines to consider the environmental impacts of pesticides because they are regulated by some other entity. See NWP003077. Even if the Corps does not have jurisdiction to permit or prohibit the use of pesticides, it is obligated to consider "other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions." NWP003074 (quoting 40 C.F.R. § 1508.7). The Corps' decision to ignore the foreseeable uses and impacts of pesticides in the activities it permitted on a nationwide basis does not comport with the mandate of NEPA or with its obligations under the CWA. Having eschewed any attempt to describe the uses of pesticides in commercial shellfish aquaculture or to analyze their likely environmental impacts, the decision to permit such activities through NWP 48 cannot stand.

(2) General Conditions of NWP 48

In making its minimal impact determinations, the Corps relied in part on the general conditions imposed on all nationwide permits. NWP003072. According to the Corps, the prohibitions it has imposed against impacts on the life cycle movements of indigenous aquatic species (general condition 2), spawning areas (general condition 3), migratory bird breeding areas (general condition 4), concentrated shellfish beds (general condition 5), and endangered or threatened species (general condition 18), and the requirements that permittees use non-toxic materials (general condition 6) and confer with other regulatory agencies as needed (general condition 19) will ensure that the individual and cumulative environmental effects of NWP 48 are minimal. Even if the Court were to assume that the general conditions will be universally heeded, regulatory fiat does not satisfy NEPA's requirement that the EA contain "sufficient evidence and analysis for determining whether to prepare an environmental impact statement or

a finding of no significant impact." 40 C.F.R. § 1508.9(a)(1). The general conditions are just that: general. They apply to all NWPs and do not reflect a "hard look" at the environmental sequellae of commercial shellfish aquaculture. For purposes of the CWA, the general conditions on which the Corps relies do not necessarily prohibit substantial impacts: general condition 3, for example, precludes the most destructive of activities in spawning areas but leaves unregulated many activities that could significantly impact those areas. In addition, the general conditions relate to only some of the environmental resources the Corps acknowledges are impacted by the permitted activities and do not address the cumulative impacts of commercial shellfish aquaculture at all. 40 C.F.R. § 1508.7 ("Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.").

The Court does not intend to suggest, and is not suggesting, that the general terms and conditions imposed on a nationwide, regional, or state permit cannot be relevant to and supportive of a finding of minimal impacts. They are simply too general to be the primary "data" on which the agency relies when evaluating the impacts of the permitted activities.

(3) Regional Conditions and District Engineers

Any permit authorizing activities on a nationwide level runs the risk of sanctioning activities that have more than minimal environmental impacts. In order to safeguard against that risk, regional district engineers have the discretionary authority to modify, suspend, or revoke the NWP within a particular region or class of waters, to add regional conditions to the NWP, to impose special conditions on a particular project, and/or to require an applicant to seek an individual permit. NWP003037 (citing 33 C.F.R. §§ 330.4(e) and 330.5). Although permittees may generally proceed with activities authorized by an NWP without notifying the district

engineer, (33 C.F.R. § 330.1(e)(1)), general condition 18(c) requires the submission of a pre-construction notification ("PCN") if the proposed activity may affect or is in the vicinity of a species listed or habitat designated as critical under the ESA. Because all aquaculture operations in the State of Washington occur in waters where there are threatened/endangered species and/or critical habitat, applicants who seek to operate under the auspices of NWP 48 in this State must submit a PCN and obtain a "verification" that the activity falls within the terms of the permit and that the requirements of the ESA have been satisfied. COE 127592. "For a project to qualify for verification under a general permit, a Corps District Engineer must conclude that it complies with the general permit's conditions, will cause no more than minimal adverse effects on the environment, and will serve the public interest." Sierra Club v. U.S. Army Corps of Eng'rs, 803 F.3d 31, 39 (D.C. Cir. 2015) (citing 33 C.F.R. §§ 330.1(e)(2), 330.6(a)(3)(i)).

There is nothing arbitrary, capricious, or unlawful about having the regional district engineer review site-specific proposals to "cement [Headquarters'] determination that the projects it has authorized will have only minimal environmental impacts." Ohio Valley Envtl. Coalition v. Bulen, 429 F.3d 493, 501 (4th Cir. 2005). Tiering the review and decision-making tasks is permissible, but there must be a national decision document that actually evaluates the impacts of the proposed activity in light of any regional conditions imposed. The problems here are that the Corps' minimal impact determinations were entirely conclusory and the regional conditions that it assumed would minimize impacts were not in place at the time NWP 48 was adopted. The record is devoid of any indication that the Corps considered regional data, catalogued the species in and characteristics of the aquatic environments in which commercial shellfish aquaculture activities occur, considered the myriad techniques, equipment, and

materials used in shellfish aquaculture, attempted to quantify the impacts the permitted activity would likely have on the identified species and characteristics, or evaluated the impacts of the as-yet-unknown regional conditions.

Faced with incredible diversity in both the environment and the activities permitted under NWP 48, the Corps effectively threw up its hands and turned the impact analyses over to the district engineers. The "Impact Analysis" section of the national Decision Document simply reiterates the district engineer's powers to revoke, modify, or condition the NWP and directs the district engineers to make minimal adverse environmental effects determinations after considering certain factors. NWP003073-74. Its "Cumulative Effects" analysis bluntly acknowledges that "[i]t is not practical or feasible to provide quantitative data" regarding the cumulative effects of NWP 48 other than the estimated number of times the permit will be used. NWP003081.

Because a nationwide analysis was impossible, the task of conducting a cumulative impacts analysis in specific watersheds was devolved to the district engineers. NWP003077. Even where adverse impacts are acknowledged, the Corps ignores its obligation to analyze and quantify them, instead relying on the district engineers to perform the analysis on a project-by-project basis. In the context of the public interest discussion regarding impacts to fish and wildlife, for example, the Corps recognizes that NWP 48 may "alter the habitat characteristics of tidal waters," that "[s]ome species of aquatic organisms will benefit from those changes, while other species will be adversely affected," and that equipment used in commercial shellfish operations may impede bird feeding activities and trap birds." NWP003087. It then states:

The pre-construction notification requirement[] provides the district engineer with

> an opportunity to review those activities and assess potential impacts on fish and wildlife values and ensure that the authorized activity results in no more than minimal adverse environmental effects.

Id. This abdication of responsibility is not authorized under the CWA or NEPA.[10]

As discussed in the preceding sections, Headquarters' prediction that the issuance of NWP 48 would have minimal individual and cumulative impacts on the environment, though repeatedly stated in the Decision Document, is not based on relevant evidence that a reasonable mind might accept as adequate to support the agency's conclusion, and the inclusion of general permit conditions does not obviate the need to analyze the impacts of proposed federal action. Thus, the Corps' impact analyses are based in large part on the hope that district engineers will mitigate any adverse environmental effects by revoking NWP 48, imposing regional or project-based conditions, and/or requiring an applicant to seek an individual permit. In this context, the Court finds that the Corps may not rely solely on post-issuance procedures to make its pre-issuance minimal impact determinations. See Bulen, 429 F.3d at 502 ("We would have substantial doubts about the Corps' ability to issue a nationwide permit that relied solely on post-

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[10] The Corps' analysis with regards to plastic debris discharged into the marine environment is even more problematic. The Corps acknowledges the many public comments raising concerns about the introduction of plastics into the marine food web, but relies on the fact that "[d]ivision engineers can impose regional conditions to address the use of plastics" in response to these concerns. NWP003402. The Seattle District, for its part, declined to quantify the impact of plastics, instead noting that "it would not be a practicable solution to regionally condition NWP 48 to not allow the use of PVC and HDPE gear as there are no current practicable alternatives to use of the materials." COE 127559. The CWA requires the Corps to make minimal adverse effect findings before issuing a general permit. If, as appears to be the case with regards to the discharge of plastics from the permitted operations, the Corps is unable to make such a finding, a general permit cannot issue. The Corps has essentially acknowledged that it needs to individually evaluate the impacts of a particular operation, including the species grown, the cultivation techniques/gear used, and the specific location, before it can determine the extent of the impacts the operation will have.

issuance, case-by-case determinations of minimal impact, with no general pre-issuance determinations. In such a case, the Corps' 'determinations' would consist of little more than its own promise to obey the law.").

CONCLUSION

A nationwide permit can be used to authorize activities involving the discharge of dredged or fill material only if the Corps makes a determination that the activity will have only minimal individual and cumulative adverse effects on the environment. In issuing NWP 48, the Corps has opted to interpret the "similar in nature" requirement of 33 U.S.C. § 1344(e)(1) broadly so that all commercial shellfish aquaculture activities in the United States could be addressed in a single nationwide permit. That choice has made assessing the impacts of disparate operations difficult: the Corps essentially acknowledges that the permitted activity is performed in such different ways and in such varying ecosystems that evaluating impacts on a nationwide level is nearly impossible. It tries to avoid its "statutory obligations to thoroughly examine the environmental impacts of permitted activities" by promising that the district engineers will do it. Hurst, 604 F. Supp. 2d at 901-02. The Court finds that the Corps has failed to adequately consider the impacts of commercial shellfish aquaculture activities authorized by NWP 48, that its conclusory findings of minimal individual and cumulative impacts are not supported by substantial evidence in the record, and that its EA does not satisfy the requirements of NEPA and the governing regulations.

For all of the foregoing reasons, plaintiffs' motions for summary judgment (Dkt. # 36 in C16-0950RSL and Dkt. # 31 in C17-1209RSL) are GRANTED and defendant's and intervenors' cross-motions (Dkt. # 44 and # 45 in C16-0950RSL and Dkt. # 43 and # 44 in C17-1209RSL)

are DENIED. The Corps' issuance of a nationwide permit, at least with respect to activities in the waters of the State of Washington, was arbitrary and capricious and not in accordance with NEPA or the CWA. Pursuant to 5 U.S.C. § 706(2), the Court holds unlawful and sets aside NWP 48 insofar as it authorizes activities in Washington.

The only remaining issue is whether NWP 48 should be vacated outright to the extent it has been applied in Washington, thereby invalidating all existing verifications, or whether equity requires that the permit be left in place while the agency performs an adequate impact analysis and environmental assessment to correct its unlawful actions. Idaho Farm Bureau Fed'n v. Babbitt, 58 F.3d 1392, 1405 (9th Cir. 1995).

> Although not without exception, vacatur of an unlawful agency action normally accompanies a remand. Alsea Valley All. v. Dep't of Commerce, 358 F.3d 1181, 1185 (9th Cir. 2004). This is because "[o]rdinarily when a regulation is not promulgated in compliance with the APA, the regulation is invalid." Idaho Farm Bureau Fed'n[, 58 F.3d at 1405]. When equity demands, however, the regulation can be left in place while the agency reconsiders or replaces the action, or to give the agency time to follow the necessary procedures. See Humane Soc. of U.S. v. Locke, 626 F.3d 1040, 1053 n.7 (9th Cir. 2010); Idaho Farm Bureau Fed'n, 58 F.3d at 1405. A federal court "is not required to set aside every unlawful agency action," and the "decision to grant or deny injunctive or declaratory relief under APA is controlled by principles of equity." Nat'l Wildlife Fed'n v. Espy, 45 F.3d 1337, 1343 (9th Cir. 1995) (citations omitted).

All. for the Wild Rockies v. United States Forest Serv., 907 F.3d 1105, 1121 (9th Cir. 2018). Courts "leave an invalid rule in place only when equity demands that we do so." Pollinator Stewardship Council v. U.S. E.P.A., 806 F.3d 520, 532 (9th Cir. 2015) (internal quotation marks and citation omitted). When determining whether to leave an agency action in place on remand,

we weigh the seriousness of the agency's errors against "the disruptive consequences of an interim change that may itself be changed." Cal. Cmties. Against Toxics v. U.S. E.P.A., 688 F.3d 989, 992 (9th Cir. 2012). In the context of environmental regulation, courts consider whether vacating the invalid rule would risk environmental harm and whether the agency could legitimately adopt the same rule on remand or whether the flaws were so fundamental that it is unlikely the same rule would result after further analysis. Pollinator Stewardship, 806 F.3d at 532.

Despite the fact that both plaintiffs clearly requested vacatur as the remedy for unlawful agency action, defendants provided very little evidence that would justify a departure from the presumptive relief in this APA action. The federal defendants state that additional briefing as to remedy should be permitted once the seriousness of the agency's error is determined. The intervenors assert that vacatur would cause disruption in the Washington shellfish farms and industry, including significant impacts to employees and the communities in which they live. Neither tact is compelling. The substantive defects in the agency's analysis when adopting the 2017 NWP are significant, the existing record suggests that adverse environmental impacts will arise if NWP 48 is not vacated, and, given the nature of the analytical defects and record evidence that seagrass is adversely impacted in the immediate vicinity of shellfish aquaculture, it seems unlikely that the same permit could issue following remand. As for the disruptive consequences to Washington businesses, employees, and communities, more information is required. As plaintiffs point out, shellfish growers can apply for individual permits (as they did before 2007). In addition, the Court has the equitable power to allow a period of time in which growers can avail themselves of that process before the existing verifications would be

invalidated or to fashion some other equitable remedy to minimize both the risks of environmental harm and any disruptive consequences.

While the current record does not support deviation from the presumptive remedy for an APA violation, the Swinomish Indian Tribal Community has requested an opportunity to be heard regarding the scope of the remedy. C18-0598RSL (Dkt. # 28). Swinomish also challenge the Corps' minimal impacts analyses in reissuing NWP 48, but, unlike the plaintiffs in the above-captioned matters, does not seek vacatur of verifications or permits issued under the NWP. The Court will accept additional briefing regarding the appropriate remedy.

Because there is a presumption in favor of vacatur, defendants, intervenors, and Swinomish will be the moving parties and may file motions, not to exceed 15 pages, regarding the appropriate relief for the APA violations discussed above. Only one motion may be filed in each of the three cause numbers at issue, C16-0950RSL, C17-1209RSL, and C18-0598RSL. The motions, if any, shall be filed on or before October 30, 2019, and shall be noted for consideration on November 15, 2019. Plaintiffs' responses, if any, shall not exceed 15 pages. Replies shall not exceed 8 pages.

The Clerk of Court is directed to docket a copy of this order in Swinomish Indian Tribal Community v. Army Corps of Engineers, C18-0598RSL.

Dated this 10th day of October, 2019.

Robert S. Lasnik
United States District Judge

Exhibit 352

From: Janet E
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Friday, December 20, 2019 10:55:54 AM

DO NOT allow Pond Creek Mine to discharge high chloride and sulfate waste water into the Big Muddy River. As a citizen of Illinois, I believe we must hold Pond Creek Mine Inc to a higher standard of environmental protection.
Janet Harris
Murphysboro, IL

Exhibit 353

From: Karen Fiorino
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine IL0077666
Date: Friday, December 20, 2019 11:56:55 AM

Karen Fiorino
45 Old US Hwy 51
Makanda, IL 62958
claylickcreek@gmail.com

20th December, 2019

Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES Illinois Environmental Protection Agency
1021 North Grand Avenue East
P. O. Box 19276
Springfield, IL 62794-9276

Re: Pond Creek Mine IL0077666

Dear Madam,
I attended the public hearing for the Pond Creek Mine on 12-18-19 and I want to enter into the record comments questioning the validity to issue a permit for this mine to dump pollutants into the Big Muddy River.

1. Several documents have said the pipeline is only for 10 years and then it will be removed. Is this the projected end of the date of the coal seam and mine closure? On page APP B-1 the IL DOA of the Results of Review, Permanent Program Permit Application No 456, says the pipeline is only for 10 years. Is this the projected end of the mine and its closure? Especially in the light that the first commenter of the night and mine booster said the mine had enough coal for the next 50 years. The citation (https address) given is grossly inaccurate as there are spelling errors within the link itself. Plus, who is going to pay for the removal of this pipeline as Foresight energy stocks which Williamson Energy, LLC is a subsidiary are tanking, and Foresight as of 12-20-19 Files An 8-K Entry into a Material Definitive Agreement https://t.co/xrHayH1eAG .

Why would the IEPA issue a permit to a company when the company is going into bankruptcy? Because Williamson Energy is a LLC, in a chapter 7 business bankruptcy, the LLCs assets are sold and used to pay the LLC's creditors. After the bankruptcy, the LLC's remaining debts are wiped and and the LLC is no longer in business. The LLC's owners are generally not responsible for the LLCs debts like retirement, ESOPs and 401K's and the 500 or so employees of Williamson Energy will have more problems besides losing just their jobs. They will lose their retirement pensions as well.

2. To address the issue of oversight of discharge from the mine, How many Marion water pollution control and mine staff are there now versus 20 years ago? There are 10 on staff 20 years ago and now 4. How will a staff of 4 people monitor the discharge from this mine along with all the other places in the region. Mines are to be inspected by the IEPA 2-4 times as a federal requirement. How many mine have between routinely inspected in the past 12 years? How many times has The Pond Creek Mine been inspected since the mine began?

How does a staff of 4 manage to do this while writing mining permits for mining companies? As per,

https://www.chicagotribune.com/news/environment/ct-met-illinois-epa-budget-cuts-20191205-pkwnmzzvuvgk3fgbplvxhbji6q-story.html Illinois also cut its environmental agency's workforce by 38% during the same period — more than any other state.

With a smaller staff and less money, the state agency has failed repeatedly to identify hazards to public health and hold polluters accountable, said Eric Schaeffer, a former top U.S. EPA enforcement official who directs the nonprofit Environmental Integrity Project and compiled one of the reports.

In conclusion, these comments along with the multitude of comments against issuing of a permit for Pond Creek Mine a private company to dump pollutants into a public waterway from my fellow citizens of the area implore you to not approve the permit referenced above to the Pond Creek Mine.

Sincerely,

Karen Fiorino

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****

Karen Fiorino
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Makanda, IL 62958
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Permanent Program Finding

Results of Review
Permanent Program Permit Application No. 456
Williamson Energy, LLC
Pond Creek No. 1 Mine

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The Illinois Department of Natural Resources, Office of Mines and Minerals, Land Reclamation Division (Department), the Regulatory Authority in Illinois under the Surface Mining Control and Reclamation Act of 1977 (Federal Act), 30 U.S.C. Section 1201 *et seq.*, has reviewed Permit Application No. 456 in accordance with the Surface Coal Mining Land Conservation and Reclamation Act (State Act), 225 ILCS 720, and the Department's regulations at 62 Ill. Adm. Code 1700-1850.

The applicant has submitted in writing the modifications required by the Department's letter dated December 20, 2018 (Appendix A). These modifications have been reviewed and approved by the Department. Pursuant to 62 Ill. Adm. Code 1773.19, the Department is approving the application as modified. The Department's decision is based upon a review of the record as a whole, and is supported and documented by the record. The findings and reasons for the Department's decision are set forth below. The period for administrative review under 62 Ill. Adm. Code 1847.3 commences as of the date of this decision.

I. SUMMARY OF APPLICATION

The application proposes a permit on 70.7 acres. The proposed permit area consists of 70.7 acres, of which all the acreage is are proposed to be used for support facilities.

The following is a summary of the pre-mining land uses and the proposed post-mining land uses. NOTE: Land uses are categorized under the definitions found in 62 Ill. Adm. Code 1701.5. Land use classifications under other regulatory programs and agencies may be different.

Land Use	Pre-Mining Acres	Post-Mining Acres
Cropland	16.4	16.4
Water Resources	0.2	0.2
Residential	0.1	0.1
Industrial/Commercial	8.2	8.2
Fish & Wildlife Habitat	45.8	45.8
Total	70.7	70.7

II. SUMMARY OF THE PUBLIC PARTICIPATION PROCESS

The Department finds that the public participation requirements of 62 Ill. Adm. Code 1773.13 and 1773.14 have been met.

The application was filed with the Department on May 25, 2017, and was deemed complete on July 13, 2017. The applicant placed a newspaper advertisement of the proposed operation in the Marion Republican and the Benton News, newspapers of general circulation in the area affected, once a week for four consecutive weeks, beginning on July 18, 2018. The applicant filed two (2) copies of the application with the County Clerks of Williamson County and Franklin County, in accordance with 62 Ill. Adm. Code 1773.13(a)(2), on July 18, 2018. Copies of the application were sent to the following State Agencies: Illinois Department of Agriculture (IDOA), and Illinois Environmental Protection Agency (IEPA), and the United States Department of Agriculture, Natural Resources Conservation Service (NRCS), and the United States Fish and Wildlife Service (USFWS) on July 13, 2018, for review and comment. In addition, copies were circulated with the appropriate Offices within the Illinois Department of Natural Resources (Department). Written notification of the application was given to those governmental agencies and entities required to receive notice under 62 Ill. Adm. Code 1773.13(a)(3).

State Agency comments on this application have been received by the Department, with the source and date of comments as follows: IDOA (September 21, 2018) and IEPA (August 30, 2018).

Comments on this application were also received from the NRCS dated September 12, 2018 and USFWS dated September 4, 2018 and October 2, 2019.

The Department received a request for a public hearing. The Department held a public hearing on October 23, 2018, in the Office of Mines and Minerals, Southern Illinois Regional Office in Benton, Illinois.

All comments received in writing and at the public hearing have been considered by the Department in reviewing this application. The Department's responses to these comments are set forth in Appendix B.

All comments received on this application have been furnished to the applicant, and have been filed for public inspection at the office of the County Clerk of the county in which the application is located.

III. SUMMARY OF THE DEPARTMENT'S FINDINGS

The Department, upon completing its review of the information set forth in the application, the required modifications submitted, if any, and information otherwise available, and made available to the applicant, and after considering the comments of State Agencies, and all other comments received, makes the following findings:

A. Findings Required by 62 Ill. Adm. Code 1773.15

REVIEW OF VIOLATIONS

Section 1773.15(b)(1): Based on a review of all reasonably available information concerning violation notices and ownership or control links involving the applicant, including information obtained pursuant to Sections 1773.22, 1773.23, 1778.13 and 1778.14, the Department has determined that the applicant or a person who owns or controls the applicant is currently in violation of the State Act, Federal Act or other law or regulation referred to in Section 1773.15(b)(1). Pursuant to this Section, the Department has determined that:

Section 1773.15(b)(1)(A): For the identified current violations, the applicant submitted proof that the current violations have been or are in the process of being corrected to the satisfaction of the agency that has jurisdiction over the violations.

Documentation provided by the applicant to comply with Section 1773.15(b)(1)(A) is attached as Appendix E.

Section 1773.15(b)(2): This permit is being conditionally issued on the basis of proof submitted under Section 1773.15(b)(1)(A) that the violation is in the process of being corrected. The conditional issuance is set forth in Part IV.

Section 1773.15(e): The Department received updated compliance information in the applicant's modifications response received October 21, 2019 and updated information on December 2, 2019. Based on the compliance review required by Section 1773.15(b)(1), a review of the OSM Applicant Violator System for outstanding violations, and in light of no new information submitted pursuant to Sections 1778.13(i) and 1778.14(e), the Department reconsidered its decision to approve the application and found that no change in its decision to issue the permit is necessary.

SECTION 1773.15(c)(1) FINDINGS

Section 1773.15(c)(1): The application, as modified, is accurate and complete and all requirements of the Federal and State Acts and the regulatory program have been met.

TOPSOIL SUBSTITUTION FINDING

Section 1817.22(b): The applicant has proposed the use of selected overburden materials as a substitution for, and a supplement to topsoil as delineated in the application. In accordance with Section 1817.22(b), the Department finds that the applicant has adequately demonstrated that the resulting soil medium is equal to, or more suitable for, sustaining vegetation than existing topsoil, and the resulting soil medium is the best available in the permit area to support vegetation. Permission is hereby granted to use the selected overburden as requested.

SEDIMENT POND EXEMPTION

Section 1817.46(e): A sediment pond exemption is requested for an area delineated in the application. The regulations at Section 1817.46(e) allow the Department to grant exemptions from the requirement to pass all disturbed drainage through a siltation structure when:

a. The disturbed drainage area within the total disturbed area is small; and

b. Alternate sediment control measures as described in Section 1817.45(b) are used in lieu of a siltation structure, and the applicant demonstrates that siltation structures are not necessary for drainage from the disturbed area to meet the effluent limitations and water quality standards for the receiving waters set forth in Section 1817.42.

The Department has determined that the area for which a sediment pond exemption is requested meets the criteria established in Section 1817.46(e) and hereby grants an exemption from the use of a sedimentation pond for this area.

STREAM BUFFER ZONE VARIANCE

Section 1817.57(a)(1): The applicant has requested a stream buffer zone variance for an area as delineated in the application. In accordance with Section 1817.57(a)(1), the Department finds that:

a. The original stream channel and its associated riparian vegetation will be restored; and

b. Surface mining activities will not cause or contribute to a violation of Section 1817.42 and will not adversely affect the water quantity and quality or other environmental resources of the stream.

Therefore, the Department authorizes surface mining activities closer than one hundred (100) feet of the top of the bank of the normal channel of the perennial or intermittent stream or through the stream.

SECTION 1773.15(c)(2) – (c)(13) FINDINGS

Section 1773.15(c)(2); The applicant has demonstrated that reclamation as required by the Federal and State Acts and the regulatory program can be accomplished under the reclamation plan contained in the application, as modified.

Section 1773.15(c)(3)(A): The proposed area is not within an area under study or administrative proceedings under a petition, filed pursuant to Section 1764, to have an area designated as unsuitable for surface coal mining operations.

Section 1773.15(c)(3)(B): The proposed area is not within an area designated as unsuitable for mining pursuant to Sections 1762 and 1764 or subject to the prohibitions or limitations of Section 1761.11.

Section 1761.11(a): The proposed area does not include any lands within the boundaries of the National Park System, the National Wildlife Refuge System, the National System of Trails, the National Wilderness Preservation System, the Wild and Scenic Rivers System, or National Recreation Areas designated by Act of Congress.

Section 1761.11(b): The proposed area is not on any Federal lands within the boundaries of any national forest.

Section 1761.11(c): The proposed surface coal mining and reclamation operations will not adversely affect any publicly owned park or any privately owned or publicly owned places included on the National Register of Historic Places.

Section 1761.11(d): The proposed area is within one hundred (100) feet measured horizontally of the outside right-of-way line of public roads in Williamson and Franklin Counties, described as follows: Interstate 57, State Route 37, Williams Prairie Road, Harris School Road, Old Ben Road, Old Frankfort Road, Eberhardt Road, Duncan Road, Monroe Road, Collin Road, Horseshoe Road, Freeman Spur Blacktop (Franklin Co. Rte. 6), Deason Road, Sandburg Road, Freemanspur Road, Gossage Road, Lake Creek Road, and Cheatman Road.

The proposed area is adjacent to the right-of-way of Interstate 57, State Route 37, Williams Prairie Road, Harris School Road, Old Ben Road, Old Frankfort Road, Eberhardt Road, Duncan Road, Monroe Road, Collin Road, Horseshoe Road, Freeman Spur Blacktop (Franklin Co. Rte. 6), Deason Road, Sandburg Road, Freemanspur Road, Gossage Road, Lake Creek Road, and Cheatman Road. The proposed activities in the application area include the installation of pipeline and boring underneath the roads

No approvals from the authority with jurisdiction over the roads were required for areas outside the right of way. The permittee shall be responsible for all permits required from the road authorities necessary for any access and operations performed within the right of way of said roads. See Condition K.

The applicant provided proper public notice and opportunity for a public hearing. A public hearing was held on October 23, 2018 and while many written comments were submitted to the Department, none of the written comments were concerning these roads.

The Department finds the interests of the public and affected landowners will be protected from the proposed mining operations as a result of the measures to be

taken by the applicant as described in the mining operations plan concerning these roads.

Section 1761.11(e): The proposed area is within three hundred (300) feet measured horizontally of several occupied dwellings.

The owners of the dwellings have provided written waivers pursuant to Section 1761.15 consenting to surface coal mining operations closer than three hundred (300) feet.

Section 1761.11(f): The proposed area is not within three hundred (300) feet measured horizontally of any public building, school, church, community or institutional building, or public park from which the applicant will be required to maintain a three hundred (300) foot buffer zone.

Section 1761.11(g): The proposed area is not within one hundred (100) feet measured horizontally of a cemetery.

Section 1773.15(c)(4): This section is applicable to surface mining operations only.

Section 1773.15(c)(5): The Department has assessed the probable cumulative impacts of all anticipated coal mining on the hydrologic balance in the cumulative impact area, in accordance with Part 1784 and finds that the operations proposed under the application have been designed to prevent material damage to the hydrologic balance outside the proposed area (see Appendix C).

Section 1773.15(c)(6): The applicant has not proposed the use of any existing structures in the application requiring compliance with Section 1700.11(d).

Section 1773.15(c)(7): The applicant will submit fees required by these regulations before the permit is issued. The fee required is $1,767.50 for the term of the permit, which may be paid in annual increments. The Department finds that the applicant has paid all reclamation fees from previous and existing operations as required by 30 CFR 870.

Section 1773.15(c)(8): See Part III – Subpart B.

Section 1773.15(c)(9): The applicant has satisfied the requirements for a long-term, intensive agricultural post-mining land use, in accordance with the requirements of Section 1817.111(d).

Section 1773.15(c)(10): The operation as approved will not affect the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitats, as determined under the Endangered Species Act of 1973 (16 USC 1531 *et seq.*, see Appendix F).

Section 1773.15(c)(11): The requirements of this section are not applicable as there are no proposed remining operations.

Section 1773.15(c)(12): The effect of the proposed permitting action on properties listed on or eligible for listing on the National Register of Historic Places has been taken into account by the Department.

Section 1773.15(c)(13): The requirements of this section are not applicable as there are no proposed remining operations.

B. Findings Required by 62 Ill. Adm. Code 1785 (Applicable Sections)

PRIME FARMLANDS

A soil survey was submitted by the applicant that shows prime farmland soils identified in this application which have been historically used as cropland. The soil survey prepared by the USDA provides the required soil information.

The applicant has, with respect to prime farmland, satisfied the requirements of Section 1785.17. (See Part B, below, and Appendices D and G.)

Section 1785.17(e)(1): The Department finds that the approved post-mining land use of the prime farmlands is cropland.

Section 1785.17(e)(2): The Department finds that the permit incorporates as specific conditions the contents of the plan submitted under Section 1785.17(c), after consideration of any revisions to that plan suggested by the State Conservationist under Section 1785.17(d).

Section 1785.17(e)(3): The Department finds that the applicant has the technological capability to restore the prime farmland, within a reasonable time, to equivalent or higher levels of yield as non-mined prime farmland in the surrounding area under equivalent levels of management.

Section 1785.17(e)(4): The Department finds that the proposed operations will be conducted in compliance with the requirements of Section 1823 and other environmental protection performance and reclamation standards for mining and reclamation of prime farmland of the regulatory program.

Section 1785.17(e)(5): The Department finds that the aggregate total prime farmland acreage has not been decreased from that which existed prior to mining. Water bodies, if any, are located within the post-reclamation non-prime farmland portions of the permit area and the consent of all affected property owners has been obtained.

Section 1785.20: The requirements of this section are not applicable to this application.

C. Compliance with 62 Ill. Adm. Code 1773.19

Section 1773.19(a)(1): The Department has based its decision to approve, as modified, the application, based on public participation as provided by Sections 1773.13 and 1773.14, compliance with all applicable provisions of Section 1785, and the processing and complete review of the application.

Section 1773.19(a)(3): The Department is providing written notification of its final permit decision to the following persons and entities:

a. The applicant, each person who filed comments or objections to the application, and each party to the public hearing;

b. The County Board of the counties in which the application is located; and,

c. The Office of Surface Mining.

All materials supporting these findings are a part of the public record and are hereby incorporated by reference.

IV. PERMIT CONDITIONS

A. The permittee shall conduct surface coal mining and reclamation operations only on those lands specifically designated as the permit area on the maps submitted with the application and authorized for the term of the permit and that are subject to the performance bond or other equivalent guarantee in effect pursuant to 62 Ill. Adm. Code 1800.

B. The permittee shall conduct all surface coal mining and reclamation operations as described in the approved application, except to the extent that the Department otherwise directs in the permit.

C. The permittee shall comply with the terms and conditions of the permit, all applicable performance standards of the Federal and State Acts, and the requirements of the regulatory program.

D. Without advance notice, delay, or a search warrant, upon presentation of appropriate credentials, the permittee shall allow the authorized representatives of the Department and Secretary of the United States Department of the Interior to:

1. Have the right of entry provided for in 62 Ill. Adm. Code 1840.12; and,

2. Be accompanied by private persons for the purpose of conducting an inspection in accordance with 62 Ill. Adm. Code 1840, when the inspection is in response to an alleged violation reported to the Department by the private person.

E. The permittee shall take all possible steps to minimize any adverse impacts to the environment or public health and safety resulting from noncompliance with any term or condition of this permit, including, but not limited to:

1. Accelerated or additional monitoring necessary to determine the nature and extent of noncompliance and the results of the noncompliance;

2. Immediate implementation of measures necessary to comply; and,

3. Warning, as soon as possible after learning of such noncompliance, any person whose health and safety is in imminent danger due to the noncompliance.

F. As applicable, the permittee shall comply with 62 Ill. Adm. Code 1700.11(d) for compliance, modification, or abandonment of existing structures.

G. The permittee shall pay all reclamation fees required by 30 CFR 870 for coal produced under this permit for sale, transfer, or use.

H. Within thirty (30) days after a cessation order is issued under 62 Ill. Adm. Code 1843.11, for operations conducted under the permit, except where a stay of the cessation order is granted and remains in effect the permittee shall either submit to the Department the following information, current to the date the cessation order was issued, or notify the Department in writing that there has been no change since the immediately preceding submittal of such information:

1. Any new information needed to correct or update the information previously submitted to the Department by the permittee under 62 Ill. Adm. Code 1778.13(c); or

2. If not previously submitted, the information required from a permit application by 62 Ill. Adm. Code 1778.13(c).

I. Species Protection:

1. Issuance of this permit under the Surface Coal Mining Land Conservation and Reclamation Act does not in any way authorize any take of any listed species in violation of the Illinois Endangered Species Protection Act, 520 ILCS 10/1 *et seq*. With respect to the Indiana bat, an Incidental Take authorization has been approved as part of this permitting action consistent with and in compliance with the Endangered Species Act of 1973, 16 USC 1531 *et seq*. The Department has determined that this project may affect the northern long-eared bat, but that any resulting Incidental Take is not prohibited by the Final 4(d) rule and is consistent with the U.S. Fish and Wildlife Service Jan 2016 Programmatic Biological Opinion on the Final 4(d) rule. The Department and the applicant are in compliance with

Section 7 of the Endangered Species Act of 1973, as amended. If any other "take" as defined by these Acts is anticipated to result from permitted activities, it is recommended that the permittee apply for an Incidental Take permit from the Illinois Department of Natural Resources, Office of Resource Conservation for state listed species.

2. Issuance of this permit under the Surface Coal Mining Land Conservation and Reclamation Act does not in any way authorize any take of a bald or golden eagle, including nests or eggs, in violation of the Bald Eagle Protection Act (16 U.S.C. 668 *et seq.*). If "take" as defined by the Bald Eagle Protection Act is anticipated to result from permitted activities, it is recommended that the permittee should apply for an Incidental Take (non-purposeful take) permit from the U.S. Fish and Wildlife Service. The Department and the U.S. Fish and Wildlife Service shall be notified if a bald or golden eagle nest is observed in the permit area or in the vicinity of the permit area.

3. If any onsite stream and/or wetland mitigation is required based on upon U.S. Army Corps of Engineers requirements, then the Department shall be notified to establish appropriate permitting actions under SMCRA.

J. If the permit is conditionally issued under 62 Ill. Adm. Code Section 1773.15(b)(2) on the basis of **(1)** a presumption supported by certification under 62 Ill. Adm. Code Section 1778.14 that the violation is in the process of being corrected; **(2)** proof submitted under 62 Ill. Adm. Code Section 1773.15(b)(1)(A) that the violation is in the process of being corrected; or **(3)** pending the outcome of an appeal described in 62 Ill. Adm. Code Section 1773.15(b)(1)(B), issuance is conditioned as follows:

1. If subsequent to permit issuance applicant is issued a failure-to-abate cessation order, the permit shall be suspended and/or rescinded in accordance with the procedures for 62 Ill. Adm. Code Section 1773.20(c) Improvidently Issued Permits within 30 days of the issuance of the failure-to-abate cessation order.

2. If subsequent to permit issuance the Department is notified by the agency that has jurisdiction over the violation that the violation is no longer in the process of being corrected to the satisfaction of said agency, the permit shall be suspended and/or rescinded in accordance with the procedures for 62 Ill. Adm. Code Section 1773.20(c) Improvidently Issued Permits within 30 days of such notification.

3. If subsequent to permit issuance the circuit or district court reviewing the violation either denies a stay applied for in the appeal or affirms the violation, then the applicant shall submit the proof required under 62 Ill. Adm. Code Sections 1773.15(b)(1)(A) within 30 days after the court's decision or the permit shall be suspended and/or rescinded in accordance with the procedures for 62 Ill. Adm. Code Section 1773.20(c) Improvidently Issued Permits within 30 days of such failure to submit required proof.

K. Pursuant to Section 1778.15, the permittee shall possess all necessary legal rights to enter and conduct surface coal mining and reclamation operations within the permit area until final bond release is obtained.

The permittee has indicated valid permits shall be obtained from the Illinois Department of Transportation and private rail lines. Pursuant to 1778.15(a), and as committed in Attachment I.2.A, the permittee shall provide the Department with valid right of entry agreements with the (1) Illinois Department of Transportation and (2) private railways prior to the commencement of operations in regard to areas controlled by the Illinois Department of Transportation and the private railway lines.

L. The permittee shall commence all groundwater and surface water monitoring approved by this permit upon initial disturbance of lands within the permit area. Monitoring shall be in accordance with the approved permit and/or as outlined in Appendix C of this finding document.

M. The substitute topsoil material referenced in the response to Part II(13) (D and F) of the application shall be limited to the Rend, Bluford, Hickory-Kell, Okaw, Belknap and Orthent soil series where the subsoil texture is a silt loam. In addition, the pH, phosphorus, and potassium of the borrow materials shall be fertilized with rates to achieve a pH of 6.5, and phosphorus and potassium levels of 50 ponds/acre and 260 pounds/acre, respectively.

N. The approved operations plan includes the installation of a pipeline within a defined permit corridor and a diffuser site in the Big Muddy River. As required by 62 Ill. Adm. Code 1784.23 and 1784.30, the permittee shall submit an as-built certification of the pipeline and discharge structure within 30 days of completion of installation of the pipeline. The as-built shall be sealed by a qualified registered professional engineer and at a minimum include the following information:

1. Verification that the pipeline was installed within the permitted corridor at the minimum depths indicated in the Illinois Department of Agriculture's Pipeline Construction Standards and Policies for Agricultural Impact Mitigation (Attachment IV.2.B.3) and in the Typical Stream Crossing Drawing (Attachment IV.7.I) included in the permit application.

2. Location of all monitoring stations on a Surface Operations Map.

3. List of the monitoring equipment installed at each station.

4. Actual diameter of the installed pipeline and/or diameter of sections of the pipeline if different diameters were used.

5. Cross section of the discharge structure/diffuser site if any changes to the approved plan were made to these structures during installation.

O. The approved operations plan includes plans for monthly visual and physical monitoring of the pipeline, as well as an annual testing of the monitoring equipment. To ensure compliance with 62 Ill. Adm. Code 1784.11(b)(6) and 1817.45(a), the applicant shall:

1. Submit to the Department the results of the pressure testing performed prior to putting the pipeline in service. The initial testing results shall be included in the as-built document required by condition N.

2. Submit to the Department the results of the annual pipeline testing of the monitoring system with a clear description of any identified deficiencies and the steps that would be taken to maintain safe pipeline performance. The results of the annual testing of the pipeline monitoring system shall be submitted to the Department within 30 days of completion.

V. CONCLUSIONS

Based upon the information contained in the application, information otherwise available and made available to the applicant, the comments of State Agencies, the foregoing analysis of the probable impact of the proposed operations, all findings and information contained herein and conditions set forth in Part IV, the Department finds that there is a reasonable basis on which to issue a permit for the application, as modified.

Enter on behalf of the Illinois Department of Natural Resources, Office of Mines and Minerals, Land Reclamation Division as Regulatory Authority.

Illinois Department of Natural Resources

Donald Stewart, Director
Office of Mines and Minerals

Dated: December 5, 2019

APPROVED FOR EXECUTION
Date: 12/4/19
Legal Counsel:

12030906.docx

APPENDIX A

REQUIRED MODIFICATIONS

ILLINOIS
NATURAL RESOURCES

Illinois Department of
Natural Resources

One Natural Resources Way Springfield, Illinois 62702-1271
www.dnr.illinois.gov

Bruce Rauner, Governor
Wayne A. Rosenthal, Director

December 20, 2018

Carson Pollastro
Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951

Via Certified Mail 7017 1000 0001 0939 4488

Re: Modification to Permit Application No. 456
Pond Creek Mine

The Department, after reviewing the information contained in the permit application and information otherwise available to the applicant, and after considering all comments received, has determined that modification of Permit Application No. 456 is necessary. The modifications to the application shall comply with the requirements of 62 Ill. Adm. Code 1777.11. The modifications required by the Department are enclosed here. If the applicant does not desire to modify the permit application as described below, it may, by filing a written statement with the Department, deem the permit application denied, and such denial shall constitute final action.

Pursuant to 62 Ill. Adm. Code 1773.15(a)(1)(B)(i), modifications required by the Department shall be received within one year from the date of this letter. Absent the modifications required by the Department, the application does not demonstrate compliance with the requirements of the Illinois Surface Coal Mining Land Conservation and Reclamation Act, Regulations and Regulatory Program and the Department will issue a written finding denying the application.

The period for administrative review (62 Ill. Adm. Code 1847.3) shall commence upon:

- receipt by the applicant of a written decision from the Department, approving the application as modified, or
- if the applicant's modifications are insufficient, or if the applicant fails to submit the required modifications in accordance with 62 Ill Adm. Code 1773.15(a)(1)(B)(i), receipt by the applicant of a written decision from the Department denying the permit application, or
- receipt by the Department of the applicant's denial statement.

The modifications required by the Department are as follows:

1. Pursuant to 62 Ill. Adm. Code 1779.25(b), 1780.14(c), and 1780.25(a), and as required by Part 1.6 of the application, the Department is requiring the applicant to modify the application by submitting engineering certifications where the modifications result in changes to maps, plans, or cross sections submitted under the original application.

2. Pursuant to 62 Ill. Adm. Code 1777.11(c), and as required by Part I.1 of the application, the Department is requiring the submittal of a verification by a responsible official of the applicant for the information being submitted as a result of this modification letter.

3. Pursuant to 62 Ill. Adm. Code 1778.15 and Operator Memorandum 2011-01, the applicant is required to provide a signed notarized waiver from landowners for properties not owned or controlled by the permittee. Information provided in Attachment I.2.A reveals property not under control by the applicant and shall require a landowner waiver.

4. Pursuant to 62 Ill. Adm. Code 1778.13(c), the applicant shall provide information for each person who owns or controls the applicant under the definition of "owned or controlled" and "owns or controls" in 62 Ill. Adm. Code 1773.5. Review of the information provided and available to the Department, the applicant failed to provide ownership and control information for an owner/controller of the applicant, specifically Foresight Energy Services, LLC and Foresight Reserves LP as part owner/controller of Foresight Energy GP, LLC. The applicant shall provide current, updated ownership and control information for Williamson Energy, LLC including the necessary information for Foresight Energy Services, LLC or end date and complete ownership and control for Foresight Reserves LP or update ownership for Foresight Energy GP, LLC removing as part owner.

   Further review of the information provided in the ownership and control should be made by the applicant for other omissions or inaccuracies. The Department finds discrepancies with begin dates for some of the officers listed in the organizations ownership and control information.

5. Pursuant to 62 Ill. Adm. Code 1773.15(b)(1)(A), the applicant shall submit to the Department proof that current violations have been or are in the process of being corrected to the satisfaction of the issuing agency. Specifically, the Department finds two violations listed in Attachment I.9, CO 171025 and CO 171028, that will require additional information regarding the progress of abatement.

   The applicant shall provide proof from the PA Department of Environmental Protection of the progress of these violations. Review shall be made by the applicant to ensure all documents are included for all outstanding violations required to be reported.

6. Pursuant to 62 Ill. Adm. Code 1778.18, an application shall contain a certificate of liability insurance in compliance with 62 Ill. Adm. Code 1800.60. The Department finds the

certificate provided is not with an "authorized" insurer and shall require a revised certificate that is in compliance with the required regulations.

7. The response to Part V.1.B of the application is incomplete. Pursuant to 62 Ill. Adm. Code 1800.14, the applicant shall include the following:

   a. Information on the costs associated with removing the diffuser and all associated items from the Big Muddy River. Include all potential costs (such as possible coffer dam to divert water from the work site, divers to work in the Big Muddy River if needed, etc.)

   b. Information on possible removal costs associated with the pipeline such as air relief valves and other pipeline structure that cannot remain permanently post reclamation.

8. Pursuant to 62 Ill. Adm. Code 1783.21, Part II.13.D of the application, page II-8, must be modified to provide for a minimum topsoil removal thickness of 6 inches or greater where present.

9. Pursuant to 62 Ill. Adm. Code 1783.21, Part IV.2.B.3 of the application, page IV-2, must be modified to identify the qualifications of the person referenced in the soil handling procedure. In addition, the response must clarify it uses the most current version of the IDOA pipeline guidelines during construction.

10. Attachment IV.1 "Figure 2 Water Flow Diagram Proposed System" shows an Outfall 010 referred to as the "Pond Creek Stormwater Mixing Zone." This outfall and mixing zone are also referenced in the Attachment IV.1 narrative. Pursuant to 62 Ill. Adm. Code 1784.14(i) the applicant shall clarify if Outfall 010, "Pond Creek Stormwater Mixing Zone" is proposed as part of Permit Application No. 456.

11. According to Attachment IV.1, the applicant states that the holding cell will hold mine infiltration water as well as decant water from the slurry cell. Pursuant to 62 Ill. Adm. Code 1784.14(i), the applicant shall clarify whether the IEPA mixing zone permit has considered potential constituents contained within the clarified decant water.

12. The following concerns the response to Part III.2.D.1.a. Considering the response to Modification Question 11 and pursuant to 62 Ill. Adm. Code 1784.14(b)(1), the applicant shall provide representative water quality data from the water holding cell and clarify whether the chloride and sulfate data represent only the infiltrating groundwater or a mix of infiltrating groundwater and process water (if applicable).

13. In response to Part III.2.D.1.a, the applicant states an anticipated maximum flow rate of infiltration water from the mine is 3,500,000 gallons per day. Pursuant to 62 Ill. Adm. Code

1784.14(b)(2), the applicant shall clarify what this value represents in relation to the amount of water the company intends to discharge from the facility.

14. The Department is in receipt of a letter addressed to the applicant dated August 30, 2018 from the Illinois EPA (IEPA) requesting changes or clarification. Pursuant to 62 Ill. Adm. Code 1784.14, the applicant shall provide responses to the questions in the IEPA letter. If any response to the IEPA letter results in changes to the permit application, the applicant shall clearly indicate which application part and/or map is being revised.

15. In response to Part IV.1, the applicant references Attachment IV.1 for operations plan information. Page 3 of Attachment IV.1 indicates the preparation plant requires 2,300,000 gpd. In contrast, the water flow diagram proposed system depicts the preparation plant supply to be of 2,880,000 gpd. Pursuant to 62 Ill. Adm. Code 1777.11, clarify the apparent discrepancy in preparation plant volumes.

16. In response to Part IV.5.C.2, the applicant references Attachment IV.5.C.2 for additional information concerning the water management pipeline. Pursuant to 62 Ill. Adm. Code 1817.41(a), the applicant shall provide the following information and update all appropriate responses as necessary:

    a. Locate on the Operations Map automatic and manual shut off valves and pressure gauges.

    b. Provide additional detail on the process to pressure test pipeline integrity after it has been constructed and prior to being placed into operation.

    c. Provide additional detail on the operational monitoring of the pipeline to detect leaks and the actions taken to shut down the pipeline should monitoring indicate a potential leak is occurring.

    d. Provide additional detail on procedures and actions to be taken should a spill occur.

17. In response to Part IV.7.I, the applicant requests a stream buffer variance to multiple streams for the temporary construction practices involved in placing the transport pipeline. Pursuant to 62 Ill. Adm. Code 1817.57, the following additional information shall be provided concerning disturbances in the buffer zone and channel of the Big Muddy River.

    a. The response discusses adequately sized riprap to be keyed into the toe of the embankment. The applicant shall provide minimum sizing design based on expected stream flow velocities to assure a stable bank is maintained.

    b. The applicant shall expand the narrative to address construction steps of the diffuser port within the Big Muddy River channel. Detail on the anticipated extent of the

disturbance during installation and specific steps to control and contain off-site impacts shall be provided.

c. The area not to be disturbed shall be designated a buffer and marked as specified in Section 1817.11.

18. In response to Part IV.7.B, it appears the applicant answered the questions referring to handling of drainage after the pipeline has been put in place and covered by soil material. To ensure compliance with 62 Ill. Adm. Code 1817.45(a), the applicant shall expand the discussion in this response to explain which erosion and sediment control measures will be used to handle drainage from unaffected areas during the construction of the waterline.

19. In Attachment IV.1, the applicant states that monitoring of the water pipeline will include a monthly visual inspection of each road and highway crossing, the Pond Creek crossing and the Big Muddy discharge site. It will also include a physical inspection of the monitoring equipment. Pursuant to 62 Ill. Adm. Code 1817.41(a), the applicant shall provide:

a. A list of all inspection sites and a map defining the inspection site locations.

b. Additional information describing how the entire pipeline corridor will be maintained for access by both the Department's staff to inspect and for company personnel to maintain and make necessary repairs in a timely manner.

c. Specifically what monitoring equipment is intended to be physically inspected.

d. Further information addressing the need to physicaliy inspect air release valve locations and other similar critical junctions in the pipeline system as part of the monthly inspection.

20. Pursuant to 62 Ill. Adm. Code 1780.23 and 1784.15, the applicant shall provide the acreage and capability of each land use within the proposed permit area, employing only land use categories of 62 Ill. Adm. Code 1701.5. Further, the "fish and wildlife" land use category must be subdivided as required by Operator Memorandum 2015-01. **Use only these land uses for completing the land use maps.**

a. The individual land use acreages provided in the Pre-mining Land Use Table in Part II.4 of the application do not calculate to the Total Permit Acreage provided within this table. The applicant shall clarify this discrepancy.

b. The applicant shall revise all Tables, Maps and Figures to reflect only the "fish and wildlife" land use categories outlined within Operator Memorandum 2015-01.

21. Pursuant to 62 Ill. Adm. Code 1777.11(a)(3) and as required by Part V.2.A of the application, the applicant shall provide acreage figures for each post-mining land use proposed and designate the post-mining land uses on the Post-Mining Land Use Maps.

    a. The applicant shall revise all Tables, Maps and Figures to reflect **only** the "fish and wildlife" land use categories outlined within Operator Memorandum 2015-01.

    b. The individual land use acreages provided in the Post-Mining Land Use Table in Part V.2.A of the application do not calculate to the Total Permit Acreage provided within this table. The applicant shall clarify this discrepancy.

    c. Acreage for post-mining land uses provided by the applicant in the Post-Mining Land Use Table in Part V.2.A of the application are not the same as that provided in the Pre-mining Land Use Table in Part II.4. The applicant states in multiple locations of the application that post-mining land uses are the same as pre-mining land use. The acreage provided within the tables contradicts this statement and the applicant shall clarify this discrepancy.

22. Pursuant to 62 Ill. Adm. Code 1817.97(f) and required by Part V.B.3, the applicant is required to provide a statement explaining how impact control measures, management techniques, and monitoring methods will be utilized to protect or enhance habitats of unusually high value for fish and wildlife such as wetlands and riparian areas to be affected by the proposed mining and reclamation operations. The applicant shall address the following pertaining to the proposed water management pipeline construction corridor.

    a. In response to Part V.B.3, the applicant states that "no habitats of unusually high value have been observed within the project area". The applicant has provided a Stream and Wetland delineation report as Attachment II.9 to Part II of the application identifying streams and wetlands located within the proposed permit area. The applicant shall provide a statement in Part V.B.3 explaining how impact control measures, management techniques, and monitoring methods will be utilized to protect or enhance these areas.

    b. The applicant has provided a Stream and Wetland delineation report as Attachment II.9 to Part II of the application. Wetland A and Wetland B are not part of this proposed permit and shall be removed from all applicable parts of the application.

    c. As required by Part V.3.B.1, the applicant shall provide information on whether or not ponds on site will contain hazardous concentrations of toxic-forming materials and if so, then describe how control measures, management techniques, and monitoring methods will be used to ensure how wildlife protected under the

Endangered Species Act, Migratory Bird Treaty Act, and the Bald Eagle Protection Act are excluded from these areas or justify why this information is not provided.

23. Pursuant to 62 Ill. Adm. Code 1817.111, 1817.114, and as required by in Part V.1.D.3, the applicant is required to describe methods to be used in planting and seeding.

    a. In response to Part V.1.D.3, the applicant refers to planting of the proposed refuse disposal area. No refuse disposal area is proposed as part of this application. The applicant shall clarify this discrepancy.

    b. In response to Part V.1.D.3, the applicant provides a list of considerations and recommendations to prepare the site for planting. The applicant is required by Part V.6.D.3 to provide the actual methods to be used in planting and seeding rather than considerations and recommendations. The applicant shall revise this response in the application to include the actual methods to be implemented.

24. Pursuant to 62 Ill. Adm. Code 1784.21(a)(2)(A) and 1817.97(b), the applicant is required to provide site specific resource information for threatened and endangered species including but not limited to the Indiana bat *(Myotis sodalis)* (INB) and northern long-eared bat *(Myotis septentrionalis)* (NLEB). This information has been provided in Attachment II.8 and Part V.3.B.4; however, the following information/updates are required:

    a. Attachment II.8 refers to Permit 434 within the title on Page 1. This shall be revised to reflect the correct permit number.

    b. Attachment II.8 and Part V.3.B.4 of the application states that NLEB were not identified within the project area and therefore, in accordance with current USFWS protocol, are not present within the project area. The applicant did not survey the entire project alignment, thus probable absence cannot be assumed within the portions of the project that were not surveyed. The applicant shall update Attachment II.8 and Part V.3.B.4 of the application, including the discussion of whether the project is consistent with the northern long-eared bat *(Myotis septentrionalis)* Final 4(d) Rule published in the Federal Register in January 2016.

    c. The applicant has identified 3.9 acres of forested acres to be disturbed within known INB habitat based on the survey information provided. It is required that at least 70 percent of the total INB habitat that will be lost should be replaced or mitigated off-site as described in the 2013 Indiana bat Protection and Enhancement Guidelines published by the USFWS. The applicant shall update the Long-Term Habitat Replacement section of the INB PEP.

d. Tree Clearing restrictions within the INB PEP state that tree clearing operations will only occur from November 15 to March 31, unless otherwise authorized. These dates are not consistent with those described in the 2013 Indiana bat Protection and Enhancement Guidelines published by the USFWS. The applicant shall clarify this inconsistency.

e. The applicant has stated within the summary of the INB PEP that forested acres cleared during construction operations will be supplemented in the short-term by erecting bat boxes. The applicant shall update the Short-term Habitat Replacement section of the PEP to reflect this statement and provided further details as to the timing and number of bat boxes to be erected.

If you have any questions, please contact this office at (217) 782-4970, or our Southern office in Benton at (618) 439-9111.

Sincerely,

Nick San Diego, Supervisor
Office of Mines and Minerals

NSD:JSc

cc: W. Gillespie
Williamson County Clerk 7017 1000 0001 0939 4495
Franklin County Clerk 7017 1000 0001 0939 4501

APPENDIX B

CONSIDERATION OF COMMENTS AND OBJECTIONS

62 Ill. Adm. Code 1773.13(b) allows submission of written comments on applications. The following are comments received from the State Agencies, County Board and other members of the public and the Department's response to those comments.

Illinois Department of Agriculture

Comment: The Illinois Department of Agriculture (IDOA) has reviewed the above referenced permit application. The application is for a 12.5-mile long 18 and 24-inch water mains to pump water from the underground mine to the Big Muddy River. All water from the mine will go through holding cells before being discharged to the pipeline. The pipeline will follow the railroad right-of-way (ROW), both active and abandoned, a gas pipeline and road ROW. Construction affects 12.67 acres of cropland. The pipeline will be in place for 10-years then removed. The mine has indicated they will follow the IDOA's Pipeline Construction Standards and Policies. The IDOA requests that the revision shown on the agricultural website be used. See: *https://www2.illinois.gov/sites/agr/Resources/LandWater/Documents/pipelinestandardspolicies.pdf.*

Response: The Department required modification of the application (Appendix A, Modification Question No. 9) to ensure the most current version of the IDOA Pipeline Constructions Standards and Policies were included in the permit.

Illinois Environmental Protection Agency

Comment:

1. To ensure compliance with 62 Ill. Adm. Code 1817.42 as it pertains to mine discharge quality, the Schedule A contained in Part III of the application should be revised as follows:
    a. Iron concentrations are indicated to be within the range of 3.0 - 6.0 mg/1. The applicant should revise this indication to provide an "estimate" of basin discharge Iron concentrations rather than the acceptable range from the Subtitle D regulations.
    b. Total Suspended Solids concentrations are indicated to be within the range of 35.0 - 70.0 mg/1. The Applicant should revise this indication to provide an "estimate" of basin discharge Total Suspended Solids concentrations rather than the acceptable range from the Subtitle D regulations.
2. The pipeline corridor area should be included in the annual stormwater monitoring plan.

Response: Please see the response to Appendix A, Modification Question No. 14.

U.S. Department of Agriculture, Natural Resource Conservation Service

Comment: Any bare soil exposed following surface coal mining should be seeded, limed, fertilized and mulched to minimize soil erosion. Please refrain from using tall fescue or reed canary grass in seeding mixtures and only plant native trees and shrubs for wildlife areas. Following pipeline installation, drainage should be provided where necessary to return the affected areas to their former land use. Wetlands should be returned to historic hydrologic conditions. Prime Farmland acreage should be reclaimed to standards established by the Illinois Surface Coal Mining Land Conservation and Reclamation Act.

Response: This comment has been noted and forwarded to the applicant.

U.S. Department of the Interior, Fish and Wildlife Service

Comment: To facilitate compliance with Section 7(c) of the Endangered Species Act of 1973, as amended, Federal agencies are required to obtain from the Fish and Wildlife Service (Service) information concerning any species, listed or proposed to be listed, that have ranges which include the project area. As the State of Illinois has been delegated the responsibility of issuing mining permits by the Office of Surface Mining, we are providing the following list of threatened and endangered species to assist in your evaluation of the proposed permit. The list for the proposed permit area includes the endangered Indiana bat (Myotis sodalis), endangered piping plover (Charadrius melodus), and threatened northern long-eared bat (Myotis septentrionalis). There is no designated critical habitat in the project area at this time.

Response: Comment noted and forwarded to the applicant.

Comment: Applicants should be directed to our Information, Planning, and Conservation System (IPaC) at the link below to determine whether any federally threatened and endangered species, designated critical habitat, or other natural resources of concern may be affected by a proposed project and to obtain a preliminary or official U.S. Fish and Wildlife species list. For projects that require FWS review, request an official species list from the Regulatory Documents page. https://ecos.fws.gov/ipac/

Response: This comment has been forwarded to the applicant. In addition, the Department has supplied the Service's website to future applicants as an encouraged and available resource.

Comment: Based on the location of the proposed permit area, the Service concurs that the proposed project is not likely to adversely affect the piping plover.

Response: Comment noted and forwarded to the applicant.

Comment: Information in the permit application indicates that 3.9 acres of known Indiana bat habitat will be impacted by the proposed mining activity. Presence of the Indiana bat was documented in a mist net survey conducted in 2017, thus a Protection and Enhancement Plan (PEP) was developed for the proposed mine area that lies within the 2.5 mile buffer of the documented maternity roost tree in accordance with the 2009 Range-wide Indiana Bat PEP Guidelines, as revised in 2013. The PEP includes a number of protection and enhancement measures including avoidance of the majority of wooded habitat within the permit area, winter tree clearing from November 15 to March 31, tree girdling and bat box installation to provide temporary habitat, riparian buffer zone protection, and maintenance of watering areas. The applicant is not proposing to replant the forested habitat acres to be disturbed.

The PEP guidelines state that at least 70 percent of the total Indiana bat forest habitat that will be lost should be replaced or mitigated off-site. The applicant should develop a replacement plan or off-site mitigation measures. Information in the permit application indicates that the post mining acres for fish and wildlife woody will increase and may account for the replacement. The PEP should be reconciled with the post-mining land use in the reclamation plan.

The applicant did not survey the entire project alignment, thus probable absence for the northern long-eared bat cannot be assumed within the portions of the project that were not surveyed. The applicant should include the northern long-eared bat in the PEP or rely upon the finding of the programmatic biological opinion for the northern long-eared bat final 4(d) rule and utilize the streamlined section 7 consultation framework to fulfill their project-specific section 7 responsibilities for the northern long-eared bat. If the applicant utilizes the streamlined consultation framework, then the streamlined consultation form should be completed.

See https://www.fws.gov/midwest/endangered/mammals/nleb/s7.html

Based on the lack of information in the permit application, the Service is not able to provide concurrence for listed bat species at this time. The Service requests the additional information be provided for review and concurrence.

Response: The Department would like to take this opportunity to outline protection an enhancement measures that have changed from the original submittal based on modification requirements.

The Indiana bat (*M. sodalis*) and northern long-eared bat (*M. septentrionalis*) Protection and Enhancement Plan (PEP) located in Attachment II.8 has been updated to address long term habitat replacement requirements. The applicant has

proposed to reforest 2.73 acres, restoring 70% of the known habitat proposed to be removed by this project and therefore complying with the 2013 Guidelines.

Additionally, tree clearing restrictions within the PEP have been modified to state that tree clearing operations will only occur from October 15 to March 31. These dates appropriately reflect those outlined for winter tree clearing in the 2103 guidelines.

The applicant has also modified the PEP to state "the probable absence of the NLEB cannot be assumed". The applicant has included a discussion utilizing the key to the northern long-eared bat 4(d) rule for federal actions to conclude that the proposed actions are not prohibited and therefore a PEP for this species is not required. However, the applicant has chosen to include this species within the PEP found in Attachment II.8 of the application. The applied protection and enhancement measures will potentially be beneficial to the northern long-eared bat.

Based on information provided by the applicant and appropriate agency consultations, the Department has determined that this project may affect the northern long-eared bat, but that any resulting Incidental Take is not prohibited by the Final 4(d) rule and is consistent with the U.S. Fish and Wildlife Service Jan 2016 Programmatic Biological Opinion on the Final 4(d) rule. The Department has completed the IPAC Determination Key: Northern Long-Eared Bat (NLEB) Consultation and 4(d) Rule Consistency, which was submitted to the Service via IPAC on July 31, 2019.

Comment: [Per the follow-up USFWS correspondence dated October 2, 2019] - Based on the lack of information in the permit application, the Service was not able to provide concurrence for listed bat species. We requested additional information be provided for our review and concurrence. Information in your response indicates that the Protection and Enhancement Plan (PEP) was updated to address long-term habitat replacement requirements for the Indiana bat. Based on this information, the Service has determined that the take of 3.9 acres of known habitat is not likely to jeopardize the continued existence of the Indiana bat.

Information in your letter indicates that consultation for the northern long-eared bat was addressed by using our northern long-eared bat determination key within our Information for Planning and Consultation (IPaC) system. Based upon the IPaC submission, the action is consistent with activities analyzed in the Programmatic Biological Opinion on the Final 4(d) Rule for the northern long-cared bat and issuance of the verification letter concludes consultation for the northern long-eared bat. This information sufficiently addresses our comments regarding the northern long-eared bat.

Response: Comment noted and forwarded to the applicant.

Comment: Although the bald eagle has been removed from the threatened and endangered species list, it continues to be protected under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act (BGEPA). The Service developed the National Bald Eagle Management Guidelines to provide landowners, land managers, and others with information and recommendations regarding how to minimize potential project impacts to bald eagles, particularly where such impacts may constitute "disturbance," which is prohibited by the BGEPA. A copy of the guidelines is available at:

http://www.fws.gov/midwest/eagle/pdf/NationalBaldEagleManagementGuidelines.pdf

The Service is unaware of any bald eagle nests in the permit area; however, if a bald eagle nest is found in the permit area or vicinity of the permit area then our office should be contacted and the guidelines implemented.

Response: The applicant has provided a statement outlining that the applicant is unaware of any bald or golden eagle nests within one mile of the project. The applicant includes a discussion committing to contacting the U.S. Fish and Wildlife Service for the development of a protection and enhancement plan if a nest is encountered. See Part V.2.B.2 of the application.

Comment: [Per the follow-up USFWS correspondence dated October 2, 2019] - The Service indicated that it is unaware of any bald eagle nests in the permit area; however, if a bald eagle nest is found in the permit area or vicinity of the permit area then our office should be contacted. The applicant provided a statement that no eagle nests are known within the project area or vicinity. This information sufficiently addresses our comments.

Response: Comment noted and forwarded to the applicant.

Comment: The permit area includes 23.0 acres of cropland, 16.8 acres of fish and wildlife herbaceous, 18.6 acres of fish and wildlife woody, 0.4 acres of fish and wildlife water, 3.7 acres of fish and wildlife wetland, 0.1 acres residential, and 8.2 acres industrial/commercial.

Response: The Department would like to take this opportunity to clarify that information in the modified permit application indicates that the permit area will includes 16.4 acres of cropland, 20.7 acres of fish and wildlife herbaceous, 21.1 acres of fish and wildlife woody, 0.4 acres of fish and wildlife water, 3.6 acres of fish and wildlife wetland, 0.2 acres developed water resources, 0.1 acres residential, and 8.2 acres industrial/commercial.

Comment: [Per the follow-up USFWS correspondence dated October 2, 2019] - Thank you for your letter dated August 6, 2019, providing response to our comments on permit

application No. 456 by Williamson Energy, LCC (Pond Creek Mine), for surface coal mining and reclamation operations in Franklin and Williamson Counties, Illinois. The permit area is 70.7 acres and the proposed mining activity will impact a total of 70.7 acres. The permit area includes 16.4 acres of cropland, 20.7 acres of fish and wildlife herbaceous, 21.1 acres of fish and wildlife woody, 0.4 acres of fish and wildlife water, 3.6 acres of fish and wildlife wetland, 0.2 acres of developed water resources, 0.1 acres residential, and 8.2 acres industrial/commercial. These comments are provided under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.); the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.) and, the National Environmental Policy Act (83 Stat. 852, as amended P.L. 91-190, 42 U.S.C. 4321 et seq.).

Response: Comment noted and forwarded to the applicant.

Comment: Information in the permit application indicates that proposed activities will impact a total of 3.7 acres of wetlands including 0.4 acres of unconsolidated bottom wetlands. The proposed post mining land use plan includes 3.7 acres of wetlands.

The Service has no objection to the proposed wetland mitigation.

The Service recommends that the seed mix for emergent wetland restoration include native forbs, which will provide greater benefits to native pollinators and the monarch butterfly.

Response: The Department would like to take this opportunity to clarify that information in the modified permit application indicates that the proposed activities will impact a total of 3.6 acres of fish and wildlife wetland and proposed post mining land use plan includes 3.6 acres of wetlands. The recommendation by the Service to incorporate native forbs into the seeding mix for emergent wetland restoration has been forwarded to the applicant.

Comment: Information in the permit application indicates that the reclaimed area will include 22.1 acres of woody fish and wildlife habitat and 21.0 acres of herbaceous fish and wildlife habitat.

The Service recommends that the planting of any non-native, exotic, and invasive species be avoided.

The Service also recommends the incorporation of native forbs in the seeding mix which will provide greater benefits to native pollinators.

The Service recommends that the applicant include an invasive species control plan in the reclamation plan.

Response: The Department would like to take this opportunity to clarify that information in the modified permit application indicates that the reclaimed area will include 21.1 acres of woody fish and wildlife habitat and 20.7 acres of herbaceous fish and wildlife habitat.

The applicant has proposed native and non-native species for Fish and Wildlife post-mining land uses (PMLUs). See Attachment V.1.D.2.b. of the application that contains species lists and justification for the use of some non-native species. The regulations found at Section 1816.111(a)(2) and (c) allow non-native species if they are necessary to achieve the desired post-mining land use or are necessary for erosion control. In addition, the 2013 Indiana bat guidelines provides the same flexibility in Section 2.4.2.2 item no. 3 for the use of non-native woody area herbaceous ground cover if the applicant demonstrates the proposed species are slow growing and beneficial for wildlife. The applicant has proposed non-native species for temporary/cover crop vegetation. The Department does not have the regulatory authority to require native species for temporary seed mixes. The recommendation by the Service to incorporate native forbs in the herbaceous seeding mix was noted and has been forwarded to the applicant.

Pursuant to Section 1816.116(b)(1) and 1784.15(b)(1), the Department required the applicant to achieve the approved species and/or PMLU vegetation success standards during the applicable period of liability. Undesirable invasive species control will be part of the remedial action plan if deemed necessary by the applicant or the Department.

Comment: [Per the follow-up USFWS correspondence dated October 2, 2019] - The Service recommended that the planting of any non-native, exotic, and invasive species be avoided and that the applicant include an invasive species control plan in the reclamation plan. The Service also recommended the incorporation of native forbs into the seeding mix. Information included in the response sufficiently addresses our comments.

Response: Comment noted and forwarded to the applicant.

Public Comments

The Department has considered and evaluated all comments concerning the effects of mining within the proposed permit areas and adjacent areas. The issues raised that are deemed pertinent to the permit application are addressed below.

Comment 1: Commenters asked if their questions were going to be answered at the hearing, expressed dismay that questions were not answered and requested clarification as to how they will obtain those answers to their questions.

Response: The regulations at 62 Ill. Adm. Code 1773.14(d)(2) states that "The hearing officer shall allow the county board, the applicant, and any interested persons to present data, views, or arguments." The purpose of the hearing is not to inform the public but to allow the public to "present data, views, or arguments" concerning the application to the Department. Comments pertinent to the application are then taken into consideration by the Department, with each specialist in their individual scientific area reviewing the application and addressing those comments in the permit decision document.

Comment 2: Commenters expressed concern over the impact of the project on the quality of the Big Muddy River.

Response: The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the Illinois Environmental Protection Agency's (IEPA). Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 3: A commenter asked what is currently being done with the water generated at the mine.

Response: It is assumed the commenter, by using the term "generated," is referring to mine infiltration water removed from the underground workings. According to the currently approved NPDES Permit IL0077666, the mine infiltration water that is pumped from the underground works is routed to Pond 006. This water is used at the wash plant or stored on the permitted surface area in existing impoundments and ponds.

Comment 4: A commenter asked about details of the water to be discharged and the concentration of pollutants in the water.

Response: Please see the response to Appendix A, Modification Question Nos. 11 and 12.

Comment 5: A commenter asked if the pipeline work had begun and when a decision on the application would be made.

Response: At the time of this comment, the Permit No. 456 application for the pipeline was still under review. Any work related to the pipeline as it relates to the proposed surface coal mining and reclamation operations detailed for this application cannot lawfully begin until the Department approves the application and issues the permit decision. Here, after completion of review, it was determined that modifications of the application were required and the applicant had one year to provide appropriate

responses to the request for modifications. Those responses have since been submitted and approved. This permit findings document memorializes the Department's decision to issue the permit.

Comment 6: Commenters questioned the impact to the water level of the Big Muddy River, including during low flow conditions as a result of the proposed discharge.

Response: Based on information provided in the application, the volume of mine water to be discharged in the Big Muddy River will be dependent on the flow of the river upstream of the point of discharge. Thus, the discharge will be intermittent and will be adjusted accordingly. The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 7: Commenters asked how the concentrations of chlorides and sulfates in the discharge water would impact the receiving stream, adjacent waterways and water courses further downstream, including the anticipated effects on local biota and the public.

Response: The IEPA is the regulatory agency that determines the concentrations of chlorides and sulfates that can be discharged into a water body through its NPDES permitting process. The potential impacts to the receiving stream, adjacent waterways and water courses further downstream, including the anticipated effects on local biota and the public, is an issue for the IEPA to address through that process. Potential impacts resulting from another agency's permitting responsibility is beyond the purview of the Department.

Comment 8: Commenters indicated the hydrologic balance investigation for the application should include the areas included within the longwall panels and that the analysis was an attempt to obscure the effects on the local water table. One of these commenters asked what the actual cone of depression created by the mine pumpage.

Response: This permit application is for the construction and operation of a pipeline to transport underground mine infiltration water to a diffuser system at the Big Muddy River. This permit application does not cover the shadow area encompassed by the longwall mining panels. Nevertheless, the Department does not believe there is a cone of depression as this water is leaking into the mine from cracks in the overlying unit above the coal seam. The water is then physically pumped out of the mine, not the overlying unit.

Comment 9: Commenters were concerned there are, or may be, adverse impacts accruing from the rate of water pumping and area groundwater drawdown, as well as the long-term impacts to local water quantity that may be needed in the future.

Response: There have been no reported issues from surrounding citizens regarding the company pumping out infiltrating groundwater out of the mine. According to data presented in the application, this groundwater is naturally high in chlorides and sulfates, making it unfavorable as a source of potable groundwater. The Department is unaware of any plans or proposals to utilize this water bearing sandstone as a source of potable water.

Comment 10: A commenter indicated Permit No. 375 incorrectly reflected the depth of the coal seam and that the shallower depth of mining negatively impacted his ponds and well. Further, the commenter indicated the Department needed to monitor his well to understand the hydraulic balance of the area.

Response: The issues raised relate to underground mining and subsidence and are not pertinent to the activities proposed in Permit No. 456. Potential subsidence impacts to a well will not provide relevant information on the hydrologic balance of the proposed permit area in this application.

Comment 11: Commenters expressed concerns that the public wasn't given adequate or appropriate notice of the permit application or the public hearing and sufficient time to prepare for the hearing. One stated that "I own a significant amount of land I do not live here full time, but I would have thought that there might be a better communication system to land owners regarding important items such as this. The meeting was quickly called and not very publicized. Your written comment deadline is also too short given that many people have only barely heard of the Big Muddy River pollution by Williamson Energy, LLC, and Pond Creek Mine, and they have not had time to read the application and gather their research and comments on the permit proposal."

Response: The purpose of the public hearing, as stated at 62 Ill. Adm. Code 1773.14(d)(2), is to "allow the county board, the applicant, and any interested persons to present data, views, or arguments." The application has been on file with the Williamson and Franklin Counties Clerk Offices since July 18, 2018. In addition, the application was posted to the Department's website on July 20, 2018. Notice of the application was published by the applicant in the Marion Republican four (4) times, with the first publication on July 18, 2018, and the last on August 8, 2018. The application was available for public review for more than three (3) months prior to the close of the comment period. It is the Department's opinion the public has been provided all the opportunities prescribed by the regulations to review the application and the additional ten (10)-day period afforded after the public hearing provided adequate time for interested parties to review the application and submit written comments.

The regulations at 62 Ill. Adm. Code 1773.14(b) require that "The Department shall publish notice of the hearing in a newspaper of general circulation within the county. Such notice shall be published by the Department at least two (2) weeks prior to the scheduled hearing date."

The notice published for the public hearing explained what application was to be covered by the hearing, and the time. place and location of the hearing. It also provided the Department's contact information. That notice was published October 2, 2018 in the Southern Illinoian.

The Department's requirements for public notification of the public hearing were met.

Comment 12: Commenters indicated that insufficient research had been done to insure irreparable damage to water systems will not occur. Those concerns addressed effects to endangered species that may come to the area (gray wolf, black bear and mountain lion), the redheaded woodpecker, hellbenders, the alligator snapping turtle and other reptiles and amphibians living in and around the waterways which would receive the discharge. Commenters also expressed concern regarding these effects on the LaRue-Pine Hills area and its diverse biota.

Response: The IEPA is the regulatory agency that determines the effluent concentrations that can be discharged into a water body through its NPDES permitting process. The potential impacts to the receiving stream, adjacent waterways and water courses further downstream, including the anticipated effects on endangered species and other local biota, is an issue for the IEPA to address through that process. Potential impacts resulting from another agency's permitting responsibility is beyond the purview of the Department.

Comment 13: A commenter indicated the bond paid for reclamation was insufficient and needed to take into account the value of fishing, boating and the ecosystem impacted by the proposed action.

Response: The regulations at 62 Ill. Adm. Code 1800.14(b) require that "[t]he amount of the bond shall be sufficient to assure the completion of the reclamation plan if the work has to be performed by the Department in the event of forfeiture..." The amount of bond calculated by the Department is in regard to the pipeline installation requested in the proposed permit. Therefore, the topics noted in the comment are beyond the purview of "completion of the reclamation plan." Any determination of the effect of the water on the ecosystem and recreational sports would be outside the scope of the Department's regulatory jurisdiction.

Comment 14: Commenters indicated an on-site water treatment system, or other solutions should be considered by the applicant in lieu of the pipeline. In addition, a commenter indicated the IDNR should require evidence of such assessments. Commenters also

asked what the mine has done to fully review other options to treat the groundwater on-site and suggested that IDNR should request that the mine show serious assessments or other ways of dealing with this water, as there were no clear examples in the permit application of other options that were considered to treat the high chloride and sulfate levels at the mine.

Response: The Department does not have the regulatory authority to require the type of assessments addressed in the comment.

Comment 15: The Douglas School is an old school turned into artists' studio spaces. A commenter expressed concerns that the Old Historic Douglas School could be negatively impacted by high water and water quality during periods of flooding.

Response: The Department does not have the regulatory authority to evaluate the potential downstream effects related to the proposed mixing zone. The authority for such an evaluation is under the regulatory jurisdiction of the IEPA.

Comment 16: The Big Muddy River is indicated as Public Waters by IDNR. Impacts of this added discharge do not appear to have been adequately evaluated and essential information for this application appears to be lacking. There is no information on what the added 2,700,000 to 3,500,000 gallons per day will mean to erosion impacts, river water levels, public use of the river for recreation or other public uses. This river is already prone to flooding and has documented low flows which clearly could mean different impacts from the proposed discharges that have not been adequately assessed. The amount of water that would flow into the Big Muddy River on a daily basis would overwhelm the levy structures in place on the Big Muddy River.

Response: Based on information provided in the application, the volume of mine water to be discharged in the Big Muddy River will be controlled by a diffuser and be metered at any given time based on the actual flow volume in the river as well as the water quality of the discharge and receiving stream.

The IEPA is the regulatory agency that determines the discharge flow volumes and concentrations of monitored parameters that can be discharged into a water body through its NPDES permitting process.

Several measures are proposed to reduce erosion impacts from the discharge flow. The design of the diffuser includes 5 ports that will be submerged to maximize dispersion and minimize effects on the receiving water. The diffuser ports will be mounted on a steel structure that will be supported by piles. A 50-inch-thick revetment with a D50 riprap size of 25 inches has been proposed to be used on the river bank where the diffuser will be located. Other temporary sediment control measures to be used during construction of the diffuser site include: silt fences, silt socks, straw/hay bales and removal and storage of subsoil and topsoil. The

Department will monitor the performance of the erosion control measures and take appropriate action should erosion become an issue.

Comment 17: A commenter suggested the mining operations should be converted from longwall mining to room and pillar mining and potentially avoid the mine water generation to begin with.

Response: The concern expressed would be better directed to the applicant. The Department is not involved in business decisions made by private entities.

Comment 18: Commenters questioned if the applicant intentionally located the pipeline diffuser below the closest gauging station and if the Department had given consideration to the volume of water proposed to be discharged and its effect on the public's right to use the river. These comments also suggested that by putting the outlet downstream of the Plumfield gauging station the Corps of Engineers would not have a true reading of the of the water level and may release more water at Rend Lake, causing more flooding downstream.

Response: Based on information provided in the application, the volume of mine water to be discharged in the Big Muddy River will be dependent on the flow of the river upstream of the point of discharge. Thus, the discharge will be intermittent and will be adjusted accordingly. The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 19: A commenter asked what the current levels of chlorides and sulfates are in the Big Muddy River.

Response: This is outside the scope of the Department's regulatory purview. The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 20: A commenter asked if full consultation with other divisions within IDNR had been conducted.

Response: The Land Reclamation Division of IDNR (LRD), upon receipt of a complete application, notifies various offices within the IDNR, as well as other State, local and Federal agencies, allowing each to submit comments to be taken in to consideration during the application review process. Here, LRD forwarded

notification to the other offices within IDNR on July 20, 2018. All agency comments have been considered in LRD's review of the application and are addressed in the Part III Summary of the Department's Findings.

Comment 21: A commenter asked why IDNR or EPA would ever allow water with elevated chlorides or sulfates to further pollute the Big Muddy River.

Response: The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 22: Commenters expressed opinions about the poor quality of old mines and asked if IDNR or EPA had been successful in cleaning up pollution caused by old mines.

Response: LRD is involved in the regulation of active coal mining operations. The reclamation of "old" mines, or lands impacted by mining prior to the permanent program rules and regulations is under the jurisdiction of the Department's Abandoned Mine Lands Division. Questions related to IEPA's involvement with "cleaning up pollution caused by old mines" should be directed to that agency.

Comment 23: Commenters asked about how climate change would impact the need for water in the future and how this proposal would affect the local water supply.

Response: The concern expressed related to climate change is outside the regulatory purview of the Department.

Comment 24: A commenter indicated the mining industry caused public health issues and this proposal would exacerbate that issue.

Response: The concern expressed is outside the regulatory purview of the Department. This comment has been forwarded to the applicant.

Comment 25: A commenter indicated that the sulfate and chloride concentrations presented throughout the application were inconsistent, and the final discharge concentration was well in excess of those concentrations expressed elsewhere in the application.

Response: Please see the responses to Appendix A, Modification Questions Nos. 11 and 12.

Comment 26: A commenter asked if the applicant is pumping to a tributary of Pine Creek (as the permit indicates) is working why do they need this application.

Response: The Department is unaware of a "Pine Creek" in the vicinity of the Pond Creek Mine, and therefore assumes that the commenter is referring to Pond Creek. The

Pond Creek Mine does not pump water directly into a tributary of Pond Creek. However, water from the mine's sediment ponds (Outfalls 001, 002, 003, 004, 005, 006, 007, and 008) can discharge into an unnamed tributary of Pond Creek. Please refer to the Department's response to Comment 3 above for a description of the mine's current handling of infiltration water from the underground works. According to the application, Williamson Energy, LLC has a finite capacity to store water and expects to encounter an increase in groundwater infiltration as mining progresses.

Comment 27: One commenter questioned why the mine is attempting to pump high sulfate and high chloride water to the Big Muddy when an earlier request for a mixing zone was rejected years ago.

Response: The IEPA is the regulatory entity that approves mixing zones. The Department permits any actual conveyance system that would be necessary for such a mixing zone. The Department received a permit application (No. 455) for such a conveyance system January 30, 2017 which the applicant subsequently withdrew on March 2, 2017. This application was withdrawn by the applicant prior to review and not denied as the commenter alludes. Any other actions taken by the IEPA on Permit No. 455 are best addressed by that agency.

Comment 28: Commenters stated that the Big Muddy River is already listed as impaired on the 2018 Illinois EPA 303(d) list and is given a medium rating. Their concern is that the river is already at risk from pollutants and there does not appear to be adequate consideration of a full range of mine alternatives to the discharges requested in this permit application or other best practices the mine could utilize are not provided in any significant variety or detail.

Response: The Department does not have the regulatory authority to require the type assessment addressed in the comment. The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 29: Commenters questioned what will the proposed daily discharge of high levels of chlorides and sulfates do to existing fish and aquatic life in the Big Muddy River and to other downstream uses? Those commenters indicated that additional pollution loading of this river, particularly at times of low flow, are a concern to us in addition to the known problems high levels of chlorides cause for fish and other aquatic life. Chlorides are stated in some sources to be accumulative. There is nothing in the application that was found to assess what the daily and long-term biological and water quality impacts of the high levels of chlorides and sulfates will do.

Response: The IEPA is the regulatory agency that determines the concentrations of chlorides and sulfates that can be discharged into a water body through its NPDES permitting process. The potential impacts the receiving stream, adjacent waterways and water courses further downstream, including the anticipated effects on local biota, such as fish and other aquatic life, is an issue for the IEPA to address through that process. Potential impacts resulting from another agency's permitting responsibility is beyond the regulatory purview of the Department.

Comment 30: Commenters had questions regarding what fish and aquatic species are currently utilizing the proposed discharge section of the Big Muddy River and are there any locations downstream that have mussel populations? What are the biological and environmental impacts of the high chloride levels? The Big Muddy River is also listed as having varieties of mussels and information on any mussel beds and what impacts the discharges could mean is lacking.

Response: The IEPA is the regulatory agency that determines the concentrations of chlorides and sulfates that can be discharged into a water body through its NPDES permitting process. The potential impacts the receiving stream, adjacent waterways and water courses further downstream, including the anticipated effects on local biota, such as fish and other aquatic species, is an issue for the IEPA to address through that process. Potential impacts resulting from another agency's permitting responsibility is beyond the regulatory purview of the Department.

Comment 31: A commenter asked what different mining practices could be done to reduce the amount of groundwater infiltrating the mine?

Response: The scope of the commenter's question falls beyond the regulatory purview of the Department. The comment has been forwarded to the applicant.

Comment 32: Commenters indicated the diffuser is located on a cut bank of the river, which could potentially experience expedited erosion and bank stability problems risking infrastructural damages.

Response: Engineering practices at the river bank will be utilized to reduce significant erosion impacts and enhance aquatic habitat. The diffuser ports will be mounted on a steel structure that will be supported by piles. Stream bank stabilization proposed for the bank of the Big Muddy River consist of a 50-inch-thick revetment using median riprap size of 25 inches. The riprap will be keyed into the toe of the slope with native plantings on the banks above. This bank stabilization will help prevent further erosion due to the stream channel and protect the water management facilities and infrastructure. The Department will monitor the performance of the erosion control measures and take appropriate action should erosion become an issue.

Comment 33: Commenters indicated it is unclear what heavy metals or other possible contaminants such as arsenic or radioactive materials and what the cumulative effect of additional pollutants will be. The application is also unclear about whether there is a chance of this water mixing with acid mine drainage.

Response: Please consult with the IEPA regarding what other parameters were reviewed for this mixing zone. The Department finds that the chance of acid mine drainage mixing with the water destined for the mixing zone is low to negligible.

Comment 34: A commenter indicated the Stream Protection Rule was created to clarify vague and problematic components of SMCRA, but even though it was rescinded it should be used to mitigate the damage caused by Foresight Energy.

Response: The Department cannot enforce regulations that have not been promulgated or are not in force.

Comment 35: A commenter asked how will the low water quality with its high sulfates and chlorides effect timber along the river and who would be responsible for the monetary loss to land owners?

Response: The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenter's concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Monetary loss to landowners based on water quality issues resulting from another agency's permitting responsibility is beyond the regulatory purview of the Department.

Comment 36: A commenter asked if they drain water into the Big Muddy, will it be via Pond Creek? If so, who will be responsible for cleaning up the creek due to the number of log jams on it.

Response: The application proposes a pipeline to pump mine water from underground into the Big Muddy River. The concerns expressed regarding the log jams are beyond the regulatory purview of the Department.

Comment 37: Commenters indicated the average concentrations listed for Chloride (2237 mg/l) and Sulfate (1940 mg/l) in the effluent, coupled with the discharge rate equal approximately 22,700 kg/d Cl2- and 19,400 kg/d SO42- were significant quantities when considering the hydrological characteristics of the Big Muddy River at this point in its watershed.

Response: The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 38: A commenter indicated the negative charges of Chloride and express a high affinity to remobilize any positively charged cations in channel sediments of the Big Muddy River. This becomes an important concern when considering metals like Manganese, Magnesium, Iron, Cadmium, Arsenic, Lead, etc. can be present in riverbed sediments. The negative charges extract these positive charged cations, causing elements that would otherwise be immobile, to be brought back into solution and transported downstream. This topic is not discussed anywhere in the application, yet is a real concern considering the quantity, concentration, and duration the mine anticipates the point source effluent to be active.

Response: The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 39: A full Environmental Impact Statement should be conducted to determine the full effects of this proposed pipeline.

Response: An environmental impact statement is not required under 62 Ill. Adm. Code Parts 1700-1850 for this proposed surface coal mining and reclamation operation.

Comment 40: Drinking water pollutant levels are more restrictive than river water; the proposed discharges fail to meet drinking water standards, which mean public uses of Big Muddy River water could incur additional treatment costs in the years ahead.

Response: The concern expressed is beyond the regulatory purview of the Department. The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenter's concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 41: Commenters indicated that we share concerns about the lack of regulatory enforcement that most mines in Illinois have not been inspected in 12 years.

Response: The regulations at 62 Ill. Adm. Code 1800.11(a-b) require that "(a) The Department shall conduct an average of at least one partial inspection per month of each active surface coal mining and reclamation operation under its jurisdiction and shall

conduct partial inspections of each inactive surface coal mining and reclamation operation under its jurisdiction to ensure enforcement of the approved State program... (b) The Department shall conduct an average of at least one complete inspection per calendar quarter of each active or inactive surface coal mining and reclamation operation under its jurisdiction..."

The Department continues to meet its inspection mandate.

Comment 42: A commenter questioned how much affect would this have on tourism which is another major resource of southern Illinois?

Response: The effects on tourism are outside scope of the Department's regulatory purview.

Comment 43: Commenters asked if the pipeline be granted eminent domain or will the mine owner purchase easements from landowners?

Response: Eminent domain is not applicable to the proposed pipeline. It is the applicant's responsibility to obtain the necessary right of entry for the project.

Comment 44: Commenters questioned that since the pipeline crosses over the county line, if the pipeline breaks in one county does the other county have to pay for the cleanup and what recourse will farmers have when the pipeline breaks and damages their field?

Response: Operators of such pipelines are responsible for cleanup of any spillage as well as damages.

Comment 45: A commenter asked what will happen to their property when the Big Muddy River floods again with the extra salt and sulfides and dead wildlife washing in? The river will flood again without the extra 2.5 million gallons of water from the Pond Creek Mine.

Response: The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenter's concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

APPENDIX C

Williamson Energy, LLC, Pond Creek Mine

Application for Permit No. 456

And Permit Nos. 375 & 417
And Revisions No. 1, 2, 3, 5, 6, 7, 9, 10, and 11 to Permit No. 375
Assessment and Findings of Probable Cumulative Hydrologic Impacts

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APPENDIX C

Williamson Energy, LLC, Pond Creek Mine
Application for Permit No. 456
And Permit Nos. 375 & 417
And Revisions No. 1, 2, 3, 5, 6, 9, 10, and 11 to Permit No. 375
Assessment and Findings of Probable Cumulative Hydrologic Impacts

Williamson Energy, LLC (hereinafter referred to as "permittee" or "applicant" as applicable) was required to submit a determination of probable hydrologic consequences of the proposed mining and reclamation operations, both on and off the permit area, pursuant to 62 Ill. Adm. Code 1784.14(e) for underground mines.

Pursuant to 62 Ill. Adm. Code 1773.15(c)(5), the Department must make an assessment of the probable cumulative impacts of all anticipated coal mining on the hydrologic balance in the cumulative impact area, in accordance with 62 Ill. Adm. Code 1784.14(f), and find in writing that the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area.

The following assessment and findings are intended to fulfill the above requirements.

I. GENERAL INFORMATION

A. Historical Coal Mines (ISGS)

Several coal mines have operated in the vicinity of the Pond Creek Mine. Former coal mines were present to the west, south and east of the Pond Creek Mine.

Both surface and underground mines operated in the area, with operations dating back to 1944.

1. Ziegler No. 4 Mine (1944-1980)

To the south and west of the Permit No. 375 area is the former Ziegler No. 4 underground mine. This mine encompasses approximately 4,726 acres and operated as a room and pillar mine.

2. Orient No. 4 Mine (1952-1987)

Also to the south of the Permit No. 375 area, the former Orient No. 4 underground mine operated. This mine was approximately 6,530 acres in size and operated as a room and pillar mine from 1952 to 1987.

3. Malone No. 1 Mine (1976-1979)

This former surface mine is located to the east of the permit area. The Malone mine operated as a small surface mine from 1976 to 1979 and was approximately 82 acres in size.

4. Phoenix No. 1 Mine (1988-1993)

To the east, occupying the same general location as the form Malone No. 1 surface mine, the Phoenix No. 1 Mine was present. Two permits were issued by the Department. Permit No. 200 was issued in 1988 and Permit No. 270 was issued in 1992. The mine ceased operations in 1993 and in 2008, the Department placed the permit areas into forfeiture status.

B. Active Coal Mines

Pond Creek Mine (2005-current)

1. Permit No. 375 (issued 2005)

The original Pond Creek Mine permit was issued for an underground coal mining operation. Permit No. 375 was originally for approximately 540 acres to be used as surface support facilities for an underground coal mining operation. The surface support facilities include a coal preparation plant, parking lots, access roads, drainage control structures, office buildings, changing rooms, assembly rooms, warehousing facilities, storage facilities, ventilation facilities, refuse disposal areas, power distribution facilities, power lines, water lines, stockpile areas and other associated facilities. Williamson Energy extracts the Herrin No. 6 Coal Seam, at a depth ranging from 450 to 600 vertical feet from the surface, utilizing room and pillar and longwall mining within the originally permitted 4,631 (approximately) acre shadow area. The room and pillar mining is designed to prevent subsidence and/or to be areas of unplanned subsidence, while the longwall mine area is planned subsidence.

2. Permit No. 375, Significant Revision Nos. 1, 3, 5, 6, 7, and 9 (issued 2007, 2010, 2011, 2012, 2013, and 2014, Respectively)

Revision Nos. 1, 3, 5, 6, 7 and 9 to Permit No. 375 approved additional shadow area to allow for both room and pillar developmental and longwall mining operations. The additional shadow area totals approximately 10,588 acres.

3. Permit No. 375, Significant Revision No. 2 (issued 2009)

Revision No. 2 to Permit No. 375 converted previously approved permit area to Refuse Disposal Area No. 2 for the mine.

4. Permit No. 375, Significant Revision No. 4 (Withdrawn)

This proposed revision was withdrawn by the applicant and not issued.

5. Permit No. 375, Significant Revision No. 8 (Withdrawn)

Revision No. 8 to Permit No. 375 is a proposal to inject coal slurry into the former underground works of the Pond Creek Mine. This application has been withdrawn.

6. Permit No. 417 and Significant Revision No. 10 to Permit No. 375 (issued 2015)

Permit No. 417 and Significant Revision No. 10 to Permit No. 375 added approximately 230 acres for an additional refuse disposal area, to be known as Refuse Disposal Area No. 3.

7. Permit No. 375, Significant Revision No. 11 (issued 2018)

Significant Revision No. 11 to Permit No. 375 added 10,913.7 acres of shadow area to the existing mining operations. To date, 57 Insignificant Permit Revisions (IPRs), 84 Incidental Boundary Revisions (IBRs), and 14 minor field decisions have been issued by the Department since the original permit was issued. The IPRs were issued for a variety of reasons, including, but not limited to: surface drainage modifications; pond design changes; rail loop load-out modifications; underground boreholes for rockdust, power supplies and ventilation; installation/replacement of groundwater monitoring wells; changes to the existing refuse disposal areas.

The IBRs were also issued for a variety of reasons, including but not limited to: refuse disposal area changes; borehole installation; soil stockpile changes; addition of diversion ditches, and other surface water drainage; mine ventilation changes and shadow area expansions of 20 acres or less. Through IBRs, Williamson Energy has added approximately 229.3 acres to the original surface facilities permit area and approximately 592 acres of shadow area.

The total surface facilities permit area is now approximately 1,070 acres, whereas, the total shadow area is approximately 25,715 acres.

8. Application for Permit No. 456

The Application for Permit No. 456 proposes to add a 12.5-mile pipeline from the currently approved water holding cells on the western boundary of the mine site to the Big Muddy River. According to the application, the pipe size will be a minimum of 18 inches throughout its total length. The permittee also has an application pending with the Illinois Environmental Protection Agency (IEPA) for a mixing zone. According to the application, the mixing zone is being requested due to the inability to dispose of water infiltrating into the mine. This water has naturally elevated chloride and sulfate concentrations. The amount of water that can be discharged into the Big Muddy River at any given moment is dependent on the chloride concentration of the mine effluent,

the chloride concentration in the receiving stream, and the flow of the receiving stream. However, the maximum pumping rate for this facility will be limited to 5,000 gallons per minute according to the draft NPDES permit and the Application for Permit No. 456 documentation.

II. PROBABLE CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT (CHIA) OF APPLICATION FOR PERMIT NO. 456

A. Cumulative Impact Area (CIA) Evaluation

For purposes of a Cumulative Hydrologic Impact Assessment (CHIA), the Cumulative Impact Area (CIA) is defined as follows:

> The area, including the permit area, within which impacts resulting from the proposed operation may interact with the impacts of all anticipated mining on surface and groundwater systems. Anticipated mining shall include, at a minimum, the entire projected lives through bond release of:
>
> the proposed operation;
>
> all existing operations;
>
> any operation for which a permit application has been submitted to the Department.

This is based upon baseline geologic and hydrologic information. See 62 Ill. Adm. Code Sections 1701.Appendix A and 1784.14.

1. Office of Surface Mining Guidance

The Federal Office of Surface Mining Mid-Continent Region (OSM-MCR) developed a document in June 2007 entitled *Hydrologic Considerations for Permitting and Liability Release, a Technical Reference for the Mid-Continent Region*. In determining whether a CHIA is required, OSM-MCR states that "the operative word in the CHIA concept is *cumulative* which seemingly necessitates the potential interaction of two or more anticipated mining operations." (p. 17) Further OSM-MCR states, "While it may be possible that for a single hydrologically isolated mine the probable hydrologic consequences determination made by the operator would be adopted by the regulatory authority as the CHIA, nevertheless such a conclusion must be reached by the regulatory authority on a case-by-case basis." (p.17)

2. CIA Determination for Application for Permit No. 456

Please see the CHIA for Significant Revision No. 2 to Permit No. 375 for baseline information regarding the original permit and shadow areas and for the Department's determination of the CIA for Permit No. 375. The proposed 12.5 – mile pipeline encompasses a total of 70.51 acres that will terminate at a mixing zone in the Big Muddy River. The proposed pipeline route will cross the

following HUC-12 watersheds, West Frankfort - Pond Creek, Lake Creek, Chittyville - Pond Creek, and Cambon Lake - Big Muddy River. Although the pipeline crosses these four watersheds the assessment area was only expanded to the permit boundaries of the proposed Application for Permit No. 456 area.

According to the Water Management Operations section in the application, the infiltrating groundwater is from an overlying sandstone which has naturally elevated concentrations of chlorides and sulfates. Part III of the application states, chloride concentration generally varies between 1,699 mg/L and 2,799 mg/L, whereas the sulfate values range between 820 mg/L and 2,120 mg/L. As mentioned previously, this water cannot be discharged through the existing sediment ponds on site without exceeding the NPDES permit limits. Therefore, the mine is seeking to discharge this water into the Big Muddy River via a pipeline and a mixing zone (pending IEPA approval).

According to the application and the draft NPDES permit, the volume of mine effluent that can be discharged to the Big Muddy River will be dependent on the flow of the Big Muddy River, chloride concentration of the Big Muddy River, and chloride concentration of the mine discharge water. The maximum pumping rate from the facility has been limited to 5,000 gallons per minute. The application states, the proposed pipeline will be an 18-inch high-density polyethylene (HDPE) pipe that will be buried and capable of handling 125 psi of pressure. The pipeline will be installed using both open trench and boring techniques. The applicant has committed to installing a secondary containment pipe outside of the transport pipe within the 100-foot stream buffer zone of Pond Creek. The applicant has additionally committed to minimize impacts to agricultural lands according to the Standards and Policies for Agricultural Mitigation.

The applicant states the pipeline will be monitored for leaks or potential problems using ultrasonic or similar technology flow meters. These flow meters will be clamped to the pipe and hooked into a telemetry or fiber optic network that can relay real-time information back to the mine. This system will also be tied to an alarm system that activates if a specific difference in flow rate is exceeded. The system will utilize pressure gauges and air release valves to release any potentially trapped air in the pipeline. In the event excessive pressure is measured, the pumps will be shut off, according to the application. The applicant has additionally committed to monthly inspections of the pipeline at road boring sites, the Pond Creek boring site, the Big Muddy River discharge site, and the monitoring stations housing the flow meters, air valves, and pressure gauges.

As mentioned previously, the proposed pipeline route will cross four watersheds. In determining a CIA area, the Department first evaluated the area encompassed by these four watersheds. However, given the construction parameters of the pipeline, the monitoring constraints, and the applicant's commitment to monthly inspections and/or maintenance, the Department does not expect there to be any negative impacts to the hydrologic balance from the proposed operations. The construction activities as proposed in the application will only temporarily affect the area encompassed by the proposed permit. The Department does not expect the surface water and groundwater will be negatively impacted by the temporary construction activities proposed for the installation of the pipeline. As such, the Department is expanding the CIA for the Application for

Permit No. 456 by 70.51 acres, which is the acreage of the proposed pipeline. The Department has determined that as long as the applicant properly operates the pipeline per the commitments given in the application, there should be minimal to no impact to the surface water or groundwater within the CIA area. Further, the Department expects no impacts outside the CIA area.

The CIA acreage has also been expanded to encompass surface IBRs previously not included in the assessment area. These surface IBRs include additional area for vertical turbine pumps, pipelines, boreholes, man/material shafts, and ventilation shafts. The original surface water and groundwater assessment areas were within the Town of West Frankfort – Pond Creek HUC-12 watershed. The additional surface IBRs spread the facility into the following watersheds: Tilley Creek – Ewing Creek, Prairie Creek – Middle Fork Saline River, Gassaway Branch – Middle Fork Saline River, Brushy Creek, and Buckley Creek – Crab Orchard Creek. The Department evaluated the above listed watersheds to account for the mine expansion and to possibly extend the assessment area. However, the Department determined that expanding the assessment area beyond the permit areas in the watersheds would make the CIA too large for the relatively minor facilities approved by the aforementioned IBRs. These IBRs were approved for facilities and the Department assumes they will not fail. Thus, the CIA has been expanded to only include the additional permitted acreage.

The new CIA acreage is 4,245 acres and depicted on Map 1. This includes the original Permit No. 375 area, Permit No. 417 area, all the surface IBRs previously not included, and the proposed Application for Permit No. 456 area.

B. Assessment of the Probable Hydrologic Consequences (PHC)

1. Permit Area and the Shadow Area

Previously, the Department conducted the required hydrologic assessment on the original Permit No. 375 permit area, shadow area, and their respective adjacent areas, as well as Significant Revision No. 11 to Permit No. 375, which added additional shadow area. Application for Permit No. 456 does not propose any additional shadow area, therefore, the Department is not revising the assessment at this time.

Per 62 Ill. Adm. Code Section 1701.Appendix A, the following terms are defined:

The "permit area" is defined as:

> [T]he area of land and water within the boundaries of the permit which are designated on the permit application maps, as approved by the Department. This area shall include all areas which are or will be affected by the surface coal mining and reclamation operations during the term of the permit indicated on the approved map which the operator submitted with the operator's application and which is required to be bonded under 62 Ill. Adm. Code 1800 and where the operator proposes to conduct surface coal mining and reclamation operations under the permit, including all disturbed areas; provided, that areas adequately

> bonded under another valid permit may be excluded from a permit area. The permit area excludes the area defined in this Part as the shadow area.

The "shadow area" is defined as:

> [A]ny area beyond the limits of the permit area in which underground mine workings are located. This area includes all resources above and below the coal that are protected by the State Act that may be adversely impacted by underground mining operations including impacts of subsidence.

The "adjacent area" is defined as:

> [T]he area located outside the permit area, or shadow area, where a resource or resources, determined according to the context in which adjacent area is used, are or reasonably could be expected to be adversely impacted by proposed mining operations.

As described in Section I.B.8 above, the proposed permit area for the Application for Permit No. 456 consists of 70.51 acres. The permittee provided information obtained from the Illinois State Geological Survey on domestic groundwater wells within ½ mile of the proposed permit area. As mentioned previously in Section II.A.2, the CIA was also expanded to encompass the acreage approved by the surface IBRs previously not included in the assessment area. Given the minimal disturbance expected from the proposed operations and the facilities approved by the aforementioned IBRs, for the purposes of this CHIA, the Department has determined there is no adjacent area as no impacts are expected outside of the proposed permit area or the IBR areas being added to the assessment area.

a. Regional Hydrologic Area

The existing permit and shadow areas, as well as the proposed permit area are located in the glaciated upland area of northern Williamson County. It is situated at the headwaters of the major drainage systems of the region. Unnamed tributaries of Pond Creek, named and unnamed tributaries of Middle Fork Saline River, as well as unnamed tributaries of the Big Muddy River pass near and through the existing and proposed permit and the existing shadow area.

b. Permit Area Surface Waters Assessment Area

The Permit Area Surface Water Assessment Area was evaluated in the CHIA for Permit No. 375 Revision No. 10 and Permit No. 417 but has been revisited by the Department for Application for Permit No. 456. The Permit Area Surface Water Assessment Area has been defined as the approximately 4,245 acres which includes the existing Permit No. 375 area, Permit No. 417 area, the surface IBR areas previously not included in the assessment area, and the Application for Permit No. 456 area (Map 1). An explanation of the delineation of the original surface water assessment area in the Pond Creek Watershed can be found in the CHIA for Permit No. 417 and Revision No. 10 to Permit No. 375. As mentioned in Section II.A.2, the Department extended the

assessment area to include the permit areas encompassed by the surface IBRs east of Permit No. 417 and the Application for Permit No. 456 area. Since all these areas are for facilities related to the mining operation (pipeline, borehole, shafts, etc.), the Department is assuming these operations will not fail and will not negatively impact the hydrologic balance.

c. Permit Area Groundwater Assessment Area

Based upon the assumption that shallow groundwater mimics the topography in the area, the Permit Area Groundwater Assessment Area is the same as has been described in II.B.1.b above and as depicted in Map 1.

d. Shadow Area Surface Waters Assessment Area

The Shadow Area Surface Waters Assessment Areas were evaluated in the CHIAs for Significant Revision Nos. 9 and 11 to Permit No. 375. The Shadow Area Surface Waters Assessment Area, associated with Significant Revision No. 11 to Permit No. 375, is approximately 17,625 acres. The Shadow Area Surface Waters Assessment Area associated with Significant Revision No. 9 to Permit No. 375 is approximately 22,441 acres. This application does not propose to modify any of the previously approved shadow area permits. Please refer to the CHIAs for Significant Revision Nos. 9 and 11 to Permit No. 375 for discussion of the Shadow Area Surface Waters Assessment Areas.

e. Shadow Area Groundwater Assessment Area

The Shadow Area Groundwater Assessment Areas are the same as the Shadow Area Surface Water Assessment Areas. The Shadow Area Groundwater Assessment Areas were evaluated in the CHIA's for Significant Revision Nos. 9 and 11 to Permit No. 375. The Shadow Area Groundwater Assessment Area, associated with Significant Revision No. 11 to Permit No. 375, is approximately 17,625 acres. The Shadow Area Groundwater Assessment Area associated with Significant Revision No. 9 to Permit No. 375 is approximately 22,441 acres. This application does not propose to modify any of the previously approved shadow area permits. Therefore, they will no longer be discussed in this CHIA. Please refer to the CHIAs for Significant Revision Nos. 9 and 11 to Permit No. 375 for discussion of the Shadow Area Groundwater Assessment Areas.

2. Geologic Information Required by 62 Ill. Adm. Code 1784.22

a. Baseline Information

Application for Permit No. 456 provides similar information on the regional bedrock geology of the area as the original Permit Application for Permit No. 375 did. The geology of the area consists of typical Pennsylvanian system formations, where approximately sixty percent of the Pennsylvanian strata is classified as sandstones and the remaining forty percent is classified as siltstones and shales. Of this forty percent, coal and/or limestones make up approximately one

percent of this material. The Cottage Grove Fault System is located in the region but is not within the existing or proposed permit areas.

Unconsolidated deposits within the proposed permit area are Pleistocene in age and range from 4 to 33 feet thick. These deposits consist mainly of clay, silt and till materials, but known, limited areas of sand can be found. Surface topography in the proposed permit area is relatively flat-lying, with the southern portion of the area topographically higher than the northern portion of the area.

Site-specific geology, was provided in the boring and corehole logs submitted with the original permit application, as well as the Applications for Permit No. 417 and Significant Revision No. 10 to Permit No. 375. The Herrin No. 6 Coal seam is overlain by alternating layers of shale and limestone.

As stated in the Application for Permit No. 456, the infiltrating groundwater is from a saline zone within the Anvil Rock or Gimlet Sandstone units. The interburden between the Herrin No. 6 coal seam and the base of the Anvil Rock varies between 10 feet and 60 feet. The applicant believes the sandstone units are mostly discontinuous and the caved zone above the mined longwall panels extends into these sandstone units which leads to the water infiltrating into the mine.

b. Geologic Information Findings

The applicant presented no acid base accounting data with this application since the applicant is not proposing any changes in the coal refuse management. The applicant has committed to constructing the pipeline using the best management construction techniques that follow the provisions of Standards and Policies for Agricultural Mitigation.

The applicant also presented information on the sandstone units overlying the Herrin No. 6 coal seam that is the source of the infiltrating groundwater. To protect the miners underground, the operator must pump this water out of the mine. Since the water is naturally high in chlorides and sulfates the applicant is requesting a mixing zone from the IEPA. Otherwise, this water could not be discharged from the existing NPDES outfalls on site without exceeding compliance limits. The Department finds as long as the pipeline is properly constructed, maintained, operated, and the limits of the NPDES permit are adhered to, any impacts to the hydrologic balance should be minimized.

3. Hydrologic Information Required by 62 Illinois Adm. Code 1784.14

a. Baseline Information

i. Surface Water Quantity Baseline Information

No baseline surface water quantity information from stream monitoring points in the vicinity of the proposed permit area was presented in this application. The applicant did provide data for the existing stream monitoring points in the vicinity of the main surface facilities. Surface water

quantity information was previously discussed in the CHIAs for the original permit application and Permit No. 417. The applicant is expecting minimal impacts to the surface water quantity in the vicinity of the proposed permit area during the construction of the pipeline and little to no impacts when the pipeline is operational. According to Attachment IV.1 of the application, the applicant will monitor the pipeline for leaks using a network of flow meters. Additionally, the plan has provisions to double wall the pipeline within the Pond Creek stream buffer zone. Attachment IV.1 of the application also states the mine can discharge as much as 5,000 gallons per minute into the Big Muddy River via a diffuser system based on the flow of the river and other conditions specified in the NPDES permit.

ii. Surface Water Quality Baseline Information

No baseline surface water quality information from stream monitoring points in the vicinity of the proposed permit area was presented with this application. The applicant did provide data for the existing stream monitoring points in the vicinity of the main surface facilities. The applicant is expecting minimal impacts to the surface water quality in the vicinity of the proposed permit area during the construction of the pipeline and little to no impacts when the pipeline is operational given the provisions discussed in the previous section.

The applicant did provide the water quality expected out of the water holding cell prior to entering the pipeline. Table III.2.D.1.a in the application displays representative data obtained from the water holding cell which could contain a mixture of mine infiltration water, process water from the preparation plant, and decant water from the slurry cells. The chloride concentration varied between 1,699 mg/L and 2,799 mg/L, whereas the sulfate concentration varied between 820 mg/L and 2,120 mg/L. According to Attachment IV.1 of the application, the water that will be discharged will be process water and mine infiltration water. The document goes on to say an Anti-Degradation document was submitted to IEPA on November 18, 2016 and the clarified decant water from the slurry cell was considered in the analysis. Surface water quality for the main surface facilities was previously discussed in the CHIAs for the original permit application and Permit No. 417 and will not be changed due to this application.

iii. Groundwater Quantity Baseline Information

The applicant installed no groundwater monitoring wells for this permit application. The applicant felt the minimal disturbance from the construction activities should not affect the shallow groundwater quantity in the vicinity of the proposed permit area. The applicant surveyed the Illinois State Geological Survey (ISGS) public water well records to identify users who may be utilizing the groundwater. In Attachment III.2.B.1 and the Hydrologic Maps of the Application for Permit No. 456, the applicant identified eight private water wells and their respective users within ½ mile of the proposed permit boundary. One of the wells is noted to be plugged according to the information the applicant obtained from the ISGS records. The applicant did not conduct a door – to – door survey given the minimally invasive construction methods and protections that will be employed to install the pipeline. As such, the applicant does not expect any listed well owner to experience groundwater quantity issues as a result of this operation.

In Attachment IV.1 of the application, the applicant states the daily quantity of mine infiltration water required to be pumped out amounts to 2,700,000 gallons per day. The applicant anticipates the maximum flow of mine infiltration water to be 3,500,000 gallons per day. The application notes the applicant is not aware of any groundwater users using the water from the Anvil Rock or Gimlet Sandstone units. Most private groundwater well users are utilizing the shallow groundwater from the unconsolidated layer. The applicant noted one user who has a well drilled down to these sandstones, however it appears it was drilled deep for additional storage capacity in the well according to the application.

iv. Groundwater Quality Baseline Information

As mentioned in the previous section, the applicant notes the construction methods to install the pipeline should be minimally invasive. As such, the applicant does not believe the shallow groundwater quality will be affected by the proposed operations. The application states the infiltrating groundwater has elevated chloride and sulfate levels that would not otherwise be allowed to discharge through the outfalls currently approved in the NPDES permit. Table III.2.D.1.a in the application displays representative data obtained from the water holding cell which could contain a mixture of mine infiltration water, process water from the preparation plant, and decant water from the slurry cells according to Attachment IV.1 of the application. The chloride concentration varied between 1,699 mg/L and 2,799 mg/L, whereas the sulfate concentration varied between 820 mg/L and 2,120 mg/L according to the application.

The applicant is assuming the primary driver for the elevated chloride and sulfate concentration is the infiltrating groundwater. Since this water has naturally elevated chlorides and sulfates, the applicant notes there are no known private users of this groundwater. As mentioned in the previous section, the applicant notes one user who has a well that is drilled into this interval, but the applicant asserts this was done for additional storage capacity in the well rather than utilization of the unit for water.

b. Findings

i. Surface Water Quantity Findings

Previous surface water assessments can be found in the CHIAs for Permit Nos. 375 and 417. The applicant presented information in the application to indicate the construction of this pipeline will be minimally invasive. Additionally, the applicant has committed to provisions in the pipeline construction and operation to prevent leaks and ensure reliable operation. Therefore, the Department finds the construction of this pipeline will cause little to no impact to the surface water quantity in the vicinity of the proposed permit area. This conclusion also applies to the previously approved surface IBRs now being included in the assessment area.

The application states up to 5,000 gallons per minute can be discharged into the Big Muddy River depending on the flow of the river and other conditions specified in the draft NPDES

permit for this mine. The mixing zone is currently pending approval by IEPA, however the draft NPDES permit suggests their analysis found the additional volume of water would not negatively affect the Big Muddy River. Therefore, the Department will not comment any further on the volume of water going to the Big Muddy River.

Shadow Area

Application for Permit No. 456 will have no impact on the surface water quantity that may be present within the existing shadow areas.

ii. Surface Water Quality Findings

Given the relatively non-invasive construction, maintenance commitment, and operational provisions of the pipeline to prevent leaks, the Department finds the surface water quality will be minimally affected or not affected at all by the proposed operations. This conclusion also applies to the previously approved surface IBRs now being included in the assessment area.

Table III.2.D.1.a in the application gave representative water quality data for the holding cell and showed elevated chloride and sulfate values. Attachment IV.1 of the application stated the water holding cell could contain a mixture of mine infiltration water, process water from the preparation plant, and decant water from the slurry cells. The applicant also stated this was considered in the Anti-Degradation Analysis conducted by IEPA for the mixing zone into the Big Muddy River. According to the draft NPDES permit, the IEPA determined the mixing zone will not negatively affect the Big Muddy River, as such, the Department will not comment further on their analysis. Therefore, the Department finds as long as the applicant follows and meets the provisions laid out in the NPDES permit, the surface water quality should not be negatively affected.

Shadow Area

Application for Permit No. 456 will have no impact on the surface water quality that may be present within the existing shadow areas.

iii. Groundwater Quantity Findings

It is not anticipated the shallow groundwater quantity will be significantly impacted by the proposed operations. Attachment III.2.B.1 and the Hydrologic Maps of the Application for Permit No. 456 identified eight private water wells and their respective users within ½ mile of the proposed permit boundary. One of the wells is noted to be plugged according to the information the applicant obtained from the ISGS records. The Department does not expect the groundwater quantity of the private well users to be impacted by the proposed operations. Given the relatively non-invasive construction, maintenance commitment, and operational provisions of the pipeline to prevent leaks, the Department finds the groundwater quantity will be minimally affected or not affected at all by the proposed operations. This conclusion also applies to the previously approved surface IBRs now being included in the assessment area.

As stated in previous CHIAs for this mine, the groundwater infiltrating in the mine works originates in sandstone aquifers that are currently (and historically) not in use by local residents for two reasons. The first is the cemented nature of the sandstone creates low aquifer yield and the second is the documented poor quality of this water. Local residents tend to obtain their drinking water from surface sources due to the highly mineralized water that is present in this sandstone unit.

Therefore, the effect of the pumping of this groundwater that infiltrates the mine workings is not anticipated to have a negative impact on any current drinking, domestic, or usable aquifer quantity.

Shadow Area

Application for Permit No. 456 will have no impact on the groundwater quantity that may be present within the existing shadow areas.

iv. Groundwater Quality Findings

Similar to the Groundwater Quantity Findings, it is not anticipated the shallow groundwater quality will be significantly impacted by the proposed operations. Attachment III.2.B.1 and the Hydrologic Maps of the Application for Permit No. 456 identified eight private water wells and their respective users within ½ mile of the proposed permit boundary. One of the wells is noted to be plugged according to the information the applicant obtained from the ISGS records. The Department does not expect the groundwater quality of the private wells users to be impacted by the proposed operations. Given the relatively non-invasive construction, maintenance commitment, and operational provisions of the pipeline to prevent leaks, the Department finds the groundwater quality will be minimally affected or not affected at all by the proposed operations. This conclusion also applies to the previously approved surface IBRs now being included in the assessment area.

As mentioned in the previous section, the groundwater infiltrating in the mine works originates in sandstone aquifers that are currently (and historically) not in use by local residents due to low aquifer yield and poor quality. Local residents tend to obtain their drinking water from surface sources due to the highly mineralized water that is present in this sandstone unit. Therefore, the effect of the pumping of this groundwater that infiltrates the mine workings is not anticipated to have a negative impact on any current drinking, domestic, or usable aquifer quality.

Shadow Area

Application for Permit No. 456 will have no impact on the groundwater quality that may be present within the existing shadow areas.

III. CONCLUSION

The surface water and groundwater monitoring programs have been designed to provide sufficient lead time for notification of any potential impacts, as well as to provide ample time for investigation and mitigation of any impacts prior to reaching off-site. Both the groundwater and surface water monitoring programs are dynamic and as such, the Department reserves the right to add monitoring parameters or monitoring locations should the need arise. The applicant/permittee is required to monitor the surface water and groundwater throughout the life of the mine, up to and including the time of final bond release.

The Department has now conducted a hydrogeologic assessment on the proposed additional acreage described in the Application for Permit No. 456 and the previously approved surface IBRs now being included in the assessment area. As noted in the discussions throughout this document, the Department has concluded that the additional proposed surface facilities permit area will not have a negative impact on either the surface water or groundwater regimes.

Neither the surface water nor groundwater within the assessment areas will be materially damaged unless the quantity and/or quality of water is degraded on a long-term or permanent basis, beyond the applicable standards or a long-term or permanent loss of use is reported. Material damage occurs when the impact is immitigable. Neither the applicant/permittee, nor the Department anticipates that this will occur.

Therefore, the cumulative hydrologic impact assessment finds that the proposed operations have been designed to prevent material damage to the hydrologic balance beyond the permitted areas.

In summary, the assessment and findings of the probable cumulative impact of all anticipated mining in the area on the hydrologic balance finds that this operation has been designed to prevent material damage to the hydrologic balance outside the permit areas.

IV. REFERENCES AND ATTACHMENTS

REFERENCES

Booth, C.J., and E.D. Spande, 1991, *Changes in hydraulic properties of strata over active longwall mining, Illinois, USA*: Proceedings, Fourth International Mine Water Congress, Portschach, Austria/Lubljana, Slovenia, September, p.12.

Cartwright, K., and C.S. Hunt, 1981, *Hydrogeologic aspects of coal mining in Illinois: An Overview*. Illinois State Geological Survey, Environmental Geology Notes #90.

Hoving, S.J. and W.C. Hood, 1984, *The Effects of Different Thicknesses of Limestone and Soil Over Pyrite Materials on Leachate Quality*. In 1984 Symposium of Surface Mining, Hydrology, Sedimentology, and Reclamation, University of Kentucky, Lexington, KY, December 2-7, p 251-257.

Infanger, M.K., and W.C. Hood, 1980, *Positioning acid-producing overburden for minimal pollution*. Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation. Univ. of Kentucky, Dec. 1-3.

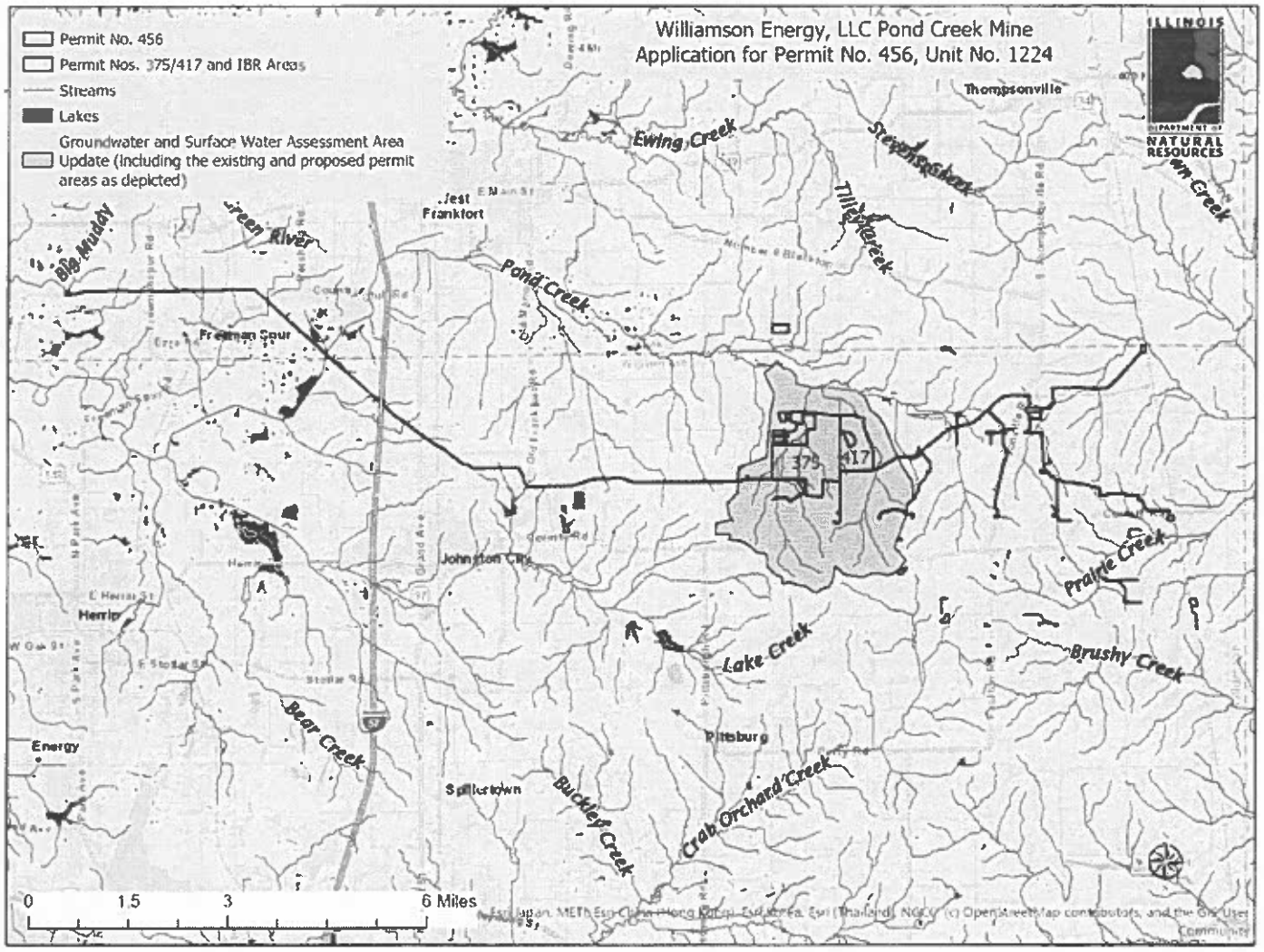
Illinois State Geologic Survey, *Coal Mines and Industrial Mineral Mines Franklin County,* August 2017.

Owili-Eger, A.A.C., 1983, Geohydrologic and hydrogeochemical impact of longwall coal mining on local aquifers. Society of Mining Engineers AIME Pre-print No. 83-376, p.16.

Pryor, W.A., 1956, *Groundwater geology in southern Illinois: A preliminary report*. Illinois State Geological Survey, Circular #212.

United States Department of the Interior, Office of Surface Mining, *Technical Reference for the Mid-Continent Region: Hydrologic Considerations for Permitting and Liability Release*, June 2007.

Zuehls, E.E., et al., 1981, *Hydrology of Area 35, Eastern Region, Interior Coal Province, Illinois and Kentucky*. United States Geologic Survey, Water Resources Investigations Open-File Report 81-403.



Map 1 – Current CIA and Assessment Map

R03597

APPENDIX D

DECISION ON PROPOSED POST-MINING LAND USE OF PERMIT AREA

The pre-mining and post-mining land use acreage of the permitted area is as follows*:

	Pre-mining	Post-mining
Cropland	16.4	16.4
Water Resources	0.2	0.2
Residential	0.1	0.1
Industrial/Commercial	8.2	8.2
Fish & Wildlife Habitat**	45.8	45.8
Total	70.7	70.7

*The Department notes that other agencies with environmental and land use authority may use land use definitions other than 62 Ill. Adm. Code 1701.5. Reports for those agencies which may be included in the application will classify and tabulate land uses based on their definitions. As a result, those land use tabulations may not directly correlate with the above tables.

** To facilitate the assessment of the revegetation success performance standards, the post-mining land use of Fish and Wildlife Habitat is broken out as follows:

Wildlife-Herbaceous	Wildlife-Woody	Wildlife-Wetland	Wildlife-Water
20.7	21.1	3.6	0.4

The Department thus finds the areas affected by surface coal mining operations will be restored in a timely manner to conditions that are capable of supporting the use which they were capable of supporting before mining or to higher or better use achievable under the criteria and procedures of 62 Ill. Adm. Code 1817.133, or as noted above. The plan of restoration submitted by the applicant does not present any actual or probable hazard to public health or safety nor does it pose any actual threat of water diminution or pollution as indicated in Appendix C, and the proposed land uses following mining are not impractical or unreasonable as all the post-mining land uses existed prior to mining and are compatible with the surrounding areas. The land uses are consistent with applicable land use policy and plans known to the Department and no objections were received from any governmental agency with such authority. The plan does not involve unreasonable delay

in implementation and is not in violation of any other applicable law known to the Department. Federal court decisions, commonly known and the "Flannery decisions" and current regulations provide for the distinct difference between surface and underground mining. In this permit the operations will involve the trenching and burying of a pipeline through the permit area. Reclamation by soil replacement and revegetation will occur shortly afterward as part of the operation with the exception of any surface access areas. There are no land use or land capability changes requested by the permitee. These disturbances are considered minor in comparison to surface mining and the removal of overburen and coal.

APPENDIX E

DOCUMENTATION PROVIDED BY APPLICANT TO COMPLY WITH
62 Ill. Adm. Code 1773.15(b)(1)(A)

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

September 13, 2017

Mr. Charles Shestak
Canterbury Coal Company
46226 National Road
St. Clairsville, OH 43950

Re: David/Dianne Mine
Permit No.03841302
Compliance Order Nos. 171025 and 171028
Kiskiminetas Township
Armstrong County

Dear Mr. Shestak:

We have enclosed an executed Consent Assessment of Civil Penalty for the above referenced compliance orders.

We appreciate your cooperation in resolving this matter. If you have any questions, please contact me at 724-925-5500.

Sincerely,

Jeffrey V. Parr
Compliance Specialist
District Mining Operations

cc: Permit File

Enclosure

New Stanton District Office
131 Broadview Road | New Stanton, PA 15672 | 724.925.5500 | F 724.925.5557
www.dep.pa.gov

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division
(Rev 06/19/17)

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

In The Matter Of:

Canterbury Coal Company	:	Compliance Order No. 171028
46226 National Road	:	Permit No. 03841302 - License No. 5006
Saint Clairsville, OH 43950	:	Kiskiminetas Township
	:	Armstrong County

CONSENT ASSESSMENT OF CIVIL PENALTY

This Consent Assessment of Civil Penalty ("CACP") is entered into this 23 day of August 2017, by and between the Commonwealth of Pennsylvania, Department of Environmental Protection ("Department") and Canterbury Coal Company ("Canterbury Coal").

The Department has found and determined the following:

A. The Department is the agency with authority to administer and enforce [The Clean Streams Law, Act of June 22, 1937, P.L. 1987, *as amended*, 35 P.S. §§ 691.1--691.1001]; [the Surface Mining Conservation and Reclamation Act, Act of May 31, 1945, P.L. 1198, *as amended*, 52 P.S. §§ 1396.1--1396.19a ("Surface Mining Act")]; [the Coal Refuse Disposal Control Act, Act of September 24, 1968, P.L. 1040, *as amended*, 52 P.S. §§ 30.51--30.66 ("Coal Refuse Act")]; [the Noncoal Surface Mining Conservation and Reclamation Act, Act of December 19, 1984, P.L. 1093, *as amended*, 52 P.S. §§ 3301 -- 3326 ("Noncoal Act")]; [the Bituminous Mine Subsidence and Land Conservation Act, Act of April 27, 1966, P.L. 31, *as amended*, 52 P.S. §§ 1406.1--1406.21 ("Bituminous Subsidence Act)]; Section 1917-A of the Administrative Code of 1929, Act of April 9, 1929, P.L. 177, *as amended*, 71 P.S. § 510-17, and the rules and regulations promulgated thereunder.

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Land Reclamation Division

H. On May 5, 2017 as evidenced by Sample No. 4137-091, Canterbury Coal caused or allowed a discharge of water at the David/Dianne Mine, from outfall 001, with an aluminum concentration of 1.524 mg/L which exceeds the permit limit of 0.75 mg/L.

I. Canterbury Coal's conduct set forth above constitutes a violation of Sections 301, 307, 315, and 611 of the Clean Streams Law, 35 P.S. §§ 691.301, 691.307, 691.315, 691.611 and Section 86.13 of the Rules and Regulations, 25 Pa. Code § 86.13.

J. The violations described in Paragraph(s) F through I above constitute unlawful conduct under Section 611 of the Clean Streams Law, 35 P.S. § 691.611 and Section 17a of the Bituminous Subsidence Act, 52 P.S. § 1406.17a and subject Canterbury Coal to a claim for civil penalty liability under Section 605 of the Clean Streams Law, 35 P.S. § 691.605 and Section 17 of the Bituminous Subsidence Act, 52 P.S. § 1406.17.

After full and complete negotiation of all matters set forth in this CACP and upon mutual exchange of the covenants herein, the parties desiring to avoid litigation and intending to be legally bound, it is hereby ASSESSED by the Department and AGREED to by Canterbury Coal as follows:

1. Assessment. In resolution of the Department's claim for civil penalties, which the Department is authorized to pursue under Section 605 of the Clean Streams Law, 35 P.S. § 691.605, and Section 17f of the Mine Subsidence Act, 52 P.S. § 1406.17(f). The Department hereby assesses a civil penalty of TWO THOUSAND FIVE HUNDRED SEVENTY-TWO DOLLARS ($2,572), which Canterbury Coal hereby agrees to pay.

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October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

2. Civil Penalty Settlement. Canterbury Coal consents to the assessment of the civil penalty assessed in Paragraph 1, which shall be paid in full upon signing this CACP. This payment is in settlement of the Department's claim for civil penalties for the violations set forth in the paragraphs above for the date[s] set forth therein. The payment shall be by corporate check or the like, made payable to the Commonwealth of Pennsylvania and sent to Compliance Specialist, PA DEP - New Stanton District Office, 131 Broadview Road, New Stanton, PA 15672.

3. Findings.

a. Canterbury Coal agrees that the findings in Paragraphs A through J are true and correct and, in any matter or proceeding involving Canterbury Coal and the Department, Canterbury Coal shall not challenge the accuracy or validity of these findings.

b. The parties do not authorize any other persons to use the findings in this CACP in any matter or proceeding.

4. Reservation of Rights. The Department reserves all other rights with respect to any matter addressed by this CACP, including the right to require abatement of any conditions resulting from the events described in the Findings. Canterbury Coal reserves the right to challenge any action which the Department may take, but waives the right to challenge the content or validity of this CACP.

IN WITNESS WHEREOF, the parties have caused this CACP to be executed by their duly authorized representatives. The undersigned representatives of Canterbury Coal certify, under penalty of law, as provided by 18 Pa. C. S. § 4904, that they are authorized to execute this CACP on behalf of Canterbury Coal, that Canterbury Coal consents to the entry of this CACP as

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an ASSESSMENT of the Department; that Canterbury Coal hereby knowingly waives any right to a hearing under the statutes referenced in this CACP; and that Canterbury Coal knowingly waives its right to appeal this CACP, which rights may be available under Section 4 of the Environmental Hearing Board Act, Act of July 13, 1988, P.L. 530, 35 P.S. § 7514; the Administrative Agency Law, 2 Pa. C.S. § 103(a) and Chapters 5A and 7A; or any other provision of law. [Signature by Canterbury Coal's attorney certifies only that the agreement has been signed after consulting with counsel.]

FOR Canterbury Coal Company:

Name Robert D. Moore
Title President + Treasurer

FOR THE COMMONWEALTH OF PENNSYLVANIA, DEPARTMENT OF ENVIRONMENTAL PROTECTION:

Name: Joseph F. Leone
Title: District Mining Manager

Name
Title Michael O. McKown
Secretary

waived
[Name
Attorney for [Operator]]

Name: Barbara Grabowski
Assistant Regional Counsel

COMMENT: If the Operator is a corporation, this document must be signed by both (1) the President or Vice President *and* (2) the Secretary or Treasurer, unless a resolution from the Board of Directors is attached that authorizes the signatory to sign on behalf of the corporation.

AUG 2 4 2017

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

James Plumley

From: Thomas, Ryan L <Ryan.L.Thomas@wv.gov>
Sent: Thursday, October 17, 2019 1:06 PM
To: Hunter, Hodge
Subject: Re: [External] S-6020-89 NOV #63 Extension

CAUTION: This email originated from outside of Murray Energy. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Yes, I will be extending this violation up to 11-14-19. I will do the paperwork as soon as I get back in the office.

Ryan Thomas
Environmental Inspector
Division of Mining and Reclamation
1159 Nick Rahall Greenway
Fayetteville, WV 25840
Office: 304-574-4465
Email: Ryan.L.Thomas@wv.gov

On Oct 17, 2019, at 1:59 PM, Hunter, Hodge <hodgehunter@coalsource.com> wrote:

> CAUTION: External email. Do not click links or open attachments unless you verify sender.
>
> Mr. Thomas,
>
> Could we get an extension for NOV #63 on permit S-6020-89?
>
> Thank you,
> Hodge Hunter
>
> Hodge Hunter | Environmental Engineer
> Murray Maple Eagle Coal, LLC | hodgehunter@coalsource.com
> 1345 Elkridge Road | Powellton, WV 25161
> Office: 304-981-4922 | Cell: 870-260-2848
>
> <image001.jpg>

MR-6
ERIS

West Virginia Department of Environmental Protection
MR-6 MINE INSPECTION REPORT

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

PERMIT NUMBER	INSPECTION DATE	TIME	REASON	TYPE	MINE STATUS	PHOTOS	BLASTING Last 30 Days?	Ins. Req'd?
O102392	11/16/2018	10 00	IN	P	AM	No	No	No

PERMITTEE NAME THE MARSHALL COUNTY COAL COMPANY MSHA # 4601437
OPERATOR NAME MR-19 DATE
NPDES # WV0020834 NPDES EXPR DATE 08/07/2019 PERMIT EXPR DATE 02/28/2021
PERMIT ACRES 1,160.68 TOTAL DISTBD 900.00 RECLMD 75 00 ANCIL-LARY 0 UNRECLMD 825
DATES: PH I PH II LAST AUG SEED MR-8
LAST INSP DATE 10/30/2018 TYPE P BOND INC 1 INC BONDED ACRES 1,160.68 CUR IBR# 28 CUR REV# 16
EXPR DATES: INACT EMER RESP PLAN INS 06/01/2019 BLAST AD
TIME USED (HRS)==> PERMIT REVIEW 0 25 INSPECT 0 25 TRAVEL 0.25 REPORT 0.25

INSPECTION COMMENTS

NOV 31 Follow-up. NOV 31 is now being enforced under the Consent Order dated May 14, 2018. The violation is terminated.

ENFORCEMENT STANDARD		EVALUATION	VIO#	ENFORCEMENT STANDARD		EVALUATION	VIO#
0100	Distance Prohibited			0200	Exceeding Limits		
0300	Signs and Markers			0400	Sediment Control		
0500	Design Certification			0600	Effluent Limits		
0700	Surface Water			0800	Ground Water		
0900	Blasting Procedures			1000	Haul Roads		
1100	Refuse Impoundments			1200	Topsoil Handling		
1300	Backfill / Grading			1400	Reclamation Schedule		
1500	Revegetation Requirements			1600	Disposal of Excess Spoil		
1700	Highwall Elimination			1800	Downslope Spoil Disposal		
1900	Postmining Land Use			2000	Ceased Mining Temporarily		
2100	Acid bearing /Toxic Material			2200	Method of Operations		
2300	Change of Operator			2400	Permit Conditions		
2500	Diversions and Drainage Control			2600	Fugitive Dust Control		
2700	Subsidence Plan			2800	Insurance Current		
2900	Bonding Current			3000	Other Conditions	FC	

WATER QUALITY TESTS

Structure ID	Outfall	pH	Fe	Mn	Al	No Flow	Not Const.	Treatment

AUTH. COMPANY REPRESENTATIVE Joe Williams
DELIVERY METHOD / DATE TIME Mail 11/21/2018 10 00 00
CERTIFIED MAIL NUMBER
ADDRESS 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950
WV DEP REP. Andrew M Coleman Andrew M Coleman

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 · (217) 782-3397
JB PRITZKER, GOVERNOR
JOHN J. KIM, DIRECTOR

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

217-782-9861

July 23, 2019

CERTIFIED MAIL # 7015 0640 0002 6956 7712
RETURN RECEIPT REQUESTED

Sugar Camp Energy, LLC
Attn: Mr. Mark G. Schuerger
11525 North Thompsonville Road
Macedonia, Illinois, 62860

Re: Notice of Non-Issuance of Compliance Commitment Agreement
Violation Notice: W-2019-50002
Sugar Camp Energy
W0558010004

Dear Mr. Schuerger:

The Illinois Environmental Protection Agency ("Illinois EPA") has reviewed the proposed Compliance Commitment Agreement ("CCA") terms submitted by **Sugar Camp Energy** in a letter dated **June 26, 2019**, in response to the Violation Notice dated **March 25, 2019**, and has decided not to issue a proposed CCA for these violations. Due to the nature and seriousness of the violations, the Illinois EPA has determined that these violations may not be able to be resolved without the involvement of the Office of the Attorney General or the State's Attorney.

Because the violations remain the subject of disagreement between the Illinois EPA and **Sugar Camp Energy**, this matter will be considered for referral to the above-referenced prosecutorial authorities for formal enforcement action and the imposition of penalties.

Questions regarding this matter should be directed to Greg Spencer at 217/782-9871. Written communications should be directed to:

Illinois EPA – Division of Water Pollution Control
Attn: Greg Spencer/CAS #19
P.O. Box 19276
Springfield, IL 62794-9276

Sincerely,

Roger Callaway

Roger Callaway
Compliance Assurance Section
Division of Water Pollution Control
Bureau of Water

4302 N. Main St., Rockford, IL 61103 (815) 987-7760
595 S. State, Elgin, IL 60123 (847) 608-3131
2125 S. First St., Champaign, IL 61820 (217) 278-5800
2009 Mall St., Collinsville, IL 62234 (618) 346-5120
9511 Harrison St., Des Plaines, IL 60016 (847) 294-4000
412 SW Washington St., Suite D, Peoria, IL 61602 (309) 671-3022
2309 W. Main St., Suite 116, Marion, IL 62959 (618) 993-7200
100 W. Randolph, Suite 10-300, Chicago, IL 60601 (312) 814-6026

PLEASE PRINT ON RECYCLED PAPER

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

MR-6
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West Virginia Department of Environmental Protection
MR-6 MINE INSPECTION REPORT

PERMIT NUMBER	INSPECTION DATE	TIME	REASON	TYPE	MINE STATUS	PHOTOS	BLASTING Last 30 Days?	BLASTING Ins. Req'd?
U200707	10/04/2019	12:00	IN	P	AM	No	Yes	Yes

PERMITTEE NAME: THE MARSHALL COUNTY COAL COMPANY MSHA #: 46-01437
OPERATOR NAME: MR-19 DATE:
NPDES #: WV0020834 NPDES EXPR DATE: 11/07/2019 PERMIT EXPR DATE: 11/18/2023
PERMIT ACRES: 158.13 TOTAL DISTBD: 110.00 RECLMD: 0.00 ANCIL-LARY: 0 UNRECLMD: 110
DATES: PH I: PH II: LAST AUG SEED: MR-8:
LAST INSP DATE: 09/20/2019 TYPE: P BOND INC: 1 INC BONDED ACRES: 158.13 CUR IBR#: 15 CUR REV#: 1
EXPR DATES: INACT: EMER RESP PLAN: INS: 06/01/2020 BLAST AD:
TIME USED (HRS)==> PERMIT REVIEW: 0.25 INSPECT: 0.25 TRAVEL: 0.00 REPORT: 0.25

INSPECTION COMMENTS

Marshall County Coal Co: 6S #1 - NOV 6 extension request beyond 90 days has been received from to company. Progress to abate the NOV has been outlined in the attached report. An additional 30 days extension is being granted to allow for completion of the access road and all drainage control. New abatement date is 11/1/2019.

	ENFORCEMENT STANDARD	EVALUATION	VIO#		ENFORCEMENT STANDARD	EVALUATION	VIO#
0100	Distance Prohibited			0200	Exceeding Limits		
0300	Signs and Markers			0400	Sediment Control		
0500	Design Certification			0600	Effluent Limits		
0700	Surface Water			0800	Ground Water		
0900	Blasting Procedures			1000	Haul Roads		
1100	Refuse Impoundments			1200	Topsoil Handling		
1300	Backfill / Grading			1400	Reclamation Schedule		
1500	Revegetation Requirements			1600	Disposal of Excess Spoil		
1700	Highwall Elimination			1800	Downslope Spoil Disposal		
1900	Postmining Land Use			2000	Ceased Mining Temporarily		
2100	Acid bearing /Toxic Material			2200	Method of Operations		
2300	Change of Operator			2400	Permit Conditions		
2500	Diversions and Drainage Control	COM		2600	Fugitive Dust Control		
2700	Subsidence Plan			2800	Insurance Current		
2900	Bonding Current			3000	Other Conditions		

WATER QUALITY TESTS

Structure ID	Outfall	pH	Fe	Mn	Al	No Flow	Not Const.	Treatment

AUTH. COMPANY REPRESENTATIVE: Joe Williams
DELIVERY METHOD / DATE TIME: Certified 10/7/2019 12:00:00
CERTIFIED MAIL NUMBER: 7017 2400 0000 3494 3808
ADDRESS: 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950
WV DEP REP.: James T. Harvey

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

MR-16

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West Virginia Department Of Environmental Protection

MR-16 VIOLATION FOLLOW-UP INSPECTION REPORT

PERMIT NUMBER	ORIGINAL INSPECTION AND VIOLATION DATA						NEW VIOLATION ACTIVITY	
	DATE	TIME	FORM #	FACILITY #	ENF STD	ORIGINAL VIOL#	DATE	TIME
U200707	07/08/2019	09:30	6		2500	6	10/04/2019	12:00

PERMITTEE NAME THE MARSHALL COUNTY COAL COMPANY

Violation is hereby: ☐ Terminated ☐ Withdrawn ☐ Remains in force as written ☐ Show Cause submitted

☑ Extended to 11/01/2019 at 12:00 ☐ NOV modified to CO # ____ ☐ CO modified to NOV # ____

Action taken to abate:

The company continues to work on completion of the access road and drainage control structures. An extension request beyond 90 days has been submitted by the company with a detailed report of activities taken thus far to abate the violation. An additional 30 days extension is being granted to a new abatement date of 11/1/2019.

INSPECTOR'S CIVIL PENALTY ASSESSMENT RECOMMENDATION (check)

Seriousness: 1☐ 2☐ 3☐ 4☐ 5☑ 6☐ 7☐ 8☐ 9☐ 10☐ Negligence: 0☐ 1☐ 2☐ 3☐ 4☑ 5☐ 6☐ 7☐ 8☐

Good Faith: 0☐ 1☐ 2☐ 3☑ 4☐ 5☐ 6☐ 7☐ 8☐ Consent Agreement in effect? ☐ Yes ☑ No

Comments:

AUTH. COMPANY REPRESENTATIVE Joe Williams

DELIVERY METHOD / DATE TIME Certified 10/7/2019 12:00:00

CERTIFIED MAIL NUMBER 7017 2400 0000 3494 3808

ADDRESS 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950

WV DEP REP. James T. Harvey

Austin Caperton
[Secretary, Department of Environmental Protection]

James T. Harvey
[WV DEP Representative]

10/7/19
Date

Names of individuals at informal Conference:

Results: CO was:	☐ Upheld	☐ Modified	☐ Terminated	☐ Withdrawn

Comments:

SUPERVISOR: _____ DATE: _____ TIME: _____

COMPANY REPRESENTATIVE: _____ DATE: _____

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

The Marshall County Coal Company
46226 National Road
St. Clairsville, Ohio 43950
Phone: 740-338-3100
Fax: 740-338-3405

October 4, 2019

James Harvey
Inspector Specialist
WV Department of Environmental Protection
Division of Mining and Reclamation
47 School Street, 301
Philippi, WV 26416

RE: The Marshall County Coal Company
6 South 1 Airshaft
U200707 NOV 6

Mr. Harvey,

This letter is in response to the remedial measures stated in NOV 6 for The Marshall County Coal Company's 6 South #1 Airshaft, WVDEP Permit U200707.

As you are aware, the completion of the site has taken longer than planned. This is largely due to the amount of unsuitable material encountered during construction. Another significant factor has been the performance of the on-site contractor. This contractor has since been removed from the project and a replacement contractor has resumed construction. The new contractor has since installed five additional culverts and removed the Trans Canada gas line that was intersecting the access road.

Currently the development of the drainage control system continues. Much of the pad and access road is at final grade and a number of culverts have been installed. Enclosed is a status report of the drainage components proposed in the design. At this time The Marshall County Coal Company requests a thirty day extension of the October 4th abatement date in order to complete the installation of the remaining ditches and culverts.

Regards,

Joe Williams
Environmental Engineer

CC: Cory Barack
Jim Turner
Guy Shelledy
Jim Mazzocca
Paul McGee
Christian Warfield
File

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October 21, 2019
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Land Reclamation Division

6 South #1 Site - Drainage Structures Status Report - 2019 10 03

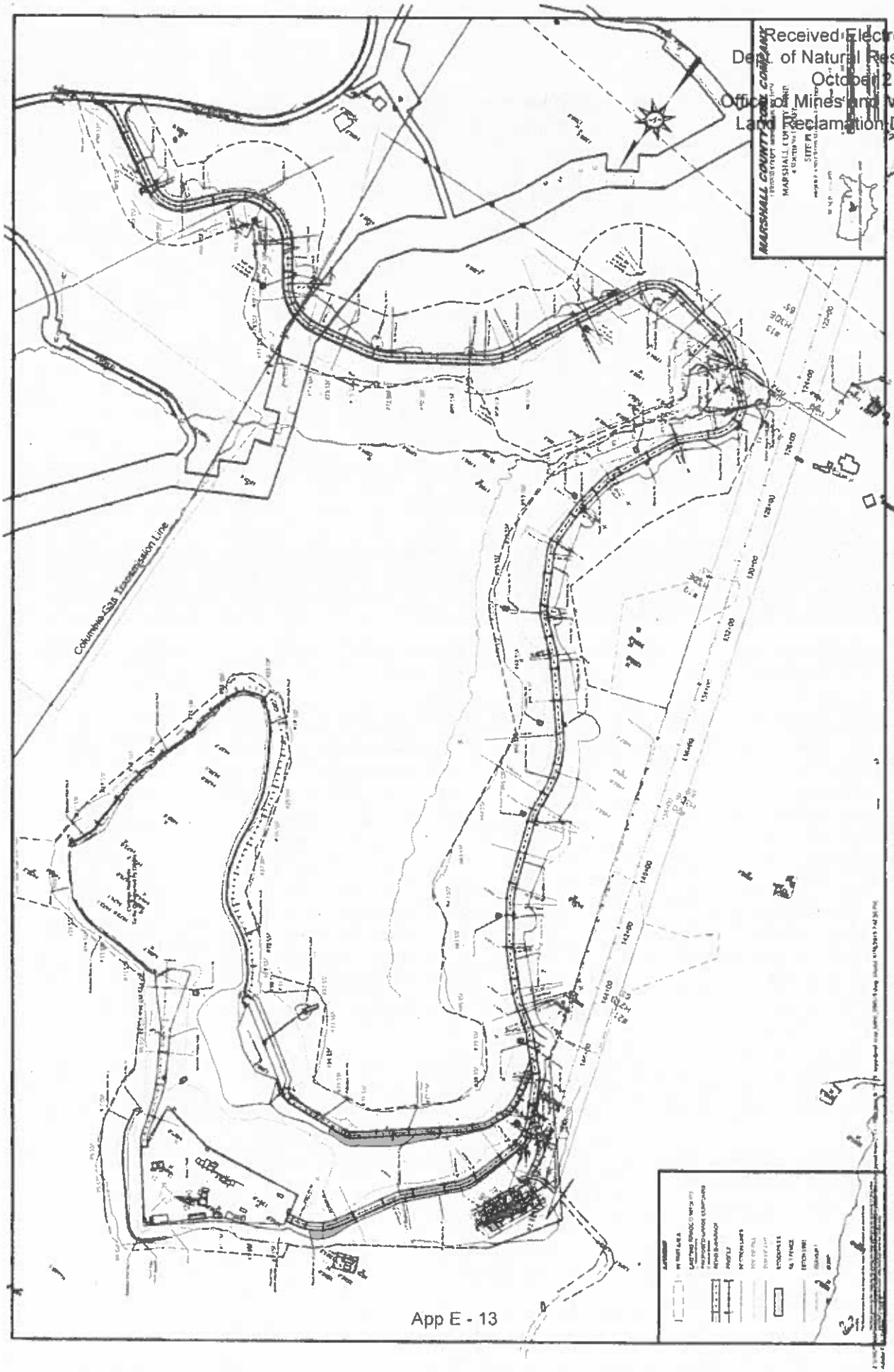
Road Ditch and Culvert Information from Rt. 250 to the Stream Crossing								
Road Ditch No.	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Start Plus	0+20	2+80	6+60	9+20	13+15	16+10	19+65	22+10
End Plus	2+80	6+60	9+20	13+15	16+10	19+65	22+10	27+20
Length (ft)	260	380	260	395	295	355	245	510
Road to Grade	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
Ditch to Grade	Complete	Complete	Complete	Incomplete	Complete	Complete	Complete	Complete
Ditch Fabric	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete
Culvert Sump	Complete	Incomplete	Incomplete	Complete	Complete	Complete	Complete	Complete
Culvert	Complete	Incomplete	Incomplete	Complete	Complete	Complete	Complete	Complete
Culvert Apron	Complete	Incomplete	Incomplete	Complete	Incomplete	Incomplete	Complete	Complete

Road Ditch and Culvert Information from the Shaft Pad to the Stream Crossing									
Road Ditch No.	No. 17	No. 16	No. 15	No. 14	No. 13	No. 12	No. 11	No. 10	No. 9
Start Plus	62+16	53+80	51+20	47+00	43+90	40+70	37+25	33+60	31+20
End Plus	53+80	51+20	47+00	43+90	40+70	37+25	33+60	31+20	27+20
Length (ft)	836	260	420	310	320	345	365	240	400
Road to Grade	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
Ditch to Grade	Complete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete
Ditch Fabric	Complete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete
Culvert Sump	Complete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete
Culvert	Complete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete
Culvert Apron	Complete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete

All Ditches that Drain to the Sediment Pond				
Ditch No.	C.D. #1	C.D. #2	C.D. #3	C.D. #4
Start Plus	0+00	18+09	14+55	0+00
End Plus	9+38	0+00	0+00	14+67
Length (ft)	938	1,809	1,455	1,467
Road to Grade	Complete	N/A	N/A	N/A
Ditch to Grade	Complete	Complete	Incomplete	Complete
Ditch Fabric	Complete	Complete	Incomplete	Complete
Culvert Sump	Complete	Complete	Incomplete	Complete
Culvert	Complete	Complete	Incomplete	Complete
Culvert Apron	Complete	Complete	Incomplete	Complete

Drainage Project Totals and % Complete			
	Total	Complete	% Complete
Road to Grade	7,134	7,134	100%
Ditch to Grade	11,865	7,355	62%
Ditch Fabric	11,865	5,050	43%
Culvert Sump	19	9	47%
Culvert	19	9	47%
Culvert Apron	19	7	37%

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Land Reclamation Division



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MR-6
ERIS

West Virginia Department of Environmental Protection
MR-6 MINE INSPECTION REPORT

PERMIT NUMBER	INSPECTION DATE	TIME	REASON	TYPE	MINE STATUS	PHOTOS	BLASTING Last 30 Days?	BLASTING Ins. Req'd?
U200707	03/29/2019	12:00	IN	P	AM	No	No	No

PERMITTEE NAME THE MARSHALL COUNTY COAL COMPANY MSHA # 46-01437

OPERATOR NAME MR-19 DATE

NPDES # WV0020834 NPDES EXPR DATE 08/07/2019 PERMIT EXPR DATE 11/18/2023

PERMIT ACRES 153.14 TOTAL DISTBD 65.00 RECLMD 0.00 ANCIL-LARY 0 UNRECLMD 60

DATES: PH I PH II LAST AUG SEED MR-S

LAST INSP DATE 03/19/2019 TYPE C BOND INC 1 INC BONDED ACRES 153.14 CUR IBR# 14 CUR REV# 0

EXPR DATES: INACT EMER RESP PLAN INS 06/01/2019 BLAST AD

TIME USED (HRS)==> PERMIT REVIEW 0.25 INSPECT 0.50 TRAVEL 0.25 REPORT 0.50

INSPECTION COMMENTS

NOV Follow-up. The permittee has provided a letter detailing the amount of soil removed from the 5N #3 site. It is estimated 20 cubic yards of topsoil and 485 cubic yards of subsoil were removed and taken to the ball field. They also provided plant nutrient testing results of the soil. A potential site has been identified to find replacement soil. The NOV will be extended to complete the required work.

	ENFORCEMENT STANDARD	EVALUATION	VIOS		ENFORCEMENT STANDARD	EVALUATION	VIOS
0100	Distance Prohibited			0200	Exceeding Limits		
0300	Signs and Markers			0400	Sediment Control		
0500	Design Certification			0600	Effluent Limits		
0700	Surface Water			0800	Ground Water		
0900	Blasting Procedures			1000	Haul Roads		
1100	Refuse Impoundments			1200	Topsoil Handling	COM	
1300	Backfill / Grading			1400	Reclamation Schedule		
1500	Revegetation Requirements			1600	Disposal of Excess Spoil		
1700	Highwall Elimination			1800	Downslope Spoil Disposal		
1900	Postmining Land Use			2000	Ceased Mining Temporarily		
2100	Acid bearing /Toxic Material			2200	Method of Operations		
2300	Change of Operator			2400	Permit Conditions		
2500	Diversions and Drainage Control			2600	Fugitive Dust Control		
2700	Subsidence Plan			2800	Insurance Current		
2900	Bonding Current			3000	Other Conditions		

WATER QUALITY TESTS

Structure ID	Outfall	pH	Fe	Mn	Al	No Flow	Not Const.	Treatment

AUTH. COMPANY REPRESENTATIVE Joe Williams

DELIVERY METHOD / DATE TIME Mail 4/10/2019 10:00:00

CERTIFIED MAIL NUMBER

ADDRESS 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950

WV DEP REP. Andrew M Coleman

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

MR-16

ERIS

West Virginia Department Of Environmental Protection

MR-16 VIOLATION FOLLOW-UP INSPECTION REPORT

PERMIT NUMBER	ORIGINAL INSPECTION AND VIOLATION DATA						NEW VIOLATION ACTIVITY	
	DATE	TIME	FORM #	FACILITY #	ENF STD	ORIGINAL VIOL#	DATE	TIME
U200707	03/19/2019	09:30	6		1200	4	03/29/2019	12:00

PERMITTEE NAME THE MARSHALL COUNTY COAL COMPANY

Violation is hereby: ☐ Terminated ☐ Withdrawn ☐ Remains in force as written ☐ Show Cause submitted

☑ Extended to 04/30/2019 at 12:00 ☐ NOV modified to CO # ____ ☐ CO modified to NOV # ____

Action taken to abate:

The permittee has provided a letter detailing the amount of soil removed from the 5N #3 site. It is estimated 20 cubic yards of topsoil and 485 cubic yards of subsoil were removed and taken to the ball field. They also provided plant nutrient testing results of the soil. A potential site has been identified to find replacement soil. The NOV will be extended to complete the required work.

INSPECTOR'S CIVIL PENALTY ASSESSMENT RECOMMENDATION (check)

Seriousness: 1☐ 2☐ 3☑ 4☐ 5☐ 6☐ 7☐ 8☐ 9☐ 10☐ Negligence: 0☐ 1☐ 2☐ 3☐ 4☑ 5☐ 6☐ 7☐ 8☐

Good Faith: 0☐ 1☐ 2☐ 3☐ 4☐ 5☐ 6☑ 7☐ 8☐ Consent Agreement in effect? ☐ Yes ☑ No

Comments:

AUTH. COMPANY REPRESENTATIVE Joe Williams

DELIVERY METHOD / DATE TIME Mail 4/10/2019 10:00:00

CERTIFIED MAIL NUMBER ____

ADDRESS 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950

WV DEP REP. Andrew M Coleman

Austin Caperton — [Secretary, Department of Environmental Protection]

[WV DEP Representative] — Date 3/29/19

Names of individuals at Informal Conference:

Results: CO was: ☐ Upheld ☐ Modified ☐ Terminated ☐ Withdrawn

Comments:

SUPERVISOR: ____ DATE: ____ TIME: ____

COMPANY REPRESENTATIVE: ____ DATE: ____

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Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

MATTHEW G. BEVIN
GOVERNOR

CHARLES G. SNAVELY
SECRETARY

ENERGY AND ENVIRONMENT CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION

ANTHONY R. HATTON
COMMISSIONER

300 SOWER BOULEVARD
FRANKFORT, KENTUCKY 40601

June 14, 2019

CERTIFIED MAIL No. 7017 0530 0000 2491 5064

The Muhlenberg County Coal Co LLC
46226 National Rd
Saint Clairsville, OH 43950

Re: Notice of Violation
AI ID: 124971
AI Name: The Muhlenberg County Coal Co LLC
Activity ID: ENV20190001
KPDES Permit #: KYGW40062
DNR Permit #: multiple

Dear The Muhlenberg County Coal Co LLC:

The Kentucky Department for Environmental Protection (DEP) has issued the enclosed Notice of Violation for violations discovered at your facility for the 2018 monitoring period attached (see 2nd page). Please review the Notice of Violation carefully to ensure that all remedial measures are completed by the specified deadlines.

Your cooperation and attention to this matter is appreciated. If you have any questions, please contact me at 502-782-6852 or linda.metts@ky.gov.

Sincerely,

Linda Metts

Linda Metts
Environmental Enforcement Specialist
Division of Enforcement

Enclosure

Kentucky UNBRIDLED SPIRIT

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October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

PERMITS REVIEWED BY THE DIVISION OF ENFORCEMENT

REVIEW PERIOD: Specified below				
LINE #	KPDES PERMIT NUMBER	DNR PERMIT NUMBER	NOV ISSUED YES	NOV ISSUED NO
1	KYGW40062 (Oct 2018-Dec 2018)	889-5020, 889-7012, 889-5021	X	
2	KYGW40011 (Sept 2018-Dec 2018)			X
3				
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35				

*The above permits were reviewed for The Muhlenberg County Coal Co LLC.
** If other permits for this company existed for the above monitoring period, that were omitted from this review, please contact Linda Metts at 502-782-6852 or linda.metts@ky.gov.

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October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

COMMONWEALTH OF KENTUCKY
ENERGY and ENVIRONMENT CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION
Division of Enforcement

NOTICE OF VIOLATION

To: The Muhlenberg County Coal Co LLC
46226 National Rd
Saint Clairsville, OH 43950

AI Name: The Muhlenberg County Coal Co LLC **AI ID:** 124971 **Activity ID:** ENV20190001
County: Muhlenberg
KPDES Permit: KYGW40062
DNR Permit: 889-5020, 889-7012, 889-9007
Date(s) Violation(s) Observed: 06/12/2019

This is to advise that you are in violation of the provisions cited below:

1 Violation Description for Subject Item AIOO0000124971():
No person shall, directly or indirectly, throw, drain, run or otherwise discharge into any of the waters of the Commonwealth, or cause, permit or suffer to be thrown, drained, run or otherwise discharged into such waters any pollutant, or any substance that shall cause or contribute to the pollution of the waters of the Commonwealth in contravention of the standards adopted by the cabinet or in contravention of any of the rules, regulations, permits, or orders of the cabinet or in contravention of any of the provisions of this chapter. [KRS 224.70-110]

Description of Non Compliance:
Failing to comply with 401 KAR 5:065, Section 2(1), which cites to 40 CFR 122.41(a), by failing to comply with the KPDES permit limits for **Total Recoverable Iron (TRFe)**, for permit KYGW40062. The permitted limits for TRFe are a monthly average of 3.0 mg/l and a daily maximum of 4.0 mg/l. The reported results are as follows:

Outfall 001: a monthly average of 5.509 mg/l and a daily maximum of 10.7 mg/l for December of 2018.

The remedial measure(s), and date(s) to be completed by are as follows:
The Muhlenberg Co Coal Co LLC shall comply with the terms and conditions of the current KPDES permit of the facility, KYGW40062. [KRS 224.70-110]

Violations of the above cited statute(s) and/or regulation(s) are subject to a civil penalty per day per violation. Violations carry civil penalties of up to $25,000 per day per violation depending on the statutes/regulations violated. In addition, violations may be concurrently enjoined. Compliance with remedial measures and their

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October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

deadlines does not provide exemption from liability for violations during the period of remediation, nor prevent additional remedial measures from being required.

If you have questions or need further information, write or call the undersigned:

Department for Environmental Protection
Division of Enforcement
300 Sower Blvd
Frankfort, KY 40601
502-782-6852 (7:30 AM –3:30 PM)
Ms. Linda Metts, Enforcement Specialist

Issued By: Linda Metts

Ms. Linda Metts
Environmental Enforcement Specialist
Compliance and Operations Branch
Date: June 14, 2019

Issued By: Lori E. Conway

Ms. Lori E. Conway
Environmental Enforcement Specialist
Compliance and Operations Branch
Date: June 14, 2019

How Delivered: Certified Mail Certified/Registered #7017 0530 0000 2491 5064

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October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

MURRAY MAPLE EAGLE COAL, LLC

46226 NATIONAL ROAD
ST. CLAIRSVILLE, OHIO 43950

PHONE: (740) 338-3100
FAX: (740) 338-3405

November 11, 2019

Ryan Thomas
Environmental Inspector
WV Department of Environmental Protection
Division of Mining and Reclamation
1159 Nick Rahall Greenway
Fayetteville, WV 25840

RE: Murray Maple Eagle Coal, LLC
Permit Renewal
S-6020-89 NOV 63

Mr. Thomas,

This letter is in response to the remedial measures stated in NOV 63 for Murray Maple Eagle Coal, LLC's permit renewal on WVDEP Permit S-6020-89. At this time, Murray Maple Eagle Coal, LLC has submitted an application for permit renewal, and is currently working on replying to the corrections sent by the DEP.

Murray Maple Eagle Coal, LLC requests a 30 day extension of the abatement date in order to finish the corrections.

Regards,

Hodge Hunter
Environmental Engineer
Murray Maple Eagle Coal, LLC

I recommend approval up to 12-12-19.

11-12-19

11 14 19

CC: Murray Maple Eagle – S-6020-89 file

From: Williams, Joseph <JosephWilliams@coalsource.com>
Sent: Monday, December 02, 2019 12:51 PM
To: Nagel, Jon
Subject: Fwd: [External] NOV 6

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

Sent via the Samsung Galaxy S® 6, an AT&T 4G LTE smartphone

-------- Original message --------
From: "Harvey, James T" <James.T.Harvey@wv.gov>
Date: 12/2/19 12:48 PM (GMT-05:00)
To: "Williams, Joseph" <JosephWilliams@coalsource.com>
Subject: RE: [External] NOV 6

CAUTION: This email originated from outside of Murray Energy. Do not click links or open attachments unless you recognize the sender and know the content is safe.

New abatement date is 12/27. I'll get the paperwork to you this week, hopefully. Thanks and have a good one.

- Jim H.

From: Williams, Joseph <JosephWilliams@coalsource.com>
Sent: Wednesday, November 27, 2019 1:33 PM
To: Harvey, James T <James.T.Harvey@wv.gov>
Subject: [External] NOV 6

CAUTION: External email. Do not click links or open attachments unless you verify sender.

Jim,

Attached is a status report and an extension request for NOV 6.

Thanks,

Joe Williams
Environmental Engineer
Murray American Energy
6126 Energy Road
Moundsville, WV 26041
(304) 709-2133

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

MR-6
ERIS

West Virginia Department of Environmental Protection
MR-6 MINE INSPECTION REPORT

PERMIT NUMBER	INSPECTION DATE	TIME	REASON	TYPE	MINE STATUS	PHOTOS	Last 30 Days?	Ins. Req'd?
U200707	11/01/2019	12:00	IN	P	AM	No	No	No

PERMITTEE NAME: THE MARSHALL COUNTY COAL COMPANY MSHA #: 46-01437
OPERATOR NAME: MR-19 DATE:
NPDES #: WV0020834 NPDES EXPR DATE: 12/07/2019 PERMIT EXPR DATE: 11/18/2023
PERMIT ACRES: 158.13 TOTAL DISTBD: 110.00 RECLMD: 0.00 ANCIL-LARY: 0 UNRECLMD: 110
DATES: PH I: PH II: LAST AUG SEED: MR-8:
LAST INSP DATE: 10/24/2019 TYPE: A BOND INC: 1 INC BONDED ACRES: 158.13 CUR IBR#: 15 CUR REV#: 1
EXPR DATES: INACT: EMER RESP PLAN: INS: 06/01/2020 BLAST AD:
TIME USED (HRS)==> PERMIT REVIEW: 0.25 INSPECT: 0.25 TRAVEL: 0.00 REPORT: 0.25

INSPECTION COMMENTS

Marshall County Coal Company - 6S #1. Company has requested an additional 30-day extension of NOV 6 to allow completion of abatement requirements. Aerial overflight inspection on 10/24 showed significant progress on the road and ditches. An additional 30 days is being granted putting the new abatement date at 11/29/2019.

ENFORCEMENT STANDARD		EVALUATION	VIO#	ENFORCEMENT STANDARD		EVALUATION	VIO#
0100	Distance Prohibited			0200	Exceeding Limits		
0300	Signs and Markers			0400	Sediment Control	COM	
0500	Design Certification			0600	Effluent Limits		
0700	Surface Water			0800	Ground Water		
0900	Blasting Procedures			1000	Haul Roads		
1100	Refuse Impoundments			1200	Topsoil Handling		
1300	Backfill / Grading			1400	Reclamation Schedule		
1500	Revegetation Requirements			1600	Disposal of Excess Spoil		
1700	Highwall Elimination			1800	Downslope Spoil Disposal		
1900	Postmining Land Use			2000	Ceased Mining Temporarily		
2100	Acid bearing /Toxic Material			2200	Method of Operations		
2300	Change of Operator			2400	Permit Conditions		
2500	Diversions and Drainage Control	COM		2600	Fugitive Dust Control		
2700	Subsidence Plan			2800	Insurance Current		
2900	Bonding Current			3000	Other Conditions		

WATER QUALITY TESTS

Structure ID	Outfall	pH	Fe	Mn	Al	No Flow	Not Const.	Treatment

AUTH. COMPANY REPRESENTATIVE: Joe Williams
DELIVERY METHOD / DATE TIME: Hand 11/4/19 0920
CERTIFIED MAIL NUMBER:
ADDRESS: 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950
WV DEP REP.: James T. Harvey

MR-16

ERIS

West Virginia Department Of Environmental Protection

MR-16 VIOLATION FOLLOW-UP INSPECTION REPORT

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

PERMIT NUMBER	ORIGINAL INSPECTION AND VIOLATION DATA						NEW VIOLATION ACTIVITY	
	DATE	TIME	FORM #	FACILITY #	ENF STD	ORIGINAL VIOL#	DATE	TIME
U200707	07/08/2019	09:30	6		2500	6	11/01/2019	12:00

PERMITTEE NAME THE MARSHALL COUNTY COAL COMPANY

Violation is hereby: ☐ Terminated ☐ Withdrawn ☐ Remains in force as written ☐ Show Cause submitted

☑ Extended to 11/29/2019 at 12:00 ☐ NOV modified to CO # ____ ☐ CO modified to NOV # ____

Action taken to abate:

Aerial overflight on 10/24 showed significant progress toward completion of the road and drainage control structures. Company has submitted written request for a 30 day extension which is being granted. New abatement date is 11/29/2019.

INSPECTOR'S CIVIL PENALTY ASSESSMENT RECOMMENDATION (check)

Seriousness: 1☐ 2☐ 3☐ 4☐ 5☑ 6☐ 7☐ 8☐ 9☐ 10☐ Negligence: 0☐ 1☐ 2☐ 3☐ 4☑ 5☐ 6☐ 7☐ 8☐

Good Faith: 0☐ 1☐ 2☐ 3☑ 4☐ 5☐ 6☐ 7☐ 8☐ Consent Agreement in effect? ☐ Yes ☑ No

Comments:

AUTH. COMPANY REPRESENTATIVE Joe Williams

DELIVERY METHOD / DATE TIME Email 11/1/19 0930

CERTIFIED MAIL NUMBER

ADDRESS 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950

WV DEP REP. James T. Harvey

Austin Caperton [Secretary, Department of Environmental Protection]

[WV DEP Representative] 11/4/19 Date

Names of individuals at informal Conference:

Results: CO was:	☐ Upheld	☐ Modified	☐ Terminated	☐ Withdrawn

Comments:

SUPERVISOR: DATE: TIME:

COMPANY REPRESENTATIVE: DATE:

APPENDIX F

THREATENED AND ENDANGERED SPECIES
Endangered Species Act of 1973, 16 USC 1531, et seq.
62 Ill. Adm. Code 1773.15(c)(10)

The Department reviewed Permit Application No. 456 for potential effects of coal mining operations and reclamation activities on federally listed threatened and endangered species. The following factors were considered for all species that could potentially be adversely affected: status of species in the proposed permit area and adjacent area, site specific resource information, direct and indirect effects, and cumulative effects.

Five primary sources were utilized to identify federally listed threatened and endangered species that could potentially be affected by the proposed coal mining operations and reclamation activities. These sources include threatened and endangered species review information submitted by the applicant, public comments, the U.S. Fish and Wildlife Service (USFWS), the Illinois Department of Natural Resources/Division of Real Estate Services and Consultation/Office of Realty and Capital Planning (ORCP), and Department records.

Information Submitted by the Applicant

The threatened and endangered species review srubmitted by the applicant as a requirement of the Department's UCM-1 application addressed state listed species known to occur in Williamson County, Franklin County, and applicable adjacent areas using records obtained from the Illinois Natural Heritage Database. Records for fourteen state listed threatened or endangered species, the barn owl (*Tyto alba*), the bewick's wren (*Thryomanes bewickii*), the ornate box turtle (*Terrapene ornate*), the chuck-will's widow (*Caprimulgus carolinensis*), the least bittern (*Ixobrychus exilis*), the little blue heron (*Egretta caerulea*), the river cooter (*Pseudemys cancinna*), the river redhorse (*Moxostoma carinatum*), the yellow-crowned night heron (*Nyctanassa violacea*), climbing milkweed (*Matelea decipiens*), dull meadow beauty (*Rhexia mariana*), eryngo (*Eryngium prostratum*), false bugbane (*Cimicfuga racemose*), and green trillium (*Trillium viride*) were deemed by the applicant as possible to occur on the proposed project area. The applicant provided Site Specific Resource Information and Protection and Enhancement Plan for each of these species. None of these species are currently listed as federally threatened or endangered.

Information in the permit application indicates that 3.9 acres of known Indiana bat habitat will be impacted by the proposed mining activity. Presence of the Indiana bat was documented in a mist net survey conducted in 2017, thus a Protection and Enhancement Plan (PEP) was developed for the proposed permit area that lies within the 2.5-mile buffer of the documented maternity roost tree in accordance with the USFWS revised 2013 edition of the "2009 Range-wide Indiana Bat Protection and Enhancement Plan Guidelines" (Guidelines).

Information in the permit application indicates that probable absence of the northern long-eared bat cannot be assumed. The project will not impact known northern long-eared bat hibernacula or disturb known northern long-eared bat maternity roost trees or trees within a quarter mile of a known maternity roost tree. Therefore, the project is consistent with the northern long-eared bat Final 4(d) rule (Federal Register, January 2016) and subsequent "no critical habitat" determination (Federal Register, April 2016) issued by the USFWS. Although the project is consistent with the 4(d) rule, the applicant chose to include the northern long-eared bat in the PEP because the species will also benefit from the outlined protection and enhancement measures.

Public Comments

Public comments were recorded from the requested Public Hearing held on October 23, 2018 and written comments submitted to the Department relevant to this application. Comments supplied by the public were focused on the effects of allowable discharge into adjacent waterways, which is not an approvable action by the Department. The Illinois Environmental Protection Agency (IEPA) is the regulatory agency that determines the effluent concentrations that are allowed to be discharged into a water body through its NPDES permitting process. The potential impacts the receiving stream, adjacent waterways and water courses further downstream is an issue for the IEPA to address through that process. Effects and potential impacts resulting from another agency's permitting responsibility is beyond the purview of the Department. Comments received by the public are further addressed within Appendix B of this findings document.

U.S. Fish and Wildlife Service

The USFWS provided comments on this application in a letter dated September 4, 2018 and follow up comments and concurrence in a letter dated October 2, 2019. The USFWS identified three federally listed species for the proposed permit area, the endangered Indiana bat, the endangered piping plover, and the threatened northern long-eared bat. The USFWS concluded that there is "no designated critical habitat in the project area at this time."

The USFWS stated that "based on the location of the permit area, the Service concurs that the proposed project is not likely to adversely affect the piping plover."

Based on confirmed presence of the Indiana bat, as documented in a mist net survey conducted in 2017, an Indiana bat PEP was developed for the proposed permit area that lies within the 2.5-mile buffer of the documented maternity roost tree. This includes 3.9 acres of known Indiana bat habitat. The USFWS stated that "The PEP includes a number of protection and enhancement measures including avoidance of the majority of wooded habitat within the permit area, winter tree clearing from November 15 to March 31, tree girdling and bat box installation to provide temporary habitat, riparian buffer zone protection, and maintenance of watering areas. The applicant is not proposing to replant the forested habitat acres to be disturbed." Upon on permit modifications supplied by the applicant as required by the Department the USFWS stated that "that the Protection and Enhancement Plan (PEP) was updated to address long-term habitat replacement requirements for the Indiana bat." Based on this information the USFWS indicated that "the Service has determined

that the take of 3.9 acres of known habitat is not likely to jeopardize the continued existence of the Indiana bat."

The Department completed the USFWS's Information Planning and Consultation (IPaC) Determination Key: Northern Long-Eared Bat (NLEB) Consultation and 4(d) Rule Consistency, which was submitted to the Service via IPaC on July 31, 2019. The USFWS stated that "Based upon the IPaC submission, the action is consistent with activities analyzed in the Programmatic Biological Opinion on the Final 4(d) Rule for the northern long-eared bat and issuance of the verification letter concludes consultation for the northern long-eared bat. This information sufficiently addresses our comments regarding the northern long-eared bat."

Illinois Office of Realty and Capital Planning

Pursuant 17 Ill. Adm. Code Section 1075 the Department consulted with ORCP (previously the Office of Realty and Environmental Planning) via the online EcoCAT (Ecological Compliance Assessment Tool) system regarding state listed species within the permit boundary and adjacent area. The initial consultation was conducted on December 5, 2018, and a termination letter was provided on December 17, 2018, which concluded that adverse effects to the protected resources identified are unlikely. Taking into account the consultation termination issued by ORCP, the Department concurs that the operations as approved are unlikely to adversely affect any species protected under the Illinois Endangered Species Protection Act (520 ILCS 10/1 *et seq.*).

Department Records and Determination

The Department utilized the Illinois Department of Natural Resources DIRT (Detailed Impact Review Tool) mapping system to review whether or not the project lies within the buffer zone of documented occurrences of any state or federally listed threatened or endangered species.

The applicant submitted the required information to the Department regarding the Indiana bat and the northern long-eared bat including summer survey data documenting the presence of the Indiana bat, suitable habitat determination, and an Indiana bat PEP. The Department has determined that the applicant correctly and diligently followed the protocol specified in the Guidelines (USFWS, 2013); by following these guidelines the applicant is in compliance with the USFWS and Office of Surface Mining Reclamation and Enforcement (OSMRE) 1996 Biological Opinion on the implementation of the Surface Mining Control and Reclamation Act of 1977 (PL 98-87) with regard to assuring compliance with the Endangered Species Act. The Department determined that a PEP was necessary for the known Indiana bat habitat within the proposed permit area that lies within the 2.5-mile buffer of the documented maternity roost tree. The applicant documented presence of the Indiana bat and followed the Guidelines (USFWS, 2013) to develop the PEP. The Department utilized the key to the northern long-eared bat 4(d) rule for federal actions to conclude that proposed actions are not prohibited, therefore a PEP for this species was not required, however the applicant chose to include the northern long-eared bat in the PEP.

The Department considered site specific resource information, information provided by the applicant, concurrence by the USFWS that adverse effects to federally listed species are not likely, termination of the ORCP Section 1075 consultation, and Department records. The Department has determined the proposed mining operations and reclamation activities will not affect the continued existence of threatened or endangered species or result in destruction or adverse modification of their critical habitats, as determined under the Endangered Species Act of 1973 (16 USC 1531 *et seq.*).

Status of Potentially Adversely Affected Species

Indiana bat

The Guidelines (USFWS, 2013) specify the necessity to consider whether known or suitable winter habitat (hibernacula) and/or suitable summer habitat (maternity roosting/feeding) and/or swarming habitat (mating behavior/assessment of hibernacula suitability (Van Schaik, 2015)) of the endangered Indiana bat are located within the proposed permit area. Winter hibernation habitat for the species includes caves, abandoned underground mine workings, and railroad tunnels. Summer maternity roosting habitat includes trees or snags greater than or equal to 5 inches diameter at breast height (dbh) with exfoliating bark (USFWS, 2013) under which female bats, usually numbering less than 100 individuals, roost (Menzel, et al 2001). Suitable swarming habitat consists of forested areas with the described trees that are located within a 10 mile radius of any potential hibernacula (USFWS, 2013).

A major cause of the decline of the Indiana bat is associated with impediments to functioning hibernacula including blocked cave entrances, improper bat gate designs which may impede bat flight into caves or impede proper air flow through caves (USFWS, 1999 and Federal Register, 2007). Arousal following human disturbance to hibernating bats can lead to premature emergence from hibernacula, decreased body condition, and decreased survival (Menzel, et al 2001). Additional causes of decline in the species can be attributed to disturbances or removal of active maternity roost trees and loss of critical habitat. More recently, White Nose Syndrome (WNS) has been identified as having a negative effect on Indiana bat populations.

The range of the Indiana bat covers most of the eastern half of the United States with the majority of roosting colonies in Indiana, Kentucky, and Missouri (USFWS, 2014). For the Indiana bat, recent population data comparing 1997 estimates with historic levels indicate that the range wide population is less than half of historical levels. Indiana bats have declined significantly in some states including Kentucky and Missouri, but have increased in some states, most notably Indiana. Population estimates show an increase of about 30% in Illinois from historical levels to the present (Clawson 2002, Clawson 2004). In 2012 the Service reported an increase in Indiana bats in Illinois from 21,677 in 2001 to 55,956 in 2011.

Northern long-eared bat

Suitable winter habitat for this species includes caves and underground mines with high humidity, no air currents, and a constant temperature range (USFWS, 2015). The USFWS indicated in the *Federal Register* (April 2016) that a critical habitat designation is not necessary for this species, however Appendix H (USFWS, 2014) does define suitable summer roosting habitat as any forested area or isolated live tree or snag that is "≥ 3 inches dbh with exfoliating bark, cracks, crevices, and/or cavities". Suitable swarming habitat is typically within 5 miles of a known or potential hibernaculum and can include linear features such as fence rows, riparian buffers, or other travel corridors (USFWS, 2014).

The USFWS indicates that because the above described roosting habitat for the northern long-eared bat is not limited, habitat loss is not a significant threat to the species. The Final 4(d) Rule (Federal Register, January 2016) prevents "take" during sensitive life stages and prohibits incidental take where WNS occurs under these circumstances: if the take occurs within a hibernaculum, if the take occurs from tree removal within 0.25 miles of a known hibernaculum, or if the take occurs from the removal of a known/occupied maternity roost tree or tree within 150 foot radius of the maternity tree between June 1st and July 31st.

The range of the northern long-eared bat in the United States extends across 37 states in the eastern and north-central areas of the country, including Illinois (Federal Register, 2015 and USFWS, 2015). A contributing factor to the overall decline of the species is WNS, a fungal disease affecting hibernating bats with widespread mortality (USGS, 2015). First observed in New York in 2006, WNS has rapidly spread throughout the Northeast and Midwest; northern long-eared bat populations have been reduced by 99% in parts of its range (USFWS, 2015). The first documented observance of WNS in Illinois affecting a northern long-eared bat occurred in LaSalle County in 2013; WNS has since been documented in at least ten additional Illinois counties (IDNR, 2015). The Federal Register Final Rule (2015) listing the species as federally threatened indicates that "overall, summer surveys from Illinois have not documented a decline due to WNS to date".

Site Specific Resource Information

A survey was conducted to assess the presence or absence of the Indiana bat and northern long-eared bat within the proposed permit area. The survey was conducted by a qualified wildlife biologist from May 18, 2017 through May 25, 2017 with tracking persisting through July 1, 2017. The survey was conducted in accordance with the USFWS's 2107 Range-Wide Indiana Bat Summer Survey Guidelines (USFWS 2017). During this survey, one pregnant/female Indiana bat was captured and tracked to a roost north of the proposed permit area, thus identifying a 2.5-mile protective buffer around the documented maternity roost tree in accordance with the USFWS Guidelines. The Department determined that a PEP was necessary for the 3.9 acres of known Indiana bat habitat within the proposed permit area that lies within the 2.5-mile buffer. The survey confirmed that the Indiana bat is present in the proposed permit area and will be adversely affected and possibly "taken" as defined in the Endangered Species Act; federal guidelines requires the applicant to obtain Incidental Take authorization for the 3.9 acres of known Indiana bat habitat within the proposed permit.

Information in the permit application indicates that no northern long-eared bats were captured during this survey, but probable absence of the northern long-eared bat cannot be assumed. Furthermore, no known caves or underground openings where northern long-eared bats hibernate or could potentially hibernate exist within the permit area. No known/occupied maternity roost tree data is known near the project area for the northern long-eared bat. The Department utilized the key to the northern long-eared bat 4(d) rule for federal actions to conclude that proposed actions are not prohibited.

Direct and Indirect Effects

Take of an Indiana bat and/or a northern long-eared bat is a possible consequence of the proposed mining operations and associated activities. Take could result from killing or injuring bats if roost trees were knocked down while occupied by vulnerable females and/or young; in areas identified as known habitat the applicant has committed to honor a "no cut" period during the time of year bats could be present in trees to minimize the likelihood of such take. Removal of feeding habitat, even if done when the bats are not present, could have indirect effects on the species until this feeding habitat can be restored. The applicant has proposed to replace the required 70% of pre-mining known habitat that is removed during the course of proposed mining operation and associated activities. Emphasis will be placed on planting tree species that are recommended in the Guidelines (USFWS, 2013) for the benefits they provide to threatened and endangered bat species. Habitat modifications resulting from clearing trees in general could also be interpreted as take under the Endangered Species Act (Romanik, 2010); the applicant has requested an Incidental Take authorization to account for this broader definition of take. Incidental Take authorization for the Indiana bat is hereby granted under the authority of the 1996 Biological Opinion issued by the USFWS to OSMRE (USFWS 1996). In addition, the Department has determined that this project may affect the northern long-eared bat, but that any resulting Incidental Take is not prohibited by the Final 4(d) rule. Therefore this project is consistent with the USFWS January 2016 Programmatic Biological Opinion on the Final 4(d) rule. The Department and the applicant are in compliance with Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

The applicant has committed to the following measures to be implemented within the identified known habitat which should serve to minimize disturbances and adverse impacts to Indiana bats and northern long-eared bats:

1. The applicant will limit tree clearing to October 15 through March 31 of any calendar year to avoid take of a female and/ or young Indiana bat or northern long-eared bat.

2. The applicant will provide short-term roosting habitat by girdling 24 trees adjacent to the project area as described in the Indiana bat and northern long-eared bat PEP.

3. The applicant will provide long term habitat replacement by restoring 70% of the known habitat with woody species known to be beneficial to threatened and endangered bat species as described in the reclamation plan and northern long-eared bat PEP.

4. The applicant will utilize herbaceous ground cover species as described in the Indiana bat PEP that will provide cover and resources for wildlife, reduce competition for tree seedlings/saplings, and provide soil stability and erosion control.

Cumulative Effects

Cumulative effects under the Endangered Species Act are defined at 50 CFR Section 402.02 which states "Cumulative effects are those effects of future state, or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation." In the case of a mining permit being issued by the State of Illinois to a private company to develop a privately owned coal reserve, there is no federal action subject to consultation. Therefore, there are no cumulative effects to consider as that term is defined under Section 402.02. The Department nevertheless has considered other future state, county, township and private activities that are reasonably certain to occur within the adjacent land area. Adjacent and nearby land consists of active coal mining operations, agricultural crop land, scattered residential areas, county roads, small lakes, streams, and forested areas. Most of the adjacent acreage is owned and managed by private entities other than the active underground mining operations which are currently owned by permittee. In regards to adjacent and nearby land holdings, the Department has no reason to believe that detrimental cumulative effects to any threatened or endangered bat species would result from state, county, township, and/or private land management practices or activities. If the applicant chooses to submit a new application to the Department for surface effects on nearby lands that contain streams or forested acres, then new threatened and endangered species reviews and PEPs will be required. The Department is not aware of any state, county, township or private activities that would reasonably be certain to occur in the area adjacent or close to the proposed permit area that would adversely affect any threatened or endangered bat species.

Summary

The Department considered the status of the federally endangered Indiana bat and the federally threatened northern long-eared bat, both with the potential to be adversely impacted by the proposed mining operations and associated activities. Although overall populations continue to decline, the Indiana bat population in Illinois is stable or increasing (Clawson, 2004 and USFWS, 2011). Northern long-eared bat population data in the Midwest is limited, however estimates indicate possibly as many as four million northern long-eared bats in 6 states of the Midwest; 21 hibernacula have been documented in Illinois, mostly from the southern region (Federal Register, 2015).

The Department has considered site specific resource information; a survey confirmed that the Indiana bat is present in the proposed permit area and will be adversely affected and possibly "taken" as defined in the Endangered Species Act; federal guidelines requires the applicant to obtain Incidental Take authorization for the 3.9 acres of known Indiana bat habitat within the proposed permit. The USFWS determined that the take of 3.9 acres of known habitat is not likely to jeopardize the continued existence of the Indiana bat. No northern long-eared bats were captured

during survey efforts, but probable absence of the northern long-eared bat could not be assumed. The Department utilized the key to the northern long-eared bat 4(d) rule for federal actions to conclude that proposed actions are not prohibited.

The Department considered direct and indirect effects of proposed operations on the Indiana bat and northern long-eared bat; the most significant threat to these species from mining operations and associated activities is take due to disturbance of an occupied maternity roost tree. The applicant has committed to honor a "no-cut" restriction period within the areas identified as known habitat to prevent the possibility of this type of take. Removal of trees may also affect feeding habitat; the best technology currently available for replacement of feeding habitat includes planting trees during reclamation. The applicant has committed to this post-mining reclamation activity along with other provision set forth in the Indiana bat PEP.

The Department has considered cumulative effects as defined under 50 CFR 402.02 and has considered future state and private activities reasonably certain to occur in the adjacent area and is not aware of any such activities which could adversely affect the Indiana bat or the northern long-eared bat.

Conclusion

Pursuant to Section 1817.97(a), the applicant has proposed to minimize disturbances and adverse impacts to the Indiana bat and the northern long-eared bat by implementing measures described above, while using the best technology currently available. Following these measures will minimize and appropriately mitigate adverse impacts to the Indiana bat and northern long-eared bat. Incidental Take for the Indiana bat is authorized by the Department via this permitting action and the Department has determined that any Incidental Take of the northern long-eared bat is not prohibited by the Final 4(d) Rule.

The Incidental Take as authorized is a take provided for by the Endangered Species Act of 1973 (16 USC 1531 *et seq.*) and is not a violation of this Act. Except as specifically authorized, no other take of a federally listed species is allowed; the applicant remains subject to the prohibitions found at Section 1817.97(d) of taking a federally listed species protected under the Endangered Species Act. Unauthorized take is a violation of Section 1817.97(d); in addition, failure of the applicant to implement the measures specified in the approved plan as part of this permit will subject the applicant to enforcement measures under Sections 1773.17(b), 1817.97(a), and in the case of a take in violation of the Endangered Species Act, Section 1817.97(d).

After having considered the status of the Indiana bat and northern long-eared bat, site specific resource information, direct and indirect effects, and cumulative effects, and in the context of the applicant's commitments for measures to minimize and mitigate disturbances and adverse impacts to the Indiana bat and northern long-eared bat and conditions imposed by the Department, the Department finds that the operation will not affect the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitats, as determined under the Endangered Species Act of 1973 (16 USC 1531 *et seq.*).

Literature Cited

Clawson, Richard L. (2002). Trends in population size and current status. Pp. 7-13 *In* The Indiana bat: biology and conservation of an endangered species. Missouri Dept. of Conservation, Columbia, Missouri.

Clawson, R. (2004). National status of the Indiana bat. pp. 1-6. *In* Vories, K.C. and A. Harrington. (eds.). 2004. Proceedings of Indiana Bat and Coal Mining: A Technical Interactive Forum. November 16-18, 2004. Louisville, KY. USDOI Office of Surface Mining and Coal Research Center, Southern Illinois University at Carbondale Illinois.

Federal Register. (2007). 50 CFR Part 17 – Endangered and Threatened Wildlife and Plants; 90 Day and 12 Month Findings on a Petition to Revise Critical Habitat for the Indiana Bat. FR/Vol. 72, No.43/Tuesday, March 6, 2007/Proposed Rules. Pp. 9913-9917.

Federal Register. (2015). 50 CFR Part 17 – Endangered and threatened wildlife and plants; Threatened species status for the Northern long-eared bat with 4(d) rule. FR/Vol. 80, No. 63/Thursday April 2, 2015/Rules and Regulations. Pp. 17974- 18033.

Federal Register. (January 2016). 50 CFR Part 17 – Endangered and threatened wildlife and plants; 4(d) rule for the Northern long-eared bat. FR/Vol. 81, No. 9/Thursday January 14, 2016/Rules and Regulations. Pp. 1900-1922.

Federal Register. (April 2016). 50 CFR Part 17 – Endangered and threatened wildlife and plants; Determination that designation of critical habitat is not prudent for the Northern long-eared bat. FR/Vol. 81, No. 81/Wednesday April 27, 2016/Rules and Regulations. Pp. 24707-24714

Illinois Department of Natural Resources. (2015). Press release: White-nose syndrome found in three additional Illinois counties. http://www.dnr.illinois.gov/news/Pages/White-NoseSyndromeFoundinThreeAdditionalIllinoisCounties.aspx. Accessed October 13, 2015.

Menzel, M. A., Menzel, J. M., Carter, T. C., Ford, W. M., & Edwards, J. W. (2001). Review of the forest habitat relationships of the Indiana bat (*Myotis sodalis*) (Vol. 284). US Department of Agriculture, Forest Service, Northeastern Research Station.

Romanik, P. (2010). Everything you wanted to know about "take" in the Endangered Species Act. *pp 45-48. In* Vories, K.C., A.H. Caswell, and T.M. Price (eds.) 2010. Proceedings of Protecting Threatened Bats at Coal Mines: A Technical Interactive Forum *August 31 – September 3, 2010 Charleston, WV.*

Van Schaik, J., Janssen, R., Bosch, T., Haarsma, A.-J., Dekker, J. J. A., & Kranstauber, B. (2015). Bats Swarm Where They Hibernate: Compositional Similarity between Autumn Swarming

and Winter Hibernation Assemblages at Five Underground Sites. *PLoS ONE*, *10*(7), e0130850. http://doi.org/10.1371/journal.pone.0130850

U.S. Fish and Wildlife Service. (1996). Endangered Species Act – Section 7 Consultation Biological Opinion and Conference Report, U.S. Dept. Interior, Office of Surface Mining Reclamation and Enforcement (OSM); Surface Coal Mining Regulatory Programs Under the Surface Mining Control and Reclamation Act of 1977, PL 95-87 issued Sept 24, 1996. 15 pp.

U.S. Fish and Wildlife Service. (1999). Agency draft. Indiana bat revised recovery plan. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota. 53 pp.

U.S. Fish and Wildlife Service. (2011). (2009 revised) Rangewide population Estimate for the Indiana Bat (*Myotis sodalis)* by Recovery Unit (http://www.fws.gov/midwest/Endangered/mammals/inba/pdf/2009inbaRangewidePopJuly2011.pdf revised 7-14-2011). 5 pp.

U.S. Fish and Wildlife Service. (2013). (2009 revised) Range-wide Indiana bat protection and enhancement plan guidelines.

U.S. Fish and Wildlife Service. (2014). Agency directive, USFWS Regions 2, 3, 4, 5 & 6. Northern Long-Eared Bat Interim Conference and Planning Guidance. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota. 67 pp.

U. S. Fish and Wildlife Service. (2015). Northern long-eared bat (*Myotis septentrionalis*) fact sheet.http://www.fws.gov/midwest/endangered/mammals/nleb/pdf/NLEBFactSheet01April2015.pdf

U. S. Fish and Wildlife Service. (2016). Northern long-eared bat (*Myotis septentrionalis*) status: Threatened with 4(d) Rule. https://www.fws.gov/Midwest/endangered/mammals/nleb/index.html

U.S. Fish and Wildlife Service. (2016). Programmatic biological opinion on the final 4(d) rule for the northern long-eared bat and activities excepted from take prohibitions, USFWS Regions 2, 3, 4, 5 & 6. Midwest Regional Office, Bloomington Minnesota. 109 pp.

U.S. Fish and Wildlife Service. (2017). 2017 Range-Wide Indiana Bat Summer Survey Guidelines.

U. S. Geological Survey. (2015). National wildlife health center: White – nose syndrome (WNS). http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/.Accessed October 13, 2015.

APPENDIX G

FINDINGS ON THE OPERATOR'S TECHNOLOGICAL CAPABILITY TO RESTORE PRIME FARMLAND

The original permit application and subsequent modification of the application addressed the requirements of Section 1785.17. Pursuant to Section 1785.17(c), the applicant submitted detailed plans for the mining and restoration of the prime farmlands affected by surface mining activities.

1785.17(c)(1): The applicant has submitted a soil survey of the permit area which meets the standards of the National Cooperative Soil Survey. Itemized prime farmland soil map units and soil descriptions can be obtained from the Custom Soil Survey Report provided in the application. Additional reference documents include the NRCS Web Soil Survey and the University of Illinois Agricultural Experiment Station - Bulletin 811, which were used as references to evaluate the pre-mining data.

1785.17(c)(2): The proposed method and type of equipment to be used for removal, storage, and replacement of the soils were described pursuant to Sections 1823.12 and 1823.14. The A, B and C horizons will be removed by conventional equipment used for pipeline installation. Replacement will be with the same equipment.

1785.17(c)(2): Soil will be temporarily stockpiled adjacent to the excavation; plans for identifying the prime soils and plans for soil stabilization before redistribution were submitted in conformance with 1823.13. Stockpile stabilization will occur by establishment of a vegetative cover and mulch, if necessary; these measures will minimize erosion.

1785.17(c)(3): Documents were reviewed supporting the use of B/C horizon mixtures in place of the original B horizon. This information supports the belief that the proposed methods of reclamation will achieve, within a reasonable time, equivalent or higher levels of yield than those of non-mined prime farmland in the surrounding area.

McCormack, Donald, 1974 "Soil Reconstruction: For the Best Results After Mining" Proc. Second Res. and Appl. Tech. Symp. on Mined Land Recl., NCA, Louisville, KY, October 22-24, 1974.

Snarski, R. R., J. B. Fehrenbacher, I. Jansen, 1981, "Physical and Chemical Characteristics of Pre-mine Soils and Post-mine Soil Mixtures in Illinois", SSSA Jour., V45:806-812.

McSweeny, I. Jansen and W. S. Dancer, 1981, "Subsurface Horizon Blending: An Alternative Strategy to B Horizon Replacement for Construction of Post-Mine Soils", SSSA, Jour., V45:784-799.

Jansen, Ivan, 1981. "Reconstruction Soils After Surface Mining of Prime Agricultural Land", Mining Eng., March SME Rpt.78-F-375.

McSweeny, I. Jansen, 1984. "Soil Structure and Associated Rooting Behavior in Minesoils", SSSA Jour 48:607-612.

Christ, Richard, 1980, "The Effect of Soil from B and C Horizons on Yield Potential of Soybeans", Unpublished Thesis, Dept. of Plant and Soil Sci., Southern Ill. Univ. Carbondale, Il.

Spindler, D. and J. Bauer, 1986 Prime Farmland Restoration Plans - Planning and Information Needs" Proc. Nat. Assoc. State Land Recl., Sept 1986, Columbia, S.C.

In addition to relying on the above data, the Department has relied on the expertise of its Land Reclamation Division and the fact that thousands of acres of prime farmland and high capability land have met the cropland productivity performance standards using a B/C soil horizon mix. Pipeline and drainage tile installation type activities have a minimum impact on farmland due to the small area of disturbance. The applicant will be following the Illinois Department of Agriculture guidelines for pipeline installation. Based on this evidence, the Department considers it quite probable that the applicant will meet bond release requirements on the prime farmland areas which will be mined and reclaimed.

1785.17(c)(4): Due to the narrow size of the individual fields, yield data was not available for the fields within the permit area. The operator will be required to lime and fertilize the reclaimed prime farmland and cropland fields as needed to bring them to levels required under an optimum level of management. In addition, to satisfy the requirements of Section 1785.17(c)(4), the Department consulted the productivity indexes for each of the soil types on the permit area in "Optimum Crop Productivity Ratings for Illinois Soil", University of Illinois, Bulletin 811.

The Department has determined the soil productivity after mining will be returned to equivalent levels of yield as non-mined prime farmlands of the same soil type in the surrounding area under equivalent management practices, as discussed hereafter.

The Federal Act specifically requires in Section 510(d)(1) that two findings be made by the Regulatory Authority in granting a permit to mine on prime farmland; the Department regulations at Section 1785.17 also require a prime farmland finding. Section 510(d)(1) states:

> "In addition to finding the application in compliance with subsection (6) of this section, if the area proposed to be mined contains prime farmland pursuant to Section 507(b)(16), the Regulatory Authority shall, after consultation with the Secretary of Agriculture, and pursuant to regulations issued hereunder by the Secretary of Interior with the concurrence of the Secretary of Agriculture, grant a permit to mine on prime farmland if the Regulatory Authority finds in writing that the operator has the technological capability to restore such mined area, within a reasonable time, to equivalent or higher levels of yield as non-mined

prime farmland in the surrounding area under equivalent levels of management and can meet the soil reconstruction standards in Section 515(b)(7). Except for compliance with subsection (b), requirements of this paragraph (1) shall apply to all permits issued after the date of enactment of this Act."

The first requirement concerns the operator's technological capability to restore the mined area, within a reasonable time, to equivalent or higher levels of yield as non-mined farmland in the surrounding area under equivalent levels of management. The Department, or the Regulatory Authority has reviewed other data not submitted by the operator which supports the Regulatory Authority's finding:

Dancer, W. S. and I. Jansen. 1981 "Greenhouse evaluation of solum and substratum materials in the southern Illinois coal field: I Forage crops", Jour. Environ. Qual. 10:396-400.

Powell, J., et al., 1985, "Reclamation of Prime Farmland in Kentucky", Pres Nat. Mtg. of Am. Soc. Surf. Min. and Recl. Oct, Denver, Co.

Spindler, Dean, 1981, "Three Case Studies on Rowcrop Production on Mined Land" prepared for the Symposium on Surface Mining Hydrology, Sedimentation and Reclamation, University of Kentucky, Lexington, KY, December 7-11.

The Regulatory Authority has also reviewed the information from its testing program that thousands of acres of prime farmland and high capability land have met the cropland productivity performance standards. These documents are available for inspection at the Land Reclamation Division Office in Springfield.

The second requirement of Section 510(d)(1) concerns soil reconstruction standards in Section 515(b)(7). The Regulatory Authority has reviewed the application concerning the operator's plan to comply with these requirements and find it complies with Section 515(b)(7) of the Federal Act and Sections 1785.17 and 1823 of the Department's regulations. In addition, the Regulatory Authority has considered the method and equipment to be utilized and has found that the planned method is appropriate to successfully comply with the requirements of 510(d)(1) and Section 1823 of the Department's regulations.

1785.17(d): The Regulatory Authority has consulted with the USDA, Natural Resource Conservation Service (NRCS), designated representative of the Secretary of Agriculture. The Department's consideration of the NRCS comments are addressed in Appendix B.

1785.17(e)(1): The approved post-mine land use of the reclaimed prime farmlands will be cropland.

1785.17(e)(2): The Department has considered the comments of the representative of the U.S. Secretary of Agriculture (NRCS).

1785.17(e)(3): As previously discussed, the Department believes the applicant has the technological capability to restore prime farmland, within a reasonable time, to equivalent or higher levels of yields as non-mined prime farmland.

1785.17(e)(4): The special requirements for prime farmland restoration of Section 1823 have been addressed below in accordance with Section 1785.17(e)(4). Some of the subsections in Section 1823 have been previously addressed by Section 1785.17 discussions. Only those items not previously discussed will be below.

1823.14(a)(1): The minimum depth of the reconstructed prime farmland soil will be 60 inches.

1823.14(a)(2): This section is applicable to the Ava series. The proposed B/C mix for root media will meet or exceed high capability standards.

1823.14(b): Topsoil will be replaced to its premining thickness after the root medium replacement and the area is returned to final grade.

1823.14(c): Compaction will be minimized by handling the soil during dry weather and/or the Department will require a compaction alleviation plan if it is determined that excessive compaction is causing low yields.

1823.14 (d): The permittee will be excavating the B and C horizons immediately underneath the B horizons as part of the pipeline trenching. Pipeline and drainage tile installation type activities have a minimum impact on farmland due to the small area of disturbance. The applicant will be following the Illinois Department of Agriculture guidelines for pipeline installation. The subsoil will be returned to its required thickness.

1823.14 (e): The original A horizon will be replaced. The operator has proposed multiple soil series sources of supplemental topsoil material in the proposed permit area. The department has limited that substitute material to the Rend, Bluford, Hickory-Kell, Okaw, Belknap and Orthent soil series where the subsoil texture is a silt loam. In addition, the pH, phosphorus, and potassium of the borrow materials shall be fertilized with rates to achieve a pH of 6.5, and phosphorus and potassium levels of 50 ponds/acre and 260 pounds/acre, respectively. Please see Part IV Condition No. M. Topsoil will be returned to the required thickness and suitably protected from erosion.

1823.14(f): The applicant has made a commitment for fertilization based on soil tests.

1823.15: The applicant will comply with the seeding and mulching requirements pursuant to Sections 1823.15, 1816.113 and 1816.114.

In making this finding, the Regulatory Authority has relied on available data and opinions of experts, as found relevant to this application. In addition, the Regulatory Authority has relied on the expert technical opinion of its staff. Such reliance was intended by Congress as is apparent in

the legislative history of the Federal Act. At page 105 of the House Conference Report No. 95-493, the Conferees state:

> "It is the intention of the Conferees that the written finding that the regulatory authority is required to make before a permit is granted to mine on prime farmland can be based in part on the expert opinion of the regulatory authority, the operator has the technological capability to perform the soil reconstruction standards of Section 515(b)(7) and the performance of those standards will result in the restoration of the mined area to equivalent or higher levels of agricultural yield as non-mined prime farmland in the surrounding area under equivalent levels of management. This does not mean that mining and restoration must have taken place in the surrounding area, but simply that the operator can show by agricultural school studies, or other data for comparable areas that equivalent yields can be obtained after mining."

This finding is based on significant and substantial evidence and is in keeping with the standards for prime farmland review approved by the Office of Surface Mining. (See letter from Acting Director Reeves to Illinois Director Evilsizer, dated April 7, 1980, which is incorporated by reference.)

This finding is based solely upon characteristics peculiar to this particular operator and the prime farmland soil types involved.

All materials supporting this finding are a part of the public record and are hereby incorporated by reference.

Based upon the foregoing analysis of the probable impact of the proposed operations and a review of the application and Interagency and public comments thereon, the Department finds that there is a reasonable basis on which to issue the permit as requested by the applicant.

Enter on behalf of the Illinois Department of Natural Resources, Office of Mines and Minerals, Land Reclamation Division, as the Regulatory Authority.

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By **ME Staff 8-k** - December 20, 2019

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Item 1.01

Foresight Energy LP Exhibit

EX-4.1 2 felp-ex41_6.htm EX-4.1 felp-ex41_6.htm EXHIBIT 4.1 SECOND SUPPLEMENTAL INDENTURE SECOND SUPPLEMENTAL INDENTURE to the Indenture (as defined below) (the "Supplemental Indenture"),...

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Foresight Energy LP is engaged in the mining and marketing of coal from reserves and operations located in the Illinois Basin. The Company controls over three billion tons of coal in the state of Illinois. Its reserves consist principally of over three contiguous

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Exhibit 354

From: Theresa Nelson
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, No!
Date: Saturday, December 21, 2019 7:46:16 AM

To whom it may concern,
I live in Murphysboro with my two year old son. No way should the Pond Creek Mine be allowed to dump into the Bug Muddy River. This river already is polluted with farm field run offs, water treatment plant waste and mine waste from other mines. Where the heck does the dumping end. There has not been enough research done to understand the effects these chemicals/ mercury levels have on our animals and plant life. You can google damage it has caused in other parts of the country. I don't want us to learn the hard way. The Big Muddy is already flooding properties and risking homes. We don't need more flooding of this river. Again, no mine waste in the Big Muddy.

Thank you,
Concerned citizen Theresa Nelson 38 yrs, Murphysboro, IL.

--

Theresa R Nelson

(630)939-3366

http://www.linkedin.com/pub/theresa-r-nelson/33/561/9b0

Please consider your environmental responsibility. Before printing this e-mail, ask yourself whether you need a hard copy!

Exhibit 355

From: Kelsie Neal
To: EPA.PublicHearingCom
Subject: [External] Pond creek mine permit
Date: Tuesday, December 24, 2019 7:42:19 AM

I am a concerned citizen on the pond creek mine permit matter. The water they are wanting to dump contains sulfides, chlorides, and other contaminants. The water should be tested by a third party not the mine for obvious reasons. They should be responsible for cleaning the water thoroughly on site not just dumping it into the river. We already have such contaminated water. Children here are getting sick, getting cancer. My child was born with breathing issues. Please, please don't bailout the mine to simply dump the water.
Thank you for your time and I hope you will reconsider this permit.

Exhibit 350

From: luca cruzat
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine IL0077666
Date: Tuesday, December 24, 2019 8:30:34 AM

Member of the IEPA panel,

I am Maria Cruzat, Carbondale resident and I attended the hearing Wednesday 18th. I am submitting my opposition to the authorization of water waste in the Big Muddy River.

I appreciate that the protocol was well conducted, the Hearing was a hearing, and concerned citizens were able to speak.

In my view, there were abundant good reasons for not granting the authorization to dump mine discharges to the Big Muddy river. I hope you consider all points of view expressed and feel comfortable and **backed** by the community to deny the authorization. Unemployment has a solution, polluted water doesn't.

I was impressed by your preparedness for the hearing, but also by a well-educated community member that cannot be disregarded. They presented multiple perspectives to shine a light on the right solution, "save our water", with the exception of the first speaker. Poetry, art, sports, nature lovers, families owning property by the river, testimonies of experts in water shed, accounting, environmental law, fishermen, farmers, indigenous people, miners, presented well-informed reports.

All my best in this endeavor, our children are thanking you all.

Maria Cruzat

Exhibit 357

From: Jim Carl
To: EPA.PublicHearingCom
Subject: [External] Pine Creek Mine NPDES IL007766
Date: Thursday, December 26, 2019 8:54:49 PM

Barb Lieberoff

Illinois IEPA

I attended the public comment hearing regarding Pond Creek Mine NPDES , on December 18, in Marion. I filled out a card prior to the 6pm meeting, but did not get a chance to speak, as the meeting was called to a close about 9:30pm. I wish to submit these comments.

I live in rural Jackson County. A am retired, after 30 years at Southern Illinois University (SIU), first as a civil servant and later as an administrator. Two and a half years were as director of admissions. I moved to southern Illinois as a student. I fell in love with the area and stayed here for the last 42 years.

The Big Muddy River is central to much of what is southern Illinois. The selling point of this area is the scenery, the forest, the fresh air, the lakes and streams. Simply, the great outdoors.

The only person, in three and a half hours of public comment, to support the permit was the representative of Williamson Energy LLC. His argument was that the pipeline and dump into the river was necessary to support the families of the mine workers. The implication was that mining is the biggest industry. Actually, SIU is the biggest employer in the region. As director of admissions, part of my job was oversight of recruitment and enrollment management. The view books my staff distributed to high school guidance counselors and to community colleges, were the primary printed material the University used to encourage prospective students to attend SIU. The cover of the viewbooks, for years, was an arieal shot of the Big Muddy River. We drew attention to that river and its surroundings to encourage people to move here, attend school here and to spend their money here. The prospective faculty, who would teach these students, must also be recruited. We don't have a big city to attract people. We have the Shawnee Forest, the lakes and the Big Muddy River.

If you look at a satellite map of southern Illinois, you will see that the Big Muddy River looks like an artery moving its life giving water through this area. This is our home.

I am a float enthusiast, both in a canoe and kayak. I am a hiker. I fish. Whether it is attending events at Riverside Park, in Murphysboro, fishing off its boat ramp or plotting float trips from it, I anticipate clean, if muddy water. When I am at Oakwood Bottoms or up overlooking the bluff at LaRue/Pine Hills, I expect the river I am enjoying to be a natural river. This proposal turns it into a sewer. ***I urge you to reject it.***

James Carl

88 Whippoorwill Lane

Makanda, Illinois 62958

Exhibit 358

From: Katie Carl
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine
Date: Friday, December 27, 2019 6:27:06 PM

I strongly object to Pond Creek Mine's proposal to discharge mine water into the Big Muddy River.

The company's poor safety and financial records make it very likely to collapse, leaving local and downstream residents stuck when the inevitable leaks, spillages, and other disasters happen. A company which has filed bankruptcy escapes any accountability for their poor management and environmental damage. It is local governments and the Illinois government who will bear the costs, and local residents who will pay the health and safety price.

The high chloride which can be expected from the discharged water has been demonstrated to harm fish and wildlife.

Kathleen Carl
Professor Emerita, John A. Logan College
Makanda, IL

Exhibit 359

From: bob swisher
To: EPA.PublicHearingCom
Subject: [External] Pond creek mine. Il0077666
Date: Thursday, January 2, 2020 8:50:11 AM

I do not think it is a good idea to let mine water be discharged into the river. This would damage everything in and along the river. Once we let the coal company start this you will not be able to control them. You can fine them, but all they will do is take you to court for years. Then it will be to late. Let's give are kids and grandkids something better than bad water and dead ground.

Bob Swisher

Mulkeytown, il.

Sent from my Verizon, Samsung Galaxy smartphone

Exhibit 340

From: Parr, Charles A
To: EPA.PublicHearingCom
Subject: [External] IL0077666
Date: Thursday, January 2, 2020 1:09:26 PM

As a resident of Jackson county, I oppose the Pond Creek Mine dumping water from their operation into the surface waters of Southern Illinois. The Big Muddy River does not have enough flow to dilute such chemical effluent. The mining industry needs to make their system clean and not dump onto the public their wastes.

Charles A. Parr
402 N. Poplar St.
Carbondale, IL
62901

Exhibit 361

From: Daniel Silver
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine - IL0077666
Date: Saturday, January 11, 2020 11:34:19 PM
Attachments: FELP 8K - Foresight Energy LP - Entry into a Material Definitive Agreement, Material Modification to Rights of Security Holders - December 20, 2019 - Fintel.io.pdf

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It would be gross negligence and a breach of fiduciary duty for the EPA to permit a permit with actual knowledge that the company making the request is insolvent. The economic impact on the many communities will be devastating in the event of even one thing going wrong, as the company is admittedly in no position to fund any necessary remedial action.

On December 20, Foresight Energy filed an 8-K Entry into a material definitive agreement. See attached.

The SEC mandates filing an **8-K** for delisting of stock, failure to meet listing standards, unregistered sales of securities, and **material** modifications to shareholder rights. An **8-K** is required when a business changes accounting firms used for certification.

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Entry into a Material Definitive Agreement, Material Modification to Rights of Security Holders

Security	FELP / Foresight Energy LP (34552U104)
Form Type	8-K
File Date	2019-12-20
Related Securities	FELPU / FORESIGHT ENERGY LP COM UNIT REPSTG LTD PARTNER INTS
Related Documents	2019-12-20 8-K Entry into a Material Definitive Agreement, Material Modification to Rights of Security Holders 2019-12-13 8-K Regulation FD Disclosure 2019-12-11 8-K Departure of Directors or Certain Officers; Election of Directors; Appointment of Certain Officers; Compensatory Arrangements of Certain Officers 2019-11-12 8-K Results of Operations and Financial Condition 2019-11-08 8-K Regulation FD Disclosure, Notice of Delisting or Failure to Satisfy a Continued Listing Rule or Standard; Transfer of Listing, Financial Statements and Exhibits

Current Document Parts

Entry into a Material Definitive Agreement, Material Modification to Rights of Security Holders - 8-K
FELP / Foresight Energy LP EX-4.1 - - EX-4.1 - EX-4.1

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SECURITIES AND EXCHANGE COMMISSION
WASHINGTON, DC 20549

FORM 8-K

CURRENT REPORT

Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934

Date of Report (date of earliest event reported): December 19, 2019

FORESIGHT ENERGY LP
(Exact Name of Registrant as Specified in Charter)

Delaware	001-36503	80-0778894
(State or Other Jurisdiction of Incorporation)	(Commission File Number)	(IRS Employer Identification No.)
211 North Broadway, Suite 2600 Saint Louis, MO		63102
(Address of Principal Executive Offices)		(Zip Code)

(Registrant's telephone number, including area code): (314) 932-6160

(Former Name or Former Address, if Changed Since Last Report)

Check the appropriate box below if the Form 8-K filing is intended to simultaneously satisfy the filing obligation of the registrant under any of the following provisions (*see* General Instruction A.2. below)

☐ Written communications pursuant to Rule 425 under the Securities Act (17 CFR 230.425)

☐ Soliciting material pursuant to Rule 14a-12 under the Exchange Act (17 CFR 240.14a-12)

☐ Pre-commencement communications pursuant to Rule 14d-2(b) under the Exchange Act (17 CFR 240.14d-2(b))

☐ Pre-commencement communications pursuant to Rule 13e-4(c) under the Exchange Act (17 CFR 240.13e-4(c))

Securities registered pursuant to Section 12(b) of the Act:

Title of each class	Trading Symbol(s)	Name of each exchange on which registered
Common units representing limited partner interest	*	*

*On November 25, 2019, a Form 25 relating to the delisting and deregistration under Section 12(b) of the Registrant's common units representing limited partner interests was filed by the New York Stock Exchange LLC. The common units currently trade on the OTCQX® Best Market under the symbol "FELPU."

Indicate by check mark whether the registrant is an emerging growth company as defined in Rule 405 of the Securities Act of 1933 (§ 230.405 of this chapter) or Rule 12b-2 of the Securities Exchange Act of 1934 (§ 240.12b-2 of this chapter).

Emerging growth company ☐
If an emerging growth company, indicate by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act. ☐

Item 1.01 Entry into a Material Definitive Agreement.

As previously disclosed, on December 13, 2019, Foresight Energy LLC and Foresight Energy Finance Corporation (wholly owned subsidiaries of Foresight Energy LP (the "**Partnership**")) (together, the "**Issuers**") solicited the consent of the holders (the "**Holders**") (such solicitation, the "**Consent Solicitation**") of the Issuers' 11.50% Second Lien Senior Secured Notes due 2023 (the "**Notes**") to amend (such amendments, the "**Amendments**") the indenture governing the Notes (as amended, supplemented or otherwise modified from time to time, the "**Indenture**"), as more fully described below. The Consent Solicitation expired at 5:00 p.m., New York City time, on December 19, 2019 (the "**Expiration Time**").

As of the Expiration Time, the Issuers had received consents to the Amendments from Holders of at least a majority in aggregate principal amount of the outstanding Notes not owned by the Issuers or their affiliates. As a result, on December 19, 2019, the Issuers, the guarantors party thereto and Wilmington Trust, National Association, the trustee (the "**Trustee**") for the Notes, entered into a second supplemental indenture (the "**Second Supplemental Indenture**") providing for the Amendments to the Indenture.

The Amendments (i) amend Section 6.01(b) of the Indenture to extend the grace period for payment of interest due on the Notes from 90 days to 150 days and (ii) amend Section 4.03 of the Indenture to eliminate the requirement that the Issuers periodically hold a publicly accessible conference call to discuss the Issuers' financial information for the relevant fiscal period.
The Partnership continues to engage in discussions with its creditor constituencies and explore potential restructuring alternatives.

The foregoing descriptions of the Amendments, the Second Supplemental Indenture and the Indenture are qualified in their entirety by reference to the full text of the Second Supplemental Indenture, the First Supplemental Indenture dated as of October 30, 2019 and the Indenture, each of which is incorporated herein by reference to **Exhibit 4.1**, **Exhibit 4.2** and **Exhibit 4.3** to this Current Report on Form 8-K, respectively.

Item 3.03 Material Modification to Rights of Security Holders.

The disclosure set forth in Item 1.01 of this Current Report on Form 8-K is incorporated into this item by reference.

CAUTIONARY STATEMENT REGARDING FORWARD-LOOKING STATEMENTS

Certain statements and information in this Current Report on Form 8-K and certain oral statements made by our representatives from time to time may constitute "forward-looking statements." The words "propose," "believe," "expect," "anticipate," "plan," "intend," "foresee," "outlook," "estimate," "potential," "continues," "may," "will," "seek," "approximately," "predict," "anticipate," "should," "would," "could" or other similar expressions are intended to identify forward-looking statements, which are generally not historical in nature. Forward-looking statements also include statements about our liquidity, our capital structure and expected results of operations. These forward-looking statements are based on the Partnership's current expectations and beliefs concerning future developments and their potential effect on us. While management believes that these forward-looking statements are reasonable as and when made, there can be no assurance that the future developments affecting us will be those that we anticipate.

We continue to experience substantial financial, business, operational and reputational risks that threaten our ability to continue as a going concern and could materially affect our present expectations and projections. For additional information regarding known material factors that could cause our actual results to differ from those contained in or implied by forward-looking statements, please see the section entitled "Risk Factors" in the Partnership's Annual Report on Form 10-K for the year ended December 31, 2018, filed with the Securities and Exchange Commission on February 27, 2019 and subsequent Quarterly Reports on Form 10-Q.

You are cautioned not to place undue reliance on forward-looking statements, which are made only as of the date hereof. We undertake no obligation to publicly update or revise any forward-looking statements after the date they are made, whether as a result of new information, future events or otherwise, except as required by law.

Item 9.01 **Financial Statements and Exhibits.**

(d) Exhibits

Exhibit No.	Exhibit Description
4.1	Second Supplemental Indenture, dated as of December 19, 2019 (to the Indenture dated as of March 28, 2017), by and among Foresight Energy LLC, Foresight Energy Finance Corporation, the guarantors party thereto and Wilmington Trust, National Association, as trustee.
4.2	First Supplemental Indenture, dated as of October 30, 2019 (to the Indenture dated as of March 28, 2017), by and among Foresight Energy LLC, Foresight Energy Finance Corporation, the guarantors party thereto and Wilmington Trust, National Association, as trustee (incorporated herein by reference to Exhibit 4.1 to FELP's Current Report on Form 8-K, filed with the SEC on October 31, 2019).
4.3	Indenture, dated as of March 28, 2017, by and among Foresight Energy LLC, Foresight Energy Finance Corporation, the guarantors party thereto and Wilmington Trust, National Association, as trustee (incorporated herein by reference to Exhibit 4.1 to FELP's Current Report on Form 8-K, filed with the SEC on April 3, 2017).

SIGNATURES

Pursuant to the requirements of the Securities Exchange Act of 1934, the registrant has duly caused this report to be signed on its behalf by the undersigned, hereunto duly authorized.

Foresight Energy LP

By: Foresight Energy GP LLC
its general partner

By: /s/ Robert D. Moore
Robert D. Moore
Chairman of the Board, President and Chief Executive Officer

Date: December 20, 2019

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EXHIBIT 4.1

SECOND SUPPLEMENTAL INDENTURE

SECOND SUPPLEMENTAL INDENTURE to the Indenture (as defined below) (the "*Supplemental Indenture*"), dated as of December 19, 2019, is made by and among Foresight Energy LLC, a Delaware limited liability company (the "*Company*"), Foresight Energy Finance Corporation, a Delaware corporation ("*Co-Issuer*", and together with the Company, the "*Issuers*"), the guarantors party hereto (the "*Guarantors*") and Wilmington Trust, National Association, as trustee (in such capacity, the "*Trustee*"), and amends the Indenture, dated as of March 28, 2017, among the Issuers, the Guarantors and the Trustee, as amended by the First Supplemental Indenture, dated as of October 30, 2019 (as further amended and supplemented from time to time, the "*Indenture*").

RECITALS:

WHEREAS, pursuant to the Indenture, the Issuers have issued $425,000,000 in aggregate principal amount of 11.50% Second Lien Senior Secured Notes due 2023 (the "*Notes*");

WHEREAS, the Issuers have requested consents of the Holders of the Notes to amend the terms of the Indenture as set forth in Article I herein (the "*Proposed Amendments*");

WHEREAS, pursuant to Section 9.02 of the Indenture, the written consent of Holders of at least a majority in aggregate principal amount of the outstanding Notes (the "*Requisite Consents*") is sufficient to adopt the Proposed Amendments set forth in Article I;

WHEREAS, the holders of at least a majority in aggregate principal amount of the Notes outstanding (which excludes any Notes owned by the Issuers or their affiliates) have validly tendered consents and not validly withdrawn their consents to the adoption of the Proposed Amendments effected by this Supplemental Indenture in accordance with the provisions of the Indenture;

WHEREAS, having received the Requisite Consents for all of the Proposed Amendments, the Issuers and the Guarantors desire to amend the Indenture as provided herein;

WHEREAS, the Issuers have delivered to the Trustee, pursuant to Section 9.02 of the Indenture, an Officer's Certificate stating that the Issuers have received the Requisite Consents, and have provided certification of such receipt to the Trustee;

WHEREAS, the Issuers have also delivered to the Trustee, pursuant to Sections 7.02(b), 9.02 and 9.05 of the Indenture, (i) a resolution of the Board of Directors of the Company authorizing the execution of this Supplemental Indenture, and (ii) an Officer's Certificate and an Opinion of Counsel, each stating that the execution of this Supplemental Indenture is authorized or permitted by the Indenture and that all conditions precedent to the execution and delivery of this Supplemental Indenture have been satisfied; and

WHEREAS, all other conditions and requirements necessary to make this Supplemental Indenture a valid, binding and legal instrument enforceable in accordance with its terms have been performed and fulfilled by the parties hereto, and the execution and delivery thereof have been in all respects duly authorized by the parties hereto.

NOW, THEREFORE, in consideration of the foregoing and for other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, the parties mutually covenant and agree for the equal and ratable benefit of the Holders of the Notes as follows:

ARTICLE I
AMENDMENTS

Section 1.01. **Amendments to Indenture**.

(i) Section 6.01(b) of the Indenture is hereby amended and restated in its entirety to read as follows:

"(b) the Issuers default in the payment of interest on any Note when the same becomes due and payable, and the default continues for a period of 150 days,"

(ii) Section 4.03(d) of the Indenture is hereby deleted and amended and restated to read in its entirety as set forth below:
"(d) [Intentionally omitted] "

(iii) Section 4.03(e) of the Indenture is hereby amended to delete the reference to ", and a publicly accessible quarterly conference call of such Parent".

(iv) The first sentence of Section 4.03(f) of the Indenture is hereby amended to (i) add the word "and" immediately before the word "furnishes", (ii) delete the reference to ", and holds a publicly accessible quarterly conference call" and (iii) replace the reference to "Sections 4.03(a) and (d)" with "Section 4.03(a)".

ARTICLE II
MISCELLANEOUS

Section 2.01. Effectiveness. This Supplemental Indenture shall become effective upon the execution and delivery of the Supplemental Indenture by the parties hereto.

Section 2.02. Confirmation. Except as expressly amended hereby, the Indenture is in all respects ratified and confirmed and all the terms, conditions and provisions thereof shall remain in full force and effect. For the avoidance of doubt, this Supplemental Indenture shall not impair or affect the contractual right of any Holder of a Note or Notes to receive any principal payment or interest payment on such Holder's Note or Notes, on or after the Stated Maturity thereof, or to institute suit for the enforcement of any such payment. Upon the execution and

delivery of this Supplemental Indenture by the Issuers, the Guarantors and the Trustee, this Supplemental Indenture shall form a part of the Indenture for all purposes, and every Holder of Notes heretofore or hereafter authenticated and delivered shall be bound hereby. Any and all references to the Indenture, whether within the Indenture or in any notice, certificate or other instrument or document, shall be deemed to include a reference to this Supplemental Indenture (whether or not made), unless the context shall otherwise require.

Section 2.03. Counterparts. The parties may sign any number of copies of this Supplemental Indenture. Each signed copy shall be an original, but all of them together represent the same agreement. The exchange of copies of this Supplemental Indenture and of signature pages by facsimile, .pdf transmission or other electronic means shall constitute effective execution and delivery of this Supplemental Indenture for all purposes. Signatures of the parties hereto transmitted by facsimile or .pdf transmission or other electronic means shall be deemed to be their original signatures for all purposes.

Section 2.04. Capitalized Terms. Capitalized terms used herein without definition shall have the meanings assigned to them in the Indenture.

Section 2.05. GOVERNING LAW. THIS SUPPLEMENTAL INDENTURE SHALL BE GOVERNED BY AND CONSTRUED IN ACCORDANCE WITH THE LAWS OF THE STATE OF NEW YORK.

Section 2.06. Effect of Headings. The section headings herein are for convenience only and shall not affect the construction hereof.

Section 2.07. Acceptance by the Trustee. The Trustee accepts the amendments to the Indenture effected by this Supplemental Indenture and agrees to execute the trusts created by the Indenture as hereby amended, but only upon the terms and conditions set forth in the Indenture; *provided, however*, that to the extent the Requisite Consents of Holders of Notes to any amendment effected by or delivered in connection with this Supplemental Indenture are determined by a court of competent jurisdiction to have not been validly obtained in accordance with the Indenture or applicable laws, such amendment shall not be deemed to have occurred.

Section 2.08. Trustee Disclaimer. The recitals contained herein and the statements made in any Officer's Certificate shall be taken as the statements of the Issuers, and the Trustee assumes no responsibility for their correctness, and none of the recitals contained herein or the statements made in any Officer's Certificate are intended to or shall be construed as statements made or agreed to by the Trustee. The Trustee makes no representations as to the validity or sufficiency of this Supplemental Indenture or the consequences of any amendment provided herein.

IN WITNESS WHEREOF, the parties hereto have caused this Supplemental Indenture to be duly executed and attested, all as of the date first above written.

ISSUERS:

FORESIGHT ENERGY LLC, as Issuer

By:/s/ Robert D. Moore
Name: Robert D. Moore
Title: President and Chief Executive Officer

FORESIGHT ENERGY FINANCE CORPORATION, as Co-Issuer

By:/s/ Robert D. Moore
Name: Robert D. Moore
Title: President and Chief Executive Officer

[Signature Page – Second Supplemental Indenture]

GUARANTORS:

ADENA RESOURCES, LLC
AKIN ENERGY LLC
AMERICAN CENTURY MINERAL LLC
AMERICAN CENTURY TRANSPORT LLC
COAL FIELD CONSTRUCTION COMPANY LLC
COAL FIELD REPAIR SERVICES LLC
FORESIGHT COAL SALES LLC
FORESIGHT ENERGY EMPLOYEE SERVICES CORPORATION
FORESIGHT ENERGY LABOR LLC
FORESIGHT ENERGY SERVICES LLC
HILLSBORO TRANSPORT LLC
LD LABOR COMPANY LLC
LOGAN MINING LLC
M-CLASS MINING, LLC
MACH MINING, LLC
MACOUPIN ENERGY LLC
MARYAN MINING LLC
OENEUS LLC D/B/A SAVATRAN LLC
SENECA REBUILD LLC
SITRAN LLC
SUGAR CAMP ENERGY, LLC
TANNER ENERGY LLC
VIKING MINING LLC
WILLIAMSON ENERGY, LLC

By:/s/ Robert D. Moore
Name: Robert D. Moore
Title: President and Chief Executive Officer

[Signature Page – Second Supplemental Indenture]

TRUSTEE:

WILMINGTON TRUST, NATIONAL ASSOCIATION

By /s/ Nedine P. Sutton
Name: Nedine P. Sutton
Title: Vice President

[Signature Page – Second Supplemental Indenture]

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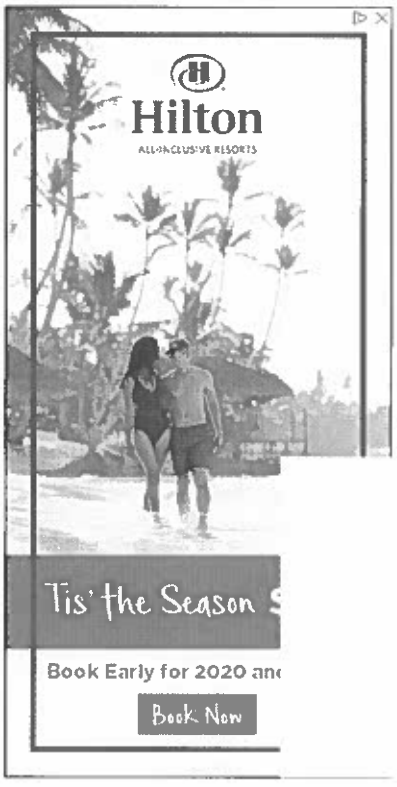
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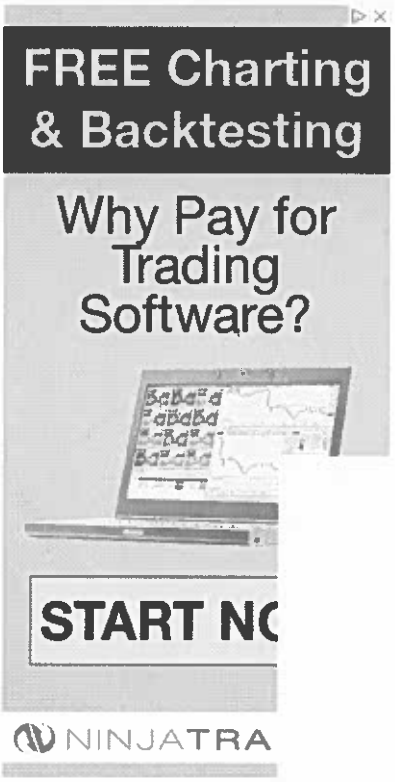
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Exhibit 362

R03668

Jan 5, 2020

Barb Lieberoff, Mail code #5
Re: Pond Creek Mine NPDES
Illinois Environmental Protection Agency
1021 North Grand Avenue East P. O. Box 19276
Springfield, IL. 62794-9276

Dear Ms. Lieberoff,

As we live within the Big Muddy River watershed – not far from it actually, I attended the public hearing on Dec. 18th and thought that your office did a very good job of managing the comment portion. It did run very long though, and I was not able to stay for my name to be called.

The following is what I would have liked to impart to you and the decision makers at IEPA. We live on Macedonia Rd. in Jackson County, but barely. We have no city water supply offered to us. Never have. All the families in our area either have cisterns to which they gather rainwater or haul water from Cobden when necessary, or they have dug wells. The majority use wells. These are primarily poor people, many of whom have lived on their land for generations, fishing from the Big Muddy and just getting by. Some of my neighbors still gather their drinking water in jugs from springs along the Snake Road, as they have for generations. Surely this ground water risks severe contamination from the Big Muddy floodwaters, which overflow regularly. Cancer has been prevalent in our area. I myself, suffered through a radical nephrectomy, after a large cancerous tumor destroyed my kidney. This was described to me as an environmental cancer.

For several generations now there haven't been ample choices for jobs for these people, but we have recently seen, mainly through the tourism and winery businesses, opportunities for economic growth. High school girls getting waitress jobs at the wineries, and guys at the orchards or in forest service part time work. But of course, most must leave the region to find good work as they raise families.

Our hope for this region relies on the renewable natural resources which we have – the forest, sustainable agriculture, our lakes and streams. We feel that the health and beauty of southern Illinois' lands and water set it apart from the rest of the state and could be our only opportunity for economic growth. We desperately need it not to be spoiled. Using our rivers as sewers for privately owned mining interests is stupid and surely could be considered criminal in the long run. The coal mining industry could not be economically feasible if all the environmental costs – such as this toxic water flushing – were taken into account.

We just want the IEPA to protect our environment. That is your job. Other agencies promote industries and their economic growth. Your job is to make sure our lands and waters stay clean and healthy to promote its economic possibilities. We hope you will always error on the side of safety when there are health concerns, such as there are in this case. We all know that the Big Muddy has been dumped in for decades, but must we make it worse? How about making it better? How about helping southern Illinois develop a clean and healthy environmental reputation? We feel our future depends on it. Thank you for listening to our concerns and working for the people.

Sincerely,

Kay Rippelmeyer & David Tippy

Kay Rippelmeyer and David L. Tippy
1451 Macedonia Rd.
Pomona, IL. 62975

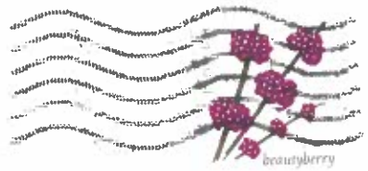
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Barb Lieberoff, MC #5
Re: Pond Creek Mine NPDES
Illinois Environmental Protection Agency
1021 N. Grand Ave. East P.O. Box 19276
Springfield, IL 62794-9276

62794-927676

Exhibit 363

From: tessford@mediacombb.net
To: EPA.PublicHearingCom
Subject: [External] pond creek mine IL0077666
Date: Monday, January 13, 2020 4:24:27 PM

I am writing to express my opposition to the release of mine waste water from the Pond Creek Mine into the Big Muddy River. My concern is two-fold:

1. We should not allow further contamination of our water resources. Animals and humans along and within the river will be negatively impacted. We cannot afford as a society to purposely contaminate our water resources.

2. I live along the river and my property already becomes flooded at times during the year. With this additional water, I likely will be severely impacted by flooding most of the year. I pay taxes on this property and to not be able to use it at all is a tremendous hardship that will not only impact me, but every other landowner along the big muddy.

To allow this to happen is just not acceptable. Please do not authorize this action. I am not opposed to mining, so long as it does not include fracking, but there has to be some other way for the mine to deal with this issue without impacting residents and the aquafer all along the river.

Please do not allow this. Thank you.

Tess D. Ford
204 Pinewood Court
De Soto, Illinois 62924

Exhibit 304

From: 52-chevy
To: EPA.PublicHearingCom
Subject: [External] Pond creek mine npdes permit
Date: Tuesday, January 14, 2020 9:17:06 AM

I vote no on the current discharge permit. Currently this will have a negative impact on this river ecosystem. Dilution is not the solution.

Jonathan Casebeer

Sent from my Verizon, Samsung Galaxy smartphone

Exhibit 365

From: Murphysboro Park District
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine, IL0077666
Date: Tuesday, January 14, 2020 11:27:46 AM

I would like to officially make public comment in opposition to the addition of a pipeline to discharge from the Pond Creek Mine into the Pond Creek and Big Muddy River. Our largest park in Murphysboro, Riverside Park, abutts the Big Muddy River downstream from the proposed pipeline. The additional 3,000,000 gallons of discharge of contaminated water has serious implications for the park district. The Big Muddy River has already been suffering increased flooding over the last three years. Our park floods significantly at even moderate flood stages and those floodwaters enter into areas of the park not only manicured and maintained but frequented by park goers and their pets. Without a complete analysis of the water to be pumped into that watershed how can we know what contaminants may be left behind in the park each time the river floods into it. Which has been 2-3 times per year in the last few years. There is also a City of Murphysboro sewer main that runs directly through the flood water path, including an area of that fills with the backwater. Could there not be a potential concern for contaminants to seep into those as well. How do we know what contaminants could be deposited without at least a full analysis prior to the permit being issued? The mine will eventually run out of minerals and move on but the elements and compounds deposited by that pipeline will remain long after that mine has closed.

Thank you for your time and consideration of our concerns.

Joe Fry

--

Joe Fry, Director of Parks & Recreation
Murphysboro Park District
618-684-3333

Exhibit 306

From: Cecilia Black
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine NPDES
Date: Tuesday, January 14, 2020 3:44:51 PM
Attachments: Pond_Creek_Mine.pdf

Dear Barb Lieberoff,
Please read my attachment in regards to the Pond Creek Mine (IL 0077666).

Sincerely,
Cecilia Albert-Black

Illinois Environmental Protection Agency

1021 North Grand Ave. East

P.O. Box 19276

Springfield, IL 62794-9276

Dear Ms. Lieberoff,

I am a student at Southern Illinois University Carbondale majoring in geology and minoring in environmental studies. As an undergraduate, I've been studying remediation methods of acid mine drainage (AMD) and coal drainage, specifically of arsenic, using clay minerals and naturally occurring nanoparticles. I am very knowledgeable of the toxic effects of AMD and am aware that it negatively affects ecosystems and human communities.

Having grown up in Carbondale since I was ten, I've come to value the Shawnee and other ecosystems deeply and personally. I speak for myself and others in the Southern Illinois community when I ask you to please protect the Big Muddy and Pond Creek from Williamson Energy Pond Creek Mine's toxic discharge.

I would really like to see the EPA step up and stand for environmental social justice by inhibiting the coal industry from polluting our waters.

Sincerely,

Cecilia Albert-Black

Exhibit 307

From: Justin Riley
To: EPA.PublicHearingCom
Subject: [External] Pond Creek mine discharge into the Big Muddy river
Date: Tuesday, January 14, 2020 12:08:38 PM

Hello,

I attended the public hearing over the discharge of mine wastewater into the Big Muddy river from the Pond Creek mine. I was unable to speak at the hearing due to the large number of people speaking against this discharge being permitted.

My specific concern is with the accumulation of heavy metals in the soil of the riverbed and flood areas. There have been articles published about similar discharge from other mines in recent years causing this problem.

The amount of heavy metals that will be discharged and how that will be monitored has not been mentioned in this case, that I have found.

Also, even if these metals are discharged into the river at low rates, or after being diluted, they will accumulate over time. This is a concern for myself and my family because we eat fish out of this river.

I am not opposed to the mine doing business, however I would like for them to be held accountable for keeping the wildlife and people affected by this operation safe.

Thank you,

Justin Riley

Exhibit 308

From: John Van Dyk
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine
Date: Wednesday, January 15, 2020 11:35:50 AM

To whom it may concern:

I urge you to reject the application to discharge polluted water into the Big Muddy River. Pollution is already one of the most significant and worrisome environmental problems we face. Allowing more pollution flies in the face of what good stewardship should look like. My children and grandchildren are avid outdoor enthusiasts. They frequently fish in the Big Muddy River. Others of them are birdwatchers, and spend time observing birds and other wildlife along the River. They deserve to inherit clean air, clean water, and a healthy planet. We owe it to them.

Please do the right thing: Do not permit pollution to continue unchecked.

Dr. John Van Dyk

12565 Sarilda Lane
Marion IL 62959

Exhibit 349

From: Matt Battaglia
To: EPA.PublicHearingCom
Subject: [External] Permit number IL0077666
Date: Wednesday, January 15, 2020 7:05:14 PM

To Whom It May Concern,

My name is Matt Battaglia and I am sending this email regarding the NPDES for the Pond Creek Mine the permit number is IL0077666. I am a fourth generation farmer and the bulk of my family's farm ground either borders the Big Muddy River or the tributary that branches off of it. My concern with allowing this permit to go through is that, in a typical year, the Big Muddy River pushes backwater into our fields in the Spring time. I am roughly 1-1.5 miles down river from where the discharge pipe is located. This waste water, as the gentleman from the mine said at the hearing, is nothing more than salt water. To anyone that knows anything about growing crops, this salt water that will back up in our fields will create dead spots. Plants do not grow in salty ground. With yearly floods, this salt water will have a cumulative effect and build up in the ground, causing lasting effects. My question to your legal department is, who will be responsible for the decline in our crop yields? The state for allowing the permit or the company for disposing the waste water? That is why I ask that you consider the smaller businesses in the area this will affect.

Sent from my iPhone

Exhibit 370

From: Patricia Wagner
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine IL0077666
Date: Thursday, January 16, 2020 11:29:36 AM

The Big Muddy River, 156 miles long, draining a 2,344-square-mile watershed, flows through the significant environmental regions, La Rue-Pine Hills and Oakwood Bottoms, to join the Mississippi River southwest of Murphysboro and on to the Gulf of Mexico. It is already an ecosystem under assault: The Illinois Department of Public Health has issued a mercury advisory on common carp, croppie, and largemouth bass. PCB contamination was noted in the common carp. IDNR has stopped recreational use during its frequent and prolonged flooding.

Williamson Energy operates Pond Creek Mine, noted as the highest producing mine in the US in 2017. The continued operation of this mine employs approximately 203 employees and an additional estimated 100 people involvbed in ancillary or support services. Yet, in order tyo ensure the safety of their employees by pumping out large amounts of excess water from groundwater infiltrating underground mining areas, they are posing, from available hydrogeologic information, serious safety, environmental and property risks affecting both these employees and hundreds of others. Such risks deserve our careful consideration.

The primary danger comes from the introduction of high concentrations of chloride--and sulfates--into the Big Muddy. Scientists who study watersheds use chloride concentrations as an indicator of pollution in a body of water. It is present in 1 to 100 ppm in solution with water in underground aquifers, geologic formations containing groundwater. Once such contaminants get into groundwater they persist there for years. Once in solution there is no biologic process known to remove chloride.

So, a high concentration of chloride is of particular concern. The effect of high levels of chloride, while always present,varies according to species and the time their life cycle is interrupted. Newly laid eggs are particularly susceptible as is the transitional life forms, larvae and tadpoles. High chloride concentrations achieve their serious effects on all life forms by interfering with osmoregulation, the process by which cells remain intact and viable, thereby hindering growth, reproduction, and, ultimately survival. Acceptable chloride levels to prevent acute exposure effects have been set at 860 ppm to prevent acute exposure effects, to prevent chronic effects at 230 ppm.

Williamson Energy proposesa as its solution specified in application #456 a 12.5-mile long pipeline carrying 21.7-3.5 million gallons/day of high-concentraTED CHLORIDE EFFLUENT TO DUMP INTO AN ALREADY FRAGILE ECOSYSTEM. tHE MINEW LISTED an veragfe chloride concentration in this effluent as 2,237 mg/L, an amount far esdceeding water

Exhibit 371

From:	Cornelius Crane
To:	EPA.PublicHearingCom
Subject:	[External] Pond Creek Mine: IL0077666
Date:	Thursday, January 16, 2020 2:13:22 PM

This Pond Creek pipe line is a terrible idea! How can it be in the year 2020 someone is still thinking that it's OK to pollute our waterways? Didn't we learn anything from the past 50 years of cleaning up our air and waterways? Are we really OK with polluting our waterways for decades so that one corporation can make profits for just a few years? It's just not worth it.

The price we'll have to pay to clean up this mess outweighs the value of allowing Williamson Energy to pollute the Big Muddy River in the first place. This is just bad economics. The easiest way to clean up environmental disasters is to not create them in the first place. It makes more sense for the state of Illinois and the EPA to help Williamson Energy properly dispose of the waste rather than dump that waste in the river. I would pay a special property tax fee to support the proper collection and disposal of that mine waste at the mine if we can avoid having it dumped into the Big Muddy River. That is a better use of our tax dollars than to create the environmental mess and later try to clean it up at an exponentially greater cost.

It is a waste of decades of taxpayer support for the EPA if in the end you rubber stamp corporate pollution plans that pollute our streams and rivers. At this very moment, January 16, 2020, the Big Muddy is backing up due to recent heavy rains. That water is being spread all over farm fields, residential yards, and in neighborhoods. It is going to seep into the ground water and into people's drinking water. If that water was filled with the pollution from the Pond Creek mine it's going to pollute the ground and the seep into the water table. It's going to get polluted water into people's drinking water. So the issue isn't just the pollution being dumped into the Big Muddy River and flowing into the Mississippi River, the concern is also about when the Big Muddy backs up and floods fields and neighborhoods.

We have a small tributary behind our house. When the Big Muddy backs up, the valley behind us fills with water. Sometimes that water sits there for weeks at a time. I don't want mine waste settling in my back yard. Am I going to have to breathe what ever is emanating from that polluted water? What if my dogs go down there and drink from it? What happens to the wildlife that lives in these back flow areas?

If Williamson Energy paid for the proper disposal of the waste and added that cost to the price of the coal, it wouldn't be economically viable for them to keep mining the coal. But they can afford to build a pipeline and add that cost to the price of their coal. We the people of Southern Illinois have to absorb their costs when they pollute our streams, rivers, and ground water. Why do corporations get away with dumping the true costs of their operations on society while they pocket the "profits" for their own private gain? Who's going to pay to clean up our waterways or deal with the cancer that will surely develop from this pollution? If society has to absorb the costs, we should get reimbursed with some of the profits. In a sense, Williamson Energy wants to promote socialism where we as a society take on some of the costs of their "for-profit" operation. Williamson Energy: please don't promote Socialism and pretend that it's Capitalism: if you want to keep the profits for yourself, then YOU must absorb ALL of the costs of bringing that product to market.

Cornelius Crane
Murphysboro, IL

Exhibit 372

From: Mary Taylor
To: EPA.PublicHearingCom
Subject: [External] IL0077666 Pond Creek Mine
Date: Thursday, January 16, 2020 8:55:17 PM

I am opposed to the issuance of a NPDES permit to Williamson Energy LLC to allow them to discharge pollutants from the Pon Creek Mine into Illinois waters.

Based on its past performance, I do not believe the company can be trusted to not exceed the maximum allowable amounts of pollutants.

Mary Taylor
305 Robinson Cir Apt CC
Carbondale, Il 62901
618-549-1059
mtaylor1968@gmail.com

Exhibit 373

From: Bob Fisher
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine; IL0077666
Date: Thursday, January 16, 2020 9:38:05 PM

The Bird Conservation Network coalition has serious concerns about the draft renewed National Pollutant Discharge Elimination System (NPDES) permit (IL0077666) for the Pond Creek Mine. We urge you to deny the proposal by Williamson Energy to pump polluted mine wastewater over 12 miles from the Pond Creek Mine into the Big Muddy River and to increase pollution into Pond Creek.

We urge the IEPA to deny the draft water discharge permit for a number of well understood reasons:

1. Williamson Energy's discharge of high chloride and high sulfate water into the Big Muddy River and Pond Creek will harm mussels, fish, and other aquatic organisms, and the various bird species that feed in the Big Muddy and nest along it.. The draft permit and anti-degradation assessment do not adequately address impacts to these organisms, nor require pre- or post- construction biological sampling.

2. Williamson Energy's plan to monitor chloride concentrations is complex and requires monitoring of several parameters and a conductivity correlation, yet gives no way for the Agency or the public to evaluate if the permittee is doing that monitoring properly. The mine proposes to continually balance their high-chloride effluent with the chloride levels already in the river. Given the public interest in this project and the company's history of past violations, the proposed monitoring plan is insufficient and infeasible.

3. The draft permit and anti-degradation assessment fail to take into consideration potential increases of Methyl-Mercury levels or other pollutants like copper, iron, selenium and nickel.

4. The anti-degradation assessment has not adequately or accurately considered the economic impacts of the proposed project. New reports have indicated a continuing and projected decline of coal production in the Illinois Basin.

5. Murray Energy, the parent company of Williamson Energy, filed for bankruptcy in fall 2019. The IEPA's estimates of local economic impact and jobs failed to consider these developments.

Thank you for considering the BCN coalition's comments in opposition to permit (IL0077666) for the Pond Creek Mine

Bob Fisher, Communications Chair
Bird Conservation Network
media@bcnbirds.org

630 985 2956
http://bcnbirds.org/

BCN promotes public awareness, knowledge, appreciation and enjoyment of birds, and other wildlife and wildlife habitat, and both proposes and supports public and private programs designed to protect, restore, and enhance the natural environment, and conserve/increase native bird populations.

BCN seeks to inform the members of our coalition, public and private agencies and landowners in our region, and the general public, about specific threats to birds, and other wildlife and wildlife habitat – and to recommend appropriate action against these threats.

BCN actively coordinates the accumulation and maintenance of long-term monitoring records and other information on Illinois birds and their habitats, to be used as an aid to their perpetuation, and as an indicator of environmental quality.

BCN is a regional coalition of about 20 organizations (bird clubs, Audubon chapters, ornithological societies and conservation organizations) sharing an interest in the conservation of birds. The groups' members aggregate to more than 35,000 people living primarily in the Chicago area, but also throughout Illinois, northeastern Indiana, and southern Wisconsin.

Exhibit 374

From: John West
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine
Date: Thursday, January 16, 2020 9:52:38 PM

To whom it may concern,

As a concerned citizen with an education and career in aquatic sciences, I prefer that the Pond Creek Mine DOES NOT build a pipeline that carries coal waste water to the Big Muddy River.

Thank you,

John West

Exhibit 375

From: Kate West
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine
Date: Thursday, January 16, 2020 9:57:27 PM

To whom it may concern,

As a concerned citizen, I prefer that the Pond Creek Mine DOES NOT build a pipeline that carries coal waste water to the Big Muddy River.

Thank you,

Katherine West

Exhibit 376

From: Cameron Smith
To: EPA.PublicHearingCom
Subject: [External] NPDES Permit No. IL0077666, Notice 7516c
Date: Friday, January 17, 2020 8:15:35 AM

Douglass School Art Place
900 Douglass St.
Murphysboro, IL 62966
618-687-3791
thedoug@artapult.com

Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P. O. Box 19276
Springfield, IL 62794-9276

January 17, 2020

Sent via email to epa.publichearingcom@illinois.gov

Re: NPDES Permit No. IL0077666, Notice 7516c- Williamson Energy, LLC

Dear Ms. Lieberoff,

Coal is dead.

No one can doubt that coal fueled the Industrial Revolution but it has out lived its livelihood. Yes our cultural roots are buried deep within coal. It is what gave us the luxuries that we have today, something we cannot ignore, but also caused many of the problems we have with today's pollution and global climate change.

All the coal that is mined in Pond Creek Mine (Mach Mine) goes overseas and none of the citizens of Southern Illinois, except the mine owners and hand full of it employees, benefit from it. I guess you could count the river barge owners and ocean vessels which are profiting from the coal in Southern Illinois, but the average landowner and people who live here do not. We are the ones who have to put up with the waste and clean up after the industry. We the citizens of Southern Illinois don't even benefit from a Severance Tax from the coal.
http://knowledgecenter.csg.org/kc/system/files/7.15.2017.pdf

Coal is like a beloved relative who won't leave after the holidays. They continue to take up space, make a mess in your home, use up your resources and will not leave. The coal industry continues to have its hand out and wants more while doing less, and we are the ones who have to clean up the mess it leaves behind. One of these clean ups will be the waste water the mine wants to dispose into the Big Muddy River, full chlorides and sulfates endangering fish and wildlife who live in and around the river.

My main concern about this permit is the excess of water being pumped into the Big Muddy. According to the FOIA reports from IEPS, stated in a letter from Alliance Consulting, Inc, the HEC-RAS steady flow model shows that the mines' addition of water to the Big Muddy River would have a maximum increase in water surface elevation of approximately 0.009 feet during "a 2-year 24-hour storm event." With the Williamson Diffuser discharging at 11.1 cfs, with a maximum of 22.2 cfs, or raising the height to .018 feet -- 1/8" to 1/4". I have to agree that does sound like much, but when you own property downstream on the Big Muddy River, and it floods continually, even 1/4" means a lot. Plus, can we truly trust the Pond Creek Mine's numbers to be correct?

As of 1/10/2020 we had another storm event. In that 24 hour period we received 5.5" of rain in Murphysboro, IL and according to the Rain Event Table for Flood Study Distributions of Heavy Precipitation in Illinois Updated Bulletin

70, Illinois State Water Survey, March 2019, that makes this a ten year storm event. Now, as of 1/15/2020, 7:30 pm the Big Muddy River is 29.92' above flood stage and has a flow rate of 17,400 cfs at the gauging station in Murphysboro, IL and they are predicting another storm event this weekend.
https://water.weather.gov/ahps2/hydrograph.php?wfo=pah&gage=muri2
https://waterdata.usgs.gov/monitoring-location/05599490/?agency_cd=USGS

On May 3, 2011 the Big Muddy River reached a record high of 40.47 feet at the Murphysboro gauge station on the Route 127 Bridge. At that time the 127 Bridge was closed and under water. The river water was so high you could no longer see the guard rails on either the side of the bridge. The Route 13 Bridge was being threatened too, but remained open and was closely monitored by IDOT. During that time the flood water was so high and strong that the water was vibrating the bridge, so it was decided by IDOT to rebuild and raise the level of the Route 13 Bridge. Meanwhile when this flood was happening I was busy sandbagging around, and pumping out the water in the basement of, The Historic Douglass School of Murphysboro. I believe I was on the sixth day of running three sump pumps in two basements on May 3. At the crest of the river I calculated that the water would have been 20 inches deep in the basements without the pumps. According to the 18435E1 Flood Map provided by Alliance Consulting, Inc, our property at 900 Douglass St. in Murphysboro, IL is completely surrounded by flood water. FEMA even has us in the **AE flood zone**. So yes, I count the water levels in quarters of inches.

I know my letter will be fruitless and fall on deaf ears but I still have to voice my concerns to **stop this permit** and all future permits of this nature. I have to ask myself, what would an IEPA employee do in my place if one of you lived where I do and owned the Historic Frederick Douglass School? We all live downstream from some peril; this just happens to mine.

But really what is the point if the current administration gets His/Their way, all NEPA reviews and concerns will be gone and our planet will be in deeper trouble than it already is.

Here is a story from Mother Jones News Service you all might enjoy:

https://www.motherjones.com/environment/2020/01/trumps-latest-environmental-rollback-is-a-middle-finger-to-common-sense/ 1/12/2020

"Trump's gift to the fossil fuel industry and special interests will silence ordinary Americans while giving polluters a free pass to trash the environment, destroy public lands and kill wildlife," Brett Hartl, government affairs director at the Center for Biological Diversity, said in a statement.

In the last decade, the US experienced at least 119 climate and weather disasters with losses exceeding $1 billion each, more than double the number of billion-dollar disasters during the 2000s, according to a federal report released this week. Costs from those disasters over the last 10 years exceeds $800 billion.

Thank you for your time, and care on.

One World, One Planet.

Cameron J. Smith

R03687

Table 7.15
STATE SEVERANCE TAXES: 2017

State	Title and application of tax (a)	Rate
Alabama	Iron Ore Mining Tax (c)	$.03/ton
	Forest Products Severance Tax	Varies by species and ultimate use.
	Oil and Gas Conservation & Regulation of Production Tax	2% of gross value at point of production, of all oil and gas produced. 1% of the gross value (for a 5-year period from the date production begins) for well, for which the initial permit issued by the Oil and Gas Board is dated on or after July 1, 1996 and before July 1, 2002, except a replacement well for which the initial permit was dated before July 1, 1996; 1.66% gross proceeds from offshore production greater than 8,000 ft. below sea level.
	Oil and Gas Privilege Tax on Production	8% of gross value at point of production; 4% of gross value at point of incremental production resulting from a qualified enhanced recovery project; 4% if wells produce 25 bbl. or less oil per day or 200,000 cu. ft. or less gas per day; 6% of gross value at point of production for certain on-shore and off-shore wells. A 50% rate reduction for wells permitted by the oil and gas board on or after July 1, 1996 and before July 1, 2002 for 5 years from initial production, except for replacement wells for which the initial permit was dated before July 1, 1996; 3.65% gross proceeds from offshore production greater than 8,000 ft. below sea level.
	Coal and Lignite Severance Tax	$.20/ton in addition to coal severance tax. In 2012 state legislature extended through 2021.
	Local Solid Minerals Tax	Varies by county for sand, clay, gravel, granite, shale, and other products.
	Uniform Natural Minerals Tax	$.10/ton.
Alaska	Common Property Fisheries Assessment (b)	$0.10/lb for 2016, determined annually by the department of revenue.
	Dive Fishery Management Assessment (b)	Elective; currently 5% or 7% of value for select dive fishery species in select management regions.
	Fisheries Business Tax	Tax based on unprocessed value of fishery resources processed in or exported from the state. 1% of value for shore-based processing in developing fisheries; 3% of value for floating processing in developing fisheries or shore-based processing in established fisheries; 4.5% of value for salmon cannery processing in established fisheries; 5% of value for floating processing in established fisheries.
	Fishery Resource Landing Tax	Tax based on unprocessed value of fishery resources processed outside and first landed in the state. 1% of value for developing fisheries; 3% of value for established fisheries.
	Mining License Tax	Up to 7% of net income and royalties received in connection with mining properties and activities in Alaska. Quarry rock, sand and gravel, and marketable earth mining operations are exempt from the mining license tax. New mining operations exempt for 3-1/2 years after production begins.
	Alaska Oil Production Tax	Alaska will impose a base rate of 35 percent on oil companies' net profits in the state.
	Salmon Enhancement Tax (b)	Elective; 2% or 3% of value for salmon sold in or exported from select aquaculture regions.
	Seafood Development Tax (b)	Elective; currently 1% of value for select commercial fish species in select seafood development regions.
	Seafood Marketing Assessment (b)	Elective; currently 0.5% of value for all commercial fish species exported from, landed or processed in-state.
Arizona	Severance Tax	.025% for metalliferous mining; 0.0312% for nonmetal mining. Additional severance taxes on these and other products are levied at the city or county level.
Arkansas	Timber Severance Tax	$0.178/ton (pine), all other $0.125/ton.
	Natural Gas Severance Tax	1.25%, 1.5%, and 5% depending on well classification.
	Oil Severance Tax	Crude oil 4% to 5% depending on production levels; additional taxes of 5 mils and $0.02 per barrel of oil produced in the state.
	Other Severance Taxes	Separate Rate for each Substance.
	Oil and Gas Conservation Assessment	Maximum 43 mills/bbl. of oil and 9 mills per MCF produced of gas.
California	Oil and Gas Production Assessment	Rate determined annually by Department of Conservation to fund agency operations; no state severance tax. The assessment rate for fiscal year 2016/17 is $0.3626051.
	Lumber Products Assessment	1% on purchases of lumber products and engineered wood products for use in California, based on the selling price of the products.
Colorado	Severance Tax	$0.803 for amount of coal produced above 300,000 tons, rate updated monthly by the department of revenue. 2.25% for metallic minerals above $19 million in gross producer income. $0.05/ton of molybdenum above 625,000 tons Oil and gas rate varies from 2% to 5% depending on gross income brackets; up to 15 barrels per day of oil 90,000 cubic feet of gas per producing day are exempt. Oil shale is taxed based on years of operation, where 1 year = 1%, 2 years, = 2%, etc. up to 4% of the gross proceeds above the threshold and after the first 180 days of production.
	Oil and Gas Conservation Levy (d)	0.07% charge on all oil, natural gas, and CO_2 produced.

See footnotes at end of table.

STATE SEVERANCE TAXES: 2017—Continued

State	Title and application of tax (a)	Rate
Florida	Oil Production Tax	5% of gross value for small well oil, and 8% of gross value for ordinary oil production, and 12.5% for escaped oil; tiered formula for tertiary oil.
	Gas and Sulfur Production Tax	The gas base rate ($0.171) times the gas base adjustment rate each fiscal year for gas (2016-17 rate $0.188 per MCF); and the sulfur base rate ($2.43) times the sulfur base rate adjustment each fiscal year for sulfur (2016–17 rate $5.13 per ton).
	Solid Minerals Tax (e)	8% of the value of the minerals severed; heavy minerals (rate computed annually at $1.34/ton plus times the base rate adjustment currently at 3.26288). Year 2017 Tax Rate $4.37 per ton; phosphate rock (rate computed annually at a base rate of $1.80/ton).
Idaho	Mine License Tax	1% of net value of ores mined or extracted and royalties received from mining.
	Oil and Gas Production Tax	2.5% of the gross income earned for the sale of oil and gas.
Illinois	Oil and Gas Production Assessment (f)	0.1% fee per well of gross revenue for oil and natural gas.
	Timber Fee	4% of purchase price.(g)
Indiana	Petroleum Severance Tax (h)	1% of value of petroleum; $0.24 per barrel for oil; and $0.03 per 1000 cu. ft. of natual gas.
Kansas	Mineral Tax (i)	8% of gross value of oil and gas, less property tax credit of 3.67%; and $1/ton of coal.
	Oil Inspection Fee/barrel (i)	$0.015/barrel
	Oil and Gas Conservation Tax	91.00 mills/bbl. crude oil or petroleum marketed or used each month; 12.9 mills/1,000 cu. ft. of gas sold or marketed each month.
	Mined-Land Conservation & Reclamation Tax	The first-time fee for a mining license is $300. Licenses must be renewed annually. The annual renewal fee varies between $25 and $150 depending upon the amount of material sold or consumed in the previous year. Plus per ton fee of $.03.
Kentucky	Oil Production Tax	4.5% of market value.
	Coal Severance Tax	4.5% of gross value, less transportation expenses; $0.50/ton minimum for extraction and processing.
	Natural Resource Severance Tax	4.5% of gross value, less transportation expenses.
Louisiana	Natural Gas Severance Tax (j)	The natural gas severance tax rate effective July 1, 2016 through June 30, 2017 has been set at 9.8 cents per thousand cubic feet (MCF) measured at a base pressure of 15.025 pounds per square inch absolute and at the temperature base of 60 degrees Fahrenheit.
	Oil/Condensate Severance Tax (j)	Value on a per barrel basis (42 gallons) the rates are: full-rate, 12.5%; incapable oil rate, 6.25%; stripper oil rate, 3.125%; reclaimed oil, 3.125%; produced water full-rate, 10%; produced water incapable oil rate, 5.0%; produced water stripper oil rate, 2.5%
	Timber Severance Tax (j)	
	Mineral Severance Tax (j)	Various fees on a per ton basis for products like sulphur, salt, marble, stone, sand, lignit, and others.
	Oil Field Site Restoration Fee	$.015 per barrel of oil and condensate; $.003 for every thousand cubic feet of gas.
	Freshwater Mussel Tax	5% of revenues from the sale of whole freshwater mussels at the point of first sale.
Maine	Mining Excise Tax	The greater of a tax on facilities and equipment or a tax on gross proceeds.
Maryland	Mine Reclamation Surcharge	$.15/ton of coal removed by open-pit, strip or deep mine methods. Of the $.15, $.06 is remitted to the county from which the coal was removed.
Michigan	Gas and Oil Severance Tax	5% (gas), 6.6% (oil) and 4% (oil from stripper wells and marginal properties) of gross cash market value of the total production. Maximum additional fee of 1% of gross cash market value on all oil and gas (2017 fee).
Minnesota	Taconite and Iron Sulfides	$2.659 per taxable ton of concentrates or pellets (rate indexed to inflation by law).
	Direct Reduced Iron (k)	$2.659 per taxable ton of concentrates plus an additional $.03 per ton for each 1% that the iron content exceeds 72%.
Mississippi	Natural Gas Severance Tax	6% of value at point of gas production; 1.3% for gas produced from a horizontally drilled well for the first 30 months from the first sale of production or until payout of the well cost is achieved, whichever comes first.
	Oil Severance Tax	6% of value at point of oil production; 3% reduced rate for wells using the enhanced oil recovery method; 1.3% for oil produced from a horizontally drilled well for the first 30 months from the first sale of production or until payout of the well cost is achieved, whichever comes first.
	Timber Severance Tax	Varies depending on type of wood and ultimate use.
	Salt Severance Tax	3% of value of entire production in state.

See footnotes at end of table.

STATE SEVERANCE TAXES: 2017—Continued

State	Title and application of tax (a)	Rate
Oregon	Forest Products Harvest Tax	$3.7487/1000 board ft. harvested from public and private land— through Dec. 31, 2017. The first 25,000 board feet of timber harvested by an owner each year is exempt.
	Oil and Gas Production Tax	6% of gross value at well.
	STF Severance Tax— Eastern Oregon Forestland Option	$4.39/1000 board ft. harvested from land under the Small Tract Forestland Option—through Dec. 31, 2017.
	STF Severance Tax— Western Oregon Forestland Option	$5.65/1000 board ft. harvested from land under the Small Tract Forestland Option—through Dec. 31, 2017.
Pennsylvania	Natural Gas Impact Fee	The state issues an annual fee based on the average price of gas for that year along with the number on a schedule that considers a wells years in production. Local fees and taxes determined by county.
South Carolina	Forest Renewal Tax	Softwood products: 50 cents per 1,000 board feet or 20 cents per cord. Hardwood products: 25 cents per 1,000 board feet or 7 cents per cord.
South Dakota	Precious Metals Severance Tax	$4 per ounce of gold severed plus additional tax depending on price of gold; 10% on net profits or royalties from sale of precious metals and 8% of royalty value.
	Energy Minerals Severance Tax (s)	4.5% of taxable value of any energy minerals.
	Conservation Tax	2.4 mills of taxable value of any energy minerals.
Tennessee	Oil and Gas Severance Tax	3% of sales price.
	Coal Severance Tax (t)	$1.00/ton (effective 7/17/13)
	Mineral Tax	Up to $0.15 per ton, rate set by county legislative body.
Texas	Natural Gas Production Tax	7.5% of market value of gas. Condensate Production Tax: 4.6% of market value of gas.
	Crude Oil Production Tax	4.6% of market value or $.046/bbl.
	Cement Production Tax	$0.55 per ton or $.0275/100 lbs. or fraction of 100 pounds of taxable cement.
	Oil-Field Cleanup Regulatory Fees	5/8 of $.01/barrel; 1/15 of $.01/1000 cubic feet of gas. (u)
	Oyster Sales Fee	$1 per 300 lb. barrel of oysters taken from Texas waters.
Utah	Mining Severance Tax	2.6% of taxable value for metals or metalliferous minerals sold or otherwise disposed of.
	Oil and Gas Severance Tax	3% of value for the first $13 per barrel of oil, 5% from $13.01 and above; 3% of value for first $1.50/mcf natural gas, 5% from $1.51 and above; and 4% of taxable value of natural gas liquids.
	Oil and Gas Conservation Fee	.002% of market value at wellhead.
Virginia	Forest Products Tax	$1.15 per 1,000 feet B.M. of pine lumber and 1000 board feet of pine logs. $0.475 collected per cord of pine pulpwood.
	Coal Surface Mining Reclamation Tax	Varies depending on balance of Coal Surface Mining Reclamation Fund and the type of mine.
Washington	Enhanced Food Fish Tax	0.09% to 5.62% of value (depending on species) at point of landing.
	Timber Excise Tax	5% of stumpage value for harvests on public and private lands.
West Virginia	Coal Severance Tax	Coal: State rate is greater of 5% or $.75 per ton. Special state rates for coal from new low seam mines. For seams between 37" and 45" the rate is greater of 2% or $.75/ton (1.65% for state purposes and .35% for distribution to local governments). For seams less than 37" the rate is greater of 1% or $.75/ton (.65% for state purposes and .35% for distribution to local governments). For coal from gob, refuse piles, or other sources of waste coal, the rate is 2.5% (distributed to local governments). Additional tax for workers' compensation debt reduction is $.56/ton. Two special reclamation taxes at $.07/clean ton and $.02/clean ton.
	Natural Resource Severance Taxes	5% for sand, gravel, oil, natural gas, coabled methane, limestone, sandstone, or other natural gas liquids.
	Timber Severance Tax	1.50%
Wisconsin	Mining Net Proceeds Tax	Progressive net proceeds tax ranging from 0% to 15% is imposed on the net proceeds from mining metalliferous minerals. The tax brackets are annually adjusted for inflation based on the change in the GNP deflator.
	Oil and Gas Severance Tax	7% of market value of oil or gas at the mouth of the well.
	Forest Crop Law Severance Tax	$2.52 per acre, rate effective through 2017.
	Managed Forest Law Tax	Open land $2.14/acre; close land $10.68/acre.

See footnotes at end of table.

STATE SEVERANCE TAXES: 2017—Continued

State	Title and application of tax (a)	Rate
Wyoming	Severance Taxes	Severance Tax is defined as an excise tax imposed on the present and continuing privilege of removing, extracting, severing or producing any mineral in this state. Except as otherwise provided by W.S. 39-14-205. The total Severance Tax on crude oil, lease condensate or natural gas shall be six percent (6%). Stripper oil is taxed at four percent (4%). Surface coal is taxed at seven percent (7%). Underground coal is taxed at three and three-fourths percent (3.75%). Trona is taxed at four percent (4%). Bentonite, sand and gravel, and all other minerals are taxed at two percent (2%). Natural Gas (6%). Uranium (4%).

Source: The Council of State Governments, 2017.

Note: Severance tax collection totals may be found in the Chapter 7 table entitled "State Government Revenue, By Type of Tax."

Key:

(a) Application of tax is same as that of title unless otherwise indicated by a footnote.

(b) Tax rates and applicability for these severance taxes determined by a vote of the appropriate association within the seafood industry, by the Alaska Seafood Marketing Institute, or by the Department of Revenue. Proceeds from these elective assessments are customarily appropriated for benefit of the seafood industry.

(c) The iron ore tax was suspended as of Oct. 1, 2014 by administrative rule due to the cost of administering the collection of the tax exceeded the total amount of the tax collected.

(d) As of July 1, 2007, set at .0007 mill/$1.

(e) Clay, gravel, phosphate rock, lime, shells, stone, sand, heavy minerals and rare earths.

(f) Fee sunsets in 2018 under state law.

(g) Buyer deducts amount from payment to grower; amount forwarded to Department of Natural Resources.

(h) Petroleum, oil, gas and other hydrocarbons. Oil inspection fee rate based Dept. of Revenue factsheet.

(i) Coal, oil and gas, based on Department of Revenue information.

(j) Oil inspection fee rate based Dept. of Revenue factsheet.

(k) Coal, oil and gas, based on Department of Revenue information.

(l) Production is considered commercial when it exceeds 50,000 tons annually. There is a six-year phase-in of the tax. In years one and two, the rate is zero. In year three, it is 25% of the statutory rate and 50% and 75% in years four and five respectively. An Aggregate Materials Tax is imposed by resolution of county boards. It is not required that any county impose the tax, which is $.10/cubic yard or $.07/ton on materials produced in the county.

(m) Metals, precious and semi-precious stones and gems.

(n) The maximum rate of 0.3% is split between the Oil or Gas Conservation Tax and the Oil, Gas and Coal Natural Resource Account Fund. Currently the Oil or Gas Conservation Tax is .18% and the Oil, Gas and Coal Natural Resource Account fund tax rate is .08%.

(o) Cement and gypsum or allied products.

(p) Natural resources except oil, natural gas, liquid hydrocarbons or carbon dioxide.

(q) Oil, coal, gas, liquid hydrocarbons, geothermal energy, carbon dioxide and uranium.

(r) Rate reduced by 50 percent if burned in cogeneration facility using renewable resources as fuel to generate at least 10 percent of its energy output. Coal shipped out of state is subject to the $.02/ton tax and 30% of the $.375/ton tax. The coal may be subject to up to the $.375/ton tax at the option of the county in which the coal is mined.

(s) Asphalt and ores bearing lead, zinc, jack, gold, silver, copper or petroleum or other crude oil or other mineral oil, natural gas or casinghead gas and uranium ore.

(t) Any mineral fuel used in the production of energy, including coal, lignite, petroleum, oil, natural gas, uranium and thorium.

(u) Counties and municipalities also authorized to levy severance taxes on sand, gravel, sandstone, chert and limestone at a rate up to $.15/ton.

(v) Fees will not be collected when Oil-Field Cleanup Fund reaches $20 million, but will again be collected when fund falls below $10 million.

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ENVIRONMENT January 12, 2020

Trump's Latest Environmental Rollback Is a Middle Finger to Common Sense

"The oil and gas industry wins. The American people lose."

Alexander C. Kaufman and Chris D'Angelo



US President Donald Trump. Nicholas Kamm/Getty

This piece was originally published in HuffPost *and appears here as part of our* Climate Desk Partnership.

The Trump administration on Thursday unveiled plans to gut one of America's most important environmental laws—a move experts say is as much of a handout to polluting industries as it is a slap in the face to science and local communities.

The proposed rules would change how the federal government implements the National

Environmental Policy Act, a 50-year-old law that protects air, water and land by requiring federal agencies to conduct detailed environmental assessments of major infrastructure projects. Agencies would no longer be required to consider climate change when evaluating the environmental effects of pipelines, power plants, oil and gas drilling, airports, highways and other development.

President Donald Trump announced the reforms in a speech at the White House Thursday morning, saying the federal permitting process is "big government at its absolute worst."

"The United States will not be able to compete and prosper in the 21st century if we continue to allow a broken and outdated bureaucratic system hold us back from building what we need," he said.

The rules from the White House Council on Environmental Quality, which oversees NEPA, have been a long time coming. They seek to codify what has become common practice since 2017, when the White House rescinded Obama-era guidelines that tasked agencies with considering greenhouse gas emissions and climate change in NEPA reviews. The move is the latest in a relentless deregulatory effort by the Trump administration that has largely benefited the fossil fuel industry.

The controversial overhaul is aimed at speeding up energy projects and other development by limiting the number of projects that require in-depth environmental review and expediting the process for those that do. It would establish strict two-year limits for completing reviews on major projects and a one-year deadline for smaller projects. Trump on Thursday highlighted a number of projects that took a decade or longer to get federal approval.

Most alarming to environmentalists is that the proposal would allow agencies to not only ignore a project's vulnerability to climate change, but also its "cumulative" effects on global warming, which is already wreaking havoc around the world.

Christy Goldfuss, a former chair of the environmental council under President Barack Obama and current senior vice president for energy and environment policy at the left-leaning Center for American Progress, called the proposal "the ultimate silencing of science and facts in our policymaking around infrastructure." She said it puts a huge amount of power in the hands of industry.

"The oil and gas industry wins. The American people lose," Goldfuss said. "The purpose of rewriting these regulations is to build new pipelines and more fossil fuel infrastructure. You would not have to look at the cumulative impacts of a wind turbine or a solar panel because there is no long-term pollution. This is about building towards the past and sticking our head in the sand about the impacts of dirty fossil fuels."

The proposal would be the first major update to the law in more than four decades. The rules are certain to face legal challenges.

NEPA has long been a target of industry groups, developers and Republican lawmakers who say it places unnecessary burdens on business and is used as a tool to block and delay fossil fuel projects. Trump has prioritized advancing major pipeline projects like Keystone XL, a proposed 1,179-mile, $8.5 billion system that would transport some 830,000 barrels of crude oil per day from Alberta, Canada, to Nebraska. A federal judge halted construction of Keystone XL in 2018, ruling that the Trump administration violated NEPA by approving a federal permit without taking into account greenhouse gas emissions and climate change effects. Trump called the judge's decision "a disgrace." And appeals court later lifted that injunction.

The American Petroleum Institute, the oil and gas industry's leading lobbying group, declined to comment on the specifics of the upcoming NEPA changes but pointed to a November letter in which it called on the Trump administration to "modernize" a review and permitting process it said would reduce "delays and uncertainties associated with infrastructure investment."

Diane Katz, a senior research fellow at the right-wing Heritage Foundation, said "streamlining provisions" would help reduce the cost of roads, bridges and railways, but may not even go far enough.

"In fact, the NEPA is entirely out of sync with current environmental, political, social, and economic realities, and outright repeal would not make a whit of difference to the environment or public health."

"In fact, the NEPA is entirely out of sync with current environmental, political, social, and economic realities, and outright repeal would not make a whit of difference to the environment or public health," she said by email.

Trump is an outspoken critic of the federal permitting process and vowed throughout his 2016 presidential campaign to cut government red tape. "We built the Empire State Building in just one year," he said in his 2018 State of the Union address. "Isn't it a disgrace that it can now take 10 years just to get a minor permit approved for the building of a simple road?"

On Jan. 1—NEPA's 50th anniversary—Trump issued a statement criticizing the law and foreshadowing Thursday's announcement.

"While the goals of NEPA remain the same as they did 50 years ago, the environmental review process designed to improve decision-making has become increasingly complex and difficult to navigate," he said. The regulatory update, he added, would "benefit our economy and environment" and provide greater certainty to "project sponsors and ordinary Americans seeking decisions on permits."

But fewer projects requiring environmental review means fewer opportunities for the public to weigh in on potentially damaging construction.

"Trump's gift to the fossil fuel industry and special interests will silence ordinary Americans while giving polluters a free pass to trash the environment, destroy public lands and kill wildlife," Brett Hartl, government affairs director at the Center for Biological Diversity, said in a statement.

If the proposed reforms take effect, taxpayers are likely to end up footing bigger bills for infrastructure damage from climate-linked environmental disasters, as agencies would no longer have to consider the threat that sea-level rise, flooding, wildfires or extreme weather pose to a project.

"We will now be building infrastructure with a blindfold at a time when we know extreme weather is just getting more and more extreme," Goldfuss said.

In the last decade, the US experienced at least 119 climate and weather disasters with losses exceeding $1 billion each, more than double the number of billion-dollar disasters during the 2000s, according to a federal report released this week. Costs from those disasters over the last 10 years exceeds $800 billion.

Interior Secretary David Bernhardt, a former oil lobbyist, said Thursday at the White House news conference that he was "thrilled" by Trump's decision. The reforms "will be the most significant deregulatory proposal" the president implements during his time in office, he said.

"This proposal affects virtually every significant decision made by the federal government that affects the environment," Bernhardt added.

Trump stressed the administration was just getting started.

"We will not stop until our nation's gleaming new infrastructure has made America the envy of the world again," he said. "It used to be the envy of the world, and now we're like a third world country. It's really sad."

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FACT:

Mother Jones was founded as a nonprofit in 1976 because we knew corporations and the wealthy wouldn't fund the type of hard-hitting journalism we set out to do.

Exhibit 377

From: LeCrone, Darin
To: Lieberoff, Barb; Ward, Iwona
Subject: FW: [External] Pond Creek Mine IL0077666
Date: Friday, January 17, 2020 8:51:39 AM

Darin E. LeCrone, P.E.
Manager, Industrial Unit, Permit Section
Division of Water Pollution Control
Illinois Environmental Protection Agency

Ph: 217/782-0610

From: Jason Eisele <jasonleisele@gmail.com>
Sent: Thursday, January 16, 2020 9:08 PM
To: LeCrone, Darin <Darin.LeCrone@Illinois.gov>
Subject: [External] Pond Creek Mine IL0077666

To whom it may concern:
My wife and I have lived on the banks of the Big Muddy River for years. Dumping untreated wastewater from the mine into the river is a terrible idea, and should most definitely not be allowed. Neither we nor our neighbors support this, and I struggle to understand how anyone possibly could. If you want to dump wastewater into the river, it should be treated first. We often drink water from our well near the river, and we eat fish caught from the river by our house. In addition, the river regularly floods, exposing all the farmland near the river as well as the crops grown on it to contaminants from the mine. I absolutely insist that any wastewater dumped into the river by the mine be treated before putting it into the river. I strongly urge the EPA to do their duty and to forbid the mine from dumping untreated wastewater into the river.
Thank you for your consideration in this matter.
Rev. Jason Eisele and Dr. L. Petrice Eisele
1032 Koonce Rd.
Murphysboro IL 62966

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Exhibit 378

From: Baker, Joe A
To: EPA,PublicHearingCom
Subject: [External] Pond Creek Project
Date: Friday, January 17, 2020 9:29:11 AM

Hello, I am adding my voice in opposition to the Pnd Creek Project. It will cause generations of unintended consequences for future generation of people, lasting problems for the environment, and shows a general lack of respect for the public if it is allowed to go forward. Thanks for your time. Joe Baker, a resident of carterville, IL.

Exhibit 379

From:	Jan thomas
To:	EPA.PublicHearingCom
Subject:	[External] 7516c- NPDES Permit No. IL0077666, Notice Williamson Energy, LLC
Date:	Friday, January 17, 2020 9:51:03 AM

17 January 2020

Re: Pond Creek Mine NPDES
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P. O. Box 19276
Springfield, IL 62794-9276

Barb Lieberoff, Mail Code #5
Sent via email to epa.publichearingcom@illinois.gov

Re: 7516c- NPDES Permit No. IL0077666, Notice Williamson Energy, LLC

Dear Ms. Lieberoff,

I am a resident of Murphysboro, Illinois, a member of SAFE and a property owner near the banks of the Big Muddy River, and I am totally opposed to the issuance of this permit. I have several objections.

The first is the financial unreliability of this company. Foresight Energy is in near bankruptcy, its partner company, Murray Energy, having gone into bankruptcy in October of 2019. Murray owned 80% of Foresight's stock which has dropped from $17.17 per share on the NYSE in 2015 to less than $.06 per share right now. Foresight missed a 24.4 million dollar interest payment at the end of the third quarter of 2019, got an extension from the SEC twice and still has not made this payment on their 1.25 billion dollar debt. https://ieefa.org/coal-analysts-say-bankruptcy-filing-is-increasingly-likely-for-illinois-basins-foresight-energy/ Coal mines are going bankrupt at record rates as electricity generation transitions to cheaper fracked gas and even solar and wind, as storage abilities increase and become more economical. In the big picture, Illinois basin coal mines will be out of business in twenty years at the latest according to The IEEFA, the Institute for Energy Economics and Financial Analysis. https://ieefa.org/wp-content/uploads/2019/12/Dim-Future-for-Illinois-Basin-Coal_December-2019.pdf

Why should we permit the build out of expensive infrastructure for a dying industry? Who will pay for the cleanup when this company goes down? Peabody just closed the Wildcat Hills Mine in Energy; Murray/Foresight has put its Paradise #9 in Kentucky on "temporarily idled" status as of April of last year. ("Temporary idled status" is basically a legal dodge which permits companies from discharging their financial obligations to laid-off workers who, theoretically, could be recalled at any time.) Many of the coal burning power plants that Foresight's website says it sells to domestically are scheduled to close in the next few years. International sales are declining too, as other countries strive to cut their carbon emissions; also Russia and Columbia, among others, are dumping a lot of cheap coal on the international market. The IDNR Permit states that the proposed pipeline will only be in place for ten years and then be removed. Why is that? And will Foresight still exist then anyway? Will the Foresight miners find themselves in the same state as those Blackjewel Miners in Harlan County KY this last summer who had to camp out on the tracks to prevent the last shipment of coal from their newly bankrupt coal company from being carried out, when their paychecks had

bounced and new ones were not forthcoming? Recently the US Congress approved a bailout of 100,000 miners' pensions caused by the demise of coal mining companies, another example of coal mines not paying their contractual obligations and leaving the tab to the American people. And by the way, Robert Murray, CEO of Murray Energy, got 14 million dollars before his company went belly-up, and gave 1 million to climate-change-denying groups.

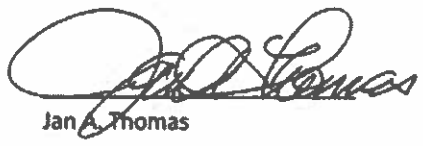
At the December 18 Hearing I asked the question of why the option of deep injection wells for this salty water has not been considered. The answer given was that Foresight has tried this option at Sugar Camp Mine, and it proved not to be economical for them. That seems to me to be an inadequate response. Who determines what is economically acceptable? Has Foresight provided any hard numbers to the IEPA to justify their assertion? Have they provided any concrete evidence that other options, such as pre-treating the water for removal of salts before dumping, are not "economical" for them? Or are you just taking their word for it?

Deep injection wells are a common practice in the fracking industry in which each frack produces millions of gallons of toxic water, at least as much as this mine is producing. And we are told this water contains none of the toxic industrial chemicals such as benzene, formaldehyde, lead, etc. which are added to frack water, and which are implicated in causing earthquakes and polluting ground waters, nor any of the toxins contained in the flowback water picked up from the deep earth such as TENORMs. If it comes from saline aquifers why not return it to them instead of dumping it into surface waters containing life?

This brings me to the really critical issue, the climate catastrophe which is barreling down upon us. I realize that you are supposed only to consider legal and technical issues in deciding this permit, but the time for that has passed. Many other commentators will be discussing the numerous violations of Foresight with regard to their already existing permits, the technical issues around pollution limits, the chemistry of salts on existing pollutants in the riverbed, the effects of salty water on wildlife, the lack of any substantive environmental studies and many other such issues. I am asking you to also consider the bigger picture because you are charged with **protecting our environment.** Article XI of the Illinois Constitution mandates that "The public policy of the State and the duty of each person is to provide and maintain a healthful environment for the benefit of this and future generations" and that "Each person may enforce this right **against any party, governmental or private..."** It is way past time to start thinking holistically. What this permit would do is basically allow Foresight Energy to export Illinois coal to the rest of the world to burn inexpensively, thus exacerbating the climate crisis and endangering us all. There is no benefit to the people of Illinois, not even a Severance Tax! Business as usual will not save us now. Indeed business as usual is what has gotten us into the crisis we are now facing. With the current national administration doing its worst to deregulate all polluting industries and limit citizens' rights to resist, as exemplified by the current assault on NEPA, it is more crucial than ever for states to stand up and protect their citizens.

Please deny this permit for the good of us all.

Sincerely,



Jan A. Thomas

Jan Thomas
433 N 7th St
Murphysboro, IL 62966
Jan@artapult.com

IEEFA November 25, 2019

Coal analysts say bankruptcy filing is 'increasingly likely' for Illinois Basin's Foresight Energy

S&P Global Market Intelligence ($):

One of the few major U.S. coal companies to dodge the bankruptcy court may soon need to file for Chapter 11 restructuring if the current market and economic forces working against the coal industry persist, according to recent securities filings.

Over the past few weeks, Foresight Energy LP exercised an option to delay a $24.4 million interest payment and negotiated the right to skip a publicly accessible quarterly call to discuss its third-quarter finances. As management of the Illinois Basin coal miner management works to restructure its balance sheet, the New York Stock Exchange delisted its stock and Foresight affiliate Murray Energy Corp. filed for a bankruptcy reorganization.

"With a significant debt load and a near-term pricing recovery increasingly unlikely, a Chapter 11 bankruptcy filing appears increasingly likely," B. Riley FBR analyst Lucas Pipes wrote in a Nov. 14 note.

While some coal companies struggled to sell assets even through bankruptcy auctions, Pipes noted that Foresight still owns some attractive mining assets, with its longwall mines capable of producing coal at a lower cost than its peers. However, the company has about $1.25 billion in gross debt on its balance sheet.

"The partnership continues to engage in discussions with its creditor constituencies and is exploring potential restructuring alternatives," Foresight wrote in a Nov. 12 securities filing. "As a result of these discussions and potential restructuring efforts, it may be necessary for us to file a voluntary petition for relief under Chapter 11 of the United States Bankruptcy Code in order to implement a restructuring, or our creditors, under certain circumstances, could force us into an involuntary bankruptcy or liquidation."

Illinois Basin producers turned to a recent boom in export markets to make up for a decline in domestic demand, but that demand is retrenching. In the third quarter of 2018, Foresight captured $140.8 million in international coal sales. In the third quarter of 2019, it reported $34.8 million from export markets, a 75.3% decline. Domestic sales fell from $151.2 million to $146.7 million in the same period.

More ($): Weakening coal market conditions move Foresight to shakier ground

Posted in: Foresight Energy, Illinois, Illinois Basin Coal, Murray Energy, News, Newsletter Daily, Newsletter News Weekly, US Coal Markets

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Seth Feaster, IEEFA Data Analyst
Karl Cates, IEEFA Transition Policy Analyst
December 2019

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Dim Future for Illinois Basin Coal

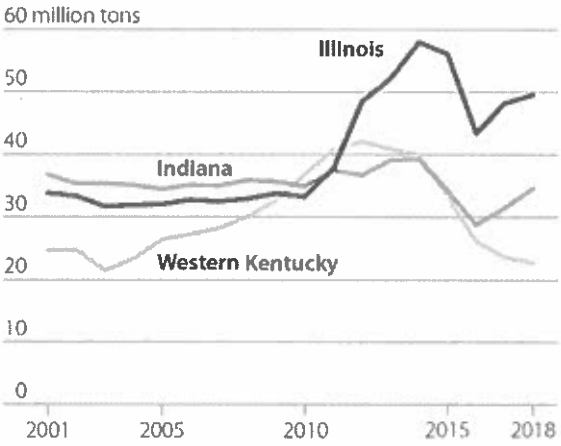
Market Forces and Shifting Preferences Are Eroding Customer Base Domestically and Abroad

Executive Summary

Twenty years from now, most of the Illinois Basin coal industry will be gone. Currently one of the major U.S. producing regions of thermal coal for domestic and foreign electricity generation, by 2040 it will have largely faded away as utilities shift to cleaner, cheaper generation resources.

In 2018, the Illinois Basin produced 106.8 million tons of thermal coal, about 14 percent of the total mined nationwide. Most of that total was used domestically, the remainder was exported. The Basin, which straddles the Ohio River in parts of three states—southern Illinois, southwest Indiana and western Kentucky—does not produce any of the metallurgical coal used in steelmaking, meaning it cannot escape the rapid transition now under way in the electric generation sector, both domestically and abroad.

Illinois Basin Coal Production by State



Source: Energy Information Administration

Domestic utilities, which bought nearly 80 percent of the region's coal in 2018, have already announced retirement dates for a significant number of plants over this period, as competitive electric markets compel a shift to newer, less expensive and cleaner wind, solar and gas generation, increasingly supported with energy storage. Notably, these retirements include the largest single purchaser of Illinois Basin coal, Duke's Gibson plant in Indiana, which will close in phases by 2038.

Gibson's closing will not be unique, however. From the beginning of 2019 through 2024, at least 15 U.S. plants that buy Illinois Basin coal—in Alabama, Florida, Georgia, Indiana, Kentucky, North Carolina and Tennessee—will be fully or partially retired. That number, which only reflects formal announcements by utilities, is likely to grow as the economics of coal-fired generation continue to deteriorate relative to renewables and gas.

Even those plants that remain online are likely to be used less and less, reflecting a trend that has seen capacity factors at most coal-fired power plants in the U.S. decline sharply over the past decade.

Coal exports, seen just a decade ago as a potential growth market, face the same market threats, particularly in Europe which is moving aggressively away from thermal coal. In addition, there is growing competition from foreign coal suppliers such as Russia and Columbia for this shrinking market.

These threats are already having a major impact in the region. Just in the past year, producers have closed or idled mines that produced almost nine million tons of coal in 2018. Further closures are likely, both in the near- and long-term.

The Illinois Basin will clearly be hit hard economically by the structural decline of the region's coal industry. Now is the time for local, state and federal policymakers to be planning for the transition in order to minimize the impact of additional coal mine closures, job losses and mining company financial hardships.

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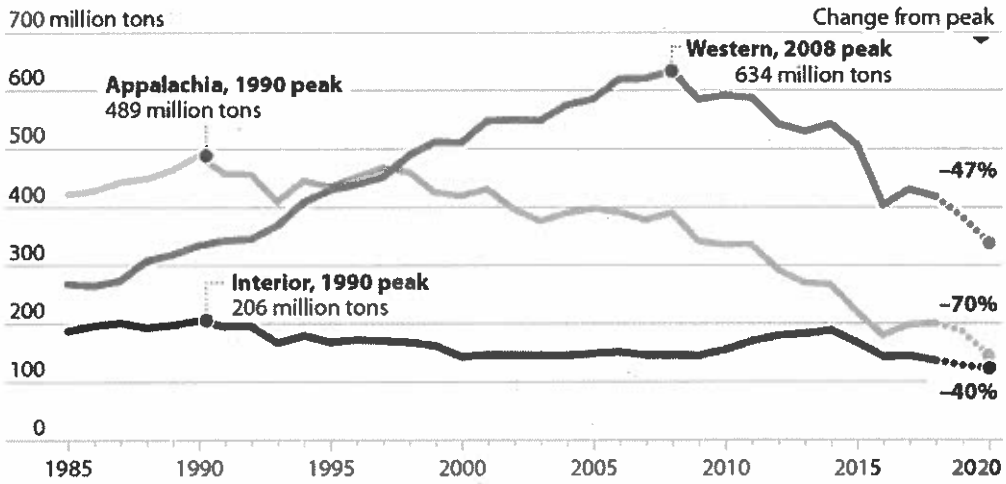
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Overview

By 2020, Illinois Basin production will have fallen 40 percent since its peak in 1990, part of a widespread decline in the U.S. (see the chart below). Other major coal-producing regions such as Appalachia[1] and the Powder River Basin[2] [3] are faring even worse, with the drop in Appalachian production expected to hit 70 percent by next year compared to its peak, also in 1990. In the West, the decline has been happening even faster, and on a bigger scale: peak production occurred only a decade ago, in 2008, but by the end of 2020 will have been cut almost in half. The entire U.S. coal sector—long dominant in terms of electricity generation market share—is losing out to cheaper forms of energy that include gas-fired power and renewables (wind and solar), and it is doing so at a quickening pace.[4]

U.S. Regional Coal Production, 1985-2018, With Estimates to 2020

Output has fallen sharply in all three major coal mining regions. From their peak years to 2020 (using the latest estimates from the U.S. Energy Information Administration), production is expected to have fallen by 40 percent in the Interior, which includes the Illinois Basin, 47 percent in the West, and 70 percent in Appalachia



Source: Energy Information Administration (2019-2020 estimates from Nov. 2019 Short-Term Energy Outlook)

Power markets are modernizing, and traditional coal-fired generation is becoming increasingly anachronistic. In 2018, 15,500 megawatts (MW), or 6 percent of all coal-fired capacity in the U.S., was retired, with an additional 14,000MW retiring this year, and many plants that are still in operation are being used less and less frequently by utilities. This year alone, power generation from coal has fallen by 13.4 percent through September, compared to the same period in 2018.[5] The result has been widespread financial carnage over the past two years for the coal industry,

[1] S&P Global Market Intelligence. Coal production fell 15.1% quarter to quarter at top Northern Appalachia mines, November 2019.
[2] IEEFA. Powder River Basin Coal Industry Is in Long-Term Decline. March 2019.
[3] S&P Global Platts. Moody's expects Powder River Basin coal mine closures in early 2020s. October 2019.
[4] IEEFA. Data shows U.S. shift away from coal-fired generation is intensifying. November 2019.
[5] EIA, Electric Power Monthly, November 2019, table ES1.B.

R03705

in which 11 U.S. mining company bankruptcies have occurred. One recent news headline crystallized the trend and put the very future of American coal mining in question—"Bankrupt giants hand unwanted coal mines to unknown firms."[6]

In the Illinois Basin specifically, the pace of mine closure announcements has picked up in recent months. In addition, other Illinois Basin mines have been "temporarily idled," a misleading industry term that suggests those mines will reopen when economic conditions improve, but in fact likely will never return to production. Such idlings, can, however, serve as a way to stave off mandated reclamation.

Put bluntly, declining demand means more mines across the Illinois Basin will need to close in the months and years ahead—just as more coal mines will close nationally—and those closures will likely come at a faster rate than has previously been seen.

The decline of the American coal industry more generally is gaining momentum, pushed out by cheap gas from fracking and rapidly falling costs for wind, solar and storage. These trends are discussed in greater detail in IEEFA's annual coal-outlook report published eight months ago[7] and in regional IEEFA research published this year that has included analysis of the Powder River Basin of Montana and Wyoming and of coal-fired generation in the Southeast U.S. (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee and Virginia).[8]

The continuing rise of renewables, which are increasingly competitive and in many cases cheaper than coal-fired power, was detailed in a Lazard report published just this month.[9] "That phenomenon has increased this year," a Lazard representative said in a report follow-up.[10] "There are situations where the cost of building new wind and the cost of building new solar are cheaper than keeping a coal or nuclear plant operating. And even on an unsubsidized basis, we're starting to see those costs undercut the marginal cost of coal and nuclear."

Similar sentiments have even been voiced by executives within the coal-mining industry itself. Speaking generally of Illinois Basin coal mines, a Hallador Energy executive, for instance, said on an earnings report call in May of this year, "Some of these assets are not long for this world."[11]

Likewise, executives at big utility companies are openly acknowledging the phase-out of coal-fired generation. The CEO of Xcel Energy, for example, said in a June 2018 speech, "It's not a matter of if we're going to retire our coal fleet in this nation, it's just a matter of when."[12] Xcel is of note for two reasons. One, its size (Xcel sells power across the Upper Midwest and in the West), and, two, its aggressive renewable energy buildout, which S&P Global Market Intelligence concluded in a

[6] E&E News. Bankrupt giants hand unwanted coal mines to unknown firms. November 2019.
[7] IEEFA. Coal Outlook 2019: Domestic Market Decline Continues. March 2019.
[8] IEEFA. Coal-Fired Power Generation in Freefall Across Southeast U.S. October 2019.
[9] Lazard: Lazard's Levelized Cost of Energy Analysis, Version 12.0. November 2019.
[10] S&P Global Market Intelligence. Renewable energy costs continue to abate, beating coal and nuclear, Lazard says. November 2019.
[11] Hallador Energy Company. First Quarter 2019 Earnings Conference Call. May 2017.
[12] Greentech Media. Xcel CEO Says Retiring the US Coal Fleet 'Just a Matter of When'. June 2018.

September 2018 analysis "augers well" for Xcel to deliver on its goals of increasing long-term earnings per share by 5 to 6 percent annually and increase dividends annually by 6 to 7 percent.[13]

As the decline in Illinois Basin's coal-production continues, companies that have mines in the region will continue to face market pressure. They include (ranked by amount of Illinois Basin production) Alliance Resource Partners, Murray Energy and its partner Foresight Energy, Peabody Energy, Hallador, Arch Coal and White Stallion.

State-by-state reviews of these companies' utility customers offer another window on why the Illinois Basin coal industry is in such peril. As major customers in states like Florida, for instance, continue to move aggressively away from coal, demand for Illinois Basin coal will weaken further. And export markets aren't likely to be of much help, as Murray Energy executives conceded when the company filed for bankruptcy in October.[14]

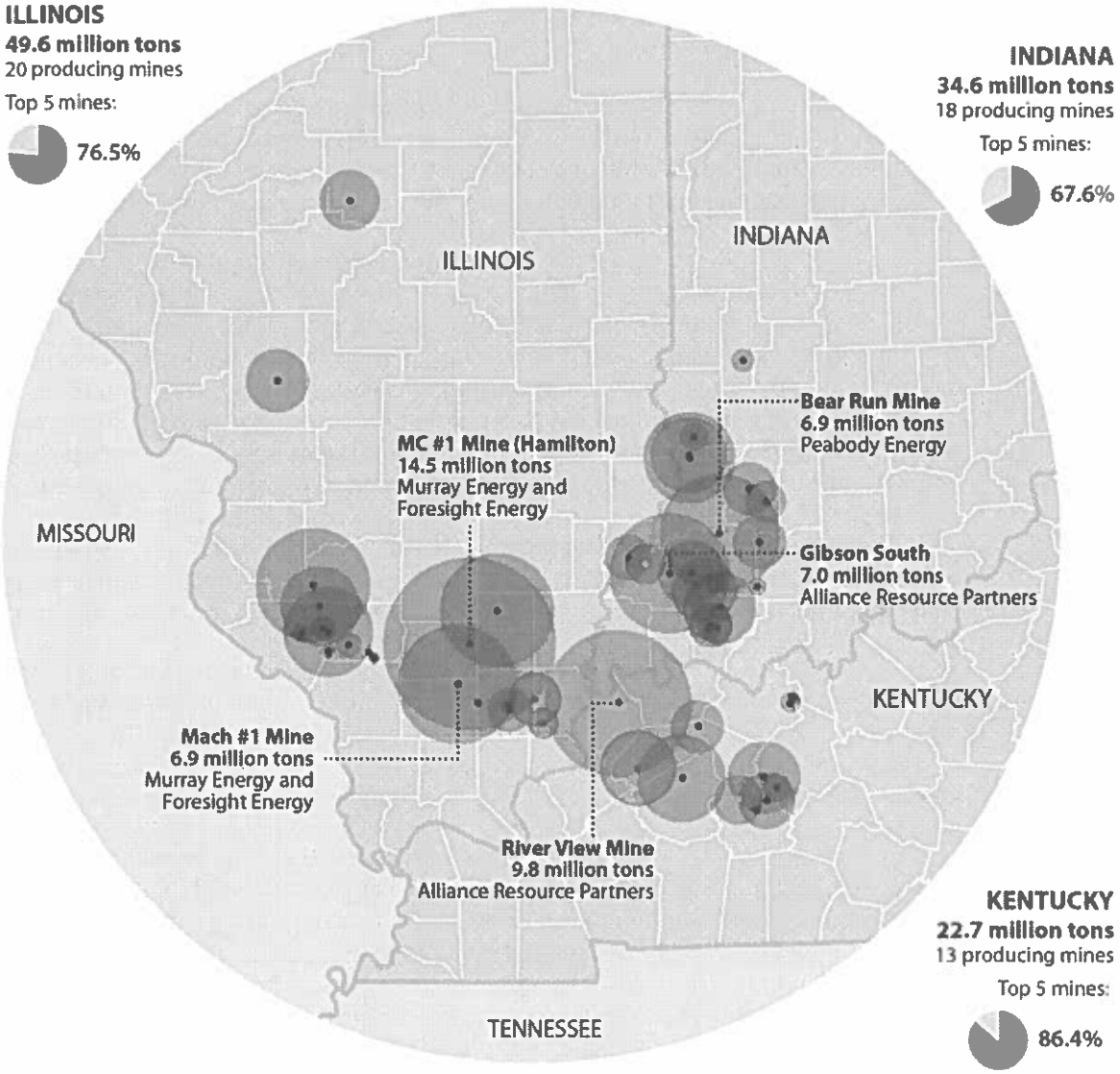
The map on page 7 shows recent coal-industry activity across the Illinois Basin.

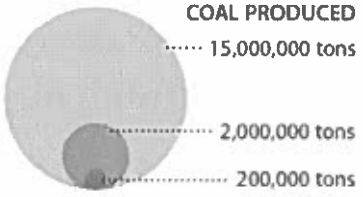
[13] S&P Global Market Intelligence. With wind at its back, Xcel Energy's renewables build-out augurs well for growth. September 2018.
[14] S&P Global Market Intelligence. Logistics chain adapting to US coal sector's decline, export volatility. November 2014.

Illinois Basin Coal Production, 2018

Total production: **106.8 million tons**

Market forces are beginning to work against the coal-mining industry in the Illinois Basin. Declines in export demand and gathering momentum around retirements of coal-fired plants will affect every state and every company in the basin. Recent mine closures and idlings are part of an emerging long-term trend that will likely result in fewer mines regionally and far less production. On this map, circle sizes are proportional to production; the top five regional mines are labeled.





COAL MINE STATUS
As of November 2019

- Active
- Temporarily idled
- Permanently closed

Institute for Energy Economics and Financial Analysis
IEEFA.org

Sources: Energy Information Administration; S&P Global Market Intelligence

The Company-by-Company View

Alliance, Murray-Foresight, Peabody, Hallador, Arch, White Stallion

The company-by-company maps on the following pages show the geographic presence of the six biggest producers in the basin. Ranked by Illinois Basin production in 2018, they are Alliance Resource Partners (29.9 million tons), Murray/Foresight Energy (28.6 million tons), Peabody Energy (18.6 million tons), Hallador Energy (7.6 million tons), Arch Coal (6.3 million tons) and White Stallion (5.6 million tons); together these companies produced 90 percent of all the coal mine produced in the basin in 2018.

Collectively, the maps suggest stability—that is, they show how most mines in the region remain open. But they also show a developing trend of either permanent closures or companies designating mines as "temporarily idled," a highly misleading term. The reality in today's rapidly changing electric generation market is that these idled mines will probably never reopen.

Thus, the "temporary" idling in November of the Gibson North Mine in Indiana by Alliance likely means this mine will never again produce coal; 185 workers were affected. Gibson North produced nearly 900,000 tons in 2018, and 1.7 million tons in the first nine months of 2019.15 In August, Alliance permanently closed the Dotiki mine in Kentucky, affecting about 200 workers. At this mine, production in 2018 totalled 2.5 million tons.16 Similarly, Murray Energy/Foresight Energy ceased production in April at Paradise #9 in Kentucky, which produced 1.1 million tons in 2018, and Peabody in October closed the Somerville Central Mine in Indiana, which produced 2.1 million tons in 2018. In December, Peabody will finish closing its Wildcat Hills mine complex in Illinois, which produced 1.7 million tons in 2018, and the company in the past year has closed two smaller mines—one each in Illinois and Indiana— that together produced 600,000 tons in 2018.

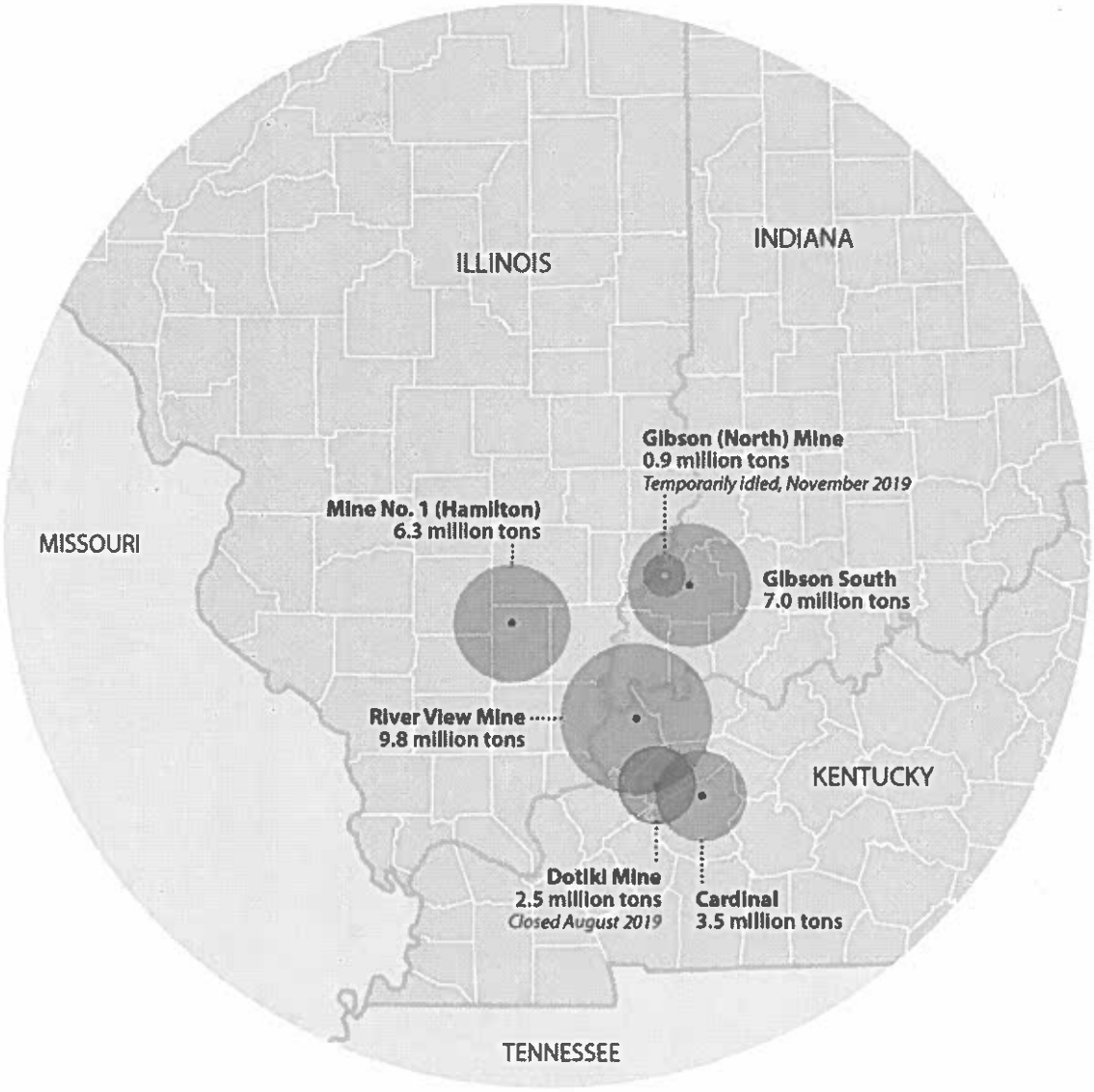
Collectively, then, almost 9 million tons, or 8.4 percent of the Illinois Basin's 106.8 tons of production in 2018 has been taken off the market in the past year or so for lack of demand, and additional production cuts are likely based on the EIA's short-term forecast for 2020, which sees production cuts increasing to 11 million tons.

The effect will be substantial on companies that operate in the Illinois Basin, and the recent mine closures noted above—by Alliance, by the recently bankrupt Murray/Foresight and by Peabody—signal a future in which Illinois Basin producers will continue to lose customers in the U.S. and in foreign markets alike.

[15] Alliance Resource Partners. Alliance Resource Partners, L.P. Announces Issuance of WARN Act Notice at Gibson Complex. November 2019.
[16] Alliance Resource Partners. Alliance Resource Partners, L.P. Announces Coal Production Ceasing at Dotiki Mine, August 2019.

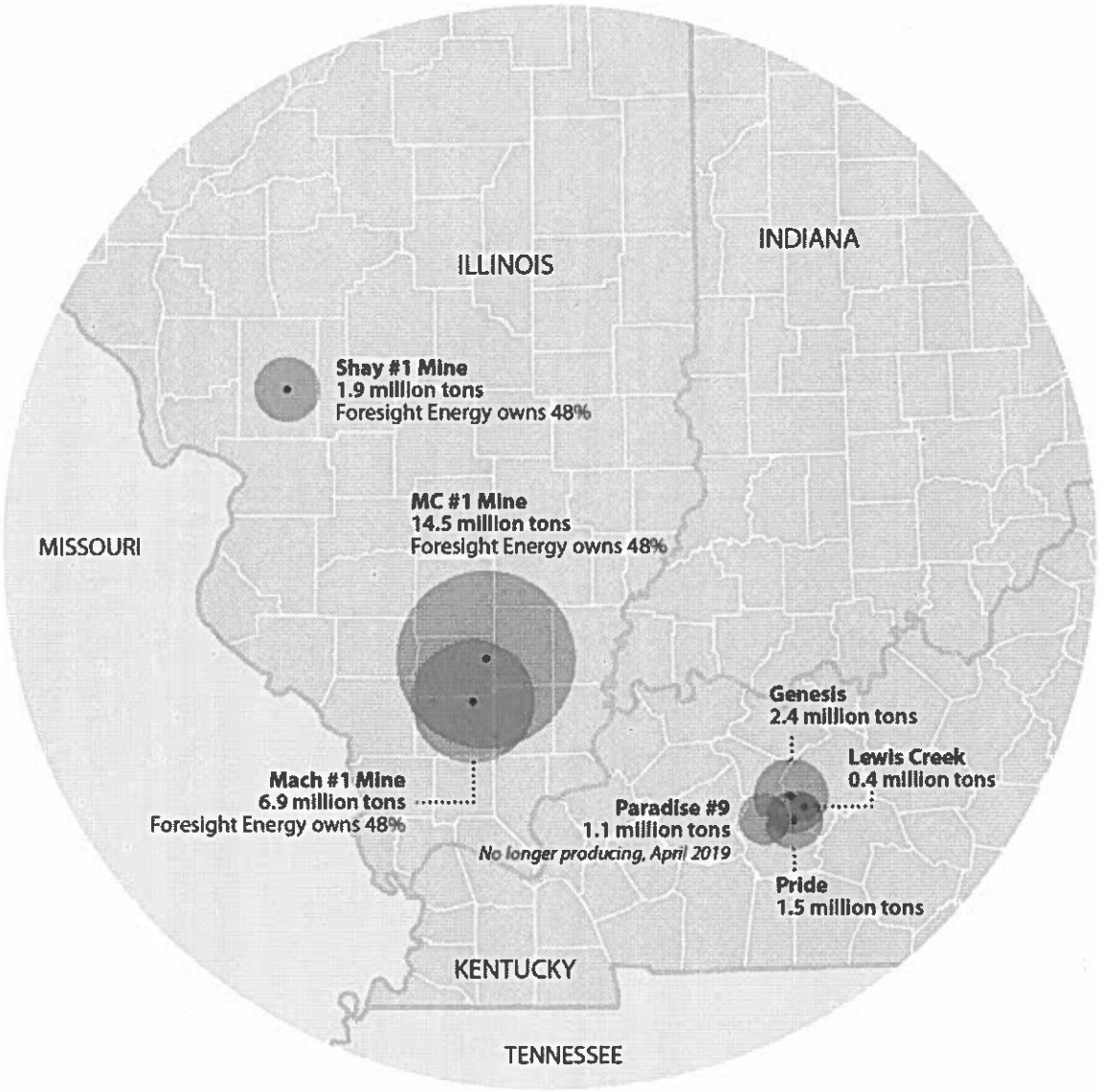
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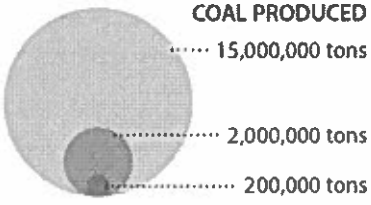
Alliance Resource Partners
29.9 million tons produced
6 mines
28.0% of Illinois Basin production, 2018



Murray Energy – Foresight Energy
28.6 million tons produced
7 mines *4 Murray Energy mines*
and 3 mines 48% owned by Foresight Energy

26.8% of Illinois Basin coal, 2018





COAL MINE STATUS
As of November 2019
- Active
- Temporarily idled
- Permanently closed

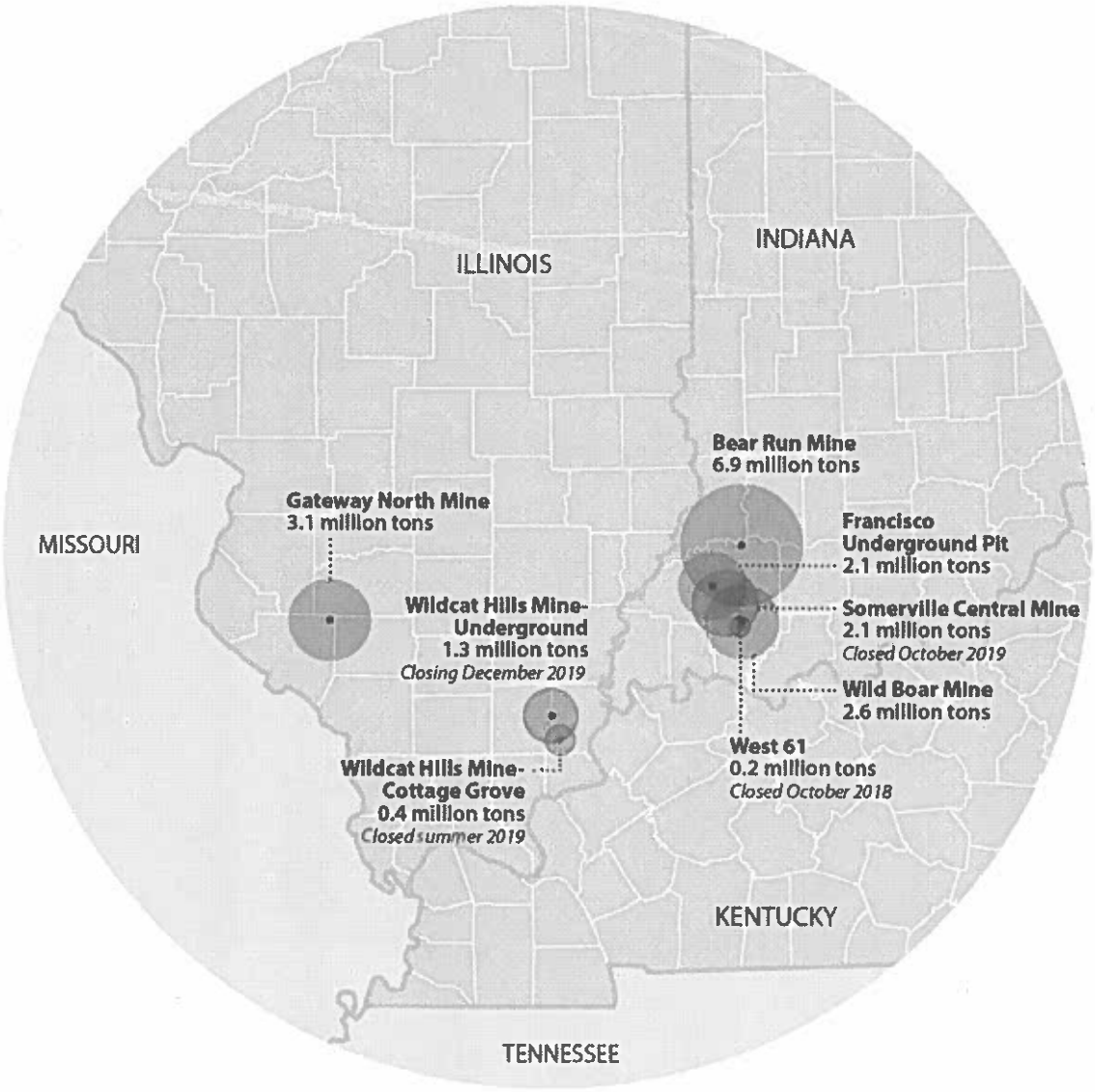
Institute for Energy Economics and Financial Analysis
IEEFA.org

Sources: Energy Information Administration; S&P Global Market Intelligence

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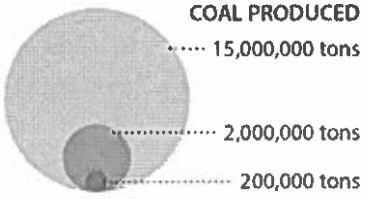
Peabody Energy
18.6 million tons produced
8 mines

17.4% of Illinois Basin production, 2018



Hallador Energy
7.6 million tons produced
4 mines
7.1% of Illinois Basin production, 2018





COAL MINE STATUS
As of November 2019
- Active
- Temporarily idled
- Permanently closed

Institute for Energy Economics and Financial Analysis
IEEFA.org

Sources: Energy Information Administration; S&P Global Market Intelligence

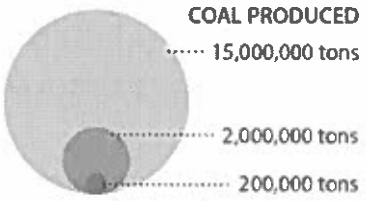
Arch Coal

6.3 million tons produced

5 mines *Includes 4 mines 51% owned by CBR Investments*

5.9% of Illinois Basin production, 2018





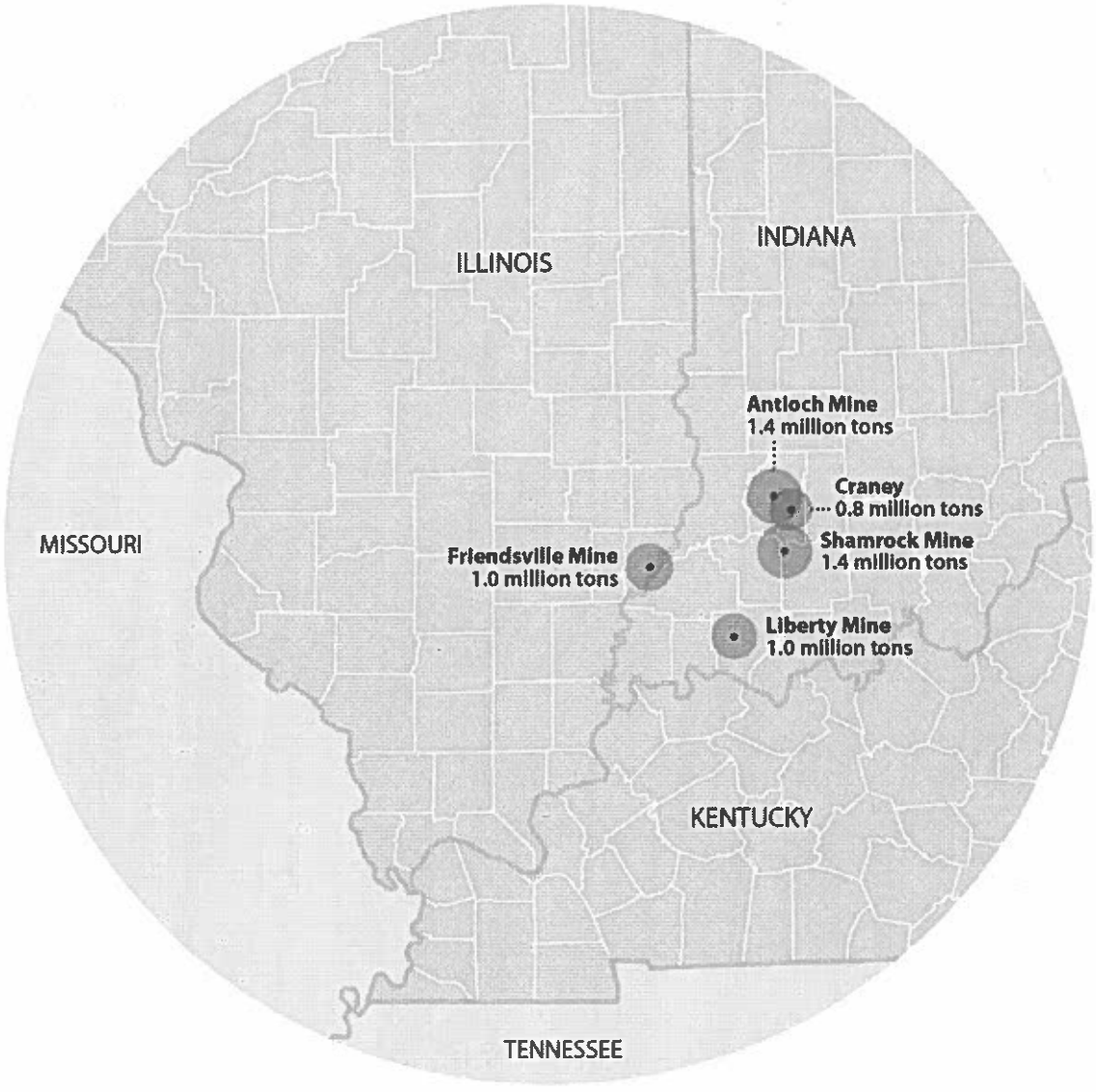
COAL MINE STATUS
As of November 2019

- Active
- Temporarily idled
- Permanently closed

Institute for Energy Economics and Financial Analysis
IEEFA.org

Sources: Energy Information Administration; S&P Global Market Intelligence

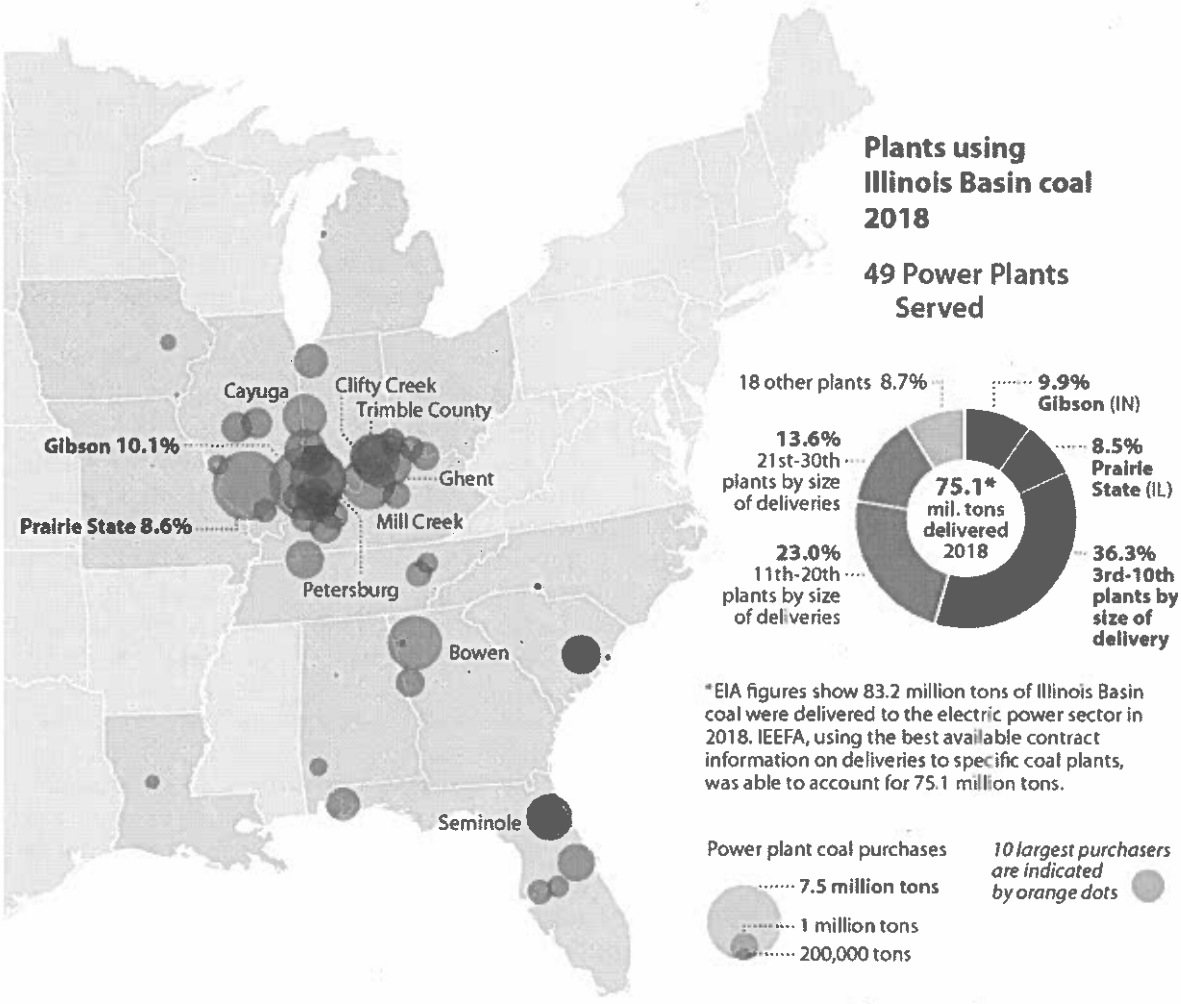
White Stallion
5.6 million tons produced
5 mines
5.2% of Illinois Basin production, 2018



State-by-State and Customer-Base Slippage

Retirement Dates Loom for More Coal Plants

The problem facing the Illinois Basin coal-mining industry is made clear by focusing on its 49 domestic power-plant customers, which collectively consumed nearly 80 percent of 2018 production and are scattered across states that run from the heart of the Midwest into the Deep South. The 10 largest customers, shown below with orange circles, stretch across Florida, Georgia, Illinois, Indiana and Kentucky, and together use more than half of the coal the basin delivers domestically. The other 39 customers are marked by purple circles. The size of the circles is proportional to the amount of Illinois Basin coal delivered.



Sources: S&P Global Market Intelligence; Energy Information Administration

A significant portion of this customer base will be phased out over the next five years, based on already-announced retirement plans (see the map on page 17).

A clear view of the future of the basin's customer base can be seen in Duke Energy Indiana's June announcement about its retirement plan for the Gibson coal-fired plant. The closure of this plant, the Illinois Basin's largest single coal customer, accounting for almost 10 percent of sales in 2018, almost certainly signals an end date for most of the Illinois Basin coal industry. Situated on the Wabash River across from Mt. Carmel, Ill., the Gibson plant is one of the largest power plants in the U.S., with more than 3,100MW of capacity, and it sits in the heart of Indiana's coal-mining area, very close to Alliance Resource Partners' Gibson coal mine complex.

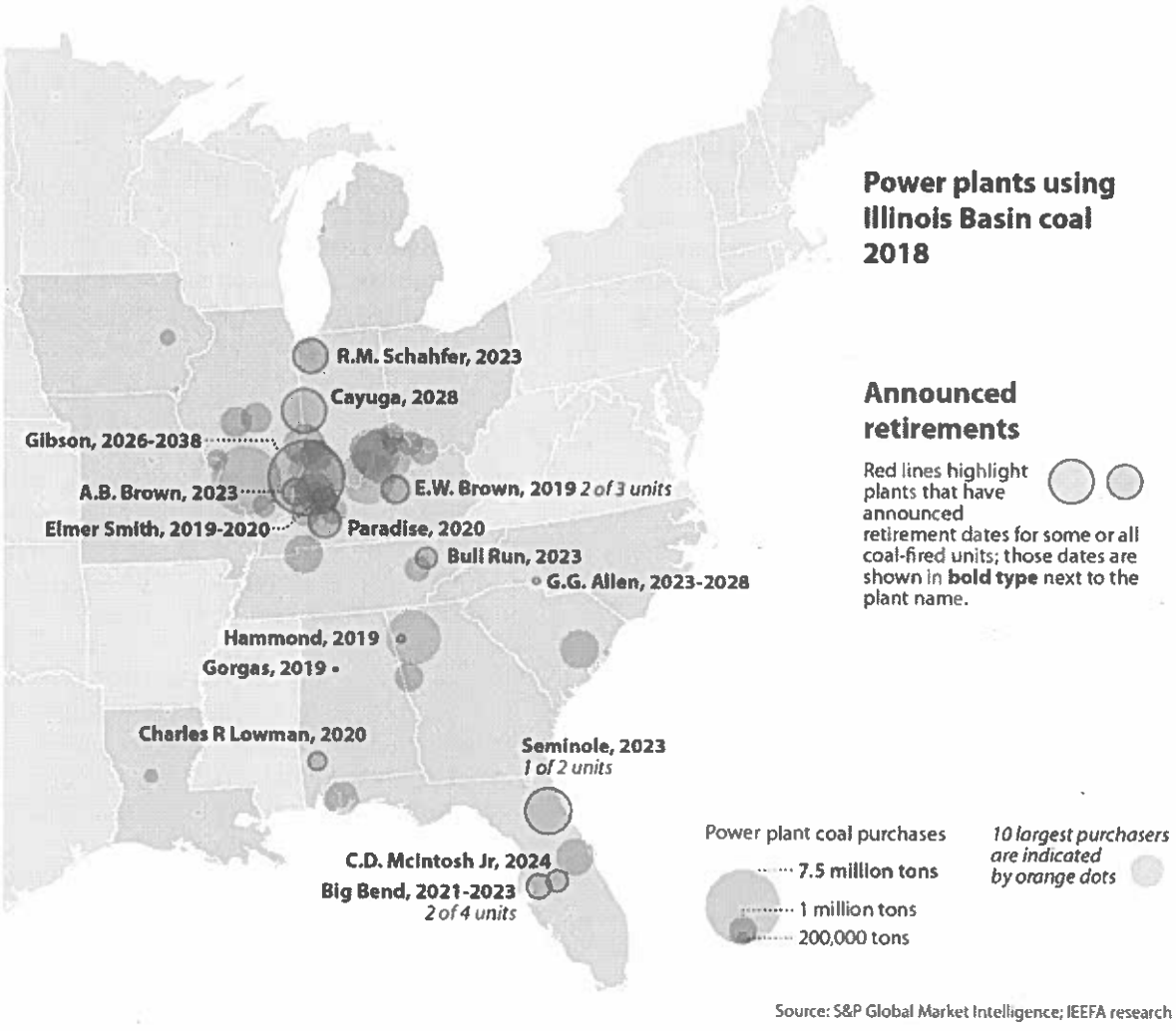
The dates of the planned closures of the plant's five units, each of which has a nameplate capacity of about 630MW, suggest the timeline the decline of the region's coal industry will follow as well. Unit 4, for example, will now be shut down in 2026, nearly 20 years earlier than its originally-planned retirement in 2044, according to Duke (all the units began operation between 1975 and 1982). Units 3 and 5 will now be shut in 2034, a decade before their previously expected retirements in 2043 and 2047, respectively. The last two units, Units 1 and 2, will be retired in 2038 instead of 2041 and 2040. Yet even these retirement dates may be optimistic: utilities have frequently accelerated their retirement timeframes as coal-plant economics have worsened.

Existing plants have been running less, too. As coal has become less competitive against gas and renewables, larger utilities have been able to fuel-switch across their generation fleets, favoring these cheaper sources whenever they can. As a result, Gibson has been running less than it could. In August, for example, the plant operated at just 33 percent of capacity, its lowest monthly level in at least two decades. In addition, as coal plants like Gibson age, they require more maintenance, and if they are run less, the overall cost of their power goes even higher, making such plants even less competitive.

With the economics of coal-fired power deteriorating, more and more utilities have been accelerating retirement dates. In northern Indiana, for instance, the utility NIPSCO recently said it would save $4 billion by retiring its coal plants early and passing those savings on to customers.

It is worth noting that the corporate and financial relationships between the coal-mining companies and the utilities that buy their coal plays a significant role in how quickly coal is being phased out in the Illinois Basin—and across the U.S., for that matter. For the most part, utilities do not have financial stakes in coal mining, and the coal plants they have are usually part of a larger fleet of generation assets that run on a mix of fuels. This encourages them—as is broadly required by state utility oversight agencies—to operate their plants in the most economically efficient way possible, freeing them to cut expensive coal generation without incurring losses when the mines they buy from are closed. They are usually just buyers of fuel, and not in the business of extracting and processing that fuel.

In Illinois, though, there is one major exception: the 1,624MW Prairie State Energy Campus in Washington County. Prairie State is owned by a group of municipalities, public authorities and rural electric cooperatives who also own the neighboring Lively Grove coal mine that supplies the generation station. This practically-new plant, opened in 2012, is the second-largest consumer of Illinois Basin coal, accounting for 8.6 percent of all production in 2018, but it comes entirely from the Lively Grove mine. This self-contained economic structure has locked the owners into very high power costs without much flexibility to shift to cheaper and cleaner generation resources, either from their own renewables or from regional power markets that are increasingly supplying low-cost wind power. IEEFA has written extensively about the situation in past reports.[17] [18]



[17] IEEFA. Cost of Coal From 'Mine-Mouth' Prairie State Plant Isn't the Bargain That Was Promised. April 2015.

[18] IEEFA. 2014, Another Year of Unmet Promises for the Prairie State Energy Campus. February 2015.

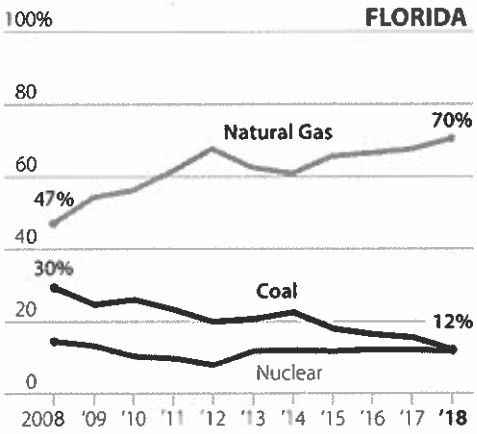
Florida, Georgia, Illinois, Indiana, Kentucky

FLORIDA

Coal-fired generation in the Sunshine State is on the way out, as can be seen in well-rooted trends that date back a decade at least. Gas-fired generation now accounts for 70 percent of all electricity production in Florida. Coal-fired plants contributed 30 percent to Florida's power mix as recently as 2008; that number had fallen to 12 percent by 2018.

The 2010 census put the state's population at 18.8 million, and by 2018 that number had risen 6 percent, to 21.3 million.[19] While electricity consumption in the state has climbed with its population boom, none of that demand increase was supplied by coal.[20]

Fuel Share for Electric Power Generation (Utility Scale, All Sectors)



Only fuels with 5% or more share in any year are shown.
Source: Energy Information Administration

While gas-fired generation has taken a bigger and bigger share of the market, the state's three biggest utilities—Duke Energy Florida, Florida Power and Light, and Teco Energy—have plans to install more than 11GW of solar over the next 10 years.[21] While the state comes belatedly to solar—a circumstance rich with irony, considering how Florida's nickname is the Sunshine State—it has recently made a hard pivot toward utility-scale solar. In 2018, the three major utilities brought a total of 876MW of utility-scale solar online,[22] roughly enough capacity to power almost a million homes. Simultaneously, battery storage is coming online in a fast-spreading advance that stands to bolster the uptake of solar.

Florida's coal-fired capacity has fallen by more than half over the past decade to 7,883MW, of which 2,094MW will be retired by 2024, according to utility-company announcements.

[19] U.S. Census Bureau. Quick Facts Florida, July 2018.
[20] IEEFA. Coal-Fired Power Generation in Freefall Across Southeast U.S., October 2019.
[21] Ibid.
[22] Smart Electric Power Alliance. SEPA's 2019 Solar Snapshot Report Finds Florida's Solar Market is Flourishing, June 2019.

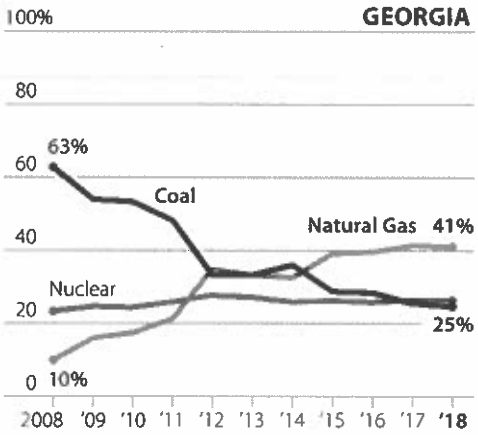
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GEORGIA

Electricity-generation trends in Georgia are similar to Florida's. Coal-fired generation market share fell from 63 percent in 2008 to 25 percent in 2018. That share will drop further in the near future— and for the same reasons seen in Florida. Gas-fired generation is cheaper, as is utility scale solar (Georgia Power plans to have 2,260MW of utility-scale and distributed solar online by 2024).

Georgia has only three coal-fired generation plants, although two are the largest in the U.S., the 3,392MW Plant Scherer and the 3,200MW Plant Bowen. The third, 1,744MW Plant Wansley, is very likely to follow in the footsteps of Plant McIntosh (142MW) and Plant Hammond (840MW),[23] both of which were retired this past July. Plant Bowen is an especially big Illinois Basin customer, ranking fifth among Illinois Basin users in 2018 (3.93 million tons). Its owner, the Southern Company subsidiary Georgia Power, published an updated integrated resource plan (IRP) this year noting "economic challenges"[24] facing the plant.

Fuel Share for Electric Power Generation
(Utility Scale, All Sectors)



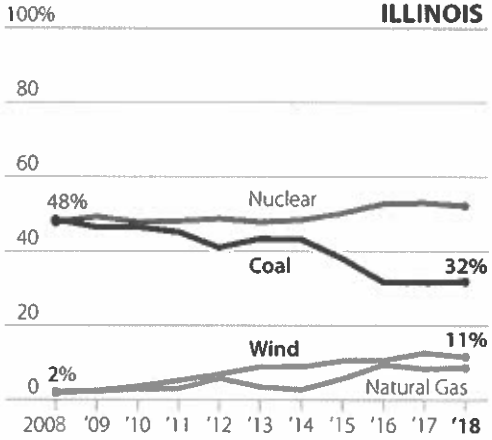
Only fuels with 5% or more share in any year are shown.
Source: Energy Information Administration

ILLINOIS

Illinois has the strongest renewable energy standards of the five states noted here, with a goal of getting 25 percent of its power from renewable sources by 2025.[25]

It is also where markets are driving a wave of coal plant closures that are very quickly reshaping the state's energy economy. Vistra Energy is the prime example, having recently announced that it would close the 585MW E.D. Edwards plant at the end of

Fuel Share for Electric Power Generation
(Utility Scale, All Sectors)



Only fuels with 5% or more share in any year are shown.
Source: Energy Information Administration

[23] IEEFA. Coal-Fired Power Generation in Freefall Across Southeast U.S., October 2019.
[24] Georgia Power. 2019 IRP, Docket #42310, Section 1-7, Unit Retirements. December 2018, 1-7.
[25] National Conference of State Legislatures. State Renewable Portfolio Standards and Goals. accessed November 2019.

2022.[26] The company had already announced that it would close four other coal-fired plants in Illinois this year with a total capacity of about 2,000MW.

Vistra, an energy behemoth with 10 coal-fired plants in the U.S. that have a total of 11,000MW of generation capacity, in October announced new emissions-reduction goals in which executives at the company said it "anticipates retiring more coal assets."[27]

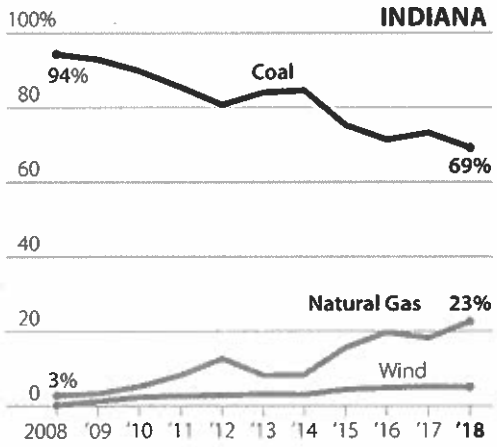
INDIANA

Indiana is not considered a leader in electricity-generation transition policy, but market-driven changes are occurring, nonetheless.

The state has a formal goal of getting 10 percent of its electricity from "clean energy" by 2025, but the parameters for meeting that target are loosely defined and favor "clean coal" technology and gas-fired generation.

Market changes may outpace state policy, however. The Northern Indiana Public Service Company (NIPSCO) this year announced plans to abandon coal-fired electricity generation entirely and to focus on utility-scale solar generation and other renewable generation. In October, NIPSCO published requests for proposals for development of 2,300MW of solar and 300MW of wind-powered generation.

Fuel Share for Electric Power Generation (Utility Scale, All Sectors)



Only fuels with 5% or more share in any year are shown.
Source: Energy Information Administration

"The driver for how we make decisions is really rooted in economics and costs for our customer," an executive at the company said when the RFPs were announced.[28]

KENTUCKY

Even Kentucky, reliant on coal for 94 percent of its electricity generation a decade ago, is changing. Coal's share of the state's power-generation market dropped 19 points from 2008 to 2018, a shift owing almost entirely to the rise of gas-fired generation.

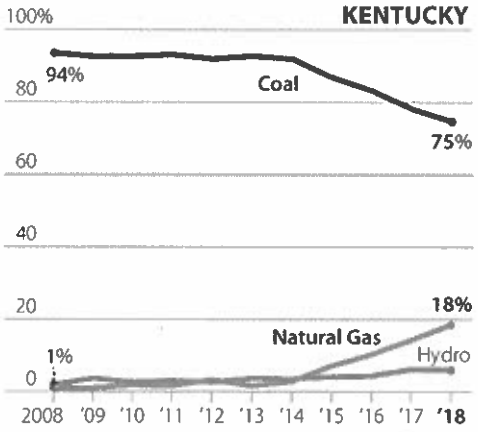
[26] **Utility Dive.** Judge OKs $8.6M Vistra coal plant closure settlement seen by NGOs as model for helping impacted communities. November 2019.
[27] **Vistra Energy.** Vistra Energy Announces Long-Term Emissions Reduction Targets and Support for Market-Based Carbon Reduction Regime. October 2019.
[28] **Greentech Media.** The Solar Boom Takes Off in the Industrial Midwest. October 2019.

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Although Kentucky has deep cultural connections with coal, existing national power-generation trends will likely gain momentum in the state for purely economic reasons. They will be driven also by corporate policy initiatives, as U.S. companies that do business in Kentucky are adopting increasingly stringent requirements on where their electricity comes from.

Utility companies in Kentucky are also evolving. Kentucky Utilities and Louisville Gas & Electric are both subsidiaries of PPL Corporation, which last year announced plans to cut its carbon-dioxide emissions by 70 percent from 2010 levels by 2050. According to the corporation, among the measures that will be needed to reach that goal "include replacing Kentucky coal-fired generation over time with a mix of renewables and natural gas while meeting obligations to provide least-cost and reliable service to customers."[29]

Fuel Share for Electric Power Generation
(Utility Scale, All Sectors)



Only fuels with 5% or more share in any year are shown.
Source: Energy Information Administration

The Export-Market Problem

Market Forces Continue to Work Against Coal Overseas, Too

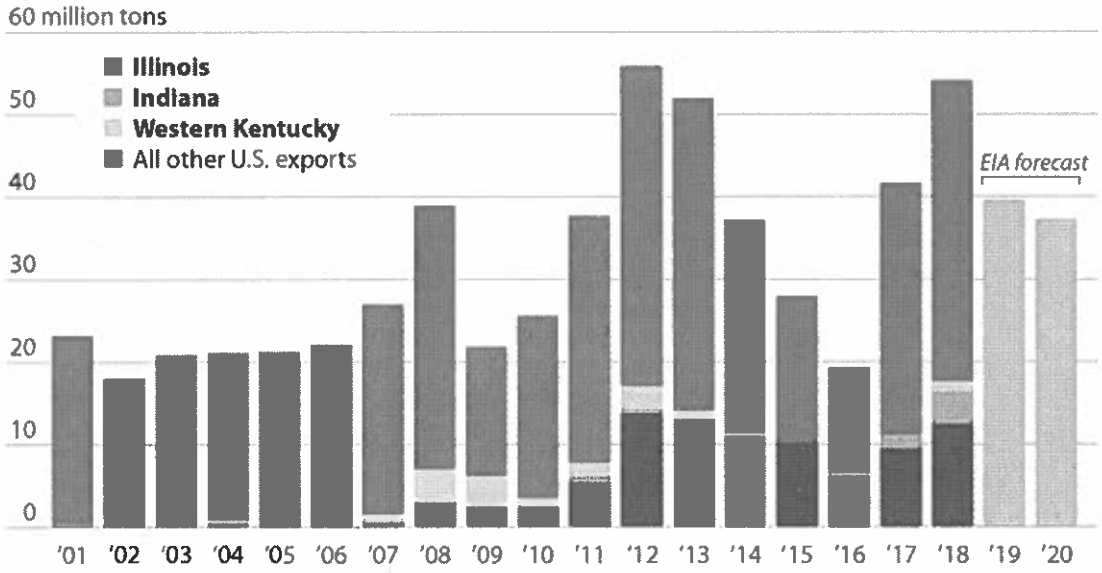
Beginning about a decade and a half ago, Illinois Basin producers saw potential in shipping coal to Europe, India and elsewhere for power-generation purposes.

These ambitions paid off as European demand for U.S. coal rose—for a while. But the same market forces that are moving against coal in the U.S. are working against European coal-fired generation too. A handful of countries in the 28-member European Union continue to rely heavily on coal-fired power but even nations like Poland, which in some ways is the Kentucky of Europe, are seeing change.[30]

[29] PPL Corporation. 2018 Sustainability Report.
[30] S&P Global Market Intelligence. A way back for onshore wind as Poland revises draft energy policy to 2040. November 2019.

U.S. Thermal Coal Exports, and Exports from the Illinois Basin

Exports from the Illinois Basin have surged over the past decade, rising to roughly one-third of all U.S. exports. Most of that volume is from mines in one state, Illinois.



Source: Energy Information Administration, Annual Coal Distribution Reports

An October report published by the Carbon Tracker Initiative showed how four of five coal-fired power plants in the EU are losing money.[31] The report put EU coal fleet losses at €6.6 billion (US$7.1 billion) in 2019 alone.

"Policymakers and investors should prepare to phase out coal by 2030 at the latest," Carbon Tracker concluded, and—indeed—financiers,[32] political leaders,[33] and even mining companies[34] continue to distance themselves from European coal-fired power.

In addition, competition from other thermal coal-exporting countries is increasing, and they may be better positioned than exporters in the Illinois Basin. For example, Platts recently reported that Colombian and Russian coal is more price competitive in European markets than Illinois Basin, Northern and Central Appalachian coal."[35]

Outside Europe, other countries that are big importers of U.S. thermal coal, including India, South Korea and Japan, are also accelerating their adoption of renewable power in an effort to both cut pollution and reduce dependence on imported energy. As demand for coal declines, it will be increasingly difficult to

[31] Carbon Tracker Initiative. Four in five EU coal plants unprofitable as renewables and gas power ahead. October 2019.
[32] BBC News. European Investment Bank drops fossil fuel funding. November 2019.
[33] Reuters. Worried by climate change, EU moves to end fossil fuel funding. November 2019.
[34] Bloomberg News: Another Big Mining Company Hints at a Coal-Free Future. November 2019.
[35] Platts Coal Trader. "Russian, Colombian competition continuing to slow thermal coal exports". December 2, 2019. p.8.

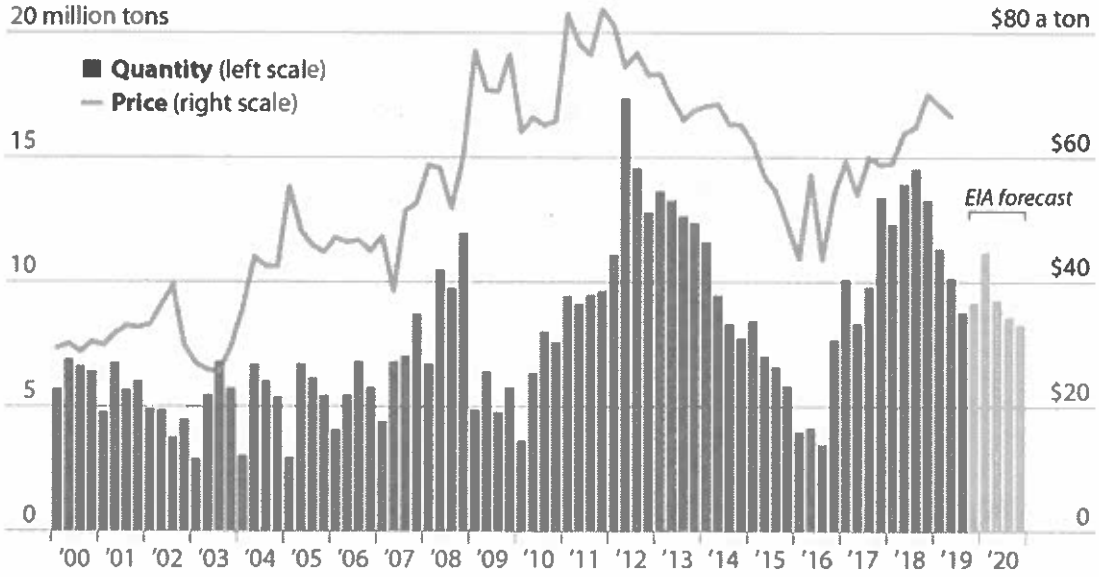
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sustain Illinois Basin exports.

All U.S. coal exports are highly dependent on international market prices, and volumes have waxed and waned with those price fluctuations, illustrating the fundamental volatility that defines the basin's export market.

U.S. Thermal Coal Exports, Quarterly

U.S. coal export volume has fluctuated considerably in recent years, but has tracked closely with market prices. Forecasts for the fouth quarter of 2019 and 2020 are from the EIA's November Short-Term Energy Outlook.



Source: Energy Information Administration

Conclusion

Structural and Permanent Decline; Opportunity in New Energy Models

The Illinois Basin's coal industry is entering a period of structural decline.

Within the next 20 years, virtually all of the U.S. coal-fired plants that currently buy the basin's coal will be either retired or little used, the result of an economic and technologically driven energy transition in the electric power industry that favors lower-cost and cleaner alternatives. In particular, wind, solar and battery storage—especially when combined—already offer utilities distinct advantages in grid resiliency, modernization and low maintenance, all with zero fuel expenses and declining construction costs. Inexpensive gas from hydraulic fracturing is also playing a major role in this transition, though the cost of renewables has already reached parity or undercut gas in many areas. No new American coal plants will be built.

As a result of this transition, a significant portion of the Illinois Basin's domestic power-plant customers now have dates for retirement within the next few years. IEEFA expects many more retirements beyond those over the next two decades. Further, coal consumption at existing power plants has begun to decline as they become less economically competitive, a trend that will accelerate as the difference in generation cost widens.

Growth in exports, which had masked declines in domestic demand until recently, appear to have peaked and turned lower. The same technology and market-based forces at work in the U.S. are at work as well in many of the basin's current or potential export markets, including Europe, India, Japan and South Korea, where utilities plan to cut coal use while increasing power generation from renewables. This will make it challenging for U.S. thermal coal exports over the long term. As demand in these markets starts to fall, international coal markets will likely be oversupplied, leading to intense price competition. The inherent volatility of the international export market, combined with permanently shrinking domestic demand and the generally weak financial condition of the coal-mining sector will necessarily lead to lower production and fewer companies (either from attrition or consolidation) operating in the region.

Twenty years from now, most of the Illinois Basin coal industry will be gone. While this may seem like a relatively far-off time, the economic impact from the constant drumbeat of coal-plant closures, mine closures and job losses will likely be significant in the region. Limiting the harm—and benefiting from the emerging economic opportunities—from this transition will require leadership, planning and support from federal, state and local officials.

And there are many real benefits, including long-term, non-agricultural income for farmers and counties from renewable power projects, lower electricity costs for individuals and businesses, economic activity from a regional buildout of renewables, improved power-grid resilience and construction and engineering jobs. Policymakers and communities that embrace this transition will be in the best position to gain a long-term advantage from these changes, and better able to offer lasting improvements that will be beneficial for everyone.

About IEEFA

The Institute for Energy Economics and Financial Analysis conducts research and analyses on financial and economic issues related to energy and the environment. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

About the Authors

Seth Feaster

Data Analyst Seth Feaster has 25 years of experience creating visual presentations of complex data at the New York Times and more recently at the Federal Reserve Bank of New York. Feaster specializes in working with financial and energy data. He lives in New York.

Karl Cates

Transition Policy Analyst Karl Cates has been an editor for Bloomberg LP and the New York Times and a consultant to the Treasury Department-sanctioned community development financial institution (CDFI) industry. He lives in Santa Fe, New Mexico.

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From: Shari Sweeney
To: EPA.PublicHearingCom
Subject: [External] NPDES IL0077666 and Notice No. 7516c
Date: Friday, January 17, 2020 10:03:06 AM

The Union County Democrat Central Committee Members are 100 percent against the Pond Creek Mine Pipeline to Big Muddy River The wastewater flow would have a daily rate of 2.7 to 3.5M to 3.5 million gallons daily and contain toxic chloride and sulfate that typically exceed allowed standards. The amount of water discharged would be equal to about 10% of the Big Muddy's Flow during the dry summer months.
Due to the following:
The effects of high concentrations of chlorides and sulfates on fish and other wildlife
Increased flooding in your area
The effects of sedimentation on wildlife, covering up fish eggs or insect larvae
Areas where you have seen erosion caused by flooding
Your concern about direct contact with the water because of chlorides and sulfates when you are fishing, canoeing or kayaking on the Big Muddy River
Effects on sensitive wildlife areas, such as LaRue Swamp
The effects on riparian vegetation –
What more need be said? Come on EPA protect our environment!
Shari Sweeney-Sadowski
Secretary Union County Democrats
365 Neely Rd
Anna, Il 62906
618-559-7393

--
Shari Sweeney-Sadowski
"That which you give to another will become your own sustenance; if you light a lamp for another, your own way will be lit." ~Nichiren

From: L Evans
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine proposal
Date: Friday, January 17, 2020 11:04:53 AM

Dear members of the EPA,

Southern Illinois has been about as perfect a place to grow up in as I could ask for. My family moved here in 2007, when I was four years old. Many of my favorite memories have to do with Southern Illinois' waterways--kayaking in Devil's Kitchen Lake, catching crawdads in the creek in Ferne Clyffe, swimming in Big Creek. As I get older, I'm learning that these places are valuable not only for their place in the hearts of many locals, but also for scientific and economic reasons. Southern Illinois is home to a Ramsar Wetland of International Importance, a flourishing tourism industry including a wine trail, and over 250,000 acres of national forest.

However, Southern Illinois is currently caught up in a tiresomely cliche story: a big company trying to profit off small town folks by misusing local resources. If this were a storybook and I a publisher, I wouldn't take the story because it's been overdone. Everyone knows how it goes and what's supposed to happen: the community should rise up, led by the children, and send the company packing (with, of course, a happy ending as the mine owners turn their resources towards clean energy and the miners can work in renewable energy fields).

Foresight Energy has applied for a permit to discharge more mine water from the Pond Creek Mine into Pond Creek and to run a pipeline over 12 miles to dump some directly into the Big Muddy, a beautiful river that's already struggling with pollution.
At the public hearing, I heard a representative from Williamson Energy claim that the water that the Pond Creek Mine proposes to dump into the Big Muddy is simply slightly brackish and salty water, because it's groundwater seepage rather than water from a treatment process. However, that is misleading. The West Virginia Geological Survey explains, "When coal is mined, fresh sulfur-bearing minerals in the coal and rocks are exposed to air and water. The resulting chemical reactions produce sulfuric acid and precipitates. The acid water flowing from coal mines, if not treated, can damage life forms in the receiving streams" (2017). The mine water is not, in fact, harmless, but will further pollute Pond Creek and the Big Muddy, damaging our natural resources and endangering aquatic life.

The sections of the Big Muddy and Pond Creek that would receive the extra mine water discharge are on the United States Environmental Protection Agency's 2016 and 2018 biannual list of impaired waters (p. 3, 40). Once a section of water is put on the list of impaired waters, additional pollutant loadings are not allowed until that section is removed from the list. Sections of water can be removed either because the pollution levels have subsided, or because a total maximum daily load for each pollutant has been approved by the EPA and put into practice (IEPA, 2014). I am concerned that these sections of the Big Muddy and Pond Creek will be removed from the list by statistical recalculations without significant change in the chemical content of the water. The current pollution level of the water needs to be addressed before we consider adding new point sources.

These proposed discharge sites will affect not only the immediate area, but everything downstream. For example, the LaRue swamp, listed as a priority resource by the Illinois

Department of Natural Resources (2019), is downstream from the current discharge sites and the proposed new ones. LaRue is listed for its "high diversity of reptiles and amphibians," certainly species that are affected by water quality. Although much research has been done on the LaRue area, it's a wonderfully rich habitat and there's still a lot of potential for new discoveries. It's imprudent to risk either the value that we already understand or the value we haven't yet discovered. Foresight Energy's financial savings are not worth jeopardizing areas and species that we haven't fully researched yet. The species in this area, and in all the downstream areas that will be affected, should be exhaustively mapped and understood before introducing potentially ecosystem-altering chemicals.

Freshwater mussels in the Big Muddy River have already been affected by pollution levels, as reported by concerned local citizens at the EPA hearing who have lived near the Big Muddy for decades and have noticed a decline in the population. The US Fish and Wildlife Service reports that freshwater mussels are "one of the most imperiled groups of animals in the world," and are "generally underrepresented in toxicity databases" (2019). In a study done on a similar species, fingernail clams, acute concentrations less than 150% of the allowed chloride limit were enough to kill half of the population of clams in 96 hours (Linton, 2008, p. 9). It has also been shown that the early development of native fish can be disturbed by high levels of sulfates (Wang et al. 2015a).

Many studies on aquatic life are done on daphnia and tubifex worms, tiny creatures that few non-biologists have heard of. In general, the studies show a level of sensitivity to pollution that should cause us to be very careful about the decision to dump pollutants (Wang et al., 2015b). Other tiny creatures that are critical to the food web have been shown to be negatively affected by higher levels of total dissolved solids (Timpano et al., 2010), such as would result from this proposed additional pollutant load. It can be difficult to care deeply about the well-being of water fleas, but these microscopic creatures are deeply enmeshed in the food web, supporting the bluegill, kingfishers, and other river life that we do know and love.

Pollutant limits ought to keep wildlife safe. However, based on the company's record, it's questionable at best whether Foresight Energy can be trusted to follow the limits set out in the proposed permit. In the last three years, Foresight Energy has violated the legal pollutant limits during five of the 12 quarters (US EPA 2019). Foresight Energy has been recorded discharging over 300% of the allowed chloride limit, an amount known to be detrimental, if not lethal, to aquatic life (Linton et al., 2008).

However, the effects of water pollution reach far beyond the health of the river. The beautiful natural areas of Southern Illinois are a reason for the growing importance of tourism in the region. Tourists come to enjoy the rivers flowing through our beautiful parks and national forest through canoeing and kayaking, hiking, and fishing. If we allow our waterways to become spoiled, we'll certainly incur losses in tourism.

Foresight Energy is pushing its costs onto the community. The costs of repairing or avoiding any environmental damage caused by the company should rightfully be part of its cost of operation. By taking a cheaper water disposal option and failing to cover the costs of treating the damage it causes, the company is forcing the community to bear its costs in the form of health costs, water treatment, and loss of beauty and health of the environment. If the company doesn't have the financial resources to cover its own costs, it should not be in operation.

This story is so cliche that were this a storybook, the next step in the chapter would be to call on the Secret Magical Forces of the river. Unfortunately, it seems that we may have to rely on the forces of common sense. Tourism is a growing part of the economy, and mining is a dying part. As a community, as a state, and as a nation, we must look ahead for the long term good. It is not profitable, advisable, or sensible to prop up a dying company with the resources belonging to the community. This is the world that I and my generation will inherit. We are counting on the Environmental Protection Agency to manage our natural resources for the long term.

Thank you for considering my comment.

Sincerely,

Laurel J. Evans
2114 Market Road
Marion, IL 62959

References:

Illinois Department of Natural Resources. (2019). Illinois wildlife action plan: LaRue-Pine Hills. Retrieved from https://www.dnr.illinois.gov/conservation/IWAP/Pages/LaRue-PineHills.aspx

Illinois Environmental Protection Agency. (2018). Illinois integrated water quality report and section 303(d) list - 2018, appendix A-2 [PDF document]. Retrieved from https://www2.illinois.gov/epa/Documents/iepa/water-quality/watershed-management/tmdls/2018/303d-list/appendix-a-2.pdf

Illinois Environmental Protection Agency. (2016). Illinois integrated water quality report and section 303(d) list - 2018, appendix A-2 [PDF document]. Retrieved from https://www2.illinois.gov/epa/Documents/iepa/water-quality/watershed-management/tmdls/2016/303-d-list/appendix-a2.pdf

Illinois Environmental Protection Agency Bureau of Water, Division of Water Pollution Control. (2019, July). NPDES permit no. IL0077666 notice no. 7516c [Fact sheet]. Retrieved from https://go.boarddocs.com/il/coc/Board.nsf/files/BETQJ6697CAC/$file/IEPA%20NPDES%20Public%20Notice%20-%20Fact%20Sheet%20-%20Williamson%20Energy%2C%20LLC%20-%202019-08-12.pdf

Illinois Environmental Protection Agency Bureau of Water, Watershed Management Section. (2014, November). The total maximum daily load (TDML) program in Illinois [PowerPoint slides]. Retrieved from https://www2.illinois.gov/epa/Documents/iepa/water-quality/watershed-management/tmdls/tmdl-presentation-2014.pdf

Linton, T., Tarr, C. D., Rickramanayake, N., Soucek, D. J., Dickinson, A.(2008, October). Acute toxicity of chloride to selected aquatic invertebrates [PDF document]. Retrieved from https://www.fwspubs.org/doi/suppl/10.3996/052013-JFWM-033/suppl_file/patnodere

ference+s5.pdf

Timpano, A. J., Schoenholtz, S. H., Zipper, C. E., Soucek, D. J. (2010). Isolating effects of total dissolved solids on aquatic life in central Appalachian coalfield streams [PDF document]. Retrieved from https://www.asmr.us/Portals/0/Documents/Conference-Proceedings/2010/1284-Timpano.pdf

US Environmental Protection Agency. (2019, September). Detailed Facility Report: Williamson Energy. Retrieved from https://echo.epa.gov/detailed-facility-report?fid=IL0077666

US Fish and Wildlife Service. (2019, May). America's mussels: Silent sentinels. Retrieved from https://www.fws.gov/midwest/Endangered/clams/mussels.html

Wang, N., Dorman, R. A.,, Ingersoll, C. G.,, Hardesty, D. K., Brumbaugh, W. G., Hammer, E. J., . . . Mount, D. R. (2015, December). Acute and chronic toxicity of sodium sulfate to four freshwater organisms in water-only exposures. Abstract retrieved from https://www.ncbi.nlm.nih.gov/pubmed/26139383

Wang, N., Ingersoll, C., Besser, J., Ivey, C., Kunz, J., Brumbaugh, B., . . . Soucek, D. (2015). Minimum data requirement for developing water quality criteria: use of toxicity data from under-represented organisms [PowerPoint slides]. Retrieved from https://www.epa.gov/sites/production/files/2016-01/documents/12_wang_-_revised_9-8-2015_secure.pdf

West Virginia Geological and Economic Survey. (2017, June). Sulfur in coal. Retrieved from http://www.intranet.gis.wv.gov/www/faq/sulfur.htm.

Exhibit 382 R03738

From: LeCrone, Darin
To: Lieberoff, Barb; Ward, Iwona
Subject: FW: [External] Pond Creek Mine
Date: Friday, January 17, 2020 1:17:39 PM

Darin E. LeCrone, P.E.
Manager, Industrial Unit, Permit Section
Division of Water Pollution Control
Illinois Environmental Protection Agency

Ph: 217/782-0610

From: Michael Durr <mikedurr1@gmail.com>
Sent: Friday, January 17, 2020 12:57 PM
To: LeCrone, Darin <Darin.LeCrone@Illinois.gov>
Subject: [External] Pond Creek Mine

Darin,

I am writing to object to the IEPA granting permission to Pond Creek Mine to pump mine wastewater into the Big Muddy River. Our farm of 355 A. and home are located along the banks of the Big Muddy River in Jackson County south of DeSoto and down river from the effluence point of the pipeline. Every year we are dealing with more flooding issues due to more levee building or heightening of existing levees. As I compose this email we have 30 + acres of farmland with winter wheat under water from the Big Muddy. I fear the additional millions of gallons the mine wishes to pump into the Big Muddy daily will have a devastating impact on our farm and eventually our home in two ways! First, the addition of millions of gallons of water will raise the level of an already flooded river resulting in more acres under water. Second, the salts of chlorides and sulfates will negatively impact the productivity of good farmland. The combination of these effects will be devastating! Additionally, the negative environmental impact on the ecology of the river will lead to loss of the recreational use of the river.

It seems your duty is to protect our environment. Please make the correct decision.

Please deny permission to Pond Creek Mine for this pipeline.

Thank you for your service and consideration of my request.
Regards,
Michael R. Durr, D.M.D.
864 Koonce Rd.
Murphysboro,
Illinois

Exhibit 383

From: Mary Ellen DeClue
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine IL0077666
Date: Friday, January 17, 2020 1:55:45 PM
Attachments: Pond Creek Mine IEPA 1-17-2020 .docx

Dear IEPA Members,

Please accept the attached letter as my comments for the proposed transport of coal mine waste water from Pond Creek Mine to the Big Muddy River.

Thank you for your assistance,

Mary Ellen DeClue

Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276
January 17, 2020

Sent via email: epa.publichearingcom@illinois.gov

RE: Pond Creek Mine IL0077666

Thank you for the opportunity to make comments on the transporting of coal mine wastewater from the Pond Creek Mine to the Big Muddy River.

I respectfully request that this proposal by Williamson Energy, LLC be denied due to the undoubted negative effects on the ecology and quality of water resources. The toxicity of coal and the unhealthy impacts of coal and products exposed to coal must be addressed.

Impacts to coalfield communities have been essentially ignored by IDNR and IEPA. Reading through responses of IDNR to the comments related to the construction of the pipeline, the same pattern of approving the request of the mine over the outcries of the surrounding communities was apparent.

Experiencing firsthand the construction of Deer Run Mine in Hillsboro, IL gave me a view of the imbalance of how coal mining regulations are applied to communities versus the coal industry. Coalfield communities are not protected from harmful health impacts or damage to their environment.

At the public hearings related to Permit 399, IDNR assured concerned citizens that their air and water would be overseen by IEPA and that there would be no violations of the Clean Water Act and the Clean Air Act. Permit 399 was approved with the coal processing plant next door to Hillsboro Hospital.

IEPA conducted public hearings on the NPDES permit for Deer Run Mine discharges. The mine discharges drained into Structure 5 that then passes through Central Park Creek. This creek was located between Hillsboro High School and Hillsboro Middle School as it progressed through the community. This exposure of mine waste to the youth and citizens in the area was disconcerting to all of us.

Through a FOIA request to the IEPA, I received the NPDES application that Hillsboro Energy, LLC (HEL) used to apply for the water permit necessary to mine coal. Basically, the form listed what organic and inorganic chemicals were "believed" to be present or involved in their operation. The chemicals that were checked had to be monitored for a certain time. The only toxic chemical that HEL indicated as being present was mercury.

We all know that coal has many other harmful chemicals including metals like arsenic, lead, cadmium, chromium, cobalt, selenium, etc. Most importantly, coal contains many polycyclic aromatic hydrocarbons that are mutagenic, teratogenic, and carcinogenic. The Agency for Toxic Substances and Disease Registry (ATSDR) published a list of the top 20 Hazardous Substances in 2001. Coal has 7 of the top 10 chemicals on the list that exist in all coal and coal by products.

There was no public hearing involved with the air permit for Deer Run Mine. In the air permit application to IEPA, HEL listed how much coal would be processed per year. With that information and a small fee, the construction air permit was granted to Deer Run Mine. A little later the construction permit became a lifetime air permit with no particulate restrictions or air monitoring.

Once Deer Run Mine was in operation, there was a major problem with coal dust permeating the area. The community signed 2 petitions to IEPA asking for air monitors in the community to determine what days were not safe for school children and health compromised individuals to be outside. The petitions for air monitors were turned down with the community still lacking any safe air monitoring in the area.

The pendulum to promote and subsidize coal must swing toward cleaner and safer energy sources. Communities are tired of the damaging impacts from coal mining and having regulatory agencies disregard the negative outcomes on their lives.

Please do not allow Pond Creek Mine to continue to abuse the environment and the Big Muddy River. The proposal by Williamson Energy, LLC must NOT be approved.

Sincerely yours,

Mary Ellen DeClue
366 Westlake Trail
Litchfield, IL 62056

jwdmed@consolidated.net

From: Cindy Skrukrud
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine
Date: Friday, January 17, 2020 2:50:30 PM
Attachments: Public Comments on Pond Creek Mine IL0077666.pdf

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Jan. 17, 2020

To: Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES

Hi Barb,

Sierra Club, Illinois Chapter collected comments from our members and other members of the public on the proposed renewal of the Pond Creek Mine's NPDES Permit IL0077666. We have compiled those comments into one document for you. The attached file contains responses from 132 people who signed on to our basic comment letter. Another 187 people added their own personal comments to the letter which we have listed individually with their name and town. Please let me know if you or any other staff have any questions about these comments.

Thanks!

Cindy

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photo

I work Monday-Wednesday so I will be slow to respond to emails on other days.
Please do not feel obligated to respond to email after hours or on weekends.

Cindy Skrukrud PhD
Clean Water Program Director
Illinois Chapter, Sierra Club
312.251.1680 x1015
cindy.skrukrud@sierraclub.org

Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land.
Luna Leopold, Hydrologist

SIERRA CLUB
ILLINOIS CHAPTER

January 17, 2020

Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P. O. Box 19276
Springfield, IL 62794-9276

Dear Ms. Lieberoff and other IEPA officials,

I ask you to deny Williamson Energy's proposal to pipe polluted water from the Pond Creek coal mine 12 ½ miles to the Big Muddy River and to increase their pollution to Pond Creek. The IEPA should deny the permit because:

1. Williamson Energy's proposal is not a benefit to the community at large who wish to see improved conditions in the Big Muddy River and Pond Creek, not an increase in pollution.
2. Increased salt levels in river water can increase the bio-available form of toxic mercury, harming aquatic life in the waterways.
3. Williamson Energy has not provided the proper water quality testing of their discharges and the receiving streams to justify their proposal to increase the pollution they discharge into waterways.
4. The Big Muddy floods. The potential impacts of an increase in salinity in the river's water on farms, private properties and natural areas including the Little Grand Canyon and LaRue Pine Hills have not been properly evaluated.

Thank you for this opportunity to comment on the proposed changes to the Clean Water Act permit held by Williamson Energy.

Signed:

Ann Stahlheber	*Alto Pass*	*James O'Donoghue*	*Carbondale*
Bobbi Rains	*Alto Pass*	*Eileen Troutt-Ervin*	*Carbondale*
Heather Barrow	*Anna*	*Karen Linduska*	*Carbondale*
Reece Barrow	*Anna*	*Gail Helton*	*Carbondale*
Jess Macy	*Anna*	*Stephanie Dukat*	*Carbondale*
Nicoll Earl	*Anna*	*Rachel Bozarth*	*Carbondale*
Matt Brooks	*Anna*	*Jean Todd*	*Carbondale*
Jamie Lundberg	*Aurora*	*Lia Driscoll*	*Carbondale*
Natalie Lohrberg	*Bloomington*	*Leila Kassim*	*Carbondale*
Genevieve Cyrs	*Caledonia*	*Nicholas Congiardo*	*Carbondale*
Sydney Hall	*Carbondale*	*Peggy Maggos*	*Carbondale*
Dorcy Prosser	*Carbondale*	*Jesse Maggos*	*Carbondale*

Bonnie Juul	*Carbondale*
Donna Koepsel	*Carbondale*
Rachel Cristaudo	*Carbondale*
Elizabeth Hughes	*Carbondale*
Robert Grimmer	*Carbondale*
Christopher Midden	*Carbondale*
Deborah Tate	*Carbondale*
Laura Van Abbema	*Carbondale*
Joek Wise	*Carbondale*
Lora Carlson	*Carmi*
Robert Mckenzie	*Carterville*
Joseph McCamish	*Carterville*
Amanda Pankau	*Champaign*
Charlotte Gano	*Charleston*
Holly Andrews	*Charleston*
James Sarelas	*Chicago*
Amy Johnson	*Chicago*
Lyman Welch	*Chicago*
Tony Fuller	*Chicago*
Joe Ulmer	*Chicago*
Christopher Harrison	*Christopher*
David Parrish	*Cobden*
Melanie Morrison	*Cobden*
Carol S Savini	*Cobden*
Norma Weaver	*Cobden*
Kim Harvel	*Cobden*
Jamie White	*Crainville*
Nancy Schietzelt	*Crystal Lake*
Melodie Huffman	*Danville*
Mitchell Ulrich	*Dongola*
Kathy Stanton	*Dowell*
Rita Clark	*Duquoin*
Todd Cisna	*Effingham*
Jeffrey Kotner	*Eldorado*
James Hinton	*Elgin*
Bob Adams	*Elkville*
Danielle O'Connell	*Energy*
Marty Monroe	*Fayetteville*
Jim Heflin	*Flora*
Mallory Crider	*Grand Tower*
Rose Cripps	*Grand Tower*
Lynne Galassi	*Herrin*
Kim Stone	*Highland Park*
Lucas Zuklic	*Homer Glen*
Jacqueline Norton	*Jacob*
Carla Harvel	*Jonesboro*
Sophie Twichell	*Lake Bluff*
Jes Weber	*Machesney Park*
Jeff Kammerer	*Machesney Park*
Patrick King	*Makanda*
Karen Baumann	*Makanda*
Marissa Godlewski	*Makanda*
Darren James	*Makanda*
Carla Tutt	*Makanda*
Ellen Ritter	*Marengo*
Neil Leach	*Marion*
Ray Liss	*Marion*
Jessica Rucker	*Marion*
Sara Goff	*Marion*
Quincy Gordon	*Marion*
Anne Basten	*McHenry*
Kelsey Kennedy	*Metropolis*
Jessica Darnell	*Metropolis*
Ginger Alvarez	*Metropolis*
Jeremy Taylor	*Montrose*
Don Ulrich	*Mt Vernon*
Mark Coats	*Mt Vernon*
Brian Wells	*Mt Vernon*
Kevin Lyerla	*Murphysboro*
P. Levous	*Murphysboro*
Christie Burgett	*Murphysboro*
Stacy Bunton	*Murphysboro*
Alaina Stone	*Murphysboro*
Kimberly Alexander	*Murphysboro*
Lida Burns	*Murphysboro*
Denise Brown	*Murphysboro*
Maggie Lewsader	*Murphysboro*
Cody Lennon	*Murphysboro*
Linda Herrold	*Murphysboro*
Cheryl Schmit	*Murphysboro*
Thomas Gordon	*Murphysboro*
Diana Sussman	*Murphysboro*
Meghann Shelato	*Murphysboro*
Micah Bennett	*Naperville*
Alexa Macy	*Olmsted*
Robin Nolting	*Pekin*
Julie Luner	*Peoria*
Brian Noe	*Plainfield*
Eric Morris	*Pomona*
Rhonda Rothrock	*Pomona*
James Willis	*Ridgway*
Julie Moller	*River Forest*

Eve Barrs	*Riverside*	*Eric Dirnbeck*	*West Frankfort*
Jennifer Alongi	*Riverton*	*Holly Reach*	*West Frankfort*
Maureen Linson	*Royalton*	*Elizabeth Burroughs*	*West Frankfort*
Sarah Wolf	*Springfield*	*Jeffrey Gahris*	*Wheaton*
Diane Stull	*Thompsonville*	*Joe Dick*	*Wheaton*
Brittany Rogers	*Tunnel Hill*	*Donna Pucciani*	*Wheaton*
Alice Englebretsen	*Urbana*	*Douglas Ower*	*Zion*
William Mills	*Vienna*		
Berna Gerard	*Vienna*		

These additional people signed the above comment letter and added their personal comments as follows:

Allowing this proposed dumping of waste water threatens our most important resource directly: water. Threatening the quality of our water puts everything we have at risk. Our region has only our beautiful land and waterways and rich wildlife as an asset; our rural land's agriculture is one of the few ways our citizens can profit financially in order to support our families. Our land and water is already stressed and threatened in so many ways; allowing this proposed dumping adds unacceptable insult to our lives, from which we may never recover. Allowing this will ultimately force our people out of their homes as we see life wither away from the damage it will cause. We have so few job opportunities here, we have only our way of lives which we have built on beautiful land with beautiful resources. This will rob us of our lives. Dumping this waste water will leave our region more impoverished, and likely diseased. Then where would we go? Away from here. Dont allow it
Rebecca King, Harrisburg

Why should they be able to dump their poisonous waste into a public river without doing anything to lean it up first? Floods of polluted water will impact natural areas, agricultural property, homeowners, and businesses along the Big Muddy River and in the watershed. It does not benefit the community-at-large. Instead it increases pollution in waterways used for boaters, paddlers, anglers, and hunters. High levels of salts can increase the availability of toxic mercury to aquatic life. 7 Million gallons per day of toxic pollution dumped into this river is completely unacceptable. They made the mess. Tell them to find some other place to dump it. It is a coal mine. Who needs coal these days? Shut down the mine and save the lives of the miners. This is a state subsidy to the fossil fuel industry. Don't do it!!
Richard Stuckey, Chicago

i was a pumper in old ben mine number 26 as such i pumped a lot of water out of the mine. it was very clear but if you left a brand new shovel in the water it would rust away in a couple of weeks .I was also a material man and hauled in barrels of oil every shift ..55gallon barrels as well as glue for roof bolts by the pallet .i also hauled solscenic fluid for the longwall mine system when the roof got bad sometimes i brought barrels of glue which was pumped into the roof to stabilize it . all i ever brought out was empty barrels.nothing else the rest of the chemicals were left underground
Richard Livingston, Carterville

Water is sacred because all life depends on it. It is our Civic and spiritual duty to protect it. It's also in our economic interest, because the natural beauty of Southern Illinois drawers tourist from all over, bringing much-needed Revenue to depressed areas. If the delicate ecosystem is thrown out of balance, no one will come hiking, or boating, or enjoy driving around the wine trail, or go ziplining. Please say no to this company, who is in constant violation of their current regulations and has built no trust with the people of this state that they will protect our aquifers.
Bridget Rose, Carbondale

This decision would ultimately cause long term effects that would be detrimental to the ecology of the big muddy river as well as surrounding natural areas throughout southern Illinois that this river feeds. By allowing this decision to past, you are making the decision to destroy natural areas that have been here much longer than any of us, and will continue to remain given that we don't allow this type of infliction, all for the progress and profit of an industry that has already been shown to lack sustainability and concern for the regions it resides.
Alec Ashby, Carterville

This issue matters to me because I manage a park system that has direct contact with the big muddy downstream. With us constantly getting flood waters in our public park additional, potentially polluted water is a huge concern. Also as we plan recreational activities such as kayaking and canoeing our participants' safety would have a new layer of concern we can't even calculate. I urge you to deny this application for a mine that has a relatively short lifespan asking to pollute the natural beauty and waters of our rivers that could generational effects.
Joe Fry, Murphysboro

No other entity, such as businesses and municipalities, are al,lowed to dump toxic materials into Waters of the State without thoroughly cleaning it first. Why should a coal company be exempt? Besides, the long-term environmental effects of coal mining and burning include a continued ramping up of greenhouse gases which increase the climate crisis. Coal companies are going bankrupt all over the Illinois basin. What guarantee do the people of Illinois have that Williamson Energy will not follow suite and leave us with yet another environmental cleanup?
Jan Thomas, Murphysboro

I am dismayed, to say the least, to find out about this action by IIDNR which is especially disconcerting because water quality issues are still being protested to the IEPA. The IEPA and IDNR are integral aides of the problems that will be caused by the Pond Creek mine proposal. There is no longer any reason of any kind to delay addressing problems caused by industries whose products are central to the problems of carbon pollution. This is a dilemma that we need to have solved by yesterday so today is certainly a time when we should act!
Edward Brunner, Carbondale

We own the Historic Douglass School in Murphysboro by the Big Muddy River and we are in the FEMA AE flood zone. I know mine says the amount of water will only raise the water an 1/8 of an inch, but I don't believe them. Do you? Plus why would I want the extra pollution on my property when the river floods and it will flood. It has every year. Last spring the water was in

our yard for 180 days. As I write this we are in other torrential rain storm. Please take your time and look at all the facts, better yet don't permit this pipeline.
Cam Smith, Murphysboro

This proposal to dump coal waste contaminants into the Big Muddy river is wrong on so many levels. It threatens to destroy aquatic life in the river and has the potential to endanger one of our most prized treasures, the natural environment of the Shawnee National Forest. We have seen increased flooding in our area in recent years. Floods of this polluted water will affect even more human and wildlife in our Southern Illinois homeland. I urge you to deny the request of Williamson energy to pollute our environment in this way.
Sherry Sullivan, Goreville

I am a geologist. You do not need me to tell you that poisoning our rivers will not only harm the natural ecosystem, but permeate to into groundwater reservoirs and potentially risk the health of thousands in the Southern Illinois area. The fact that this is even being debated is obscene. This situation is occurring because private coal companies have claimed natural resources as their own despite unified public interest in them, and have now found it profitable to risk public safety. Be ashamed.
David Szoke, Carbondale

As a former resident of southern Illinois I still find myself connected to the community and the land as it is a unique and beautiful place. My concern is the flooding of the Big Muddy and the reach of the contamination. Southern Illinois is home to such a diverse ecosystem. Something like dumping contaminated water in the largest flowering source of water wool certainly have a negative effect on that ecosystem. Please do not allow the dumping of waste in a place I still consider home.
Jaclyn Kern, Springfield

As somebody who has well water in a Northern county in Illinois, McLean specifically I find this devastating. I can't imagine having to worry about the water that my children and I drink. And even if I did want to move to another area with somebody else want to buy the house with tainted water. The state is a disaster I need to stop making decisions that help big business think about the people that elect you and pay taxes. Also think about the families and children this will impact.
Tracie Chamberlain, Arrowsmith

Do not allow Williamson Energy to discharge these toxic mine waste contaminants into the Big Muddy River, an Illinois river that flows through the Shawnee National Forest. a recreational destination beloved by my family and me, and many others. The high levels of chlorides and sulfates from the polluted wastewater will kill fish and other aquatic life and negatively impact the region's ability to offer residents and visitors a healthy environment in which to live, work, and play.
Susan Lannin, Chicago

Pollution from mines, agriculture (chemicals and siltation) and industry already negatively impact the Big Muddy River. Adding an additional 7 million gallons of heavily polluted mine waste per day is unacceptable. As a state we should be focused on improving our waters that the

benefit of the people and wildlife that depend upon clean water, not on satisfying the self-serving needs of one corporation. Please deny Williamson Energy's proposal to pollute the Big Muddy River.
Theresa Treacy, Petersburg

I walk my dog every single day at Riverside Park. The Big Muddy is now overflowing its banks. How can it even be a possibility to dump toxic chemicals into this waterway, increasing the spread of the pollution? Do the right thing and not allow this to happen. As a side note - what kind of piping system will not be corroded by the chemicals over time? Not only the Big Muddy will be polluted, but the 12 1/2 miles of land to get to the river risks becoming polluted too.
Shirley Krienert, Murphysboro

5. Because this is the 21st century. Have we not learned that polluting our waters is bad for people, planet and progress? 6. Who does this benefit other than Williamson Energy? 7. We, as a human race, are smarter than this! There are alternatives! Please, PLEASE. It is time to respect our planet, not continue to damage it for the benefit of the few; for the benefit of a faceless corporation while residents suffer the consequences.
Sincerely,
Celeste Longbucco, Champaign

There is no possible justification for approving this pipeline, which would dump millions of toxic mine waste water into the Big Muddy daily. There is even less justification given the failure of the IEPA to collect all the data necessary for a full vetting of the impactTs of the proposed pipeline and also given the highly questionable financial status of Williamson Energy LLC, owned by Murray, which recently declared bankruptcy.
Lynn Winston, Carbondale

Williamson Energy has a horrible track record with regards to polluting the environment. They will take advantage of any ability to dump into the waterways and abuse it. Allowing this would be the kiss of death to our local waterways affecting flora and fauna in innumerable ways. We depend on fishing, hunting and clean water for human health as well. Please do not allow this to devestate our area in so many ways. Thank you.
Jon Womack, Pomona

I lam a monitor for the Illinois Butterfly Network and my transect runs along the Snake Road adjacent to the river. This is a high quality area that is home to many songbirds as well as butterflies, dragonflies, and other indicators of high quality habitat. I also regularly paddle the Big Muddy and have brought Boy Scout groups to hike and paddle in this area. This high quality area needs protection not pollution.
Mary McCarthy, Murphysboro

I already sent in comments but have another question. Is there a regulation requiring discharge pipelines to be a certain distance from each other? This was not addressed I don't think in the draft permit. Sugar camp mine discharge, I believe, is less than fifteen miles away, closer to 12

from proposed pond Creek pipeline. If there is indeed a regulation what is the accepted distance between two discharges?
Lucia Amorelli, Carbondale

Do not dump polluted wastewater into Big Muddy River. This wastewater does not benefit the community at large. This wastewater increases pollution in waterways used by boaters, paddlers and fishermen. The high levels of salt are toxic to aquatic life. Floods from polluted water impact us ALL. We are all down stream! I am against Pond Creek coal mine dumping their polluted wastewater into Big Muddy River!
Kathryn Jenkel, Carbondale

In a time where we are at the very cusp of a catastrophic climate crisis, it is astounding that any institution would even consider allowing companies to further pollute the environment. Enough is enough. We need to be reversing damage, not adding more. We need to protect our community instead of bowing down to corporations again and again. Please, fight this with us. Be on the right side of history.
Rachel Brenningmeyer, Goreville

As a resident and outdoor enthusiast I see only degradation as an effect of this project. Our economy will not benefit nor the ecological diversity that does encourage tourism and sporting in our area. Corporations do not need our protection and allowances; they are taking advantage of our uneducated population and lack of political involvement. Please advise considering the community's input.
Trisha Morelli, Makanda

I have lived in southern Illinois for over 5 decades and during everyone of those I have hiked, camped, biked and kayaked the area...especially the Big Muddy River. Early morning trips are especially rewarding with viewing many wildlife, having baby wood ducks follow your craft, a lone coyote at the edge of the bank treating himself to a drink. This can all change in a short time. It is WRONG!
Michael Scott, Goreville

We know only too well how heavy rains, such as we had this past weekend, quickly result in the Big Muddy overflowing its banks. The same is true of the tributary streams that flow into it. All of this drainage area is potentially at risk if Williamson Energy is permitted to discharge pollutants into the river. Please live up to your name and protect our environment. Sincerely,
Roland Person, Carbondale

Please say no to this proposal. The flood impact itself is hard enough. With more pollutants in the water it will make our already devastating flooding problem worse. Please don't make ya the next Flint, Michigan. Think of the residents that are stuck dealing with the repercussions of your decisions. A mom of 3 with one already in heaven. Please don't risk the health of my rainbow babies.
Christina Chancey, Murphysboro

Yet another reason this permit should be denied is because this is another example of dumping toxic waste where it will negatively affect some minority families and poor families as many of the residents along the Big Muddy fit into those categories. It's time we stop victimizing those who cannot speak up for themselves or who might be unaware of the danger they are being threatened with.
Rhonda Rothrock, Pomona

This dumping will poison waters in an area prone to flooding. Poisoning the water is unacceptable. Poisoning the water where there is a high likelihood flooding will spread the toxins in ways no one can accurately predict is even worse. Coal companies have a pattern of declaring bankruptcy and leaving the clean-up for taxpayers. There are no acceptable reasons to allow this dumping.
Jill Skinner, Cobden

Do not allow the mine to dump polluted wastewater into the Big Muddy River. This will disrupt the watershed and floodplain. Salt and pollutants from the waste water will change the delicate balance of freshwater communities and decrease the abundance and biodiversity of the area. In flooding events, local homeowners, farms and businesses should not need to worry about their health.
Kimberly Rohling, Marion

As a 35 year resident of the area I find it appalling that the State of Illinois would even consider this proposal that would ONLY benefit a profit making corporation and pollute our precious watershed for generations. My children and their children deserve a better solution! Do not allow this apocalyptic proposal to proceed!
Malcolm Robertson, Carbondale

As a citizen of Illinois, I say enough with rampant pollution that puts the lives of Illinois citizens at risk. People's lives are at risk. As a polluter, you are destroying ecosystems, communities, aquatic life, agricultural land, property values, and businesses. This will lead to nothing but devastation. Accountability is essential! Time is of the essence!
Nicole Saulsberry, Springfield

Although I now live in Springfield, most of my family and friends still live in southern Illinois. I was born and lived, worked, camped, hiked, fished, rode, and enjoyed every square foot of the BM floodplain. My family began in Zeigler and Macedonia. I plan on returning upon retirement. Please don't allow this pipeline and the pollution of this river.
Jason Kern, Springfield

Any polluted water must be completely treated before discharging into any stream, river, lake or pond. Anything less than this is completely unacceptable. While the location of this request does not directly affect m, I am concerned that if approved, it will be used through out the state to justify similar requests.
James McGrath, Barrington

I don't want to drink or use nasty water for the rest of my life because you sellouts want to make a quick dollar! Disgusting! What about our children? Can't you do this in a way that doesn't destroy our environment? If you can't, then we don't want your business here in Illinois, or this continent for that matter!
Steven Bozarth, Carbondale

My mom lives near the Big Muddy in Grand Tower. When it floods, AND IT WILL FLOOD, the polluted water will cause hazardous conditions for the people, and animals in the area. This polluted water will make its way to the Mississippi. Please deny this pipeline, it's not just the Big Muddy that will be affected.
Johnna Russell, Anna

We should not further pollute our environment, affecting not only the health of the aquatic creatures but also the health of humans who come in contact with this waterway. Furthermore, we should not require the future payments of millions/billions of dollars to clean up the damage incurred in this action.
Anna Morris, Carterville

What Williamson Energy is proposing is totally irresponsible! They apparently care little for the environment and its inhabitants that rely on the ecosystem they are proposing to foul! Send the message to them to step up and become part of the solution to be caretakers of our precious resources and world!
Marsha Bockmann, Stonefort

Southern Illinois depends on tourism. I addition to the reasons listed above adding additional potential toxins to the Big Muddy (and eventually Mississippi) systems can never have a beneficial effect in this area. Please look at this decision in long term rather than short term consequence. Thank you.
Anthony y Gerard, Vienna

Water is a human right, adding known pollutants to our waterways has always eventually come back to bite us- and really to disadvantage local communities who rely on that water table for survival. Companies who cause this pollution should be the ones bearing the burden of their waste not the community.
Mel Whitehouse, Chicago

Helens Ford crosses the Big Muddy in Franklin Co. My sister owns that property. We have spent the last 48 years on the river fishing, camping and enjoying it. Contaminating that water is wrong and will break our hearts and our children and grandchildren. Please think about your decision. Thank you
Melody Gulley, Buckner

My child is fighting brain cancer right now. Let's NOT dump more junk into our water which may have unknown consequences like this. Let your children eat from these waste waters if you

want, but nobody in their right mind would be comfortable with this. I'm ashamed this is even being considered.
Elizabeth Mckinney, Vergennes

I am very Against The Dumping of this polluted water into the Big Muddy River. My home currently is on a private well not very far from the river. This would mean a significant increase for me every year financially in that i will need to have pollution levels checked with in my drinking water.
Laura Herzog, Pomona

Can I dump my garbage in the street? Look---there is no such place as "away"--every disposal affects nature and biology. Believe it or not, you are part of nature. Respect the others. We are already "knee deep in the Big Muddy" with Trump---don't be another "big fool (who) said to push on."
Margaret Glaser, Chicago

When will the Environmental Protection Agency actually stand up and protect the environment? At a minimum, pretreatment procedures should be required to remove much of the salts and pollution from the water prior to discharge. The Big Muddy River should not be a dumping ground for mining.
Natalie Neuman, Glenwood

We are seriously blessed in southern IL to have clean and abundant aquifers, when we watch the western states struggle with water shortages. Why would contaminating our water sources even be an option. Say absolutely NO to allowing a commercial mining company to destroy our environment!!
Erin Downs, Cobden

Williamson Energy has NOT earned the public trust required to allow this. Their record is dismal. Short-term profits for a few should not trump clean water for people and wildlife. They will simply declare bankruptcy and walk away. Please at least DELAY this request, if not DENY it.
Kathleen Carl, Makanda

It's time we stand up to companies, municipalities that are only looking at money and not anticipating the long term effects that filling the Big Muddy would have on fish, wildlife, as well people that use that water. Yes, some still do. Please, help us fight against this atrocity!
Lisa Childers, Carbondale

Please do not contaminate our water. There must be a different way to get rid of the waste. As of now I will not eat fish and I am telling my friends and family to not eat fish or any marine life. It is not safe. Cancer is at an all time high and we cant ignore the causes of it.
Melissa Waun, Jonesboro

Please do not jeopardize the community, we rely on you to stand up for our safety and our environmental concerns. This company needs to find alternative collection and treatment processes for it's waste. Releasing it into the community rivers is not an acceptable option .
Dawn Kwiatkowski, Woodridge

It's sickening to hear that dumping polluted water would even be voted upon. The safety and health of my three children and all the children in this region should be at top priority. Coal mining is not the future, our environment and children are. Do the right thing.
Ashley DeVillez, West Frankfort

These areas have been damaged enough. The public should not have to pay the environmental cost for such pollution! Nor should the public pay anymore than they already have for the environmental and health costs. The stakeholders should eat all the costs. Every cent.
Kathryn Kinder, Grayslake

Please do not allow Williamson Energy to pollute the Big Muddy River. The river is used for recreation and provides water for wildlife all along its shores.Rather than pollute the river and Pond Creek why can't the waste water be dumped into abandoned mine shafts?
Beverly Mason, Newton

The Shawnee National Forest and other natural areas are critically important to southern Illinois. The extraordinary natural splendor is what keeps me here, even though I could make a lot more money elsewhere. Please help protect the Big Muddy River and Pond Creek.
Joshua Vossler, Carbondale

I fear for the lives of the human beings that live near The Big Muddy, as well as the animals. Its a chain reaction by poisoning one thing. Please be considerate and think about future generations and what they will have to live with. Sincerely,
Sarah Smith, Argenta

It is past time for the energy industry to look at the after effects of production in coal, gas and nuclear waste products. Time to draw the line and look at clean energy! The Big Muddy flows through such a big stretch of land. Do not pollute our backyard!
Barbara Rester, Carbondale

the solution to pollution is NOT dilution. The people in Southern Illinois do not pack up and move away like the miners after they have finished mining and polluting. The Big Muddy deserves to remain free from the prospect of contamination forever.
Ruth Schroeder, Hillsboro

We have to protect the natural beauty & environmental diversity of our region! The coal industry should not call the shots. Those workers should be retrained so we can shut down the coal industry as much as possible & protect our waterways. Thanks!
Craig Wilson, Carbondale

I have grown up on the big muddy river fishing for catfish and duck hunting and expect my kids to do the same. Please stop greedy companies and/or anyone from polluting this waterway. If it's not an improvement to the quality it shouldn't be done.
Dan Pestka, Carterville

The Big Muddy River is an important part of southern Illinois. My family lives within a stone's throw of it, we fish in it, camp on its banks and enjoy the beautiful scenery on boat rides. Tell the coal company to dump their sh** somewhere else!!!
Patricia Barone, Rockwood

Here in Farmersville, we deal with the impact of the mines daily and for the rest of our lives. Our water, land and environment has been changed forever. Water is life and very few, if any places have clean uncontaminated water. WATER IS LIFE!
Kelly Robbins, Farmersville

Thousands of local residents and countless more people visit Southern Illinois to experience nature and recreate. We value our natural resources and want to protect them. We need to break the cycle of fossil fuel dependence, not enable it.
Tharran Hobson, Murphysboro

Please don't destroy our water ways and environment by dumping this poison in our water. This river floods into the lake I live at and I don't want it to kill the fish and wildlife in our area and other areas it will affect. Thank you.
Ranae Irvin, Mulkeytown

This issue matters to me in Central Illinois because this mine has a history of lack of compliance with regulations and is harming what are public resources, risking public health and the environment for all creatures who depend on it.
Joyce Blumenshine, Peoria

Recreation contributes to personal well-being. It is important for a community to have recreation opportunities that appeal to a wide diversity of interests. Clean waters contribute to healthier individuals and a healthier economy.
Susan Murray, Godfrey

I attended that hearing. We in Southern Illinois do not want pollution, cancer causing chemicals or other bad things to happen in our area. The owners of the mine have had other safety violations. Do not allow a permit for this.
Carla Womack, Pomona

There is no acceptable dumping of chemicals - it will harm the ecosystem and our quality of life - this is management and laziness- if you can't handle the process of mining then figure it out but dumping is not acceptable-
Danielle Taylor, Dongola

I visit this beautiful area of our state every year. I hope degradation of the area from such acts against nature don't stop me and scores of others from visiting and contributing to the local economy in the future.
Athena Hubert, Pontoon Beach

Coal is a fuel that endangers the planet and our very existence. Our resources should be directed at developing clean energy alternatives that will gradually reverse global warming. The permit should be denied.
Hal Ensor, Murphysboro

Please do not pass this polluting exemption. The area to be impacted are extremely unique habitats. I have hiked LaRue Pine Hills on a reptile & amphibian tour. It is an amazing place and needs to be preserved.
Claire Entas, DeKalb

Allowing Williamson Energy to dispose of their wastewater in the Big Muddy River is a tragic act of government bowing down to the very industries that are decimating our communities and our natural resources.
Amelia Estrich, Chicago

We suffer enough from the climate changes in this country. Please don't add to the pollution and climate issues. We live in a beautiful area in our state. Please don't help destroy this beauty and wildlife
Nancy Reach, Marion

Clean water is one of the most important things on earth. We don't need salts and toxins in our clean water. The pollutants will harm local agriculture and the health of citizens who live in Southern IL.
Robert Jorgensen, East Peoria

You know the only right thing to do is stop any effort to pipe polluted water into the Creek. Do the right thing. It will feel good and it will be so much more comfortable looking yourself in the mirror.
Kathleen Van Kampen, Palos Park

Please do not destroy the Big Muddy by allowing this to happen. People in my community depend upon fish from that river to provide food for their families and quality time outdoors with their children.
Shannon Clapsaddle, Cobden

I live in the Shawnee National Forest and want to protect it from pollution. Please don't allow this company to kill our aquatic life and destroy the natural balance of our beautiful river. Thank you.
Kate Zager, Cobden

I've lived by the big muddy river my whole life. I dont want to see my hometown and other towns affected negatively from waste being dumped into the big muddy river. Please stop this from happening.
Lacey Randall, Murphysboro

I have lived in southern Illinois all my life.. I do not want the water ways to be polluted by waste from mining. Clear creek is a run off of the big muddy.. please stop this hurt to the earth.
Catrina Craver, McClure

We must stop polluting our waterways and seek clean energy alternatives. The CEJA provides job training and future employment opportunities to assist workers displaced from dirty energy jobs.
Jan Mangers, Aurora

Jeopardizing the health and safety of the community members and environment is unacceptable! Deny Williamson Energy permission to run waste of any kind into or near the Big Muddy River.
Lisa Bustos, Murphysboro

I live very close to this river and it's very special to us. All the plants and animals that live on the river are special. They are already at risk for the pollution already dumped.
Theresa Nelson, Murphysboro

I will be spreading the word about this cause to my friends in southern Illinois, but also those with local roots who live in other areas of the state, the country and the world.
Susan Drone-Prickett, Carbondale

Whether Lake Michigan or Big Muddy, water in Illinois is an asset too valuable to contaminate or waste. The permit should be revoked or conditioned to comply with good practices.
David Bryant, LaGrange

Please don't allow our rivers and streams to be polluted. Those chemicals will poison everything they touch and kill animals, likely including threatened and endangered species.
Elisabeth Turner, Galatia

Southern Illinois is beautiful and fun, it's a wonderful respite from polluted Chicago. For God's sake don't allow an important natural water source to be polluted.
Sarah Fiola, Chicago

Southern Illinois is a gem that shouldn't be ruined by high sulfur coal from Illinois. So you ruin the area taking it out and then pollute the skis burning it. makes no sense.
Brad Grey, Glen Ellyn

Disappointment again over the lack of compassion of compassion... Please do your part to ensure the future planet we are leaving to our children has been loved and cared for!
Jennifer Johnson, Ozark

And as 1-14-20 foresight energy, the parent company of Williamson energy, stacks are tanking at .06 per share. I wouldn't want to invest in such a loser company. Would you?
Karen Fiorino, Makanda

I have fond memories of vacations and holidays spent down on the big muddy, please do not let mining destroy our beautiful Illinois ecosystems and wilderness territory.
Max Lewis, Park Ridge

The Big Muddy is ONE property from my house. The Bald Eagles who nest here cannot be exposed to these chemicals (much less all of the other 100s of species present)!!
Liz Robinson, Murphysboro

Please do not allow this to happen. I am very concerned about the pollution to the River & our water resources and flooding of the river downstream. Thank you.
Tess Ford, De Soto

I live less than 1/4 mile from the Big Muddy, and rely on it for recreation. Allowing these discharges will greatly negatively impact the quality of this waterway.
James Ricks, Murphysboro

I am pro coal. But I'm not for this. There is no good reason to dump in a river for everyone to have to deal with. You handle your own waste and issues from it.
Crystal Keigley, Dowell

As an Ecologist working in southern Illinois, I've seen the damage from poor environmental policies firsthand. Please protect our water by denying this permit.
Chris Benda, Makanda

Please protect the beauty and quality of natural resources in Southern Illinois. I appeal for the sake of my five grandchildren. Sincerely,
Joanna Christopher, Gorham

Hi, although I'm sorry the miners will have to find other work, I am strongly OPPOSED to allowing this waste to be discharged into the Big Muddy. Thank you.
Amelia Robinson, Carbondale

I enjoyed the waterways of southern IL as a child and I'd like to protect them, as well as downstream areas for my children and their children to enjoy.
Victoria Goessling, Waterloo

are you all crazy? dumping dirty waste water into our protected areas and water sources. your grandkids are all doing to die from cancer at young ages.
Wil Maring, Cobden

Southern Illinois is important and waste dumping is not the answer. If we dilute our natural resources we will destroy our much needed eco systems.
Lori Kenniker, Christopher

Illinois EPA should not allow this burden of pollution to be carried by the public. Pond Creek Coal Mine should clean up its mess or stop mining.
Linda Sullivan, Lombard

My home is near this river and we've survived three 50 year floods in the last 10 years - the waterways can't support this business's waste.
Jennifer Haselhorst, Murphysboro

No more polluting! We have to learn how to protect, maintain, and improve our natural resources for all wildlife and our future generations.
Moira sims, Creal Springs

The flooding in Jackson County concerns me the most. Spreading pollutants onto the land and then into the air, our lungs and our food.
Michael Wagner, Carbondale

What a terrible, selfish, greedy action to take. You don't care to poison people, the Earth and her inhabitants. This is disgraceful!
Tami Hottes, Pinckneyville

Why would this be ok? Because you can't afford to pay to have the water treated before discharging it? This is absolutely ridiculous!
Heather Craver, Carbondale

As a resident of Murphysboro, IL, I have seen the flooding. It would be wrong for the coal company to jeopardize fragile ecosystems.
Cindy Parrone, Murphysboro

Please don't allow this. Think of all the harm it will do to the ecosystem. We are counting on you to protect our natural resources.
Amber Boulton, Murphysboro

This river already has to many pesticides that run off into it. Quit destroying everything south of Chicago with all the pollution
Blaine Bunton, Duquoin

As if the environment is not under enough assault! Can we please for just one moment think of the impact on our children's lives!
Debby Towne, Energy

Water is life. This proposal threatens our water quality and resources. Please say no to Pond Creek coal mine pipe line proposal.
Heather Horsley, West Chicago

My kids and I live in this area and play in this water. There HAS to be an alternative to dumping waste into our water system.
Jessie Warner, Cobden

We cannot continue to pollite our waters. For the people, the environment, the animals. Take care of your business cleanly.
Roger Palmer, Mt Vernon

Clean water is critical to our existence. Please help stop this and understand how important this is to protect this land.
Milisa Parrish, Chicago

No more pollution in this watershed! As an organic grower, no more destruction of our watershed & recreational locations.
Kathryn Ward, Carbondale

I live downstream of the big muddy River, I don't want this poison to get in to the aquifer. My house uses well water.
Chris Ortolano, Carbondale

You are going to kill the ecosystem !!! How would you like this kind of waste going into your home and drinking water?
Ric Thalman, Carbondale

I went to college at SIU. The forest and biodiversity is what makes southern Illinois unique. Please don't ruin that.
Katherine Pultorak, Rockford

How would you like it if you had a Riverside house near where they plan to dump? Please deny the mine's request.
Ross Bauer, Carbondale

This is so alarming! Please help our environment! Our legacy should be to help the environment not destroy it!!
Mickey Finch, Anna

We are made out of water. We need fresh water to survive and so do fish and other animals. Clean water for all.
Susan Livingston, Carbondale

No more polluting and dumping in rural areas where it affects agriculture, drinking water and so much more!
Joan Listen, Carbondale

This mine is directly behind my property and I don't want your pollution in my ground water and water ways
Roger Mull, West Frankfort

The people working in the mines are exposed to toxins, and the mine has already outgrown its usefulness.
Dorothy McDaniel, Carbondale

My property goes to the edge of the Big Muddy. Please protect my beautiful river from chemical damage!
Joan Bishop Murphysboro

Do not allow this to happen. It will destroy a fishery that has fish up to one hundred years old..
Walter Ridgeway, Pinckneyville

Southern Illinois is an amazing and beautiful place, but it won't be if we don't take care of it.
Jennifer Kennedy, Pomona

Deny making our water, land, air a dumping ground. More people will leave IL if turn it trashier
Kris Flint, Mt Vernon

You say it's safe but why take the chance? The Big Muddy is too beautiful to risk it! Please no!
Ellen Meinhardt, Springfield

This is heartbreaking. No waste should be dumped into waterways. We must protect wildlife.
Lily Robinson, Anna

Please protect the purity of our rivers and streams. Future generations will be thankful.
Michael Horsley, West Chicago

Stop corporations from destroying our environment. This is unacceptable and disgusting!
Jennifer Miller, Mattoon

This is a growing community of families, please think of the future of this community.
Judith Jones, De Soto

We do not need more toxins in the waters, nor in the public use areas. Please vote no!
Phillip North, Jonesboro

PLEASE DENY THE PROPOSAL!!! This is way too harmful and awful to even think of doing
Hallie Lundberg, Alto Pass

Simply ridiculous. They can drill a well 5000' deep and dispose of the water safely.
Kris Mason, Flora

Please don't let money mean more than the health of citizens and the environment!
Aleska Hagan, De Soto

Pond creek mine waste released into the Big Muddy River will ruin our community.
Rachel Ensor, Murphysboro

We should be moving away from coal, not letting this company pollute our waters.
Mark Giardina, Chicago

I do not want to see another river ruined in our State Thank you
Linda A Cole, Aurora

Please push forward with some other resolution to this disagreeable decision.
Shannon Sweetin, West Frankfort

We, the citizens of Illinois, are counting on you to protect our environment.
Jane Ward, Peoria

It is time to hold polluters accountable, not to ease their polluting ways.
Mike Dudley, Harrisburg

It matters to me because, bio life means alot & it's harming aquatic life!
Tiffany Fairless, Tunnel hill

Please for the sake of our children's future and this planet's. Thank you,
Laura Eriks, Carterville

This has to stop! Clean water is a neccesity we can't live without it!
Sherma Boner, Jonesboro

This is a big mistake. Help keep Southern Illinois beautiful and SAFE!
Michelle Stokes, Carbondale

I live close to the Big Muddy and am asking your help in this matter.
Brynn Freed, Murphysboro

I'm a nature lover. I do not want this danger for me or my children!!
Deanna Tate, Jonesboro

Please deny the proposal. It is so very vital that this not happen...
Deborah Nash, Cobden

No one should ever be allowed to dump harmful toxins into waterways!
Kary Brenton, Edwardsville

We experience flooding regularly. This will only add to the problem.
Helen Cox, Virgennes

This issue matters to me because the health of the earth matters!
Elnora Maggos, Carbondale

Please do not let them poison our water. Our future is at stake.
Shannon Griffin, Carbondale

Protect our water resources from harmful coal mine waste water.
Mary Ellen DeClue, Litchfield

Have We not made a BIG enough mess of the Environment already
John Kennedy, Batavia

Please don't make my kids swim in even heavier polluted water!
Alycia Stephenson, De Soto

Please help keep our water source safe for our kids. Thank you,
Stephanie McCarty, Harrisburg

Dumping your bi-product downstream is not responsible policy.
Orlan Brown, Murphysboro

WE all know better than to let this pipeline be installed!
Daniel Huntsha, Rolling Meadows

EPA protect the quality of the Big Muddy and Pond Creek!
Shari Sweeney-Sadowski, Anna

Please, save the Bug Muddy. Do the right thing here.
Adam Stenhaug, Alton

This doesn't need to take place on so many reasons
Margie Dailey, Cobden

Humans have done enough damage to our waterways.
Tonya Browning, Anna

For obvious reasons please deny this pipeline.
Kelsie Smith, Goreville

My children deserve better than a poison river
Temetra Gibson, Herrin

This is such a bad idea. Totally unacceptable.
Ginny Lee, Springfield

Absolutely not, we do not want or need this
Rachel Bozarth, Carbondale

Please save our enviroment for our children
Laura Sperstad, Joliet

I want clean water. I need clean water.
Rose Hogan, Cobden

Please protect the Big Muddy River !
Mark Sanders, Royalton

Please don't pollute the Big Muddy!
Darla Judd, Bush

Polluting our water is unexceptable
Ruth Hoak, Makanda

I support saving the muddy river
April Elliott, Anna

Please SAVE our water resources.
Annette Jaynes, Murphysboro

People matter more than profit.
Ellen Wolcott, Charleston

STOP the Pollution NOW, Please!
Patricia Preston, Carbondale

Protect us, don't infect us!
Wendy Garner, DuQuoin

Have a conscious! Please!
Barbara Burke, Monee

Stop ruining our planet!
Kimberly Mott, West Frankfort

Please have some sense.
Braden Fritsche, Carbondale

PLEASE SAVE OUR WATER!
Jennifer McSparin, Carbondale

Stop killing earth!!
Marta Ayala, Bensenville

It's never too late
Mark Denzer, Carbondale

stop the pollution!
Abby Nickens, Du Quoin

Stop this madness!
Lance Jack, Carbondale

Thank you.
Selena Sasser, Marion

Stop this
Judi Holcomb, Rockwood

From: Laurel Toussaint
To: EPA.PublicHearingCom; LeCrone, Darin
Subject: [External] Written Comments for Pond Creek Mine NPDES Permit No. IL0077666
Date: Friday, January 17, 2020 3:18:19 PM

01/16/2020

Written Comments for Pond Creek Mine NPDES Permit No. IL0077666

To:
Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES
Illinois Environmental Protection Agency
1021 N. Grand Ave. East
P.O. Box 19276
Springfield, IL 62794-9276
epa.publichearingcom@illinois.gov
darin.lecrone@illinois.gov

From:
LaurelToussaint
10 Pinewood Drive
Carbondale, IL 62901
618-924-2454
laureltous@hotmail.com

I am submitting comments for Pond Creek Mine NPDES Permit No. IL0077666, specifically regarding the portion of the permit concerning Outfall #011 which would allow significant amounts of mine wastewater to be pumped into the Big Muddy River. For the reasons included in these comments, other evidence submitted at the December hearing in Marion, and the inability of the applicant to adequately respond to many crucial questions, I am asking that IEPA to reject this permit.

I have lived in Southern Illinois for 40 years. I am a retired nurse, who is concerned about the health of area residents. I have seen first hand, the impact of coal mining on the health of area residents. I am a hiker and birder in our extensive public lands, both State and Federally owned. I canoe area rivers (including the Big Muddy), swamps and lakes.. Southern Illinois is my chosen home because its natural beauty and rich biodiversity. I belong to several environmental organizations and work with fellow members to protect area natural resources. I am aLife member of Sierra Club , holding leadership positions, over several decades. I am also a member to Prairie Rivers Network. I support the comments submitted to IEPA regarding Pond Creek NPDES Permit No. IL0077666 by Sierra Club Illinois Chapter and Prairie Rivers Network.

I live a few blocks from Little Crab Orchard Creek, a major tributary of the Big Muddy. I walk along Little Crab Orchard at least once a week. Green Earth Chautauqua Bottoms, a 37 acre privately owned nature preserve is dissected by Crab Orchard Creek, and its trails are used by dozens of people every day. In recent years flooding has occurred much more frequently and the Creek is often out-of-bank. After heavy rainfalls roads near the Creek become impassable and the Creek flows upstream.

In recent years the Mississippi River is flooding more frequently. Record rainfall is being recorded in Illinois and as far north as Minnesota and the Dakotas.. In 2019 our region received 60" of rainfall, and thousands of acres in the Big Muddy flood plain in Jackson County, remained flooded from February through

September. Mississippi flooding was so extensive that it broke the record set by the 1927 Great Flood. Today the National Weather Service measured the Big Muddy at, flood stage (29.67 ft.). 2020 is likely to break 2019 flooding records.

When the Mississippi floods, water flows backwards up the Big Muddy. These waters also back up in its tributaries, including Little Crab Orchard Creek, and contaminants discharged into the Big Muddy flood waters flow directly into our community.

It is obvious that when terrestrial flooding occurs, the amount of contaminated water from Pond Creek Mine discharged into the Big Muddy will also increase, adding more water to the already flooded Big Muddy. The permit application analysis includes no projections on what will happen when the the Big Muddy flood water flows backwards and water covers the flood plain and backs up into tributaries. ***How will this stagnation of river waters during floods impact assumptions and projections on the "dilution" process and the distribution of polluted mine water across the landscape? Will the applicant be allowed to pump contaminants into the Big Muddy during periods when it is flowing backwards? How will the applicant monitor dilution of mine wastes in the water column during periods of backwards flow and stagnation? If the mine waste contaminants don't go downstream, will they spread out over fields and forests and how will the applicant monitor the distribution of mine wastes?*** Typically, as Big Muddy flood waters recede, isolated "ponds" of water are left behind for months, and are frequented by large flocks of wading birds and ducks. ***Will contaminants become more concentrated as the flood water recede? What will be the impact of these mine waste contaminants on farm soils and wildlife?***

The permit application analysis also did not include an adequate consideration of the impact of mine waste contaminants on the unique environmental resources downstream of the proposed discharge point, especially during high flood stages when the river is stagnant and contaminants can potentially concentrate and settle into the surrounding landscape. The Big Muddy River flows along Little Grand Canyon and LaRue-Pine Hills, a National Natural Landmark, in the Shawnee National Forest. These are areas of spectacular beauty and unique geology, and plant and animal life. The LaRue Swamp is a wetland of international significance.

> *LaRue-Pine Hills' unique physical characteristics dictate and support a rich biodiversity not found anywhere else in the country. In all, the area covers about 4.5 square miles (3547 acres) and contains 14 natural communities including forests, wetland, prairie, glade and barren ecosystems and geologic features. Please help protect this special place for future generations to enjoy, study and appreciate.*
>
> *Shawnee National Forest* https://www.fs.usda.gov/recarea/shawnee/recarea/?recid=35185

The Big Muddy Levy is intended to protect LaRue Pine Hills from Mississippi and Big Muddy River flood waters. However, in 2019 the levies failed to protect thousands of acres on both sides of Route 3. The levies were not overtopped or breached. Saturated soil allowed water to percolate under the levies and form lakes in fields where farmers were unable to plant crops last year. Roads were underwater for months and large flocks of birds inhabited the flood waters trapped behind the levees. When U.S. Route 3 was flooded, the bridge from Illinois to Cape Girardeau was closed and traffic was diverted north to Chester. The economic and human costs were tremendous.

Given the importance of these resources to the State and Nation, the applicant must consider and document the potential harm from mine waste discharge to this area, especially during periods of high waters and sluggish flows. ***What are the impacts to the LaRue Swamp if polluted mine water seeps under the Big Muddy Levy?***

Once again, I urge the IEPA to reject this application. Thank you for this opportunity to comment on this important public decision.

Sincerely,

Laurel Toussaint

Exhibit 386 R03773

From:	Clint Samuel
To:	EPA,PublicHearingCom
Subject:	[External] Pond Creek Mine NPDES IL0077666 and Notice No. 7516c
Date:	Friday, January 17, 2020 3:38:07 PM

Dear Sir(s),
I am commenting on the Pond Creek Mine permit to dump mining waste into our environment. I am someone who benefits from hunting and fishing. I am also dependent on our local tap water and local crops. I strongly discourage you from allowing this permit. The waste must be treated and stored until it will no longer endanger our natural resources.
Sincerely,
Mr. Clint David Samuel
706 North Division Street
Carterville, IL 62918-1033

Exhibit 387

From: Covell, Michael D
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine IL0077666
Date: Friday, January 17, 2020 3:42:28 PM

I am concerned, as a Union Count resident, about the push by the IEPA and the EPA to permit the Pond Creek Mine to dump millions of gallons of toxic waste into the Big Muddy River endangering local farms, wildlife, and a beautiful natural resource in Illinois. Please do not tell me that monitoring by the IEPA and or the EPA will protect the river. Information has been extremely vague on how much water will be added to the Big Muddy River, what is the exact and total chemical composition, and the safety and regular inspection of the proposed 12 mile pipeline to carry this disgusting and poisonous venom. My past experiences with monitoring factory farms was very disappointing. Many officials and supporters of these two organizations, local and statewide, had strong connections to the corporate or local economic practices that had little or no concern for the environment. I am now in the process of researching members of the EPA and the IEPA and their connections and close alliances to members of corporations. I distinctly remember the recent meeting with other citizens about The Pond Creek Mine in Marion Illinois where a women reminded the representatives of the EPA what those letters represented.
She stated loudly "ENVIRONMENTAL PROTECTION AGENCY". It is time for you to do your mission, protect the environment, not corporate interests.

Exhibit 388 R03775

From: Sabrina Hardenbergh
To: EPA.PublicHearingCom
Subject: RE: [External] Pond Creek Mine, IL0077666
Date: Friday, January 24, 2020 12:55:36 PM

Christine Zeivel:

The WSJ article example was included to simply document the pending bankruptcy status of Foresight Energy, and its business associates that are already in bankruptcy, wherein other articles and the other SEC filings weblinks I gave could potentially be substituted to document the pending bankruptcy status, or house-of-cards. From news and SEC filings, it appears the immediate subsidiary coal company is possibly maneuvering on your permit decision; however, their operations are clearly unstable at this point, with the history of Williamson Energy/Pond Creek violations and problematic market. Bob Murray's other coal mining is also unstable and in bankruptcy (e.g., https://cases.primeclerk.com/MurrayEnergy/), although he has a history of flipping assets for some years now which doesn't bode well for things like pensions or environmental clean up, despite the redirection of large sums of payments to cover his tracks (https://theintercept.com/2019/12/17/murray-energy-bankruptcy-climate-change/, https://www.documentcloud.org/documents/6580262-142050311162-Rep-1412102639.html). Peabody is decommissioning a nearby mine, so this is really a prime time to be transitioning to renewable energy and more energy efficient design, as the earlier federal administration was attempting to do with its Clean Power Plan, and our own state's related FEJA and CEJA legislation. However, if you open up the weblink (https://www.wsj.com/articles/foresight-energy-seeks-more-time-for-bondholder-talks-after-missed-interest-payment-11576269555?fbclid=IwAR1G0jeE_a9RHUElbtjKrnrP-LtyFAr18VAhY_AC8WjkcXWzupQaW5ENRgQ), it reads as follows, below:

*****

"PRO BANKRUPTCY DISTRESS

Foresight Energy Seeks More Time for Bondholder Talks After Missed Interest Payment

Foresight, the coal miner controlled by bankrupt Murray Energy, missed an interest payment in October

By Soma Biswas
Dec. 13, 2019 3:39 pm ET

Foresight Energy LP, the coal miner controlled by bankrupt Murray Energy Corp., asked bondholders for more time to negotiate after missing an interest payment and starting restructuring talks.

The St. Louis-based company missed an interest payment of over $24 million Oct. 1, starting the clock on a grace period that is scheduled to end at the end of the year. Now, Foresight is asking bondholders to give the company until the end of February.

Foresight and Murray, both producers of thermal coal, have struggled to cope with declining demand in recent years as coal-fired power plants shut down around the country and suppliers switched to cheaper natural gas and renewables. Foresight has roughly $1.3 billion of debt on its balance sheet.

Foresight and Murray, both producers of thermal coal, have struggled to cope with declining demand in recent years as coal-fired power plants shut down around the country and suppliers switched to cheaper natural gas and renewables. Foresight has roughly $1.3 billion of debt on its balance sheet.

The company has given bondholders until Thursday to vote on the extension request.

Foresight's bonds due 2023 last traded at close to 4 cents on the dollar last week, according to MarketAxess.

Murray Energy, which acquired a majority stake in Foresight in 2015 for $1.4 billion, filed for bankruptcy in October as declining coal sales and export prices and high interest on debt choked off the company's cash flow.

In November, Foresight reported a 38% decline in coal sales for the most recent quarter compared with the same period last year. Foresight is working with Jefferies LLC and Paul Weiss Rifkind Wharton & Garrison LLP on restructuring talks, according to people familiar with the matter.

Foresight and Paul Weiss didn't respond to requests for comment. A spokesman for Jefferies declined to comment."

****

Thank you to you and the other EPA staff for reviewing the many factors and details of this case, and its place in the bigger picture of a clean energy transition for our state, in the context of broader considerations like the Paris Agreement (or its update) and IPCC reports (https://www.ipcc.ch/reports/).

Sincerely,

Sabrina Hardenbergh
1 Hardenbergh Road
Carbondale, IL 62902
618-549-2608 (landline)
sabrina@midwest.net

-----Original Message-----
From: "EPA.PublicHearingCom"
Sent: Jan 23, 2020 2:05 PM
To: Sabrina Hardenbergh
Subject: RE: [External] Pond Creek Mine, IL0077666

Ms. Hardenbergh,

Thank you for submitting your comments regarding NPDES Permit No. IL0077666. The email below and its linked information will be entered into the hearing record as Exhibit 388. However, the link you included to the WSJ website only allows subscription access, so if you want that particular article included in the record for review, I will accept your submission of the article to this email address within three calendar days. If it is not received by midnight on Sunday, January 26, 2020, Agency staff will not have that specific information available as part of the permit hearing record.

Thank you,

Christine Zeivel
Hearing Officer
Illinois EPA
217.524.1628

From: Sabrina Hardenbergh <sabrina@midwest.net>
Sent: Friday, January 17, 2020 3:51 PM
To: EPA.PublicHearingCom <EPA.PublicHearingCom@Illinois.gov>
Subject: [External] Pond Creek Mine, IL0077666

Barb Lieberoff
Mail Code #5, RE: Pond Creek Mine NPDES
Illinois EPA
1021 North Grand Ave. East
P.O. Box 19276
Springfield, IL 19276

Re: Pond Creek Mine, IL0077666

Dear Barb Lieberoff:

Over the past year and a few months, I have emailed the IEPA in opposition to the Pond Creek Mine, IL0077666, pipeline permit, wherein Williamson Energy LLC proposes to dump their coal mine waste water into the Big Muddy River and its tributary Pond Creek. I am emailing to oppose this again, plus I attended your public hearing on Dec. 18, 2019 in Marion, IL, in opposition to the pipeline permit.

I hope you will continue to include my concerns indicated in earlier publications re Pond Creek Mine's many violations and pending water pollution, as well as the problem that their coal becomes some of that burned in nearby Indian's power plants that contributes to our regional air pollution and health problems:
https://www.sierraclub.org/sites/www.sierraclub.org/files/sce/shawnee-group/ShawneeTrailsDec2018forWeb.pdf
https://www.sierraclub.org/sites/www.sierraclub.org/files/sce/shawnee-group/ShawneeTrailsMar2019forWeb.pdf

Foresight Energy, of which Williamson Energy LLC is a subsidiary, is in bankruptcy court, wherein their likelihood of remediating their pollution is in serious question. They already don't seem to be concerned about the many violations they've incurred discharging toxic chemicals into Pond Creek over the years they've been in operation, so why would you give them a permit to continue such acts?
https://www.otcmarkets.com/filing/html?id=13805068&guid=UCdjUnejEdjreEh (Note amendment, extending interest payment out 150 days; they're not solvent.)
https://www.otcmarkets.com/stock/FELPU/disclosure
https://www.wsj.com/articles/foresight-energy-seeks-more-time-for-bondholder-talks-after-missed-interest-payment-11576269555

Please also consider the health cost to our medically under served, low-income community by the company's coal being used in our wider region, such as Indiana power plants. See for instance, health costs of the coal mine continuing, contributing to regional air pollution (assuming Indiana burns some of our coal, http://www.foresight.com/sales-markets/, https://www.eia.gov/state/analysis.php?sid=IN), as well as the water pollution of more specific focus in the permit application issue:
SW Indiana
https://ejscreen.epa.gov/mapper/ (the PM 2.5 concentration has diminished in our region since the time of the article's writing a year ago...compare current maps to screen shot in https://www.sierraclub.org/sites/www.sierraclub.org/files/sce/shawnee-group/ShawneeTrailsMar2019forWeb.pdf)
https://www.psr.org/wp-content/uploads/2018/05/coals-assault-on-human-health.pdf
https://www.gem.wiki/Category:Existing_coal_plants_in_Indiana
https://www.gem.wiki/Rockport_Plant
https://www.gem.wiki/Gibson_Generating_Station
https://www.gem.wiki/Petersburg_Generating_Station
S Illinois
https://www.gem.wiki/Baldwin_Energy_Station

https://www.gem.wiki/Marion_Plant_(existing)
https://www.gem.wiki/Joppa_Steam_Plant
We've long had to treat Black Lung disease and COPD in S. IL: https://www.sih.net/about-us/history-of-sih, http://www.shawneehealth.com/services/black-lung-program/, http://www.dph.illinois.gov/sites/default/files/publications/IL-Counties-COPD-111716.pdf

Southern Illinoisans must deal with the flood and other climate change weather-related costs that harm agricultural land and health. Similar to the Deception Dossiers (re oil/climate change), coal knew too... https://www.huffpost.com/entry/coal-industry-climate-change_n_5dd6bbebe4b0e29d7280984f?guccounter=1&fbclid=IwAR2sMxeEnL084IEPe2zGMDpjemRV-0uZ_IQcaHk58JsMk_Gc8acjC5Ip3yM

I personally would like to be able to enjoy wildlife viewing along the Big Muddy since I frequent places like Little Grand Canyon just above it. I have canoed on the river too, but I'm not sure that this is safe. It would be a shame if our national bird, the bald eagle, were diminished by lack of food or poisoned food (fish) in the Big Muddy River. I believe this is a federal offense to damage our national bird. Don't allow the mine to do so.

Also, following the health references above, given that previous coal mine air pollution has quite possibly been among contributing factors to my mother's Alzheimer's condition, which has taken a great financial and physical toll on me to be her caretaker, I am very angry that anyone would allow such socioeconomic and human health costs to be allowed to continue. The coal mining and power generation pollute our air, and harm us all in myriad ways.

You are supposed to be the Environmental Protection Agency, put in place under President Nixon, despite our current federal administration's attempt to do away with its mandate. Please DO NOT PERMIT the Pond Creek Mine pipeline to be built, and keep on top of the mine's other pollution violations. Maybe the mine should be decommissioned soon as other mines are doing elsewhere in the country so as to transition to cleaner energy sources.

Sincerely,

Sabrina Hardenbergh
1 Hardenbergh Road
Carbondale, IL 62902
618-549-2608 (landline)
sabrina@midwest.net

State of Illinois - CONFIDENTIALITY NOTICE: The information contained in this communication is confidential, may be attorney-client privileged or attorney work product, may constitute inside information or internal deliberative staff communication, and is intended only for the use of the addressee. Unauthorized use, disclosure or copying of this communication or any part thereof is strictly prohibited and may be unlawful. If you have received this communication in error, please notify the sender immediately by return e-mail and destroy this communication and all copies thereof, including all attachments. Receipt by an unintended recipient does not waive attorney-client privilege, attorney work product privilege, or any other exemption from disclosure.

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Shawnee Trails

http://www.sierraclub.org/illinois/shawnee

Find Us On facebook

Sierra Club – Shawnee Group **December 2018 – February 2019 QUARTERLY**

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Calendars for Sale Pg 8
Volunteer Pg 8

Shawnee Group Contact Information:
Shawnee Group Sierra Club
PO Box 117, Carbondale, IL 62903-0117
http://www.sierraclub.org/illinois/shawnee
also http://shawneegroup.blogspot.com

Chair, Membership/Political Chair: Jane Cogie 618-549-4673 jane.cogie@gmail.com
Vice Chair: Carla Womack, crusso1957@yahoo.com
Treasurer: Patty Weyhrich pweyhrich711@hotmail.com
Secretary: John Magney 618-529-3194 jmagney@siu.edu
Program Committee: Jane Cogie, John Magney, Elizabeth Donohue, glendagreenhouse@gmail.com
Lobbying Chair, Conservation Co-Chair: Jean Sellar 618-893-1379 biojean@peoplepc.com
Conservation Co-Chair, Shawnee National Forest Committee, Cool Cities Initiative: Barb McKasson 618-529-4824 babitaji@aol.com
Outings Chair: Steve Eberhart, eberpsy@icloud.com 618-687-2998
Fundraising Committee:
Carla Womack (native plant sale)
Barb McKasson (calendars)
Hospitality: (vacant, please volunteer!)
Newsletter Editor, Webmaster: Sabrina Hardenbergh sabrina@midwest.net
Publicity: Mike Covell emike@siu.edu

Pond Creek Mine Pipeline Permit No. 456 and TMDL

by Sabrina Hardenbergh

> *"The purpose of the Water Management Pipeline and the diffuser is to discharge high concentrations of sulfites and chlorides.... There are no public water supplies near the Water Management Pipeline discharge; therefore, no adverse effects are anticipated."*
> *--Foresight Energy, Pond Creek Mine, permit application No. 456*

You might have easily missed notice of the recent public hearing and comment periods for the Pond Creek Mine Pipeline Permit No. 456 and draft report for the Big Muddy Watershed Total Maximum Daily Load (TMDL), given IDNR did their typical scheduling, concurrent with congressional debates, elections and holidays. However, Chris Cline and Bob Murray are furthering their Foresight Energy enterprise with plans to pipe process and mine infiltration water from their longwall coal mine 12 miles across farmland, streams, federal wildlife land, under roads, past homes, and into the Big Muddy River. Presently the waste water has been discharged into a nearby tributary of Pond Creek; Pond Creek has been 303(d) listed for high chloride levels. Review the mine's repeated EPA non-compliance or violations for its three discharge points on the perimeter of the mine site, wherein high chloride and sulfate levels are recurrent issues. The high-sulfur coal gets sold to foreign countries to offset financial asset and debt juggling; millions of gallons of polluted water could soon be dumped into the river near Zeigler, Illinois, where it then meanders to Murphysboro, Oakwood Bottoms (by Little Grand Canyon and Inspiration Point), and the Mississippi River.

Basically, the Foresight Energy aka Williamson Energy aka Mach Mine aka Pond Creek longwall coal mine floods with mine infiltration water from the overlying sandstone. The company chose to invest hundreds of millions of dollars to develop such a site that puts underground miners' safety at risk, and that causes environmental and property risk to properly hold back polluted water; IDNR permitted the initial mine. The average 2,237 mg/L chloride and 1,940 mg/L sulfate concentration of this water exceeds quality standards allowed to be discharged into receiving waters. Approximately 2.7 million gallons of water are pumped from the mine daily, and this may increase to 3.5 million gallons. While the application admits chloride and sulfate issues, nothing is said of other toxic trace elements potentially found in Herrin coal, that might end up in the infiltration water. Oxidizing coal particles in water reduce the oxygen available for invertebrates like mussels, with damages up *(Continued on Page 2)*

(Pond Creek Mine Pipeline , Continued from Page 1)

the food chain, and water quality for local mussel and fish diversity are of concern on the Big Muddy River. The application denies acidic impact to the river, yet such water pollution is common with coal mining, and the Pond Creek Mine has had non-compliant pH discharge levels. Acid mine drainage from high sulfur coal mining contaminates drinking water, disrupts aquatic plant and animal growth and reproduction, and corrodes infrastructure such as bridges and culverts (and by inference, pipelines); we know this from Appalachian mining and our own Will Scarlet Mine debacle. Foresight has incurred such problems, including its Hillsboro Deer Run mine (also recently offloaded because of a combustion event and unrecoverable buried equipment). Foresight proposes water go to water holding cells on the mining site (and possibly to their preparation plant or slurry impoundment), and then through the pipeline and diffuser to a "mixing zone" in the Big Muddy River.

Transcripts and news articles of the October 23rd public hearing document complaints of minimal notice, speaking and research time for those concerned about the pipeline permit and the larger coal industry operations. People are concerned about drop in the water table impacting their ponds and wells, high chloride and sulfite levels' impact on human and wildlife health, impact to outdoor recreation (canoeing, kayaking, fishing), and the overall impact of the coal industry to climate change and economic imbalances. In reviewing the company's application, maps, and their correspondence with IDNR, a little more geographical detail was added to the paperwork, and the pipeline plans changed to boring under roads and streams instead of cutting through them. However, the updated Foresight application superficially accounts for environmental impact in the immediate pipeline construction zone, and it largely ignores the project's impact to the Big Muddy River and its surrounding watershed habitat. Foresight admits earlier violations in its application, including poor water quality (e.g., acidic, high iron, aluminum, manganese, chloride, black water/coal fine, drilling fluid, ammonia/ nitrogen, dust suppressant, possible asbestos, etc.), inappropriate discharges into wetlands and streams, coal waste in ditch, inappropriate or lack of water monitoring, gob pile gullies, and pipe breakage. Such issues do not prompt confidence in a safe pipeline project; instead, Foresight seems to be taking advantage of the recent federal administration's repeal of the new Stream Protection Act and weakening of EPA Acts and Rules.

> *"When coal is mined, fresh sulfur-bearing minerals in the coal and rocks are exposed to air and water. The resulting chemical reactions produce sulfuric acid and precipitates. The acid water flowing from coal mines, if not treated, can damage life forms in the receiving streams. The iron and sulfate precipitates often discolor stream beds with yellow and orange stains. In a similar manner, when burned, sulfur escaping in the flue gases can combine with water in the atmosphere to produce acidic precipitation ("acid rain"). For the same reasons, burning high-sulfur coal can be corrosive to the metal equipment used in a power plant." -- WV Geological & Economic Survey*

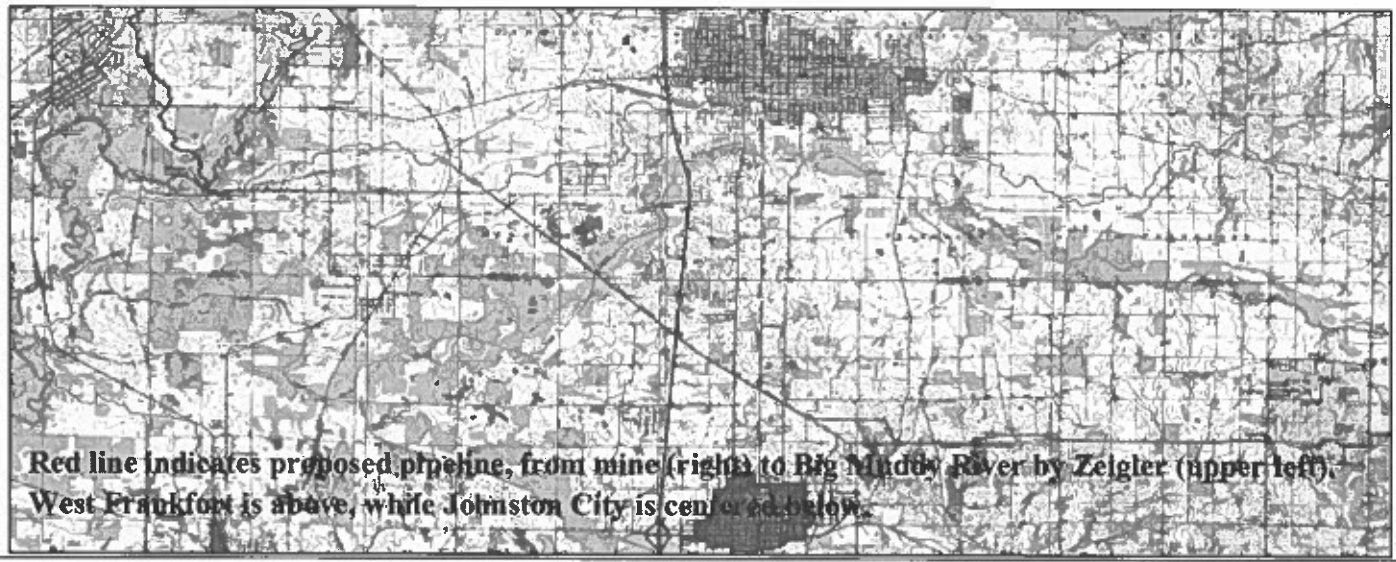
> *"The negative impacts of acid mine drainage are high levels of dissolved solids, especially iron, sulfates, chlorides, and manganese associated with the mine drainage." -- IEPA*

Some of us possibly remember the poor condition of the Big Muddy River a few decades ago before it became somewhat more cleaned up. However, significant sections of the Big Muddy and Pond Creek are still 303(d) listed for pollution problems. In 2012, the Big Muddy was still a Priority 1 on the 303(d) list for cleanup, whether sulfates, fecal matter, or other water quality problems. Its tributary Pond Creek had high chloride levels, near Foresight's mine. Another tributary, the Middle Fork Big Muddy near Foresight's Sugar Camp mine, also has been 303(d) listed for chloride. In 2004, the Big Muddy River had low pH and Dissolved Oxygen, and too much manganese and sulfate, attributed to local coal mines impact on groundwater. Earlier reports indicate exposed gob piles in Franklin County coal mining impacted the Big Muddy and its fish with acid runoff. The federal government attempted to change the forest habitat in the lower *(Continued on Page 3)*

(Pond Creek Mine Pipeline, Continued from Page 2)

Oakwood Bottoms to improve habitat for endangered and threatened wildlife species, and the area has been a fishing and canoeing or kayaking recreation area. This river and wetland habitat support bald and golden eagles, river otters, bats and other endangered, threatened and protected wildlife species. High chloride levels are no help to the water resistance of river otter's fur, and the food chain for otters (which are making a comeback); aquatic wildlife and eagles could diminish from the chloride and sulfite pollution. Foresight's pipeline application does not indicate how they intend to protect such species.

While the public comment period for Foresight's pipeline already passed on November 2nd, a public comment period on a related draft report on Total Maximum Daily Load (TMDL) for the Big Muddy River watershed is open until **December 15th**. Directions to write a comment to Abel Haile, Manager, Planning (TMDL) Unit Watershed Management Section, Bureau of Water, Illinois Environmental Protection Agency 1021 North Grand Avenue East, P.O. Box 19276, Springfield, IL 62794-9276, Abel.Haile@illinois.gov, are here. Copy your comment to the pipeline public comment emails too, dnr.mmlrd@illinois.gov, and nick.sandiego@illinois.gov, with subject line "Permit Application No. 456, Williamson Energy, LLC, Pond Creek Mine, Williamson County." If a site is 303(d) listed, no additional loadings are to be permitted until the waterbody is delisted; however, shenanigans are happening with the 303(d) listing and TMDL. The draft report indicates that parts of the Big Muddy River (IL_N-11 - Sulfates) and its tributary Pond Creek (IL_NG-02 Chloride) by the mine can be delisted, with the aid of a new TMDL calculation method that adjusts for seasonal/periodic water flow variation. Thus, Pond Creek's periodic high concentration of chloride becomes mathematically "diluted" with other seasonal measurements, even though periodic high concentrations during dry seasons may impact aquatic life. Interaction of varying combinations of water quality variables like sulfate, pH, and temperature is unclear. Pond Creek has been 303(d) listed for chloride in 2016, 2014 and 2012 reports, concurrent with Foresight's nearby mine operation, and the mine has repeatedly violated chloride discharge levels. The explanation of the math focuses the reader on fecal matter examples, deflecting attention from the sulfate, chloride, manganese and pH violations from mining. Yet the strategy to delist sulfite and chloride impairments may now "legitimate" permitting Foresight to pollute the waterways with the very delisted items, when they should be denied the pipeline permit and continue to be monitored for chloride, sulfites, and other TMDL violations (and possibly shut down). The pipeline shunts the TMDL problem down river, to the edge of the TMDL reporting area, pushing the impact off on areas of the Big Muddy River that have been improved. One wonders about industry and government collusion in the concurrent adoption of new TMDL sampling and calculations and the expensive and invasive pipeline project. Foresight just closed their Hillsboro mine after an incident, so they continue financial asset and debt management with sale of their more productive mines' coal to foreign buyers, helped by the recent lenient federal administration, and possibly the state of Illinois with this pipeline permit.



Red line indicates proposed pipeline, from mine (right) to Big Muddy River by Zeigler (upper left). West Frankfort is above, while Johnston City is centered below.

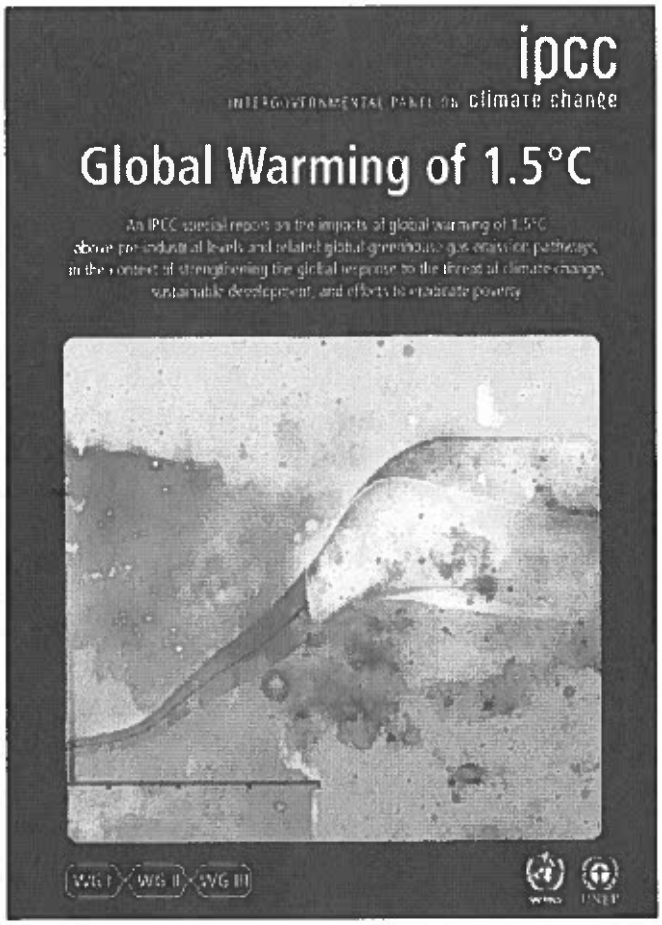
WINTER 2018/2019 SIERRA CLUB PROGRAMS:

Note: Access Carbondale Township Hall (217 E. Main) via REAR entrance, a green door in the alley, across from Rock Hill Baptist Church (at Monroe and Marion Streets). The front door is locked! FREE and open to the public. Refreshments and socializing before and after meeting.

Thursday, December 13, 2018
6:15 pm: Member & Guest Potluck
7:00 pm to 8:15 pm: Reflecting Back on 2018 and Looking Forward to 2019 — Join us for a year-end discussion of our activities this past year and priorities for projects to pursue in the coming year.
Location for both potluck and meeting: Carbondale Township, 217 E. Main Street

Thursday, January 17, 2019, 7 pm
Title: Solar for Southern Illinois Energy Forum: Reaping the Benefits of the Future Energy Jobs Act for Rooftop and Community Solar Projects
Presenters: Rebecca Judd, Sierra Club Illinois Clean Energy Advocate and Scott Allen, Citizens Utility Board
Location: TBD
5 pm Dinner: location TBA

Thursday, February 21, 2019, 7 pm
Title: Unpacking the 2018 Intergovernmental Panel on Climate Change Report
Presenter: Prof Justin Schoof, SIUC Dept. of Geography & Environmental Resources
Location: Carbondale Township, 217 E. Main Street
5 pm Dinner: location TBA



Volunteers Needed to Help Protect Shawnee National Forest
Protecting Shawnee National Forest involves frequent communication with the Forest Service, research on issues, and educating others about those issues. We especially need help in keeping oil and gas wells out of the forest - including fracking wells. Please contact Barb at babitaji@aol.com if you are interested in helping in any way.

The Illinois Chapter Sierra Club's Frack Fight Team is steered by Terri Treacy (terri.treacy@sierraclub.org).
To receive periodic updates and communications from local and national Sierra Club, become a member of Illinois Chapter's Frack Fight Team:
http://action.sierraclub.org/site/Survey?ACTION_REQUIRED=URI_ACTION_USER_REQUESTS&SURVEY_ID=138181

FYI, to receive more timely alerts from the Illinois Chapter of the Sierra Club, sign up online at their state website:
https://secure.sierraclub.org/site/SPageNavigator/Chapter/il_newsletter_signup.html;jsessionid=84420F4C49A5A8CD264E1E3C3F131E25.app205a

Call for articles and photographs for Shawnee Trails! The next issue will be published in March. Please send your Word, PDF or JPG files to sabrina@midwest.net by **February 4th.**

WINTER 2018/2019 SHAWNEE GROUP SIERRA CLUB OUTINGS

Rim Rock and Garden of the Gods Hike, Sunday, December 2, 2018
We will meet in the Murdale Shopping Center parking lot in Carbondale near the Murdale sign before 10 am. We will then travel together south of Harrisburg to the Rim Rock National Recreation Trail and the Garden of the Gods Recreation Area. They are both scenic, unique sites with beautiful views. We will do approximately 1-mile hikes at each site. Wear appropriate hiking shoes and bring water and a hiking staff. To sign up for the hike, call Steve Eberhart at 618-967-8690. The hike may be cancelled if no hikers have signed up prior to December 2.

Giant City Red Cedar Trail Hike, Sunday, January 6, 2019
Meet at the Giant City Visitor's Center before 10 am. This will be a moderate hike of 3 miles. We will see bluffs and other beautiful views in Giant City State Park. Resolve to start your new year out right by hiking and experiencing nature. Be sure to wear appropriate clothing and hiking shoes. You must call Bob Mulcahy at 618-942-6342 to go on this hike.

Jackson Hollow Hike, Sunday, February 24, 2019
Meet at Murdale shopping center in Carbondale (by the Murdale sign) before 9:30 or at the Marion Rural King parking lot (near the trailers/farm implements) before 10 am. The Jackson Hollow Natural Area features incredible rock formations and rare plant species. We will hike along the bluff lines on the north and south sides of the hollow. It will be a moderately difficult hike of about 3 miles. We may have to cross over downed trees and water. Wear appropriate hiking shoes and bring water. You must call Kevin Rohling at 618-694-8150 in order to attend this hike.

***

High Quality Natural Areas Need Your Help: Helping to Preserve Rare Native Plants
Shawnee Group Sierra Club is working with Illinois DNR to protect some of the highest quality natural areas in Illinois from non-native invasive plants (NNIS). Currently, we are focusing on Fern Rocks Nature Preserve. To save these areas from being overrun by invasive species and to protect the rare and beautiful native plants, we need lots of help. Each outing will include introductions and orientation on the invasive plants and safety measures.

Fern Rocks Nature Preserve in Giant City State Park, Saturday, December 8 2018, 1:00 – 4:00 PM
Meet at Giant City Visitor's Center in Makanda – about six miles south of Carbondale. We will also meet people who need transportation at the SIU arena parking lot at NOON, if you contact us at least by noon two days before the event.

Bring a water bottle and work gloves (if you have some). We will provide work gloves to those who need them, plus snacks. Wear appropriate clothing, including closed toe sturdy shoes and long pants and sleeves. IDNR will provide orange vests.

Contact: Barbara McKasson, certified Sierra Club Outings Leader at 618-529-4824 or Email at babitaji@aol.com or Text 618-534-7440.

Piasa Palisades Group Outings Chair:
Carol Klinger, 618-288-5506, ciklinger@yahoo.com
http://www.sierraclub.org/illinois/piasa-palisades

Eastern Missouri Group Outings Chair:
Doug Melville, 636-288-1055
douglas.k.melville@gmail.com
http://sierraclub.org/missouri/eastern-missouri

Future Outings TBA:
Updates listed on our or Illinois Chapter websites:
http://www.sierraclub.org/illinois/shawnee
http://illinois.sierraclub.org/calendar
Other short notice outings and events may be announced on our Facebook page:
https://www.facebook.com/SierraClubShawnee

Dear Governor-Elect Pritzker
By Barbara McKasson, Conservation co-chair

Illinois Chapter Sierra Club endorsed JB Pritzker for Governor and worked hard to help elect him. Now is the time to speak up for the trees, wildlife and environment… and for the Illinois Department of Natural Resources (IDNR). You may have read Les Winkeler's excellent open letter to Pritzker that was in The Southern on November 9th that addressed the need to rebuild IDNR, which has been decimated by years of budget cuts and sweeping of funds meant for the agency. Now it is our turn to add our voices to support increased funding of IDNR and increased concern for the wildlife and natural resources that IDNR has a mandate to protect. So let's start sending Emails and Facebook messages to JB to let him know how much we care about those special places, plants and animals. Offered here are some facts, arguments, perspectives in support of greater funding for IDNR that may help get you thinking of what you would like to include in your letter to the Governor-Elect.

- At what points – besides tax time – do people really feel the state government affects them? How about when they can spend a Sunday afternoon with their whole family taking a walk in a state park or when their child comes home from a school field trip excited about seeing salamanders under a log, a long snake skin or crayfish in a stream. Those great experiences are possible only when there is money to maintain those trails or to pay a site interpreter. Please increase IDNR funding to maintain our state parks and to hire more full-time site interpreters. There are currently only seven full-time site interpreters in the whole state!

- The IDNR has a mandate to protect our natural resources, not encourage exploitation by corporations to mine or drill on our public lands. I urge you to appoint a biologist as Director of IDNR and highly qualified professionals for the departments within IDNR to make sure the agency does not lose sight of its primary mission.

- As Les Winkeler points out in his November 9th article in The Southern, each wildlife and fisheries biologist is currently covering five or six counties and each conservation police officer covers several counties. This makes it very difficult to protect the wildlife and the natural resources from damage. I urge you to fully staff the Illinois Department of Natural Resources so our parks and wildlife will be adequately protected. In fact, our most popular state park, Starved Rock, is being loved to death, and sorely needs more staff to make sure it does not die a slow death, which is where it is headed.

- Site superintendents are stretched so thin that they must shuttle between two, five or even twelve sites, with maintenance workers and volunteers left to greet the public and make sure public property is not damaged. This is abuse – of our parks and of the superintendents, who do their best to fulfill the demands of an impossible job. I urge you to hire enough site superintendents so that one superintendent does not have to oversee more than one major state park and so that each major state park has its own superintendent.

- Mr. Pritzker, we know you are concerned about childhood education, but how familiar are you with the gaping hole in our children's education and well-being, which is now called "nature deficit disorder." The iGeneration is so glued to their iphones and other screens that most of them hardly ever play outside and are increasingly disconnected from nature. An increasing number of studies have shown that this is resulting in a generation of kids that have trouble navigating their physical environment, have trouble with dexterity, and have increased anxiety and decreased attention span. You can help solve this problem by increasing the budget for parks, open spaces and environmental educators and park site interpreters.

- I urge you, Mr. Pritzker, to make a New Year's Resolution to not sweep any funds from the Open Space Lands Acquisition and Development Fund (OSLAD) and the Natural Areas Acquisition Fund (NAAF). OSLAD helps local governments acquire, protect and manage public parks and open space, which is a state-financed grant program. NAAF money is for acquisition, preservation and stewardship of natural areas, including high quality natural communities, habitats for endangered and threatened species and natural heritage sites. Since Illinois is 48th out of the 50 states in amount of publicly accessible state and national lands per capita, it is evident that we need to spend OSLAD and NAAF funds for their intended purpose.

- I urge you to suspend bobcat hunting until scientific studies determine that there is a low risk of the species returning to protected list status. The hunting and trapping of bobcats is currently unconscionable since there is not sufficient scientific evidence to support it.

- I urge you to bring stakeholders together to plan a comprehensive strategy to protect Monarch butterflies in Illinois. Having the Illinois Department of Transportation planting and preserving milkweed is not enough, especially since roadways are dangerous areas for butterflies and other pollinators. We need cooperation between government and organizations to map out protected areas for planting and protecting milkweed for the larvae and nectar flowers for the adults.



Illinois Legislative Contacts: CALL YOUR LEGISLATORS TODAY!

State Dist. 109 Rep. David Reis: 618-392-0108 or 217-782-2087; www.davidreis.org
State Dist. 115 - Rep. Terri Bryant: 618-242-8115; 217-782-0387; staterepterribryant@gmail.com
State Dist. 116 - Rep. Jerry Costello II - 618-282-7284; 217-782-1018 Staterepcostello@gmail.com
State Dist. 117 - Rep. Dave Severin - 618-440-5090; 217-782-1051; www.ilhousegop.org/contactseverin
State Rep. 118 - Rep. Natalie Phelps Finnie - 618-253-4189; 217-782-5131; repphelpsfinnie@gmail.com
Senate Dist. 55 Senator Dale Righter: 217-235-6033 or 217-782-6674
Senate Dist. 58 - Senator Paul Schimpf: 618-684-1100; senshimpf58@gmail.com
Senate Dist. 59 - Senator Dale Fowler: 618-294-8951; 217-782-5509; senatorfowler59@gmail.com
Governor Bruce Rauner: 217-782-0244, http://www2.illinois.gov/gov/Pages/ContacttheGovernor.aspx
Speaker of the House Madigan: 217-782-5350; 773-581-8000; http://www.housedem.state.il.us
Senate President Cullerton: 217- 782-2728; 773-883-0770; jcullerton@senatedem.illinois.gov

Congressional Contacts: CALL YOUR CONGRESSMEN TODAY!

Senator Dick Durbin: 618-351-1122; 202-224-2152; http://www.durbin.senate.gov/
Senator L. Tammy Duckworth: (202) 224-2854; https://www.duckworth.senate.gov/
Representative Mike Bost: 618-457-5787; 202-225-5661; https://bost.house.gov/
Representative John Shimkus: 618-252-8271; 202-225-5271; https://shimkus.house.gov/

Has Your Email Address Changed?

To receive notification when the latest Shawnee Group newsletter is posted online, be sure to inform the Group when you change your email address. Send email address updates to: jane.cogie@gmail.com

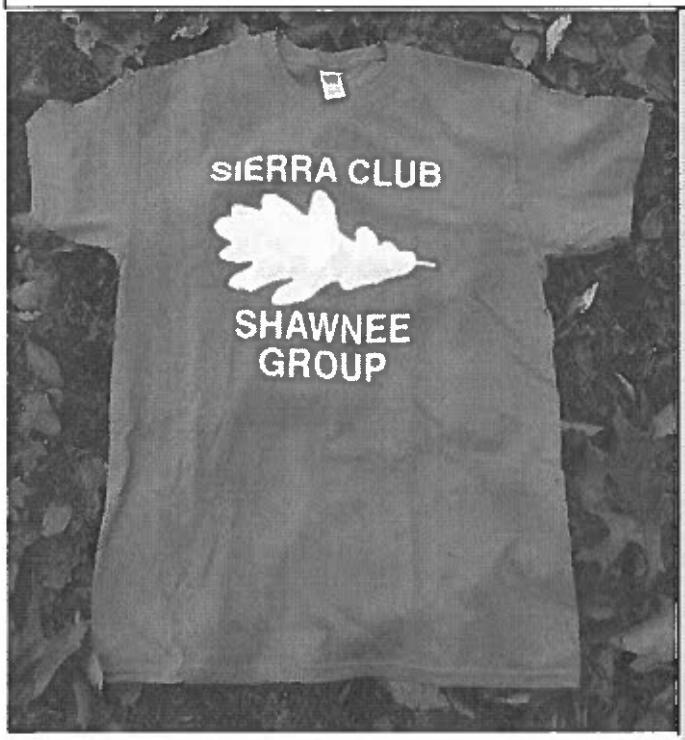
Read current and past newsletters on our website: http://www.sierraclub.org/illinois/shawnee. The website also lists information on upcoming local programs and outings, plus state and national Sierra Club issues.

Leadership Opportunities

Run for the Board! We need a few good women and men. Join the board of directors (the executive committee, also known as the ExCom) in overseeing the Shawnee Group's strategic direction and economic health. Board members meet monthly for about 2 hours. Board terms are for two years. We are always interested in potential candidates.

We need Hospitality team members

Provide refreshments for one monthly meeting each year (2nd Thursday). Be the Hospitality Chair to organize refreshment providers and greeters OR Act as a greeter for a monthly meeting or welcome and assist our speaker OR Select and make reservations at a local restaurant for our monthly "Dinner Before the Meeting." Contact Jane Cogie, 618-549-4673 jane.cogie@gmail.com.



Shawnee Group Sierra Club T-Shirts for Sale!

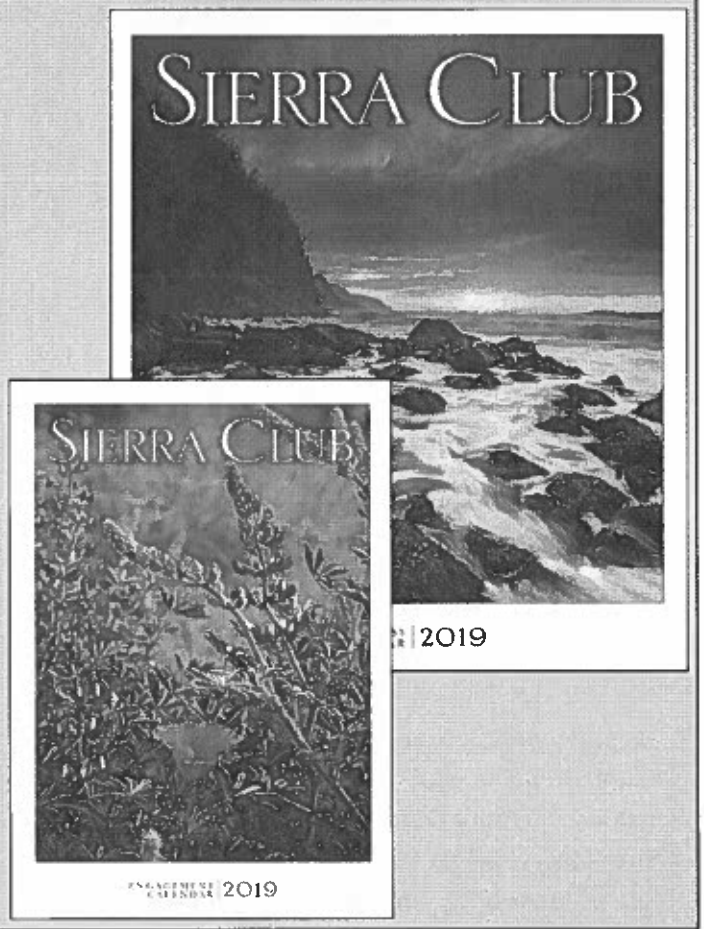
Show your support for our local group's activities. For sale during our monthly meetings.

Color: White logo on blue T-Shirt

$15 Medium Large or X-Large

2019 Sierra Club Calendars!

Buy at our monthly meetings this fall. Or contact Barb McKasson (babitaji@aol.com). We also seek volunteers to sell calendars.



SIERRA CLUB
FOUNDED 1892

Shawnee Trails

http://www.sierraclub.org/illinois/shawnee

Find Us On facebook

Sierra Club – Shawnee Group **March – May 2019 QUARTERLY**

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Shawnee Group Contact Information:
Shawnee Group Sierra Club
PO Box 117, Carbondale, IL 62903-0117
http://www.sierraclub.org/illinois/shawnee
also http://shawneegroup.blogspot.com

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Vice Chair: Carla Womack, crusso1957@yahoo.com
Treasurer: Patty Weyhrich pweyhrich711@hotmail.com
Secretary: John Magney 618-529-3194 jmagney@siu.edu
Program Committee: Jane Cogie, John Magney, Elizabeth Donohue, glendagreenhouse@gmail.com
Lobbying Chair, Conservation Co-Chair: Jean Sellar 618-893-1379 biojean@peoplepc.com
Conservation Co-Chair, Shawnee National Forest Committee, Cool Cities Initiative: Barb McKasson 618-529-4824 babitaji@aol.com
Outings Chair: Steve Eberhart, eberpsy@icloud.com 618-687-2998
Fundraising Committee:
Carla Womack (native plant sale)
Barb McKasson (calendars)
Hospitality: (vacant, please volunteer!)
Newsletter Editor, Webmaster: Sabrina Hardenbergh sabrina@midwest.net
Publicity: Mike Covell emike@siu.edu

VP Pence: Another Dirty Secret Back Home Entering Our Backyard

By Sabrina Hardenbergh

Environmentally concerned southern Illinoisans have spoken up about the many problems of coal and the need to transition to renewable energy for many years. The recent federal repeal of EPA regulations intended to protect water, air, and our health, and the many fossil fuel proponents in top federal positions, is disturbing, to say the least. We fight in Springfield and Washington, yet we also need to look just across our state border at our neighbors' decisions that impact us. While reading yet another health research article on a topic of key interest concerning a relative, regarding PM 2.5 air pollution's relationship to Alzheimer's (a condition where many systemic or inflammation factors are of concern), the thought occurred to look up the air pollution maps on the EPA EJScreen. Particulate matter is also a factor in asthma, lung cancer, heart disease, diabetes, and premature birth; Illinois is among states with high PM 2.5. On the EJScreen map, southern Illinois is layered with even higher proportions of PM 2.5, ozone and other hazards. Upon zooming out, the PM 2.5 pollution appears to emanate from Evansville, Indiana. A Google search reveals coal power plants and a new permit for a plant to liquify coal to gas. EPA EasyRSEI air data is discouraging too. Not recalling the exposé of Evansville's air pollution health hazard being well known in southern Illinois, despite its being an Indiana Sierra Club Beyond Coal issue, some details follow.

Seven coal fired power plants are within 40 miles of Evansville. In 2014, the Center for Public Integrity examined two large toxic air release and greenhouse gas emissions databases. A third of toxic releases come from a top 100 out of 20,000 power plants, factories and other sources. Twenty-two "Super Polluters" appeared on both lists. **Four** Super Polluters are in southwest Indiana, home to 5 of Indiana's 6 coal fired power plants. The study found that more toxic pollution from utility coal plants was sent into the air within 30 miles of Evansville than around any other mid-sized or large American city, which also is impacted by air pollution from other manufacturing. The 6 Indiana power plants made a quarter of Indiana air emissions, and within its 7 most southwestern counties, three-quarters of the air pollution recorded in the inventory came from the 6 coal plants. A couple nearby Kentucky plants add to regional air pollution. Indiana ranks first out of 56 states/territories nationwide based on total highest toxic chemical releases per square mile, although part of the pollution is produced by manufacturing such as steel, aluminum and plastics production. Some coal-fired plants are being closed, but mostly in central Indiana. Indiana, then under Governor Pence, was among 27 states suing the federal government over the Clean Power Plan. Eight northeastern states sued the EPA for permitting too much air pollution in upwind Indiana and other coal mining and coal power plant states.

By the Wabash River and I64, 25 miles northwest of Evansville, **Gibson** is Duke Energy's largest plant at 3,145 megawatts, *(Continued on Page 2)*

(Our Backyard , Continued from Page 1)

the 4th-largest coal plant in the country by capacity. It released 2.9 million pounds of air pollutants in 2014, according to the toxics inventory, much of that sulfuric acid, contributing to the formation of fine particles, a lung irritant. Lead, arsenic and mercury, all neurotoxins, added up to 1,000 pounds that year too. Gibson was the 4th top greenhouse gas polluting site nationwide.

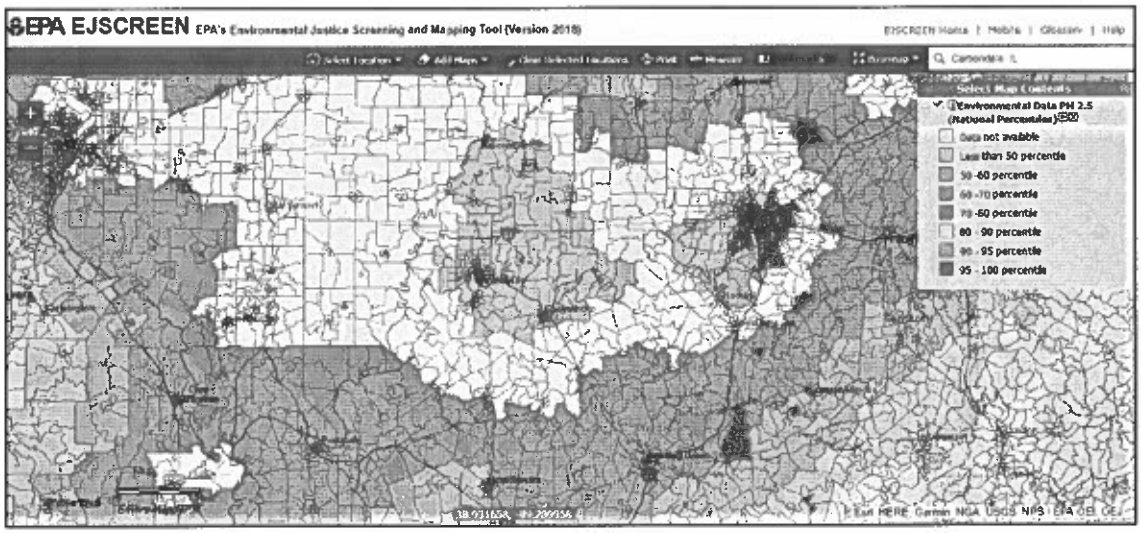
Rockport Generating Station, with its nearly world record 1,038-foot stack, operated by Indiana Michigan Power, a subsidy of American Electric Power, tied for tenth-largest coal plant in the country. Spencer County ranks 23 for toxic releases among all United States counties in the EPA's Toxic Release Inventory, from AK Steel and this coal-fired power plant, which has non-compliance violations. In 1999, the EPA, environmental groups and eight states (not Indiana) sued American Electric Power for emissions at coal plants; settlement remains pending.

Recently, although Indiana Department of Environmental Management denies significant impact, southwestern Indiana residents are also concerned about a new coal hydrogenation plant in Dale, IN adding to Spencer County and the region's pollution. Finely ground coal slurry mixed with hydrogen, heated to 450° C, yields hot gas, which then is condensed to liquid crude oil to fractionate into gasoline, middle oil, and heavy oil. Riverview Energy Corporation anticipates marketing 4.8 million barrels of low-sulfur diesel fuel, 2.5 million barrels of naphtha, and sulfur, made from 1.6 million tons of coal a year. This process can release hydrogen cyanide, phenols, cresols, carbonyl and hydrogen sulfides, ammonia, mercaptans, thiocyanides, aniline, arsenic, trace metals and various polycyclic hydrocarbons if mismanaged, risks for cancer, cardiac, endocrine, neurological and respiratory problems.

AES Corp.'s Petersburg power plant, 40 miles northeast of Evansville, put more chemicals into the air in 2014 than all but eight other sites nationwide. **Petersburg** was 35th for greenhouse gases. The plant had multiple emissions violations.

Warrick (Alcoa) and F.B. Culley (Vectran Corp.) coal-fired power plants are located 7 miles southeast of Evansville in Warrick County. **Warrick** power plant is also among the top 100 toxic releases and greenhouse gas emissions in the nation, and has had many violations. F.B. Culley has also had violations.

"In Southwest Indiana, ozone pollution is a problem during spring, summer, and early fall, while fine particulate pollution may be a problem year-round. These and other air pollutants can be hazardous to our health and environment." – Vanderburg County Health Department



Vanderburg County Health Department acknowledges the health hazard of air pollution around Evansville, including posting alerts of days with high ozone and particulate matter. However, they do not say anything about the many area power plant sources. Instead they advise residents to reduce their own fossil fuel consumption by less vehicle, lawn mower and appliance use, insulating homes, and planting trees. They state that this upholds their mission to "insure that the citizens of Southern Indiana have healthy air to breathe, while not suffering hindered economic development due to air quality problems." Other websites report air quality, like the EPA's Air Now, Easy RSEI, and Weather Underground. A local group, Valley Watch, notes that air pollution monitors have often been down for "maintenance" when air pollution is high, lending to no alerts or documentation. Vanderburg had higher PM 2.5 levels than nearly 90 percent of U.S. counties.

SPRING 2019 SIERRA CLUB PROGRAMS:

Note: Access Carbondale Township Hall (217 E. Main) via REAR entrance, a green door in the alley, across from Rock Hill Baptist Church (at Monroe and Marion Streets). The front door is locked! FREE and open to the public. Refreshments and socializing before and after meeting.

Thursday, March 14, 2019 Program 7 pm
Title: Discovering the Shawnee
Presenter: Prof Gary Kolb, SIUC Cinema & Photography Department, Emerita
Location: Carbondale Township Hall, 217 E. Main (back entrance)
5 pm Dinner: Keeper's Quarters

Thursday, April 11, 2019 Program, 7 pm
Title: Regenerative Agriculture: The What, Where & Why
Presenter: Kim Erndt-Pitcher, Habitat & Agriculture Programs Specialist, Prairie River Network
Location: Carbondale Township Hall, 217 E. Main (back entrance)
5 pm Dinner: Location TBA

Thursday, May 23, 2019 Program, 7 pm
Title: Molecular Evolution Research: What Is It, Why Is It Important, and Why Do Scientific Names Change Because of It?
Presenter: Marisa Szubryt, SIUC Graduate Student in Plant Biology
Location: Carbondale Township, 217 E. Main Street
5 pm Dinner: location TBA



Save the Date: Sunday, June 30, 2019 for a member-guest gathering, sharing a meal at Scratch Brewery in Ava. This event will replace our June Picnic. Details will follow, in our summer newsletter and the Shawnee Group of the Sierra Club Facebook page.

Volunteers Needed to Help Protect Shawnee National Forest
Protecting Shawnee National Forest involves frequent communication with the Forest Service, research on issues, and educating others about those issues. We especially need help in keeping oil and gas wells out of the forest - including fracking wells. Please contact Barb at babitaji@aol.com if you are interested in helping in any way.

Concerned about fracking?

Contact Barb McKasson at babitaji@aol.com if you are interested to help. New bills to support in Springfield, include HB282 (fracking transparency bill) and HB1562 (People's Property Protection Act, concerning subsurface trespass), so do contact your legislators. However, Barb can alert you of many action, outreach and planning opportunities that come up.

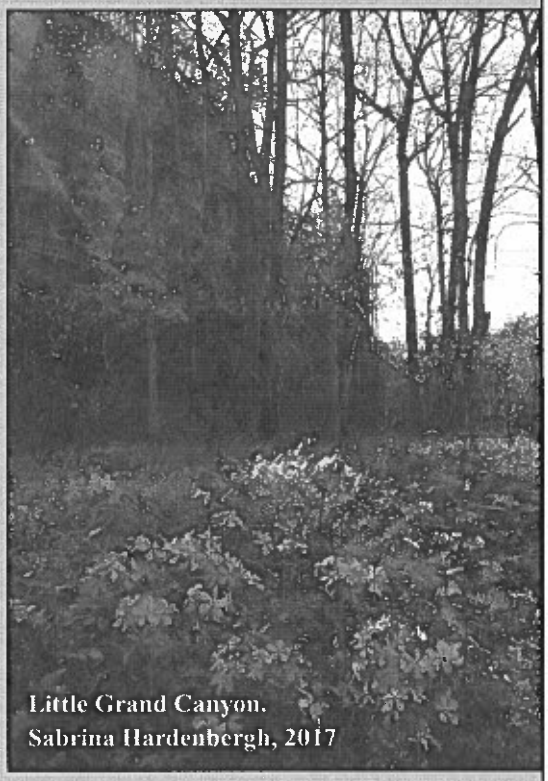
FYI, to receive more timely alerts from the Illinois Chapter of the Sierra Club, sign up online at their state website: https://secure.sierraclub.org/site/SPageNavigator/Chapter/il_newsletter_signup.html;jsessionid=84420F4C49A5A8CD264E1E3C3F131E25.app205a

Call for articles and photographs for Shawnee Trails! The next issue will be published in May. Please send your Word, PDF or JPG files to sabrina@midwest.net by **May 6th.**

SPRING 2019 SHAWNEE GROUP SIERRA CLUB OUTINGS

Kincaid Lake Trail hike; Sunday, March 10, 2019, 10:00 AM
Meet at the US Forest Service at 2221 Walnut in Murphysboro before 10 am to carpool. This moderate hike of up to 5 miles will offer views of Kinkaid Lake, rock ledges and a cave. Wear hiking shoes and bring water. Contact Bob Mulcahy at 618-942-6342, bobmulcahy29@yahoo.com, to sign up for the hike.

Little Grand Canyon Hike; Sunday, April 14, 2019, 10:00 AM
Meet at the Forestry Station at 2221 Walnut St in Murphysboro before 10 am to carpool to this moderate hike. We will hike along the upper trail and then down and through the canyon. We will also see views of the Big Muddy river valley. Bring water, hiking staff, and hiking boots. Contact Steve Eberhart at 618-967-8690, eberpsy@icloud.com, to sign up for the hike.


Little Grand Canyon.
Sabrina Hardenbergh, 2017

Jackson Hole and Double Branch Hole hike; Sunday, May 5, 2019, 9:30 AM
Meet at the Murdale shopping center in Carbondale by the Murdale sign before 9:30 am or at the Marion Rural King parking lot before 10 am. This moderate 3-mile hike will go through two natural areas of the Greater Shawnee Hills. We will see cliffs, valleys and waterfalls. Call Kevin Rohling at 618-694-8150, kgr7998@gmail.com, to sign up for the hike.

***

Service Outings – Native Plant Rescue Team

Shawnee Group is committed to helping rid high-quality natural areas of non-native invasive plants (NNIS) that are threatening to out-compete the natives, many of which are threatened, endangered or rare. In particular, we have been holding invasive pulls and lopping at the Fern Rocks Nature Preserve (Trillium Trail) and at LaRue – Pine Hills area in Shawnee National Forest.

Because our ability to hold these service outings depend so much on the weather and condition of the ground, we cannot nail down dates very far ahead. Thus, if you are interested in participating, please contact us and we will put you on our Email list to be notified when we do set dates. Please respond to Barb to be on our Native Plant Rescue Team with your name and Email address.

Contact Barb by phone at 618-529-4824 (voice mail) OR by text only to 618-534-7440.

Piasa Palisades Group Outings Chair:
Carol Klinger, 618-288-5506, ciklinger@yahoo.com
http://www.sierraclub.org/illinois/piasa-palisades

Eastern Missouri Group Outings Chair:
Doug Melville, 636-288-1055
douglas.k.melville@gmail.com
http://sierraclub.org/missouri/eastern-missouri

Future Outings TBA:
Updates listed on our or Illinois Chapter websites:
http://www.sierraclub.org/illinois/shawnee
http://illinois.sierraclub.org/calendar
Other short notice outings and events may be announced on our Facebook page:
https://www.facebook.com/SierraClubShawnee



Spring 2019 Monarch Team News

Reports indicate increased monarch hibernation in Mexico, according to a recent World Wildlife Fund survey. However, they also warn that monarch butterflies continue to face threats such as climate change, forest degradation in Mexico, and milkweed depletion along their migratory route.

Photo by Terry Foster, Master Naturalist/Master

"Pollinators~ Through the Artist's Eye" ART SHOW Coming to Carbondale in June!

It won't be long until Monarchs that overwintered in the forested mountains of Michoacán, Mexico start making their way northward. In mid-April, when weather warms, we'll start seeing their orange and back wings flitting above our greening meadows.

For butterflies and other pollinators, June is high season. Milkweeds, wildflowers and home gardens are in full bloom; a veritable nectar feast and procreation party.

June is the perfect time to celebrate pollinators! In collaboration with Carbondale Community Arts, we are putting on an art show, *"Pollinators ~ Through the Artist's Eye"*. Drawings, paintings, photography, fiber art and sculpture by local artists and students will on exhibit during June at CCA's, Gallery 304, located at 304 W. Walnut. The show is made possible by a grant from the Illinois Sierra Club and generous in-kind donation from CCA.

Please watch for the show flyer with specifics about entering the show, and info on the opening reception, workshops and lectures on the life cycles and conservation of pollinators in the on-line CCA newsletter, www.carbondalearts.org.

Kathy Belletire
KBelletireArt@gmail.com



Monarch Metamorphosis, Kathy Belletire

URGENT!! Will Illinois Be a Leader In Easing the CLIMATE CRISIS? YOU DECIDE!

By Barbara McKasson

Illinois Chapter Sierra Club and hundreds of environmental, healthcare, consumer, faith-based, community, and environmental justice groups plus businesses have joined together as the Illinois Clean Jobs Coalition to up the ante on fighting against the worst consequences of our human-caused climate crisis. We partnered to pass the Future Energy Jobs Act of 2016, which has led to a winning solar and energy efficiency industry. Now we are raising the level of our game to pass the new Clean Energy Jobs Act (CEJA).

The finer details of CEJA are still being worked out, but the "Clean Energy Jobs – Tech" bills have been introduced in both the Illinois House (HB3624) and the Illinois Senate (SB2132). Rep. Ann Williams is the main sponsor in the House, and Senator Cristina Castro is the main sponsor in the Senate. There are a good number of legislators signed on as co-sponsors of the bills, but more are needed to help move the bills along in the process. We need you to educate your legislators now.

The recent Intergovernmental Panel on Climate Change (IPCC) "Special Report on Global Warming of 1.5° C" is strongly urging all earthlings and governments to take immediate action to keep earth from warming to 1.5° C above pre-industrial levels to avoid many dire consequences, and that the pledges made in the Paris COP21 Agreement is insufficient to meet the "below 1.5° C" goal. The report warns that to stabilize global temperatures at any level requires us to reduce net CO2 emissions to ZERO! Earth has already warmed by 1° C and the current rate of warming is 0.2° C per decade. We have LESS THAN TWELVE YEARS TO GET DOWN TO ZERO NET CO2 EMISSIONS!

The Clean Energy Jobs Act will repower Illinois equitably with the following goals:

- Power more than 4 million homes and lower electricity bills while pushing back against harmful federal attacks on clean energy.
- Create more than $30 billion in new private investment in Illinois through incentives.
- Expand access to clean energy careers, build community wealth, and improve air and water quality, leading to healthier communities.
- Reduce pollution from transportation by increasing electric vehicles and support systems, and cleaner, more convenient public transportation.
- Decarbonize the electric grid.
- Prioritize jobs and economic opportunities, especially for economically disadvantaged and minority communities.

HOW YOU CAN HELP

1. Find your State Representative's and Senator's contact information on the list on page 7 OR go online at www.illinoispolicy.org/maps and type in your address.
2. Call their offices and ask them to co-sponsor the Clean Energy Jobs Act – HB3624/SB2132.
    a. State your name and let them know you live in their district.
    b. Say you want your Rep/Senator to co-sponsor HB3624/SB2132, the Clean Energy Jobs Act. If they are already a co-sponsor, thank them for co-sponsoring.
    c. Let them know your personal concerns if you want to – don't be shy!

Note: Gov. Pritzker signed Illinois onto the U.S. Climate Alliance, and he supports the CEJA bill.

REGISTERING YOUR SUPPORT FOR ENVIRONMENTAL LEGISLATION

We hope you will join us in Springfield for the following Spring 2019 Lobby Days. Each one focuses on legislation targeting specific high priority environmental issues:

- **Conservation and Nutrient Pollution Lobby day - March 13:** To express your support for conserving our water and protecting it from nutrient pollution, such as from CAFOs and other agricultural practices.

- **Water & Toxics Lobby Day - April 10:** To forward legislation on lead service line replacement, water infrastructure, and more.

- **Clean Energy Lobby Day -- May 9:** To support sustainable energy and jobs created from its infrastructure.

Opportunity for Constituents in IL Senate District 59 (Dale Fowler) and IL House District 117 (Dave Severin) or 118 (Patrick Windhorst): GRASSROOTS VOLUNTEER LOBBY TEAM VACANCIES: If you are a constituent of Dale Fowler and either Dave Severin or Patrick Windhorst and are interested in lobbying these legislators in their in-district offices on Sierra Club environmental legislative priorities, please contact the Shawnee Group Chair, Jane Cogie (see contact information below).

The aim in pushing to fill these vacancies is to ensure state legislators hear about our top environmental bills face-to-face from their constituents.

Lobby team members need not have previous lobbying or policy experience. We provide them with basic lobby training and a briefing on priority bills. To volunteer for this position, you need only to be a strong communicator and be willing to attend trainings and schedule and attend lobby visits.

For more information on the three spring lobby days or the in-district lobby team openings for Senate District 59, please contact Jane Cogie, Chair, Shawnee Group of the Sierra Club (618-713-7024; jane.cogie@gmail.com).

Illinois Legislative Contacts: CALL YOUR LEGISLATORS TODAY!

State Dist. 109 - Rep. Darren Bailey: 618-665-4109 or 217-782-2087; http://www.ilhousegop.org/contactbailey
State Dist. 115 - Rep. Terri Bryant: 618-242-8115; 217-782-0387; staterepterribryant@gmail.com
State Dist. 116 - Rep. Jerry Costello II: 618-282-7284; 217-782-1018 Staterepcostello@gmail.com
State Dist. 117 - Rep. Dave Severin: 618-440-5090; 217-782-1051; www.ilhousegop.org/contactseverin
State Rep. 118 – Rep. Patrick Windhorst: 618-294-8703; 217-782-5131;www.ilhousegop.org/windhorst_contact
Senate Dist. 55 - Senator Dale Righter: 217-235-6033; 217-782-6674; dalerighter.com/Contact
Senate Dist. 58 - Senator Paul Schimpf: 618-684-1100; senshimpf58@gmail.com
Senate Dist. 59 - Senator Dale Fowler: 618-294-8951; 217-782-5509; senatorfowler59@gmail.com
Governor JB Pritzker: 217-782-6830; https://www2.illinois.gov/sites/gov/contactus/Pages/default.aspx
Speaker of the House Mike Madigan: 217-782-5350; 773-581-8000; mmadigan@housedem.state.il.us
Senate President John Cullerton: 217-782-2728; 773-883-0770; jcullerton@senatedem.illinois.gov

Congressional Contacts: CALL YOUR CONGRESSMEN TODAY!

Senator Dick Durbin: 618-351-1122; 202-224-2152; http://www.durbin.senate.gov/
Senator L. Tammy Duckworth: (202) 224-2854; https://www.duckworth.senate.gov/
Representative Mike Bost: 618-457-5787; 202-225-5661; https://bost.house.gov/
Representative John Shimkus: 618-252-8271; 202-225-5271; https://shimkus.house.gov/

Has Your Email Address Changed?

To receive notification when the latest Shawnee Group newsletter is posted online, be sure to inform the Group when you change your email address. Send email address updates to: jane.cogie@gmail.com

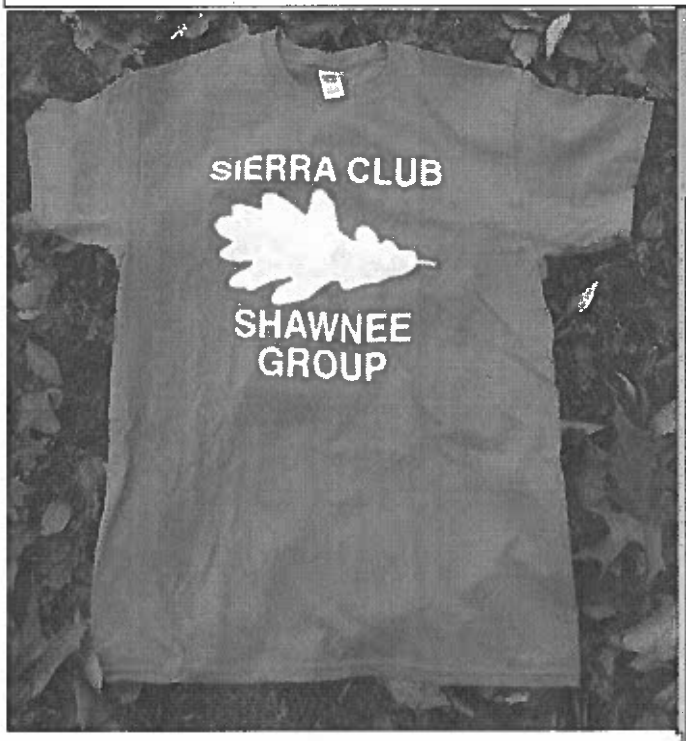
Read current and past newsletters on our website: http://www.sierraclub.org/illinois/shawnee. The website also lists information on upcoming local programs and outings, plus state and national Sierra Club issues.

Leadership Opportunities

Run for the Board! We need a few good women and men. Join the board of directors (the executive committee, also known as the ExCom) in overseeing the Shawnee Group's strategic direction and economic health. Board members meet monthly for about 2 hours. Board terms are for two years. We are always interested in potential candidates.

We need Hospitality team members

Provide refreshments for one monthly meeting each year (2nd Thursday). Be the Hospitality Chair to organize refreshment providers and greeters OR Act as a greeter for a monthly meeting or welcome and assist our speaker OR Select and make reservations at a local restaurant for our monthly "Dinner Before the Meeting." Contact Jane Cogie, 618-549-4673 jane.cogie@gmail.com.



Shawnee Group Sierra Club T-Shirts for Sale!

Show your support for our local group's activities. For sale during our monthly meetings.

Color: White logo on blue T-Shirt

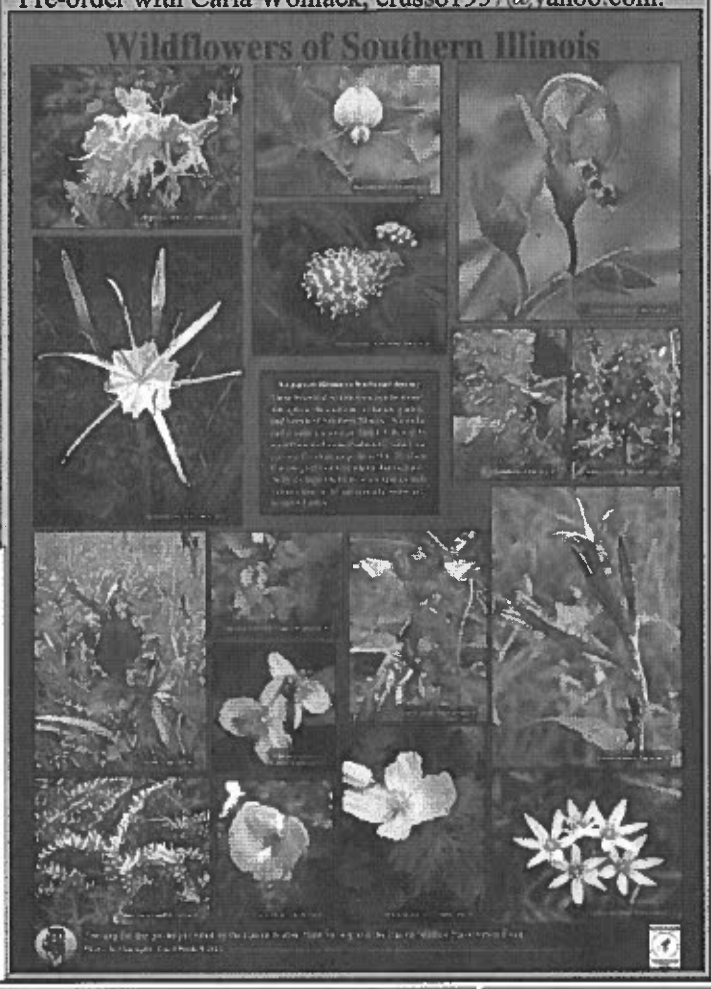
$15 Medium Large or X-Large

Sierra Club Native Plant Sale!

May 4, 2019, 10 am - 2 pm

Townsquare Pavilion, Rt. 51 & 13, Carbondale, IL

Pre-order with Carla Womack, crusso1957@yahoo.com.



UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
WASHINGTON, DC 20549

FORM 8-K

CURRENT REPORT

Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934

Date of Report (date of earliest event reported): December 19, 2019

FORESIGHT ENERGY LP

(Exact Name of Registrant as Specified in Charter)

Delaware	001-36503	80-0778894
(State or Other Jurisdiction of Incorporation)	(Commission File Number)	(IRS Employer Identification No.)
211 North Broadway, Suite 2600 Saint Louis, MO (Address of Principal Executive Offices)		63102 (Zip Code)

(Registrant's telephone number, including area code): (314) 932-6160

(Former Name or Former Address, if Changed Since Last Report)

Check the appropriate box below if the Form 8-K filing is intended to simultaneously satisfy the filing obligation of the registrant under any of the following provisions (*see* General Instruction A.2. below):

? Written communications pursuant to Rule 425 under the Securities Act (17 CFR 230.425)

? Soliciting material pursuant to Rule 14a-12 under the Exchange Act (17 CFR 240.14a-12)

? Pre-commencement communications pursuant to Rule 14d-2(b) under the Exchange Act (17 CFR 240.14d-2(b))

? Pre-commencement communications pursuant to Rule 13e-4(c) under the Exchange Act (17 CFR 240.13e-4(c))

Securities registered pursuant to Section 12(b) of the Act:

Title of each class	Trading Symbol(s)	Name of each exchange on which registered
Common units representing limited partner interest	*	*

*On November 25, 2019, a Form 25 relating to the delisting and deregistration under Section 12(b) of the Registrant's common units representing limited partner interests was filed by the New York Stock Exchange LLC. The common units currently trade on the OTCQX® Best Market under the symbol "FELPU."

Indicate by check mark whether the registrant is an emerging growth company as defined in Rule 405 of the Securities Act of 1933 (§ 230.405 of this chapter) or Rule 12b-2 of the Securities Exchange Act of 1934 (§ 240.12b-2 of this chapter).

Emerging growth company ?
If an emerging growth company, indicate by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act. ?

Item 1.01 Entry into a Material Definitive Agreement.

As previously disclosed, on December 13, 2019, Foresight Energy LLC and Foresight Energy Finance Corporation (wholly owned subsidiaries of Foresight Energy LP (the "**Partnership**")) (together, the "**Issuers**") solicited the consent of the holders (the "**Holders**") (such solicitation, the "**Consent Solicitation**") of the Issuers' 11.50% Second Lien Senior Secured Notes due 2023 (the "**Notes**") to amend (such amendments, the "**Amendments**") the indenture governing the Notes (as amended, supplemented or otherwise modified from time to time, the "**Indenture**"), as more fully described below. The Consent Solicitation expired at 5:00 p.m., New York City time, on December 19, 2019 (the "**Expiration Time**").

As of the Expiration Time, the Issuers had received consents to the Amendments from Holders of at least a majority in aggregate principal amount of the outstanding Notes not owned by the Issuers or their affiliates. As a result, on December 19, 2019, the Issuers, the guarantors party thereto and Wilmington Trust, National Association, the trustee (the "**Trustee**") for the Notes, entered into a second supplemental indenture (the "**Second Supplemental Indenture**") providing for the Amendments to the Indenture.

The Amendments (i) amend Section 6.01(b) of the Indenture to extend the grace period for payment of interest due on the Notes from 90 days to 150 days and (ii) amend Section 4.03 of the Indenture to eliminate the requirement that the Issuers periodically hold a publicly accessible conference call to discuss the Issuers' financial information for the relevant fiscal period.
The Partnership continues to engage in discussions with its creditor constituencies and explore potential restructuring alternatives.

The foregoing descriptions of the Amendments, the Second Supplemental Indenture and the Indenture are qualified in their entirety by reference to the full text of the Second Supplemental Indenture, the First Supplemental Indenture dated as of October 30, 2019 and the Indenture, each of which is incorporated herein by reference to **Exhibit 4.1**, **Exhibit 4.2** and **Exhibit 4.3** to this Current Report on Form 8-K, respectively.

Item 3.03 Material Modification to Rights of Security Holders.

The disclosure set forth in Item 1.01 of this Current Report on Form 8-K is incorporated into this item by reference.

CAUTIONARY STATEMENT REGARDING FORWARD-LOOKING STATEMENTS

Certain statements and information in this Current Report on Form 8-K and certain oral statements made by our representatives from time to time may constitute "forward-looking statements." The words "propose," "believe," "expect," "anticipate," "plan," "intend," "foresee," "outlook," "estimate," "potential," "continues," "may," "will," "seek," "approximately," "predict," "anticipate," "should," "would," "could" or other similar expressions are intended to identify forward-looking statements, which are generally not historical in nature. Forward-looking statements also include statements about our liquidity, our capital structure and expected results of operations. These forward-looking statements are based on the Partnership's current expectations and beliefs concerning future developments and their potential effect on us. While management believes that these forward-looking statements are reasonable as and when made, there can be no assurance that the future developments affecting us will be those that we anticipate.

We continue to experience substantial financial, business, operational and reputational risks that threaten our ability to continue as a going concern and could materially affect our present expectations and projections. For additional information regarding known material factors that could cause our actual results to differ from those contained in or implied by forward-looking statements, please see the section entitled "Risk Factors" in the Partnership's Annual Report on Form 10-K for the year ended December 31, 2018, filed with the Securities and Exchange Commission on February 27, 2019 and subsequent Quarterly Reports on Form 10-Q.

You are cautioned not to place undue reliance on forward-looking statements, which are made only as of the date hereof. We undertake no obligation to publicly update or revise any forward-looking statements after the date they are made, whether as a result of new information, future events or otherwise, except as required by law.

Item 9.01 Financial Statements and Exhibits.

(d) Exhibits

Exhibit No.	Exhibit Description
4.1	Second Supplemental Indenture, dated as of December 19, 2019 (to the Indenture dated as of March 28, 2017), by and among

Item 9.01 Financial Statements and Exhibits.

(d) Exhibits

Exhibit No.	Exhibit Description
4.1	Second Supplemental Indenture, dated as of December 19, 2019 (to the Indenture dated as of March 28, 2017), by and among Foresight Energy LLC, Foresight Energy Finance Corporation, the guarantors party thereto and Wilmington Trust, National Association, as trustee.
4.2	First Supplemental Indenture, dated as of October 30, 2019 (to the Indenture dated as of March 28, 2017), by and among Foresight Energy LLC, Foresight Energy Finance Corporation, the guarantors party thereto and Wilmington Trust, National Association, as trustee (incorporated herein by reference to Exhibit 4.1 to FELP's Current Report on Form 8-K, filed with the SEC on October 31, 2019).
4.3	Indenture, dated as of March 28, 2017, by and among Foresight Energy LLC, Foresight Energy Finance Corporation, the guarantors party thereto and Wilmington Trust, National Association, as trustee (incorporated herein by reference to Exhibit 4.1 to FELP's Current Report on Form 8-K, filed with the SEC on April 3, 2017).

SIGNATURES

Pursuant to the requirements of the Securities Exchange Act of 1934, the registrant has duly caused this report to be signed on its behalf by the undersigned, hereunto duly authorized.

Foresight Energy LP

By: Foresight Energy GP LLC
its general partner

By: /s/ Robert D. Moore
Robert D. Moore
Chairman of the Board, President and Chief Executive Officer

Date: December 20, 2019

EXHIBIT 4.1

SECOND SUPPLEMENTAL INDENTURE

SECOND SUPPLEMENTAL INDENTURE to the Indenture (as defined below) (the "*Supplemental Indenture*"), dated as of December 19, 2019, is made by and among Foresight Energy LLC, a Delaware limited liability company (the "*Company*"), Foresight Energy Finance Corporation, a Delaware corporation ("*Co-Issuer*, and together with the Company, the "*Issuers*"), the guarantors party hereto (the "*Guarantors*") and Wilmington Trust, National Association, as trustee (in such capacity, the "*Trustee*"), and amends the Indenture, dated as of March 28, 2017, among the Issuers, the Guarantors and the Trustee, as amended by the First Supplemental Indenture, dated as of October 30, 2019 (as further amended and supplemented from time to time, the "*Indenture*").

RECITALS:

WHEREAS, pursuant to the Indenture, the Issuers have issued $425,000,000 in aggregate principal amount of 11.50% Second Lien Senior Secured Notes due 2023 (the "*Notes*");

WHEREAS, the Issuers have requested consents of the Holders of the Notes to amend the terms of the Indenture as set forth in Article I herein (the "*Proposed Amendments*");

WHEREAS, pursuant to Section 9.02 of the Indenture, the written consent of Holders of at least a majority in aggregate principal amount of the outstanding Notes (the "*Requisite Consents*") is sufficient to adopt the Proposed Amendments set forth in Article I;

WHEREAS, the holders of at least a majority in aggregate principal amount of the Notes outstanding (which excludes any Notes owned by the Issuers or their affiliates) have validly tendered consents and not validly withdrawn their consents to the adoption of the Proposed Amendments effected by this Supplemental Indenture in accordance with the provisions of the Indenture;

WHEREAS, having received the Requisite Consents for all of the Proposed Amendments, the Issuers and the Guarantors desire to amend the Indenture as provided herein;

WHEREAS, the Issuers have delivered to the Trustee, pursuant to Section 9.02 of the Indenture, an Officer's Certificate stating that the Issuers have received the Requisite Consents, and have provided certification of such receipt to the Trustee;

WHEREAS, the Issuers have also delivered to the Trustee, pursuant to Sections 7.02(b), 9.02 and 9.05 of the Indenture, (i) a resolution of the Board of Directors of the Company authorizing the execution of this Supplemental Indenture, and (ii) an Officer's Certificate and an Opinion of Counsel, each stating that the execution of this Supplemental Indenture is authorized or permitted by the Indenture and that all conditions precedent to the execution and delivery of this Supplemental Indenture have been satisfied; and

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WHEREAS, all other conditions and requirements necessary to make this Supplemental Indenture a valid, binding and legal instrument enforceable in accordance with its terms have been performed and fulfilled by the parties hereto, and the execution and delivery thereof have been in all respects duly authorized by the parties hereto.

NOW, THEREFORE, in consideration of the foregoing and for other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, the parties mutually covenant and agree for the equal and ratable benefit of the Holders of the Notes as follows:

ARTICLE I

WHEREAS, all other conditions and requirements necessary to make this Supplemental Indenture a valid, binding and legal instrument enforceable in accordance with its terms have been performed and fulfilled by the parties hereto, and the execution and delivery thereof have been in all respects duly authorized by the parties hereto.

NOW, THEREFORE, in consideration of the foregoing and for other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, the parties mutually covenant and agree for the equal and ratable benefit of the Holders of the Notes as follows:

ARTICLE I
AMENDMENTS

Section 1.01. Amendments to Indenture.

(i) Section 6.01(b) of the Indenture is hereby amended and restated in its entirety to read as follows:

"(b) the Issuers default in the payment of interest on any Note when the same becomes due and payable, and the default continues for a period of 150 days;"

(ii) Section 4.03(d) of the Indenture is hereby deleted and amended and restated to read in its entirety as set forth below:
"(d) [Intentionally omitted]."

(iii) Section 4.03(e) of the Indenture is hereby amended to delete the reference to ", and a publicly accessible quarterly conference call of such Parent".

(iv) The first sentence of Section 4.03(f) of the Indenture is hereby amended to (i) add the word "and" immediately before the word "furnishes", (ii) delete the reference to ", and holds a publicly accessible quarterly conference call" and (iii) replace the reference to "Sections 4.03(a) and (d)" with "Section 4.03(a)".

ARTICLE II
MISCELLANEOUS

Section 2.01. Effectiveness. This Supplemental Indenture shall become effective upon the execution and delivery of the Supplemental Indenture by the parties hereto.

Section 2.02. Confirmation. Except as expressly amended hereby, the Indenture is in all respects ratified and confirmed and all the terms, conditions and provisions thereof shall remain in full force and effect. For the avoidance of doubt, this Supplemental Indenture shall not impair or affect the contractual right of any Holder of a Note or Notes to receive any principal payment or interest payment on such Holder's Note or Notes, on or after the Stated Maturity thereof, or to institute suit for the enforcement of any such payment. Upon the execution and

---

delivery of this Supplemental Indenture by the Issuers, the Guarantors and the Trustee, this Supplemental Indenture shall form a part of the Indenture for all purposes, and every Holder of Notes heretofore or hereafter authenticated and delivered shall be bound hereby. Any and all references to the Indenture, whether within the Indenture or in any notice, certificate or other instrument or document, shall be deemed to include a reference to this Supplemental Indenture (whether or not made), unless the context shall otherwise require.

Section 2.03. Counterparts. The parties may sign any number of copies of this Supplemental Indenture. Each signed copy shall be an original, but all of them together represent the same agreement. The exchange of copies of this Supplemental Indenture and of signature pages by facsimile, .pdf transmission or other electronic means shall constitute effective execution and delivery of this Supplemental Indenture for all purposes. Signatures of the parties hereto transmitted by facsimile or .pdf transmission or other electronic means shall be deemed to be their

delivery of this Supplemental Indenture by the Issuers, the Guarantors and the Trustee, this Supplemental Indenture shall form a part of the Indenture for all purposes, and every Holder of Notes heretofore or hereafter authenticated and delivered shall be bound hereby. Any and all references to the Indenture, whether within the Indenture or in any notice, certificate or other instrument or document, shall be deemed to include a reference to this Supplemental Indenture (whether or not made), unless the context shall otherwise require.

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Section 2.04. Capitalized Terms. Capitalized terms used herein without definition shall have the meanings assigned to them in the Indenture.

Section 2.05. GOVERNING LAW. THIS SUPPLEMENTAL INDENTURE SHALL BE GOVERNED BY AND CONSTRUED IN ACCORDANCE WITH THE LAWS OF THE STATE OF NEW YORK.

Section 2.06. Effect of Headings. The section headings herein are for convenience only and shall not affect the construction hereof.

Section 2.07. Acceptance by the Trustee. The Trustee accepts the amendments to the Indenture effected by this Supplemental Indenture and agrees to execute the trusts created by the Indenture as hereby amended, but only upon the terms and conditions set forth in the Indenture; *provided, however*, that to the extent the Requisite Consents of Holders of Notes to any amendment effected by or delivered in connection with this Supplemental Indenture are determined by a court of competent jurisdiction to have not been validly obtained in accordance with the Indenture or applicable laws, such amendment shall not be deemed to have occurred.

Section 2.08. Trustee Disclaimer. The recitals contained herein and the statements made in any Officer's Certificate shall be taken as the statements of the Issuers, and the Trustee assumes no responsibility for their correctness, and none of the recitals contained herein or the statements made in any Officer's Certificate are intended to or shall be construed as statements made or agreed to by the Trustee. The Trustee makes no representations as to the validity or sufficiency of this Supplemental Indenture or the consequences of any amendment provided herein.

IN WITNESS WHEREOF, the parties hereto have caused this Supplemental Indenture to be duly executed and attested, all as of the date first above written.

ISSUERS:

FORESIGHT ENERGY LLC, as Issuer

By:/s/ Robert D. Moore
Name: Robert D. Moore
Title: President and Chief Executive Officer

FORESIGHT ENERGY FINANCE CORPORATION, as Co-Issuer

IN WITNESS WHEREOF, the parties hereto have caused this Supplemental Indenture to be duly executed and attested, all as of the date first above written.

ISSUERS:

FORESIGHT ENERGY LLC, as Issuer

By:/s/ Robert D. Moore
Name: Robert D. Moore
Title: President and Chief Executive Officer

FORESIGHT ENERGY FINANCE CORPORATION, as Co-Issuer

By:/s/ Robert D. Moore
Name: Robert D. Moore
Title: President and Chief Executive Officer

[Signature Page – Second Supplemental Indenture]

GUARANTORS:

ADENA RESOURCES, LLC
AKIN ENERGY LLC
AMERICAN CENTURY MINERAL LLC
AMERICAN CENTURY TRANSPORT LLC
COAL FIELD CONSTRUCTION COMPANY LLC
COAL FIELD REPAIR SERVICES LLC
FORESIGHT COAL SALES LLC
FORESIGHT ENERGY EMPLOYEE SERVICES CORPORATION
FORESIGHT ENERGY LABOR LLC
FORESIGHT ENERGY SERVICES LLC
HILLSBORO TRANSPORT LLC
LD LABOR COMPANY LLC
LOGAN MINING LLC
M-CLASS MINING, LLC
MACH MINING, LLC
MACOUPIN ENERGY LLC
MARYAN MINING LLC
OENEUS LLC D/B/A SAVATRAN LLC
SENECA REBUILD LLC
SITRAN LLC
SUGAR CAMP ENERGY, LLC

GUARANTORS:

ADENA RESOURCES, LLC
AKIN ENERGY LLC
AMERICAN CENTURY MINERAL LLC
AMERICAN CENTURY TRANSPORT LLC
COAL FIELD CONSTRUCTION COMPANY LLC
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MARYAN MINING LLC
OENEUS LLC D/B/A SAVATRAN LLC
SENECA REBUILD LLC
SITRAN LLC
SUGAR CAMP ENERGY, LLC
TANNER ENERGY LLC
VIKING MINING LLC
WILLIAMSON ENERGY, LLC

By:/s/ Robert D. Moore
Name: Robert D. Moore
Title: President and Chief Executive Officer

[Signature Page – Second Supplemental Indenture]

TRUSTEE:

WILMINGTON TRUST, NATIONAL ASSOCIATION

By:/s/ Nedine P. Sutton
Name: Nedine P. Sutton
Title: Vice President

TRUSTEE:

WILMINGTON TRUST, NATIONAL ASSOCIATION

By:/s/ Nedine P. Sutton
Name: Nedine P. Sutton
Title: Vice President

[Signature Page – Second Supplemental Indenture]

OTCMarkets IQ

Quote

Stock Screener

Market Activity / Stock / FELPU / Disclosure

FELPU

Foresight Energy LP

Units - Representing Limited Partner Interests

0.06275

-0.00435
-6.48%
0.0575 / 0.068 (10000 x 26059)

Real-Time Best Bid & Ask: 01:37pm 01/23/2020
Delayed (15 Min) Trade Data: 02:16pm 01/23/2020

Overview

Quote

Company Profile

Security Details

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FILINGS AND DISCLOSURE

OTC Disclosure & News

Active Inactive All

No financial reports have been posted for FELPU.

SEC Filings

FORM TYPE	RECEIVED	PERIOD END DATE	REPORT			
8-K	12/20/2019	12/19/2019	PDF	RTF	HTML	XLS
8-K	12/13/2019	12/13/2019	PDF	RTF	HTML	XLS
4	12/11/2019	12/10/2019	PDF	RTF	HTML	XLS
4	12/11/2019	12/10/2019	PDF	RTF	HTML	XLS
4	12/11/2019	12/10/2019	PDF	RTF	HTML	XLS
4	12/11/2019	12/10/2019	PDF	RTF	HTML	XLS
8-K	12/11/2019	12/10/2019	PDF	RTF	HTML	XLS
25-NSE	11/25/2019		PDF	RTF	HTML	
10-Q	11/12/2019	09/30/2019	PDF	RTF	HTML	XLS
8-K	11/12/2019	11/12/2019	PDF	RTF	HTML	XLS

MORE

Displaying 10 of 267 Filings

INSIDER DISCLOSURE

OTC Disclosure & News

No insider disclosure available for FELPU.

SEC Transactions Last 6 Months

Buy / Sell

BUYS
3

SELLS
4

TOTAL
7

Shares

BOUGHT
538,268

SOLD

889,497

GROSS

1,427,765

NET

-351,229

SEC Transactions Last 2 Years

TRANS DATE	FILER	OWNERSHIP	TYPE	PRICE	SHARES
12/10/2019	SULLIVAN BRIAN D Director	Direct	Disposition (Non Open Market)	0.00	191,796
12/10/2019	MOORE ROBERT D. Officer	Direct	Disposition (Non Open Market)	0.00	293,869
12/10/2019	CASEY G NICHOLAS JR. Director	Direct	Disposition (Non Open Market)	0.00	202,373
12/10/2019	HERMANN DANIEL S Director	Direct	Disposition (Non Open Market)	0.00	201,459
07/25/2019	ESTATE OF CHRISTOPHER CLINE Beneficial Owner (10%)	Indirect			
07/25/2019	ESTATE OF CHRISTOPHER CLINE Beneficial Owner (10%)	Direct			
09/11/2019	CASEY G NICHOLAS JR. Director	Direct	Acquisition (Non Open Market)	0.00	182,927
09/11/2019	HERMANN DANIEL S Director	Direct	Acquisition (Non Open Market)	0.00	182,927
08/20/2019	SULLIVAN BRIAN D Director	Direct	Acquisition (Non Open Market)	0.00	172,414
03/25/2019	RAY LESSLIE H Director	Direct			

MORE

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OTCQX Member Since 11/2019

OTCQX U.S.

OTCQX Composite

OTCQX Dividend

OTCQX U.S.

Verified Profile 11/2019

Penny Stock Exempt

Two Independent Directors

SECURITIES

Other Foresight Energy LP Securities

FEGYW

DAILY ADVANCERS

QX ISCO
+ 27.71 %

QX UGRO
+ 25.00 %

QX ALMTF
+ 16.96 %

QX BHNGF
+ 14.64 %

QX AVCNF
+ 13.99 %

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Quote

SYMBOL
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LAST
34.50

CHANGE
0.00 (0.00%)
BID
34.45
ASK
34.65
VOLUME
10701
TIME
13:54



Contact

Careers

Market Hours

Glossary

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Sales & Markets

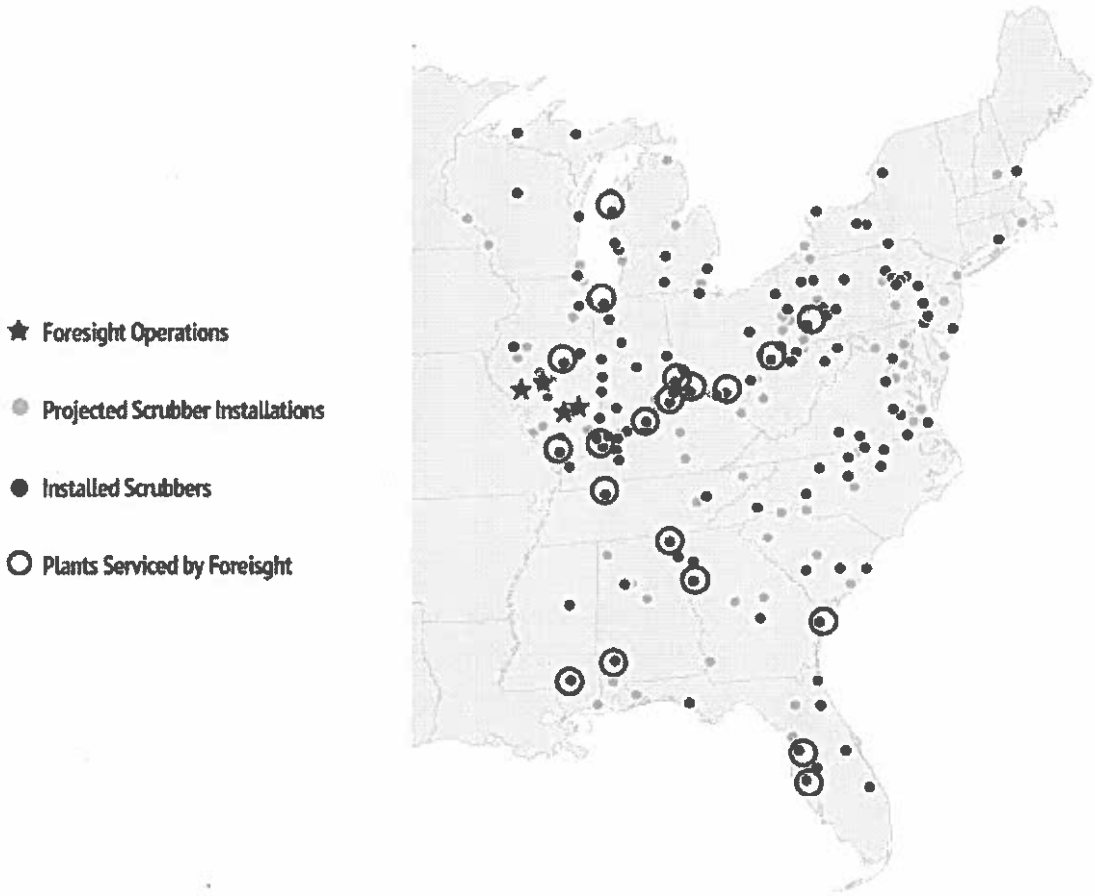
We know that it's not enough to be low cost at the mine. We also want to be low cost on a delivered basis. Our ability to access multiple rail carriers as well as other modes of transportation such as river barge and trucks allow us to reach a wide range of customers at cost effective prices. Foresight's coal production is consumed by electric utilities and industrial customers both inside and outside of the U.S.

Market Locations

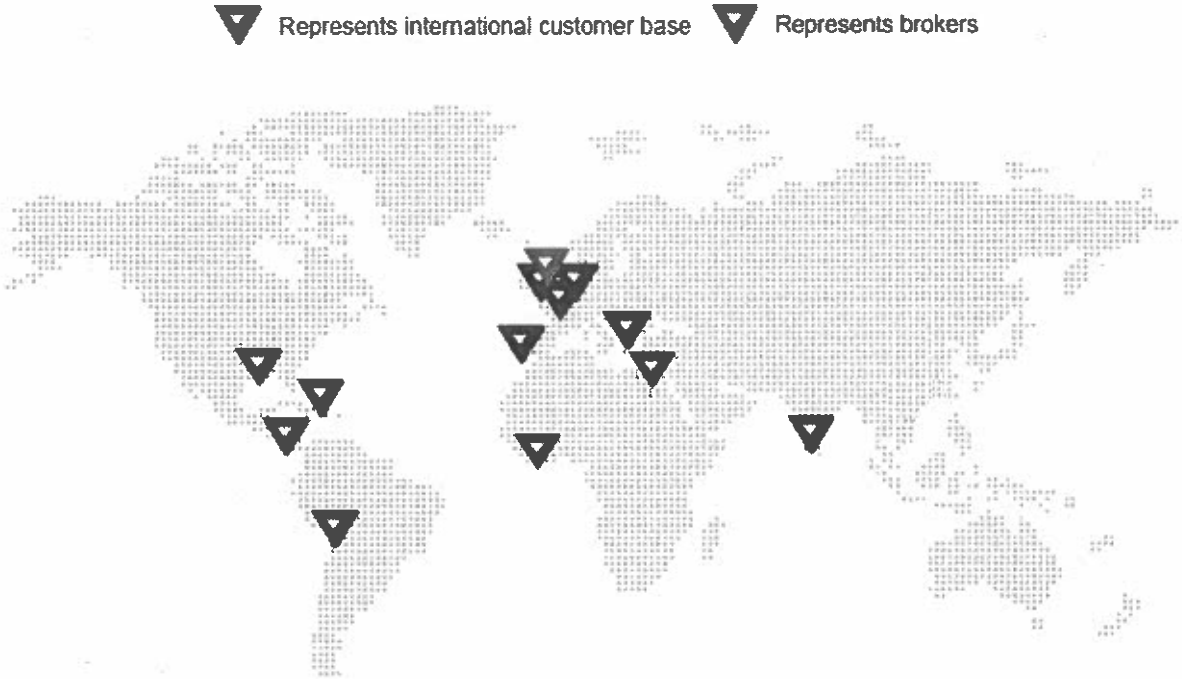
Our primary target market in the United States primarily consists of power plants located in the eastern U.S. that have been updated with emission-control equipment needed to comply with existing and future environmental regulations.

Similarly our off-shore customers consist of utilities or intermediaries that use our coal at scrubbed power plants or blend our coal to meet local environmental emission standards.

Domestic


Foresight Operations
Projected Scrubber Installations
Installed Scrubbers
Plants Serviced by Foreisght

Global


Represents international customer base
Represents brokers

Coal Quality

We have the ability to offer a range of product specifications and in addition can offer a quality blend.Listed below are three of our most popular product qualities.

	FE 2.5 Typical	FE 3.0 Typical	FE 3.5 Typical
CV, GAR btu/lb	11,700	11,300	10,800
CV, NAR kcal/kg	6,200	6,000	5,700
Moisture % (AR)	12.0	14.5	16.5
Ash % (AR)	9.50	8.50	8.00
VM % (AR)	34	35	35
Sulfur % (AR)	2.50	3.00	3.50

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One Metropolitan Square 211 North Broadway, Suite 2600 St. Louis, MO 63102 Phone: (314) 932-6160

INDIANA

State Profile and Energy Estimates



Newly released in Beta: State Energy Portal featuring customizable dashboards and more state data.

Profile Analysis

Print State Energy Profile (overview, data, & analysis)

Last Updated: May 16, 2019

Overview

Indiana, located in the nation's Interior Plains just west of the Appalachian Mountains, extends from Lake Michigan south to the Ohio River.[1,2] Sediments deposited over millions of years,[3] when the state was covered by inland seas and later by lush swamps,[4,5] became the geologic layers that contain Indiana's fossil fuel resources, predominantly coal but also crude oil and some natural gas.[6,7,8] The flat plains and slightly rolling terrain in the northern two-thirds of the state are the result of the 2,000-foot-thick glacier that covered much of the state during the Ice Ages. The retreat of the glacier more than 10,000 years ago left behind the excellent topsoil that supports Indiana's agriculture.[9] Ample summer rainfall and rich prairie soils allow Indiana farmers to produce abundant corn and soybean crops that make the state a major producer of ethanol and biodiesel.[10,11,12,13,14] Indiana's open farmland also has substantial wind energy resources, and most of the state's wind farms are in the central and western part of the state.[15,16]

Although Indiana is one of the smallest states in land area west of the Appalachian Mountains, it has a varied climate because of its length from north to south. In the north, Indiana experiences lake-effect snows and winds off Lake Michigan. In the south, the hilly terrain creates localized weather variations. The climate statewide is influenced by the interplay of polar air moving south from Canada and warm, moist air moving north from the Gulf of Mexico. Indiana's winters can be bitterly cold, spring weather often includes tornadoes, and summer days may have oppressive humidity and heat.[17] In part because of those weather extremes, Indiana ranks among the top 10 states in total and residential energy use per capita.[18,19] The industrial sector is the state's largest end-use energy consuming sector, using almost half of the energy consumed in the state.[20] Indiana's industrial activities include the energy-intensive chemical, petroleum, and steelmaking industries.[21,22] Overall, more than three times as much energy is consumed in the state as is produced there.[23]

Coal

Indiana has about 1.5% of U.S. economically recoverable coal reserves[24] and is the nation's eighth-largest coal producer. The state accounts for nearly 3% of U.S. coal production. Bituminous coal is produced from almost 20 surface and underground mines located in southwestern Indiana within the Indiana portion of the coal-rich Illinois Basin.[25,26,27] About one-fourth of the approximately 30 million tons of coal produced annually in Indiana is shipped to a dozen other states by rail, barge, and truck.[28,29] A small amount of Indiana coal is exported to other countries.[30]

Indiana is the nation's second-largest coal consumer, after Texas.

Even though Indiana is one of the top coal producers in the nation, state production does not meet state demand.[31,32] In 2017, Indiana's total coal consumption ranked second after Texas.[33] Additional coal arrives by rail and barge from mines primarily in West Virginia, Illinois, Kentucky, and Wyoming.[34] The amount of coal Indiana consumes for electricity generation ranks third in the nation, after Texas and Missouri. The state is also third, after Pennsylvania and North Dakota, in the amount of coal used by the industrial sector.[35,36] Because Indiana is a leader in steel manufacturing, nearly one-tenth of the coal used in the state is delivered to coking plants that supply the state's steel industry.[37,38,39,40] However, the industrial sector's coal consumption has declined every year, except for one, since 2005.[41] A very small amount of coal is used in the commercial sector and no appreciable coal is used in the residential sector, where 0.1% of households heat with coal.[42,43]

Electricity

Indiana is among the top five states in the share of its electricity that is generated from coal. Although coal-fired electricity generation has declined by 30% in the past decade, about 70% of the state's electricity was still generated from coal in 2018.[44,45] Eight of Indiana's 10 largest power plants are coal-fired,[46] but more than 3,300 megawatts of coal-fired capacity have retired since 2010.[47] The share of the state's net generation from natural gas has increased [48,49]

Indiana is among the top six states in electricity retail sales to the industrial sector.

more than fourfold during the same period, reaching more than one-fifth of state generation in 2018. Almost nine-tenths of the nearly 1,600 megawatts of new generating capacity that was brought online in Indiana during 2018 was powered by natural gas, while the rest of the new generation was powered by renewable energy sources.[50] Wind provided 5% of Indiana's electricity generation in 2018, and other renewable resources—biomass, solar, and hydroelectric power—together accounted for slightly more than 1% of the state's utility-scale net generation. Nearly all of Indiana's solar generation comes from larger, utility-scale facilities. The rest of the state's net electricity generation comes from other gases, other energy sources, and petroleum liquids.[51]

As coal-fired generation has decreased, Indiana's total generation has decreased. Indiana consumers use more electricity than in-state generators can supply. To meet power demand in 2017, one-tenth of Indiana's electricity supply came from other states.[52] Out-of-state power supplies are delivered by the two interstate power grids serving Indiana: the PJM Interconnect in the northeast corner of the state and the Midcontinent Independent System Operator in the west and south.[53] Indiana is among the top six states in electricity retail sales to the industrial sector.[54] Total electricity consumption from all sectors in Indiana is in the top one-fourth of the states.[55] Three in 10 Indiana households rely on electricity as their primary energy source for home heating.[56]

Renewable energy

Indiana is among the nation's top producers of liquid biofuels. The state's abundant corn and soybean crops provide the feedstock for biofuel production.[57] Indiana's 14 fuel ethanol plants use corn as their feedstock, and the biodiesel plants use soy oil and other feedstocks.[58,59,60] Indiana is the fifth-largest producer of ethanol in the nation and makes about 1.2 billion gallons per year, almost 8% of the nation's total.[61] The state also has the sixth-largest production capacity for biodiesel at more than 100 million gallons per year.[62]

Indiana is the fifth-largest ethanol producer in the nation.

Renewable energy supplied more than 6% of Indiana's net electricity generation in 2018. Wind is the state's primary renewable resource used for electric power generation, and 5% of Indiana's net electricity generation came from wind turbines in 2018.[63] Indiana's first utility-scale wind project, the 103.5-megawatt Benton County Wind Farm, came online in 2008.[64] Currently, wind turbines stretch across central Indiana, and the state has more than 2,300 megawatts of wind capacity, up from 2,100 megawatts in 2017.[65]

Additional small amounts of electricity are generated from solar, biomass, and hydroelectric facilities.[66] Extreme southwestern Indiana has the state's best solar resources, but solar facilities are found statewide.[67,68] The state's biomass resources include crop and forest residues, animal waste, and solid biomass resources.[69] Most of Indiana's biomass power plants are landfill gas facilities located in the northern half of the state.[70] There are also three small wood pellet plants in Indiana that convert wood waste into pellets used for heating and electricity generation. They have a combined manufacturing capacity of about 47,000 tons of pellets per year.[71] The state's only large hydroelectric power plant is on the Ohio River at Indiana's southeastern boundary.[72,73]

Although Indiana's geothermal energy resources are modest,[74] the state has one large geothermal installation, located at Ball State University in Muncie. That system was designed to replace aging coal-fired boilers and provide heating and cooling to 47 university buildings.[75]

In 2011, Indiana's legislature created a voluntary clean energy portfolio standard; however, as of 2018, no Indiana utility had chosen to participate.[76] If an electric utility elected to participate, they had to agree to acquire an average of 4% of the electricity they sold to customers from clean energy sources between 2013 and 2018. In 2019 the target increased to 7%, and in 2025 the target will rise to 10%.[77] Among the eligible sources are wind, solar, coalbed methane, clean coal technology, nuclear energy, combined heat and power systems, and natural gas plants built after July 1, 2011 that displace electricity generation from coal.[78]

Indiana utilities are required to offer net metering for customer-sited renewable generating facilities with less than 1 megawatt of capacity. Customers are compensated for any electricity they generate that is in excess of what they use. At the end of 2017, 49 megawatts of customer-sited capacity were connected under the net metering program. In 2017, the legislature increased the limit on a utility's net metered connections from 1% to 1.5% of the utility's peak summer load. The law reserves 40% of the 1.5% of capacity for residential customers and 15% of the 1.5% for organic biomass. There are no restrictions on the remainder. In 2017, the Indiana legislature also reduced the rate customers receive from utilities for their distributed (small-scale, customer-sited) generation. Compensation was switched from a system based on a higher retail rate for electricity to one linked to the lower wholesale power rate.[79]

Petroleum

Indiana's proved crude oil reserves are small and have declined from about 40 million barrels in 1979 to 5 million in 2017.[80,81] The Trenton Field, discovered in east-central Indiana in 1876, was the nation's first oil field to produce more than 100 million barrels of crude oil. The field ceased production in the early 20th century, and the center of the state's crude oil production moved to the Illinois Basin in southwestern Indiana, where output peaked in 1956.[82] Although advanced drilling technology had increased Indiana's crude oil production in recent years,[83] the state's production dropped to its lowest level in more than 35 years in 2018.[84,85] Indiana crude oil production now accounts for less than 0.1% of the nation's total oil production.[86]

The Whiting refinery in Indiana is the largest inland crude oil refinery in the nation.

The Whiting refinery, located in northwest Indiana, is one of the state's two petroleum refineries and is one of the oldest U.S. refineries, having opened in 1889. Whiting is the largest inland crude oil refinery in the nation; only six Gulf Coast refineries have higher capacities.[87] The Whiting refinery can process about 413,500 barrels of crude oil per calendar day and produces large quantities of motor gasoline, diesel fuel, and jet fuel as well as about 5% of the nation's asphalt.[88,89] A second, small refinery is located in Mount Vernon at the southern tip of Indiana. That refinery processes Illinois Basin crude oil from southern Indiana, southern Illinois, and western Kentucky. Its refined products—motor gasoline, diesel fuel, and lubricants—are delivered to customers in Indiana, Illinois, Michigan, Ohio, and Kentucky.[90] A plastics-to-fuel plant that will be able to process 100,000 tons of non-recycled plastic waste into 18 million gallons of ultra-low sulfur diesel fuel is in development in Indiana.[91]

Nearly half of the Indiana's petroleum consumption is in the form of motor gasoline, and three-tenths is distillate fuel oil, including diesel fuel. Although conventional motor gasoline can be used in most of Indiana, reformulated motor gasoline blended with ethanol is required in the state's northwest corner near Chicago. In addition, motor gasoline formulated to reduce emissions that contribute to ground-level ozone is required during the summer months in southeast Indiana near Louisville, Kentucky.[93,94] Most of the petroleum not used by the transportation sector is used by industry. The rest is used in the commercial and residential sectors, which consume almost equal amounts.[95] Distillate fuel (heating oil) sales to the residential sector have declined over the past three decades.[96] Currently, nearly 1% of Indiana households use fuel oil or kerosene for home heating, and 7% use hydrocarbon gas liquids, mostly propane.[97] A small amount (less than 0.2%) of Indiana's electricity is petroleum-fired.[98]

Natural gas

Indiana has minor natural gas reserves, and, in 2017, the state's annual natural gas production was only 0.02% of the U.S. total.[99,100] There was a brief spike in production in 2011 when the number of wells completed using hydraulic fracturing, which improved initial production, increased.[101,102] Most of the state's natural gas fields are in the east central part of the state where natural gas was first discovered in the mid-1870s.[103] The availability of advanced drilling technologies has created renewed interest in a shallow natural gas play in the Albany Shale in southwestern Indiana, which, along with potential coalbed methane resources, could add new natural gas reserves.[104]

Indiana is crossed by nine interstate natural gas pipelines. Those pipelines bring natural gas produced in Appalachia, the Gulf Coast, and western Canada into the state.[105] Natural gas enters Indiana primarily from Illinois and Ohio, and about one-fourth of that natural gas is used in Indiana. Most of the rest is sent on to Michigan and Ohio.[106] Some of the natural gas that enters Indiana is put in storage. The state has 21 natural gas storage fields with a combined total capacity of 113 billion cubic feet.[107,108]

Indiana has 21 natural gas storage fields that can hold 113 billion cubic feet of natural gas.

Indiana's natural gas consumption is much greater than state production.[109,110] The industrial sector is the largest natural gas consumer in Indiana and accounts for more than half of the natural gas used in the state.[111] The state's electric power sector has experienced an almost five-fold increase in the use of natural gas for electricity generation in the past decade.[112] Since 2016, the electric power sector's natural gas consumption has exceeded the residential sector's use. The residential sector uses one-sixth of the natural gas consumed in Indiana. Three-fifths of the state's households use natural gas for home heating.[113,114]

Endnotes

[1] U.S. Geological Survey, Geology and National Parks, Geologic Provinces of the United States: Interior Plain Province, updated April 21, 2017.

[2] World Atlas, Indiana Geography, accessed April 18, 2019.

[3] U.S. Geological Survey, Geology and National Parks, Geologic Provinces of the United States: Interior Plain Province, updated April 21, 2017.

[4] Gray, Henry H., Nautiloids: Shelled Marauders of Indiana's Ordovician Seas, Indiana Geological and Water Survey, accessed April 18, 2019.

[5] Indiana Department of Natural Resources, Division of Reclamation, Facts about Coal in Indiana, accessed April 18, 2019.

[6] U.S. Energy Information Administration (EIA), Annual Coal Report 2017 (November 2018), Table 15, Recoverable Coal Reserves at Producing Mines, Estimated Recoverable Reserves, and Demonstrated Reserve Base by Mining Method, 2017.

[7] U.S. EIA, Crude Oil Proved Reserves, Reserves Changes, and Production, Proved Reserves as of December 31, 2017.

[8] U.S. EIA, U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2017, Table 16, Coalbed methane proved reserves, reserves changes, and production, 2017.

[9] City-Data, Indiana-Topography, accessed April 18, 2019.

[10] Indiana State Climate Office, About Indiana Climate, updated December 2002.

[11] U.S. Department of Agriculture, 2018 State Agriculture Overview, Indiana, accessed April 18, 2019.

[12] "U.S. Ethanol Plants, RINs, Operational," Ethanol Producer Magazine, updated September 6, 2018.

[13] U.S. EIA, U.S. Fuel Ethanol Plant Production Capacity, Detailed nameplate capacity of fuel ethanol plants by Petroleum Administration for Defense District (PADD District), Nameplate Capacities of Fuel Ethanol Plants, January 2018 (Excel File).

[14] U.S. EIA, Monthly Biodiesel Production Report, U.S. biodiesel production capacity, 2018.

[15] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, WINDExchange, Wind Energy in Indiana, accessed April 18, 2019.

[16] U.S. EIA, Indiana Profile Overview, Wind Power Plant Map Layer, accessed April 18, 2019.

[17] Indiana State Climate Office, About Indiana Climate, updated December 2002.

[18] U.S. EIA, State Energy Data System, 1960-2016 estimates, Key Statistics and Indicators, Total energy consumption per capita by end-use sector and Total energy consumption per capita in the residential sector, 1960-2016.

[19] U.S. EIA, State Energy Data System, Table C13, Energy Consumption Estimates per Capita by End-Use Sector, Ranked by State, 2016.

[20] U.S. EIA, State Energy Data System, Table C1, Energy Consumption Overview: Estimates by Energy Source and End-Use Sector, 2016.

[21] U.S. Bureau of Economic Analysis, Interactive Data, Regional Data, GDP & Personal Income, Annual Gross Domestic Product (GDP) by State, GDP in Current Dollars, Classification NAICS, Indiana, All statistics in the table, 2016, 2017.

[22] Pete, Joseph, "Indiana Remains National Champion of Steel Production," nwitimes.com (March 12, 2016).

[23] U.S. EIA, State Energy Data System, Table P3, Total Primary Energy Production and Total Energy Consumption Estimates in Trillion Btu, 2016.

[24] U.S. EIA, Annual Coal Report 2017 (November 2018), Table 15, Recoverable Coal Reserves at Producing Mines, Estimated Recoverable Reserves, and Demonstrated Reserve Base by Mining Method, 2017.

[25] U.S. EIA, Annual Coal Report 2017 (November 2018), Table 6, Coal Production and Number of Mines by State and Coal Rank, 2017.

[26] Indiana Department of Natural Resources, Active Mining Permits Map, accessed April 18, 2019.

[27] U.S. EIA, Energy Explained, Coal Explained, Where Our Coal Comes From, accessed April 19, 2019.

[28] U.S. EIA, Annual Coal Report 2017 (November 2018), Table 1, Coal Production and Number of Mines by State and Mine Type, 2017 and 2016.

[29]

U.S. EIA, Annual Coal Distribution Report 2017 (November 2018), Domestic distribution of coal by origin State, Indiana, Table OS-7, Domestic Coal Distribution, by Origin State, 2017.

[30] U.S. EIA, Annual Coal Distribution Report 2017 (November 2018), U.S. Domestic and Foreign Coal Distribution by State of Origin, Domestic and Foreign Distribution of U.S. Coal by State of Origin, 2017.

[31] U.S. EIA, Annual Coal Report 2017 (November 2018), Table 6, Coal Production and Number of Mines by State and Coal Rank, 2017.

[32] U.S. EIA, Annual Coal Report 2017 (November 2018), Table 26, U.S. Coal Consumption by End Use Sector, Census Division, and State, 2017 and 2016.

[33] U.S. EIA, State Energy Data System, Table F23, Coal Consumption Estimates and Imports and Exports of Coal Coke, 2017.

[34] U.S. EIA, Annual Coal Distribution Report 2017 (November 2018), Domestic distribution of coal by destination State, Indiana, Table DS-13, Domestic Coal Distribution, by Destination State, 2017.

[35] U.S. EIA, Annual Coal Report 2017 (November 2018), Table 26, U.S. Coal Consumption by End Use Sector, Census Division, and State, 2017 and 2016.

[36] U.S. EIA, State Energy Data System, Table F23, Coal Consumption Estimates and Imports and Exports of Coal Coke, 2017.

[37] Pete, Joseph, "Indiana Remains National Champion of Steel Production," nwitimes.com (March 12, 2016).

[38] U.S. EIA, Annual Coal Distribution Report 2017 (November 2018), Domestic distribution of coal by destination State, Indiana, Table DS-13, Domestic Coal Distribution, by Destination State, 2017.

[39] "The Roles of Coal and Coke in Steelmaking," Heyl & Patter Blog (July 16, 2014).

[40] SteelWorks, Where Steel is Made, Steel Plants of North America (June 2013).

[41] U.S. EIA, State Energy Consumption Estimates, 1960 Through 2016, DOE/EIA-0214(2016) (June 2018), Indiana Table CT6, p. 179.

[42] U.S. EIA, State Energy Data System, Table F23 Coal Consumption Estimates and Imports and Exports of Coal Coke, 2017.

[43] U.S. Census Bureau, American FactFinder, Indiana, Table B25040, House Heating Fuel, 2017 American Community Survey 1-Year Estimates.

[44] U.S. EIA, Electric Power Monthly (February 2019), Tables 1.3.B, 1.4.B.

[45] U.S. EIA, Indiana Electricity Profile 2017, Table 5, Electric power industry generation by primary energy source, 1990 through 2017.

[46] U.S. EIA, State Electricity Profiles, Indiana Electricity Profile 2017, Tables 2A, Ten Largest Plants by Capacity, 2017, and 2B, Ten Largest Plants by Generation, 2017 .

[47] U.S. EIA, Electricity, Form EIA-860 detailed data with previous form data (EIA-860A/860B), 2017 Form EIA-860 Data, Schedule 3, 'Generator Data' (Retired & Canceled Units Only).

[48] U.S. EIA, Electric Power Monthly (February 2019), Tables 1.3.B, 1.7.B.

[49] U.S. EIA, Indiana Electricity Profile 2017, Table 5, Electric power industry generation by primary energy source, 1990 through 2017.

[50] U.S. EIA, Electric Power Monthly (February 2019), Table 6.3.

[51] U.S. EIA, Electric Power Monthly (February 2019), Tables 1.3.B, 1.5.B, 1.8.B, 1.10.B, 1.11.B, 1.13.B, 1.14.B, 1.15.B, 1.17.B.

[52] U.S. EIA, Indiana Electricity Profile 2017, Table 10, Supply and disposition of electricity, 1990 through 2017.

[53] U.S. Federal Energy Regulatory Commission, Regional Transmission Organizations (RT)/Independent System Operators (ISO), updated October 18, 2018.

[54] U.S. EIA, Electric Power Monthly (February 2019), Table 5.4.B.

[55] U.S. EIA, State Energy Data System, Table F20, Electricity Consumption Estimates, 2017.

[56] U.S. Census Bureau, American FactFinder, Indiana, Table B25040, House Heating Fuel, 2017 American Community Survey 1-Year Estimates.

[57] NETSTATE, Indiana Economy, accessed April 22, 2019.

[58] U.S. EIA, U.S. Fuel Ethanol Plant Production Capacity, Detailed nameplate capacity of fuel ethanol plants by Petroleum Administration for Defense District (PADD District), Nameplate Capacities of Fuel Ethanol Plants, January 2018 (Excel File).

[59] "U.S. Ethanol Plants, RINs, Operational," Ethanol Producer Magazine, updated September 6, 2018.

[60] "U.S. Biodiesel Plants, operational," Biodiesel Magazine, updated December 13, 2017.

[61] U.S. EIA, State Energy Data System, Table P1, Primary Energy Production Estimates in Physical Units, 2016.

[62] U.S. EIA, Monthly Biodiesel Production Report (March 2019), Table 4, Biodiesel producers and production capacity by state, January 2019.

[63] U.S. EIA, Electric Power Monthly (February 2019), Tables 1.3.B, 1.10.B, 1.11.B, 1.14.B.

[64] Benton County, Indiana, Wind Farms, Benton County Wind Farm, accessed April 24, 2019.

[65] U.S. EIA, Electric Power Monthly (March 2019), Table 6.2.B.

[66] U.S. EIA, Electric Power Monthly (February 2019), Tables 1.3.B, 1.10.B, 1.15.B, 1.17.B.

[67] National Renewable Energy Laboratory, Geospatial Data Science, Solar Maps, U.S. State Solar Resource Maps, Direct Normal Solar Resource of Indiana (April 4, 2017).

[68] U.S. EIA, Indiana Profile Overview, Solar Power Plant Map Layer, accessed April 24, 2019.

[69] Human, Dan, "Biomass could power 1/3 of Hoosier homes, report says," Indianapolis Business Journal (November 16, 2013).

[70] U.S. EIA, Indiana Profile Overview, Biomass Power Plant Map Layer, accessed April 24, 2019.

[71] "U.S. Pellet Plants," Biomass Magazine, updated September 21, 2018.

[72] U.S. EIA, Indiana Profile Overview, Hydroelectric Power Plant Map Layer, accessed April 24, 2019.

[73] U.S. EIA, Electricity, Form EIA-860 detailed data with previous form data (EIA-860A/860B), 2017 Form EIA-860 Data, Schedule 3, 'Generator Data' (Operating Units Only).

[74] National Renewable Energy Laboratory, Geospatial Data Science, Geothermal Maps, Resource Potential, accessed April 25, 2019.

[75] Ball State University, Geothermal Energy System, accessed April 25, 2019.

[76] Indiana Utility Regulatory Commission, 2018 Annual Report, p. 36.

[77] Indiana Office of Energy Development, Indiana Choice Program, accessed April 25, 2019.

[78] Indiana Office of Energy Development, CHOICE Program FAQ, accessed April 25, 2019.

[79] Indiana Utility Regulatory Commission, 2018 Annual Report, p. 33-35.

[80] U.S. EIA, Crude Oil Proved Reserves, Reserves Changes, and Production, Annual, Proved Reserves as of December 31, 2017.

[81] U.S. EIA, Indiana Crude Oil Proved Reserves, Annual, 1977-2017.

[82] Indiana Geological Survey, Oil and Gas, A Brief Overview of the History of the Petroleum Industry in Indiana, Trenton Field, accessed April 22, 2019.

[83] McDivitt, Herschel, Hydraulic Fracturing 101, Indiana Division of Oil and Gas, slide 35, Indiana Hydraulic Fracturing Trends, updated October 15, 2014.

[84] U.S. EIA, Indiana Field Production of Crude Oil, Annual, 1981-2017.
[85] U.S. EIA, Indiana Field Production of Crude Oil, Monthly, January 1981-January 2019.
[86] U.S. EIA, U.S. Field Production of Crude Oil, Monthly, January 1920-January 2019.
[87] U.S. EIA, Oil: Crude and Petroleum Products Explained, Refining Crude Oil, Top 10 U.S. refineries operable capacity, as of January 1, 2018.
[88] U.S. EIA, Refinery Capacity Report (June 2018), Table 3, Capacity of Operable Petroleum Refineries by State as of January 1, 2018.
[89] BP, United States, Whiting Refinery, accessed April 22, 2019.
[90] CountryMark, About Us, Refinery, accessed April 22, 2019.
[91] Zimmerman, Cindy, "Plastics-to-Fuel Plant Planned for Indiana," Energy.AGwired (November 14, 2018).
[92] U.S. EIA, State Energy Data System, Table C3, Primary Energy Consumption Estimates, 2016.
[93] American Fuel & Petrochemical Manufacturers, State Motor Fuels Specifications, Indiana, updated September 2017.
[94] American Petroleum Institute, U.S. Gasoline Requirements, Map, updated January 2018.
[95] U.S. EIA, State Energy Data System, Table F15, Total Petroleum Consumption Estimates, 2017.
[96] U.S. EIA, Indiana Total Distillate Sales/Deliveries to Residential Consumers, 1984-2017.
[97] U.S. Census Bureau, American FactFinder, Indiana, Table B25040, House Heating Fuel, 2017 American Community Survey 1-Year Estimates.
[98] U.S. EIA, Electric Power Monthly (February 2019), Tables 1.3.B, 1.5.B.
[99] U.S. EIA, Natural Gas Reserves Summary as of December 31, Wet NG, Annual, 2012-17.
[100] U.S. EIA, Natural Gas Gross Withdrawals and Production, Gross Withdrawals, Annual, 2013-18.
[101] Indiana Department of Natural Resources, Oil and Gas Division, Annual Well Completions and Hydraulic Fracturing Data, 2005 to 2012.
[102] U.S. EIA, Indiana Natural Gas Gross Withdrawals, 1967-2017.
[103] Rupp, John A., Oil and Gas, A Brief Overview of the History of the Petroleum Industry in Indiana, Indiana Geological Survey, accessed April 26, 2019.
[104] Indiana Geological Survey, Oil and Gas, Indiana Petroleum History, A Brief Overview of the History of the Petroleum Industry in Indiana, Current Activity and Future Prospects, accessed April 26, 2019.
[105] U.S. EIA, Indiana Profile Overview, Natural Gas Inter/Intrastate Pipeline Map Layer, accessed April 26, 2019.
[106] U.S. EIA, International and Interstate Movements of Natural Gas by State, Indiana, Annual, 2012-17.
[107] U.S. EIA, Underground Natural Gas Storage Capacity, Total Number of Existing Fields, Annual, 2012-17.
[108] U.S. EIA, Underground Natural Gas Storage Capacity, Total Storage Capacity, Annual, 2012-17.
[109] U.S. EIA, Natural Gas Consumption by End Use, Total Consumption, Annual, 2013-18.
[110] U.S. EIA, Indiana Natural Gas Gross Withdrawals, 1967-2017.
[111] U.S. EIA, Natural Gas Consumption by End Use, Indiana, Annual, 2013-18.
[112] U.S. EIA, Indiana Natural Gas Deliveries to Electric Power Consumers, 1997-2018.
[113] U.S. EIA, Natural Gas Consumption by End Use, Indiana, Annual, 2013-18.
[114] U.S. Census Bureau, American FactFinder, Indiana, Table B25040, House Heating Fuel, 2017 American Community Survey 1-Year Estimates.

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Category:Existing coal plants in Indiana

Indiana is 2nd in the nation in coal power generation, with 90 operating coal-fired units at 30 locations totaling 21,551 megawatts (MW). Click on the locations shown on the map for plant details. (To return to the map of existing coal plants in the U.S., click **here**.) For additional information on coal issues in Indiana, click **here**. For a list of proposed new coal plants in Indiana, click **here**.





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Bunge Decatur Power Plant

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Clifty Creek Station
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Dean Mitchell Generating Station

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Rockport Plant

For the proposed gasification plant in Indiana, go to Indiana SNG

Rockport Plant is a 2,600 megawatt (MW) coal-fired power station owned and operated by American Electric Power subsidiary Indiana Michigan Power (I&M). The plant is located near Rockport, Indiana. Indiana Michigan Power states that "portions of Rockport Plant are dedicated to I&M customers 1960 MW, Kentucky Power 390 MW, Progress Energy/Carolina 250 MW".[1]

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Location



Plant Data

Owner: Indiana Michigan Power Company
Parent Company: American Electric Power
Plant Nameplate Capacity: 2,600 MW
Units and In-Service Dates: 1,300 MW (1984), 1,300 MW (1989)
Location: 2791 North U.S. 231, Rockport, IN 47635
GPS Coordinates: 37.925861, -87.035528
Coal Consumption:
Coal Source:

Number of Employees:
Unit Retirements: Unit 1 is scheduled for retirement by 2028[2]

Emissions Data

2006 CO_2 Emissions: 20,181,545 tons
2006 SO_2 Emissions: 83,543 tons
2006 SO_2 Emissions per MWh:
2006 NO_x Emissions: 28,124 tons
2005 Mercury Emissions: 1,179 lb.

Death and disease attributable to fine particle pollution from Rockport

In 2010, Abt Associates issued a study commissioned by the Clean Air Task Force, a nonprofit research and advocacy organization, quantifying the deaths and other health effects attributable to fine particle pollution from coal-fired power plants.[3] Fine particle pollution consists of a complex mixture of soot, heavy metals, sulfur dioxide, and nitrogen oxides. Among these particles, the most dangerous are those less than 2.5 microns in diameter, which are so tiny that they can evade the lung's natural defenses, enter the bloodstream, and be transported to vital organs. Impacts are especially severe among the elderly, children, and those with respiratory disease. The study found that over 13,000 deaths and tens of thousands of cases of chronic bronchitis, acute bronchitis, asthma, congestive heart failure, acute myocardial infarction, dysrhythmia, ischemic heart disease, chronic lung disease, and pneumonia each year are attributable to fine particle pollution from U.S. coal plant emissions. These deaths and illnesses are major examples of coal's external costs, i.e. uncompensated harms inflicted upon the public at large. Low-income and minority populations are disproportionately impacted as well, due to the tendency of companies to avoid locating power plants upwind of affluent communities. To monetize the health impact of fine particle pollution from each coal plant, Abt assigned a value of $7,300,000 to each 2010 mortality, based on a range of government and private studies. Valuations of illnesses ranged from $52 for an asthma episode to $440,000 for a case of chronic bronchitis.[4]

Table 1: Death and disease attributable to fine particle pollution from Rockport Plant

Type of Impact	Annual Incidence	Valuation
Deaths	140	$1,000,000,000
Heart attacks	210	$23,000,000
Asthma attacks	2,300	$120,000

Hospital admissions	99	$2,300,000
Chronic bronchitis	84	$37,000,000
Asthma ER visits	104	$52,000

Source: "Find Your Risk from Power Plant Pollution," Clean Air Task Force interactive table, accessed March 2011

Coal Waste Site

Rockport Plant Bottom Ash Complex

Rockport ranked 87th on list of most polluting power plants in terms of coal waste

In January 2009, Sue Sturgis of the Institute of Southern Studies compiled a list of the 100 most polluting coal plants in the United States in terms of coal combustion waste (CCW) stored in surface impoundments like the one involved in the TVA Kingston Fossil Plant coal ash spill.[5] The data came from the EPA's Toxics Release Inventory (TRI) for 2006, the most recent year available.[6]

Rockport Plant ranked number 87 on the list, with 281,995 pounds of coal combustion waste released to surface impoundments in 2006.[5]

Rockport ninth in 2009 mercury emissions

The 2011 Environmental Defense Fund report, "Mercury Alert: Cleaning up Coal Plants for Healthier Lives" found that 25 plants alone are responsible for nearly a third of all mercury emissions in the power sector, while providing only eight percent of U.S. electricity. The findings are based on 2009 U.S. Department of Energy data. The plant with the ninth highest mercury emissions was **Rockport Plant**, releasing 852 lbs in 2009.[7] According to Katheryn R. Mahaffey, Ph.D., of the U.S. EPA, mercury affects the environment and human health in the following ways:[8]

Mercury in the air settles into surface waters or onto land where it is washed into water. Deposited in lakes

and ponds, this mercury is converted by certain microorganisms to a highly toxic form of the chemical known as methylmercury.

Methylmercuryaccumulates in fish and shellfish, as well as birds and mammals that feed on fish. Humans are exposed to mercury when they eat contaminated fish and shellfish. Fish and shellfish are the main sources of human methylmercuryexposure.

Mercury exposure at high levels can harm the brain, heart, kidneys, lungs, and immune system of people of all ages. Unborn babies and young children are particularly vulnerable to high levels of methylmercuryin their bloodstreams.

High levels of methylmercurycan harm the developing nervous systems of fetuses and young children, resulting in later difficulties thinking and learning.

An estimated average of 410,000 infants are born annually in the U.S. to mothers with blood mercury concentrations in excess of EPA's Reference Dose

Articles and Resources

Sources

1. ↑ Indiana Michigan Power, "I&M Fact Sheet", Indiana Michigan Power website, April 2009.
2. ↑ https://www.eenews.net/stories/1060756791
3. ↑ "The Toll from Coal: An Updated Assessment of Death and Disease from America's Dirtiest Energy Source," Clean Air Task Force, September 2010.
4. ↑ "Technical Support Document for the Powerplant Impact Estimator Software Tool," Prepared for the Clean Air Task Force by Abt Associates, July 2010
5. ↑ [5.0] [5.1] Sue Sturgis, "Coal's ticking timebomb: Could disaster strike a coal ash dump near you?," Institute for Southern Studies, January 4, 2009.
6. ↑ TRI Explorer, EPA, accessed January 2009.
7. ↑ "Mercury Alert: Cleaning up Coal Plants for Healthier Lives" Environmental Defense Fund report, March 2011.
8. ↑ Kathryn R. Mahaffey, Ph.D., "NHANES 1999-2002 Update on Mercury," Northeast Regional Mercury Conference, April 2006

Existing Electric Generating Units in the United States, 2005, Energy Information Administration, accessed Jan. 2009.

Environmental Integrity Project, "Dirty Kilowatts: America's Most Polluting Power Plants", July 2007.

Facility Registry System, U.S. Environmental Protection Agency, accessed Jan. 2009.

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Gibson Generating Station

Gibson Generating Station is a coal-fired power station owned and operated by Duke Energy near Princeton, Indiana, just opposite the Wabash River from Mount Carmel, Illinois.



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Plant Data

Owner: PSI Energy Inc.
Parent Company: Duke Energy
Plant Nameplate Capacity: 3,340 MW
Units and In-Service Dates: 668 MW (1975), 668 MW (1976), 668 MW (1978), 668 MW (1979), 668 MW (1982)
Location: SR 64 W & CR 975, Princeton, IN 47670
GPS Coordinates: 38.3725, -87.76611
Coal Consumption:
Coal Source:
Number of Employees:

Emissions Data

2006 CO_2 Emissions: 21,447,980 tons
2006 SO_2 Emissions: 155,057 tons
2006 SO_2 Emissions per MWh:

2006 NO_x Emissions: 28,533 tons
2005 Mercury Emissions: 577 lb.

Death and disease attributable to fine particle pollution from Gibson Generating Station

In 2010, Abt Associates issued a study commissioned by the Clean Air Task Force, a nonprofit research and advocacy organization, quantifying the deaths and other health effects attributable to fine particle pollution from coal-fired power plants.[1] Fine particle pollution consists of a complex mixture of soot, heavy metals, sulfur dioxide, and nitrogen oxides. Among these particles, the most dangerous are those less than 2.5 microns in diameter, which are so tiny that they can evade the lung's natural defenses, enter the bloodstream, and be transported to vital organs. Impacts are especially severe among the elderly, children, and those with respiratory disease. The study found that over 13,000 deaths and tens of thousands of cases of chronic bronchitis, acute bronchitis, asthma, congestive heart failure, acute myocardial infarction, dysrhythmia, ischemic heart disease, chronic lung disease, and pneumonia each year are attributable to fine particle pollution from U.S. coal plant emissions. These deaths and illnesses are major examples of coal's external costs, i.e. uncompensated harms inflicted upon the public at large. Low-income and minority populations are disproportionately impacted as well, due to the tendency of companies to avoid locating power plants upwind of affluent communities. To monetize the health impact of fine particle pollution from each coal plant, Abt assigned a value of $7,300,000 to each 2010 mortality, based on a range of government and private studies. Valuations of illnesses ranged from $52 for an asthma episode to $440,000 for a case of chronic bronchitis.[2]

Table 1: Death and disease attributable to fine particle pollution from Gibson Generating Station

Type of Impact	Annual Incidence	Valuation
Deaths	84	$610,000,000
Heart attacks	130	$14,000,000
Asthma attacks	1,400	$73,000
Hospital admissions	61	$1,400,000
Chronic bronchitis	51	$23,000,000
Asthma ER visits	88	$32,000

Source: "Find Your Risk from Power Plant Pollution," Clean Air Task Force interactive table, accessed March

2011

Coal Waste Sites

Gibson Generating Station East Ash Pond Number 1
Gibson Generating Station East Ash Pond Number 2
Gibson Generating Station East Ash Pond Number 3
Gibson Generating Station East Ash Pond Settling Basin
Gibson Generating Station North Ash Pond
Gibson Generating Station North Settling Basin

Gibson ranked 6th on list of most polluting power plants in terms of coal waste

In January 2009, Sue Sturgis of the Institute of Southern Studies compiled a list of the 100 most polluting coal plants in the United States in terms of coal combustion waste (CCW) stored in surface impoundments like the one involved in the TVA Kingston Fossil Plant coal ash spill.[3] The data came from the EPA's Toxics Release Inventory (TRI) for 2006, the most recent year available.[4]

Gibson Generating Station ranked number 6 on the list, with 3,030,524 pounds of coal combustion waste released to surface impoundments in 2006.[3]

Gibson ranked 4th in terms of largest carbon dioxide emissions

According to a 2009 report by Environment America, "America's Biggest Polluters," the Gibson station is the fourth dirtiest plant in the nation, releasing 22.4 million tons of carbon dioxide in 2007. Ranking is based upon Environmental Protection Agency data.[5]

Articles and Resources

Sources

1. ↑ "The Toll from Coal: An Updated Assessment of Death and Disease from America's Dirtiest Energy Source," Clean Air Task Force, September 2010.
2. ↑ "Technical Support Document for the Powerplant Impact Estimator Software Tool," Prepared for the Clean Air Task Force by Abt Associates, July 2010
3. ↑ [3.0] [3.1] Sue Sturgis, "Coal's ticking timebomb: Could disaster strike a coal ash dump near you?," Institute for Southern Studies, January 4, 2009.
4. ↑ TRI Explorer, EPA, accessed January 2009.
5. ↑ "America's Biggest Polluters: Carbon Dioxide Emissions from Power Plants in 2007" Environment America, November 24, 2009

Existing Electric Generating Units in the United States, 2005, Energy Information Administration, accessed Jan. 2009.
Environmental Integrity Project, "Dirty Kilowatts: America's Most Polluting Power Plants", July 2007.
Facility Registry System, U.S. Environmental Protection Agency, accessed Jan. 2009.

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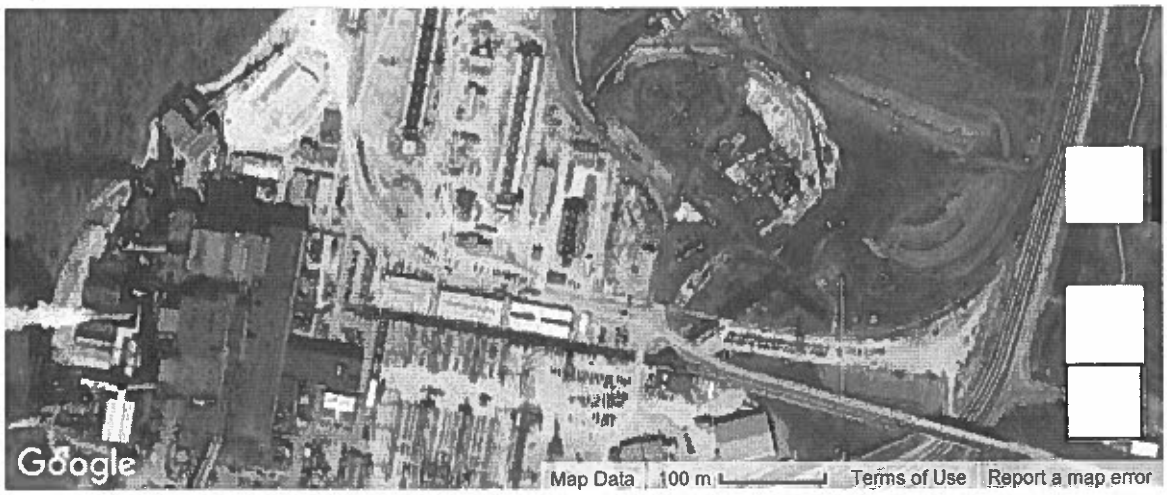
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Petersburg Generating Station

Petersburg Generating Station is a coal-fired power station owned and operated by AES near Petersburg, Indiana.

AES plans to retire Unit 1 in 2021 and Unit 2 in 2023.[1]





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Plant Data

Owner: Indianapolis Power & Light
Parent Company: AES

Plant Nameplate Capacity: 2,146.7 MW
Units and In-Service Dates: 281.6 MW (1967), 523.3 MW (1969), 670.9 MW (1977), 670.9 MW (1986)[2]
Location: 6925 N. State Road 57, Petersburg, IN 47567
GPS Coordinates: 38.529694, -87.247667
Coal Consumption:
Coal Source:
Number of Employees:

Emissions Data

2006 CO_2 Emissions: 12,826,618 tons
2006 SO_2 Emissions: 28,566 tons
2006 SO_2 Emissions per MWh: 15.25 tons per MWh
2006 NO_x Emissions: 8,729 tons
2005 Mercury Emissions: 835 lb.

Death and disease attributable to fine particle pollution from Petersburg Generating Station

In 2010, Abt Associates issued a study commissioned by the Clean Air Task Force, a nonprofit research and advocacy organization, quantifying the deaths and other health effects attributable to fine particle pollution from coal-fired power plants.[3] Fine particle pollution consists of a complex mixture of soot, heavy metals, sulfur dioxide, and nitrogen oxides. Among these particles, the most dangerous are those less than 2.5 microns in diameter, which are so tiny that they can evade the lung's natural defenses, enter the bloodstream, and be transported to vital organs. Impacts are especially severe among the elderly, children, and those with respiratory disease. The study found that over 13,000 deaths and tens of thousands of cases of chronic bronchitis, acute bronchitis, asthma, congestive heart failure, acute myocardial infarction, dysrhythmia, ischemic heart disease, chronic lung disease, and pneumonia each year are attributable to fine particle pollution from U.S. coal plant emissions. These deaths and illnesses are major examples of coal's external costs, i.e. uncompensated harms inflicted upon the public at large. Low-income and minority populations are disproportionately impacted as well, due to the tendency of companies to avoid locating power plants upwind of affluent communities. To monetize the health impact of fine particle pollution from each coal plant, Abt assigned a value of $7,300,000 to each 2010 mortality, based on a range of government and private studies. Valuations of illnesses ranged from $52 for an asthma episode to $440,000 for a case of chronic bronchitis.[4]

Table 1: Death and disease attributable to fine particle pollution from Petersburg Generating Station

Type of Impact	Annual Incidence	Valuation
Deaths	57	$410,000,000
Heart attacks	87	$9,500,000
Asthma attacks	950	$49,000
Hospital admissions	41	$950,000
Chronic bronchitis	35	$15,000,000
Asthma ER visits	60	$22,000

Source: "Find Your Risk from Power Plant Pollution," Clean Air Task Force interactive table, accessed March 2011

Coal Waste Sites

Petersburg Generating Station Pond A - Discharge
Petersburg Generating Station Pond B
Petersburg Generating Station Pond C

Petersburg ranked 85th on list of most polluting power plants in terms of coal waste

In January 2009, Sue Sturgis of the Institute of Southern Studies compiled a list of the 100 most polluting coal plants in the United States in terms of coal combustion waste (CCW) stored in surface impoundments like the one involved in the TVA Kingston Fossil Plant coal ash spill.[5] The data came from the EPA's Toxics Release Inventory (TRI) for 2006, the most recent year available.[6]

Petersburg Generating Station ranked number 85 on the list, with 309,961 pounds of coal combustion waste released to surface impoundments in 2006.[5]

Activism

Articles and Resources

Sources

1. ↑ "IPL Plans Early Retirement of Two Coal-fired Units at Petersburg Plant". *Indiana Environmental Reporter*. December 11, 2019. Retrieved 2020-01-09.
2. ↑ Form EIA-860 Data - Schedule 3, 'Generator Data' US EIA, 2014
3. ↑ "The Toll from Coal: An Updated Assessment of Death and Disease from America's Dirtiest Energy Source," Clean Air Task Force, September 2010.
4. ↑ "Technical Support Document for the Powerplant Impact Estimator Software Tool," Prepared for the Clean Air Task Force by Abt Associates, July 2010
5. ↑ [5][0][5][1] Sue Sturgis, "Coal's ticking timebomb: Could disaster strike a coal ash dump near you?," Institute for Southern Studies, January 4, 2009.
6. ↑ TRI Explorer, EPA, accessed January 2009.

Existing Electric Generating Units in the United States, 2005, Energy Information Administration, accessed Jan. 2009.
Environmental Integrity Project, "Dirty Kilowatts: America's Most Polluting Power Plants", July 2007.
Facility Registry System, U.S. Environmental Protection Agency, accessed Jan. 2009.

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Baldwin Energy Station

Baldwin Energy Station is a three-unit coal-fired power station owned and operated by Dynegy near Baldwin, Illinois.



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Retirement

In May 2016, plant owner Dynegy (now Vistra Energy) said it plans to cease operations at units 1 and 3 of its Baldwin Power Station over the next year. The company attributed the shutdowns on the failure to recover the plants' "basic operating costs" in the most recent MISO (Midcontinent Independent System Operator) electricity auction.[1]

Unit 3 was mothballed in October 2016. That month plant owner Dynegy (now Vistra Energy) said that Unit 1, which was scheduled to go offline on March 31, 2017, will retire in September 2018. Unit 2 will continue operating.[2]

The EIA 860M (November 2018) states unit 3 is "Out of service and NOT expected to return to service in next

calendar year."[3]

Ownership

On April 9, 2018, Texas-based Vistra Energy, the parent company for TXU Energy and Luminant, announced it had completed its merger with Dynegy. Vistra Energy will be the name of the combined company moving forward.[4]

Plant Data

Owner: Dynegy Midwest Generating
Parent Company: Vistra Energy
Plant Nameplate Capacity: 1,895 MW
Units and In-Service Dates: 625 MW (1970), 635 MW (1973), 635 MW (1975)[5]
Location: 10901 Baldwin Rd., Baldwin, IL 62217
GPS Coordinates: 38.203889, -89.85416
Coal Consumption:
Coal Source:
Number of Employees:

Emissions Data

2006 CO_2 Emissions: 12,826,618 tons
2006 SO_2 Emissions: 28,985 tons
2006 SO_2 Emissions per MWh:
2006 NO_x Emissions: 16,413 tons
2005 Mercury Emissions: 500 lb.

Death and disease attributable to fine particle pollution from Baldwin Energy Station

In 2010, Abt Associates issued a study commissioned by the Clean Air Task Force, a nonprofit research and advocacy organization, quantifying the deaths and other health effects attributable to fine particle pollution from coal-fired power plants.[6] Fine particle pollution consists of a complex mixture of soot, heavy metals,

sulfur dioxide, and nitrogen oxides. Among these particles, the most dangerous are those less than 2.5 microns in diameter, which are so tiny that they can evade the lung's natural defenses, enter the bloodstream, and be transported to vital organs. Impacts are especially severe among the elderly, children, and those with respiratory disease. The study found that over 13,000 deaths and tens of thousands of cases of chronic bronchitis, acute bronchitis, asthma, congestive heart failure, acute myocardial infarction, dysrhythmia, ischemic heart disease, chronic lung disease, and pneumonia each year are attributable to fine particle pollution from U.S. coal plant emissions. These deaths and illnesses are major examples of coal's external costs, i.e. uncompensated harms inflicted upon the public at large. Low-income and minority populations are disproportionately impacted as well, due to the tendency of companies to avoid locating power plants upwind of affluent communities. To monetize the health impact of fine particle pollution from each coal plant, Abt assigned a value of $7,300,000 to each 2010 mortality, based on a range of government and private studies. Valuations of illnesses ranged from $52 for an asthma episode to $440,000 for a case of chronic bronchitis.[7]

Table 1: Death and disease attributable to fine particle pollution from Baldwin Energy Station

Type of Impact	Annual Incidence	Valuation
Deaths	56	$410,000,000
Heart attacks	86	$9,400,000
Asthma attacks	940	$49,000
Hospital admissions	40	$930,000
Chronic bronchitis	34	$15,000,000
Asthma ER visits	60	$22,000

Source: "Find Your Risk from Power Plant Pollution," Clean Air Task Force interactive table, accessed March 2011

Coal Waste Site

Baldwin Energy Station Ash Pond System

Baldwin ranked 31st on list of most polluting power plants in terms of coal

waste

In January 2009, Sue Sturgis of the Institute of Southern Studies compiled a list of the 100 most polluting coal plants in the United States in terms of coal combustion waste (CCW) stored in surface impoundments like the one involved in the TVA Kingston Fossil Plant coal ash spill.[8] The data came from the EPA's Toxics Release Inventory (TRI) for 2006, the most recent year available.[9]

Baldwin Energy Station ranked number 31 on the list, with 1,324,467 pounds of coal combustion waste released to surface impoundments in 2006.[8]

Illinois Power Company and Dynegy Midwest Generation EPA Settlement

On March 7, 2005 the U.S. Department of Justice and the U.S. EPA along with the State of Illinois announced a settlement between Illinois Power Company and its sucesscor, Dynegy, addressing alleged violations of New Source Review provisions of the Clean Air Act at company's **Baldwin Energy Station**. The EPA noted that sulfur dioxide (SO2) and nitrogen oxide (NOx) emissions at the plant will decrease by 54,000 tons each year through the installation of approximately $500 million worth of new pollution control equipment. In addition to the Baldwin Generating Station, the Havana Power Station, Hennepin Power Station and Vermilion Power Station, Wood River Station were involved in the settlement.

The EPA stated that this "settlement requires installation of four new flue gas desulfurization devices (scrubbers) to control SO2; four new baghouses to control particulate matter (soot); and operation of existing control equipment, including three selective catalytic reduction (SCR) systems, year-round to control NOx. The entire five-plant system will be subject to annual emission caps to assure that significant system-wide reductions for both SO2 and NOx are achieved."[10]

Activism

Articles and Resources

Sources

1. ↑ "Dynegy to shutter Illinois coal plants," St Louis Business Journal, May 4, 2016
2. ↑ "Dynegy delays mothballing Unit 1 at Baldwin," Herald Tribune, Oct 12, 2016
3. ↑ 860M: Preliminary Monthly Electric Generator Inventory, EIA, November 2018

4. ↑ "Vistra / Dynegy Merger," Vistra Energy website, accessed August 2018
5. ↑ Form EIA-860 Data - Schedule 3, 'Generator Data' US EIA, 2014
6. ↑ "The Toll from Coal: An Updated Assessment of Death and Disease from America's Dirtiest Energy Source," Clean Air Task Force, September 2010.
7. ↑ "Technical Support Document for the Powerplant Impact Estimator Software Tool," Prepared for the Clean Air Task Force by Abt Associates, July 2010
8. ↑ [8.0] [8.1] Sue Sturgis, "Coal's ticking timebomb: Could disaster strike a coal ash dump near you?," Institute for Southern Studies, January 4, 2009.
9. ↑ TRI Explorer, EPA, accessed January 2009.
10. ↑ "U.S. Announces Settlement of Illinois Power Case - Company will spend $500 million to reduce air pollution by over 54,000 tons per year," U.S. EPA, March 7, 2005

Existing Electric Generating Units in the United States, 2005, Energy Information Administration, accessed Jan. 2009.
Environmental Integrity Project, "Dirty Kilowatts: America's Most Polluting Power Plants", July 2007.
Facility Registry System, U.S. Environmental Protection Agency, accessed Jan. 2009.

Related SourceWatch Articles

EPA Coal Plant Settlements
Existing U.S. Coal Plants
Illinois and coal
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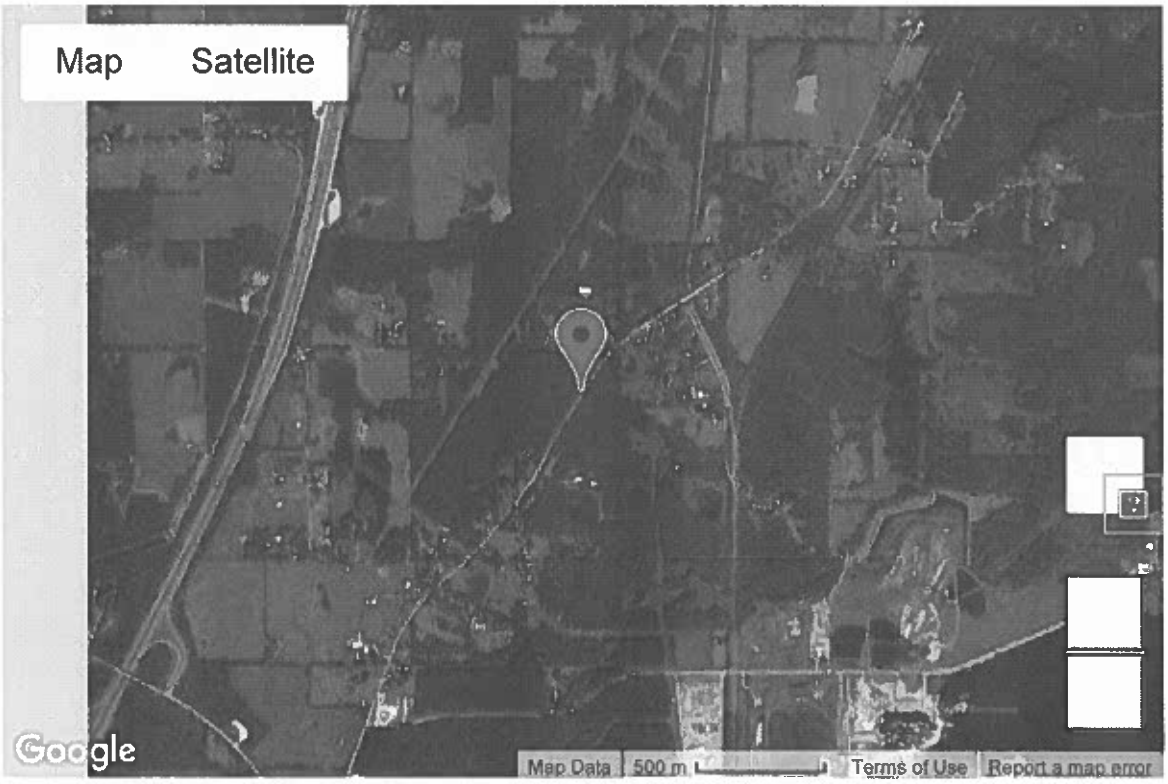


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Marion Plant (existing)

Marion Plant is a coal-fired power station owned and operated by Southern Illinois Power Cooperative near Marion, Illinois.



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Plant Data

Owner/Parent Company: Southern Illinois Power Cooperative
Plant Nameplate Capacity: 272 MW (Megawatts)
Units and In-Service Dates: 33 MW (1963), 33 MW (1963), 33 MW (1963), 173 MW (1978)
Location: 11543 Lake of Egypt Rd., Marion, IL 62959
GPS Coordinates: 37.620556, -88.955
Coal Consumption:
Coal Source:
Number of Employees:

Emissions Data

2006 CO_2 Emissions: 2,717,690 tons
2006 SO_2 Emissions:
2006 SO_2 Emissions per MWh:
2006 NO_x Emissions:
2005 Mercury Emissions:

Death and disease attributable to fine particle pollution from Marion Plant

In 2010, Abt Associates issued a study commissioned by the Clean Air Task Force, a nonprofit research and advocacy organization, quantifying the deaths and other health effects attributable to fine particle pollution from coal-fired power plants.[1] Fine particle pollution consists of a complex mixture of soot, heavy metals, sulfur dioxide, and nitrogen oxides. Among these particles, the most dangerous are those less than 2.5 microns in diameter, which are so tiny that they can evade the lung's natural defenses, enter the bloodstream, and be transported to vital organs. Impacts are especially severe among the elderly, children, and those with respiratory disease. The study found that over 13,000 deaths and tens of thousands of cases of chronic bronchitis, acute bronchitis, asthma, congestive heart failure, acute myocardial infarction, dysrhythmia, ischemic heart disease, chronic lung disease, and pneumonia each year are attributable to fine particle pollution from U.S. coal plant emissions. These deaths and illnesses are major examples of coal's external costs, i.e. uncompensated harms inflicted upon the public at large. Low-income and minority populations are disproportionately impacted as well, due to the tendency of companies to avoid locating power plants upwind of affluent communities. To monetize the health impact of fine particle pollution from each coal plant, Abt assigned a value of $7,300,000 to each 2010 mortality, based on a range of government and private studies. Valuations of illnesses ranged from $52 for an asthma episode to $440,000 for a case of chronic bronchitis.[2]

Table 1: Death and disease attributable to fine particle pollution from Marion Plant

Type of Impact	Annual Incidence	Valuation
Deaths	6	$46,000,000
Heart attacks	10	$1,000,000
Asthma attacks	100	$5,000
Hospital admissions	4	$100,000
Chronic bronchitis	4	$1,700,000
Asthma ER visits	7	$2,000

Source: "Find Your Risk from Power Plant Pollution," Clean Air Task Force interactive table, accessed March 2011

Articles and Resources

Sources

1. ↑ "The Toll from Coal: An Updated Assessment of Death and Disease from America's Dirtiest Energy

Source," Clean Air Task Force, September 2010.
2. ↑ "Technical Support Document for the Powerplant Impact Estimator Software Tool," Prepared for the Clean Air Task Force by Abt Associates, July 2010

Existing Electric Generating Units in the United States, 2005, Energy Information Administration, accessed Jan. 2009.
Environmental Integrity Project, "Dirty Kilowatts: America's Most Polluting Power Plants", July 2007.
Facility Registry System, U.S. Environmental Protection Agency, accessed Jan. 2009.
Carbon Monitoring for Action database, accessed Feb. 2009.

Related SourceWatch Articles

Marion Plant
Existing U.S. Coal Plants
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External Articles

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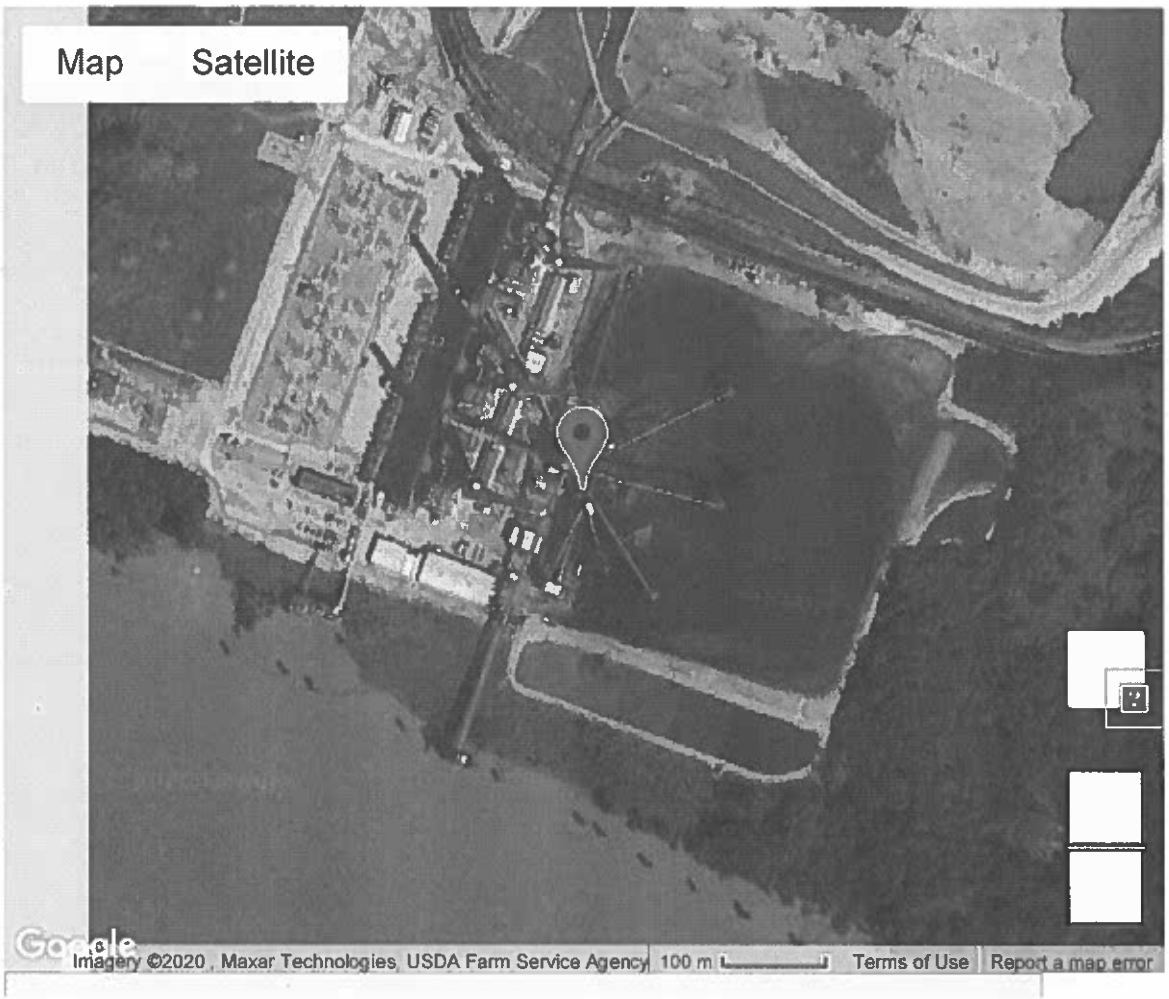


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Joppa Steam Plant

Joppa Steam Plant is a coal-fired power station owned and operated by Ameren near Joppa, Illinois.



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Violation Tracker

Discover Which Corporations are the Biggest Violators of Environmental, Health and Safety Laws in the United States

Violation Tracker is the first national search engine on corporate misconduct covering environmental, health, and safety cases initiated by 13 federal regulatory agencies. Violation Tracker is produced by the Corporate Research Project of Good Jobs First. Click here to access Violation Tracker.

Plant Data

Owner: Ameren
Parent Company: Vistra Energy
Plant Nameplate Capacity: 1,100 MW
Units and In-Service Dates: 183 MW (1953), 183 MW (1953), 183 MW (1954), 183 MW (1954), 183 MW (1955), 183 MW (1955)
Location: 2100 Portland Rd., Joppa, IL 62953
GPS Coordinates: 37.21693, -88.866096
Coal Consumption:
Coal Source:
Number of Employees:

Plant ownership

The plant was owned by Ameren, an Illinois power company. In mid-March 2013, Dynegy purchased three electric generating subsidiaries and five coal plants from Ameren, including Joppa Station.[1][2]

On April 9, 2018, Texas-based Vistra Energy, the parent company for TXU Energy and Luminant, announced it had completed its merger with Dynegy. Vistra Energy will be the name of the combined company moving forward.[3]

Emissions Data

2006 CO_2 Emissions: 9,318,296 tons
2006 SO_2 Emissions: 26,408 tons
2006 SO_2 Emissions per MWh:
2006 NO_x Emissions: 5,705 tons
2005 Mercury Emissions: 355 lb.

Death and disease attributable to fine particle pollution from Joppa Steam Plant

In 2010, Abt Associates issued a study commissioned by the Clean Air Task Force, a nonprofit research and advocacy organization, quantifying the deaths and other health effects attributable to fine particle pollution from coal-fired power plants.[4] Fine particle pollution consists of a complex mixture of soot, heavy metals, sulfur dioxide, and nitrogen oxides. Among these particles, the most dangerous are those less than 2.5 microns in diameter, which are so tiny that they can evade the lung's natural defenses, enter the bloodstream, and be transported to vital organs. Impacts are especially severe among the elderly, children, and those with respiratory disease. The study found that over 13,000 deaths and tens of thousands of cases of chronic bronchitis, acute bronchitis, asthma, congestive heart failure, acute myocardial infarction, dysrhythmia, ischemic heart disease, chronic lung disease, and pneumonia each year are attributable to fine particle pollution from U.S. coal plant emissions. These deaths and illnesses are major examples of coal's external costs, i.e. uncompensated harms inflicted upon the public at large. Low-income and minority populations are disproportionately impacted as well, due to the tendency of companies to avoid locating power plants upwind of affluent communities. To monetize the health impact of fine particle pollution from each coal plant, Abt assigned a value of $7,300,000 to each 2010 mortality, based on a range of government and private studies. Valuations of illnesses ranged from $52 for an asthma episode to $440,000 for a case of chronic bronchitis.[5]

Table 1: Death and disease attributable to fine particle pollution from Joppa Steam Plant

Type of Impact	Annual Incidence	Valuation
Deaths	40	$290,000,000
Heart attacks	61	$6,700,000
Asthma attacks	670	$35,000
Hospital admissions	28	$670,000
Chronic bronchitis	24	$11,000,000
Asthma ER visits	42	$15,000

Source: "Find Your Risk from Power Plant Pollution," Clean Air Task Force interactive table, accessed March 2011

Joppa ranked 75th on list of most polluting power plants in terms of coal waste

In January 2009, Sue Sturgis of the Institute of Southern Studies compiled a list of the 100 most polluting coal plants in the United States in terms of coal combustion waste (CCW) stored in surface impoundments like the one involved in the TVA Kingston Fossil Plant coal ash spill.[6] The data came from the EPA's Toxics Release Inventory (TRI) for 2006, the most recent year available.[7]

Joppa Steam Plant ranked number 75 on the list, with 366,675 pounds of coal combustion waste released to surface impoundments in 2006.[6]

Articles and Resources

Sources

1. ↑ Boshart, Glen. "Dynegy Bid to Buy Ameren's Merchant Plants Makes Its Way to FERC." *SNL Power Daily with Market Report.* April 18, 2013.

2. ↑ Yeagle, Patrick. "Shell Game." *Illinois Times*. September 19, 2013
3. ↑ "Vistra / Dynegy Merger," Vistra Energy website, accessed August 2018
4. ↑ "The Toll from Coal: An Updated Assessment of Death and Disease from America's Dirtiest Energy Source," Clean Air Task Force, September 2010.
5. ↑ "Technical Support Document for the Powerplant Impact Estimator Software Tool," Prepared for the Clean Air Task Force by Abt Associates, July 2010
6. ↑ [6.0] [6.1] Sue Sturgis, "Coal's ticking timebomb: Could disaster strike a coal ash dump near you?," Institute for Southern Studies, January 4, 2009.
7. ↑ TRI Explorer, EPA, accessed January 2009.

Existing Electric Generating Units in the United States, 2005, Energy Information Administration, accessed Jan. 2009.
Environmental Integrity Project, "Dirty Kilowatts: America's Most Polluting Power Plants", July 2007.
Facility Registry System, U.S. Environmental Protection Agency, accessed Jan. 2009.

Related SourceWatch Articles

Existing U.S. Coal Plants
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History of SIH

In 1938, local physicians Dr. J.W. Barrow and Dr. Leo J. Brown formed a partnership to practice

medicine in Carbondale, Illinois. Two years later, they were joined by Dr. John Lewis and Dr. John Taylor, eventually calling their group the Carbondale Clinic. The physicians practiced together until World War II intervened, leaving only one of them behind to treat patients. When the group reassembled after the war, their increasing knowledge of medicine made it obvious to them that new medical specialties would be needed in the region. To carry out their plans they needed their own hospital but, under Illinois law, would also need their own corporation for ownership.

About that time, Dr. Brown made a trip to nearby Herrin Hospital to promote his radiology services. Herrin Hospital had been built in 1914 as a center for black lung disease and other coal mine-related injuries; ten dollars was taken out of each miner's paycheck to fund the hospital. By the end of the war, the town was economically depressed and it was doubtful the hospital could remain open. Upon Dr. Brown's visit to Herrin in 1946, he learned the hospital was for sale for the asking price of $105,000. Two days later, the four physicians of the Carbondale Clinic formed the not-for-profit Southern Illinois Hospital Corporation in order to purchase Herrin Hospital.

Shortly thereafter, the doctors decided to move ahead with plans to also construct their own hospital, and by 1950 Doctors Hospital had opened in Carbondale. In 1961, they also purchased nearby Holden Hospital, which was subsequently torn down to expand Doctors Hospital, rather than attempt to renovate the facility originally built in 1875 as a drug treatment center.

The two remaining hospitals in Herrin and Carbondale existed as Southern Illinois Healthcare until 1995, when it was agreed they would purchase St. Joseph Memorial Hospital in nearby Murphysboro, Illinois. St. Joseph had begun as a makeshift emergency center after a railroad accident in 1895. The Franciscan Sisters, who spearheaded the permanent facility originally called St. Andrews, ran the hospital for 58 years before handing it over to the Sisters Adorers of the Most Precious Blood. When the current facility was built in 1960, the name was changed to St. Joseph from St. Andrew to avoid confusion with a local public home for aged men.

Today, Southern Illinois Healthcare remains a not-for-profit integrated health system and employs nearly 3,400 people. It is now comprised of over thirty facilities, including three inpatient hospitals, three clinics, numerous physician offices, three walk-in clinics and dedicated centers that include neurology, cancer, heart, sleep and rehabilitation.

Although the three hospitals retain strong individual cultures from their very diverse beginnings, the corporation as a whole is still guided by the values of its founding physicians: respect, integrity, compassion, collaboration, stewardship, accountability and quality. They remain as committed to

quality health services today as when the first hospital opened, and strive to treat every patient as if that patient is the person most cared about in the world, and treat them like that person every single time.

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History of SIH

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Memorial Hospital of Carbondale
618-549-0721

St. Joseph Memorial Hospital
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Herrin Hospital
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System Office
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BLACK LUNG PROGRAM

Southern Illinois and Southwestern Indiana Respiratory Disease Program

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Through the Southern Illinois and Southwestern Indiana Respiratory Disease Program/Black Lung Program, coal miners are receiving assistance for the diagnosis and treatment of black lung disease and other breathing disorders. Our services are FREE. The Southern Illinois and Southwestern Indiana Respiratory Disease Program provides the following:

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- Black Lung Widow's Claim
- Case Management
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- Community Resource Referrals
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6355 Brandhorst Drive, Carterville, IL

Benton UMWA Office
1530 North Main Street, Benton, IL

Golden Circle/Smith-Moore Center
15 Veterans Drive, Harrisburg, IL

Hayer Senior Center
500 West Walnut St., Sparta, IL

Glenburn Community Center
509 Glenburn Road, Linton, IN

109 California Street
P.O. Box 577
Carterville, IL 62918

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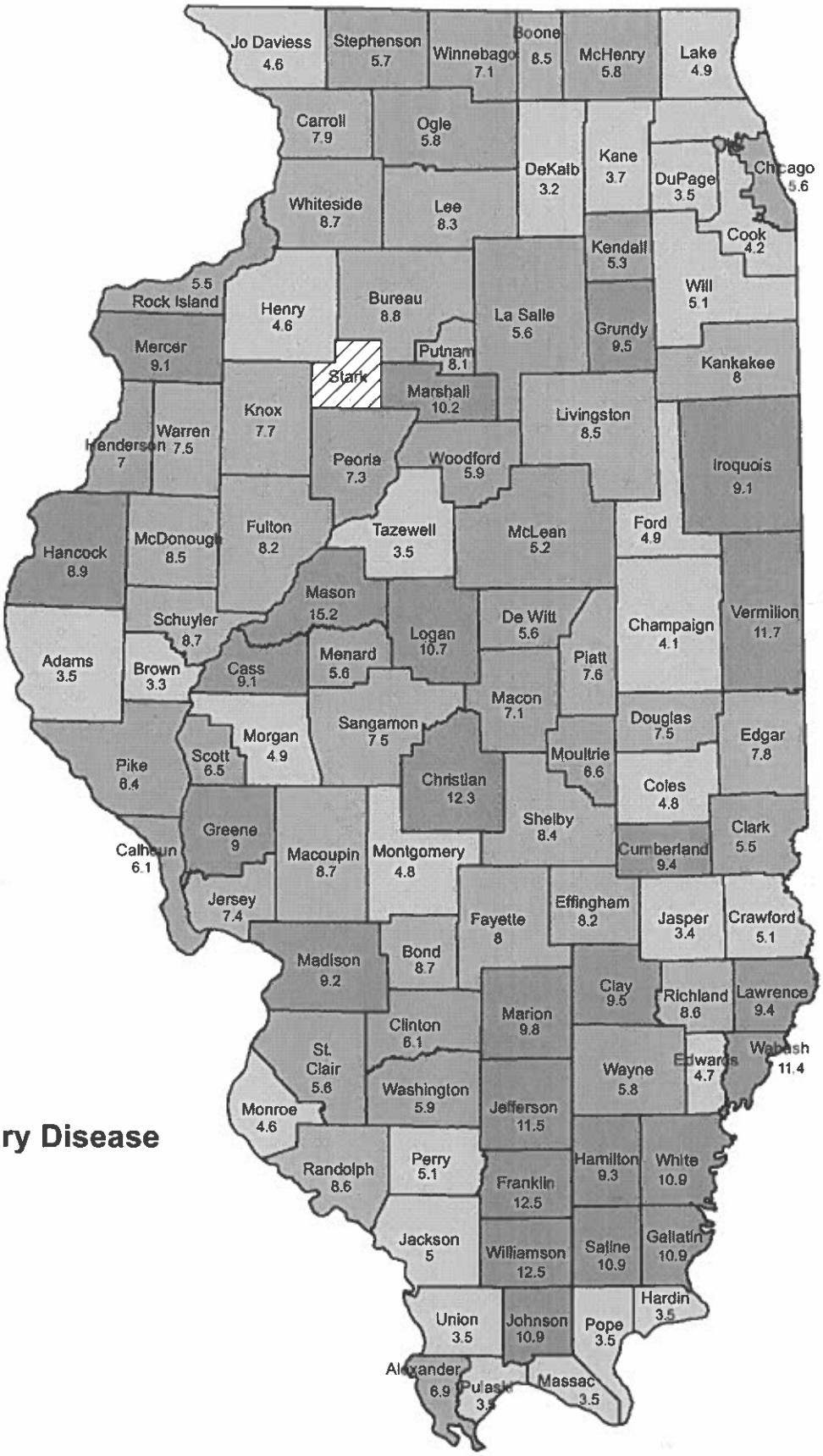
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This health center receives HHS funding and has Federal Public Health Service (PHS) deemed status with respect to certain

health or health-related claims, including medical malpractice claims, for itself and its covered individuals.

Prevalence of Adult Chronic Obstructive Pulmonary Disease by County, Illinois, 2010 - 2014



Percent of Adults with Chronic Obstructive Pulmonary Disease

- < 5.0
- 5.1 - 7.2
- 7.3 - 8.7
- >8.8
- No data available

Prevalence measured by a positive response to the question:
Have you ever been told my a doctor, nurse, or other healthcare professional that you have chronic obstructive pulmonary disease?

Source: Illinois County Behavioral Risk Factor Surveys, 2010 - 2014
Retrieved by IDPH Office of Health Promotion 4/14/2016

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Illinois Department of Public Health

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Illustration: Rebecca Zisser; Photos: Getty

Coal Knew, Too

A newly unearthed journal from 1966 shows the coal industry, like the oil industry, was long aware of the threat of climate change.

By Élan Young

| 11/22/2019 05:45 am ET | **Updated** Dec 16, 2019

AdChoices

"Exxon knew." Thanks to the work of activists and journalists, those two words have rocked the politics of climate change in recent years, as investigations revealed the extent to which giants like Exxon Mobil and Shell were aware of the danger of rising greenhouse gas emissions even as they undermined the work of scientists.

But the coal industry knew, too — as early as 1966, a newly unearthed journal shows.

In August, Chris Cherry, a professor in the Department of Civil and Environmental Engineering at the University of Tennessee, Knoxville, salvaged a large volume from a stack of vintage journals that a fellow faculty member was about to toss out. He was drawn

to a 1966 copy of the industry publication Mining Congress Journal; his father-in-law had been in the industry and he thought it might be an interesting memento.

Cherry flipped it open to a passage from James R. Garvey, who was the president of Bituminous Coal Research Inc., a now-defunct coal mining and processing research organization.

"There is evidence that the amount of carbon dioxide in the earth's atmosphere is increasing rapidly as a result of the combustion of fossil fuels," wrote Garvey. "If the future rate of increase continues as it is at the present, it has been predicted that, because the CO2 envelope reduces radiation, the temperature of the earth's atmosphere will increase and that vast changes in the climates of the earth will result."

"Such changes in temperature will cause melting of the polar icecaps, which, in turn, would result in the inundation of many coastal cities, including New York and London," he continued.

Cherry was floored.

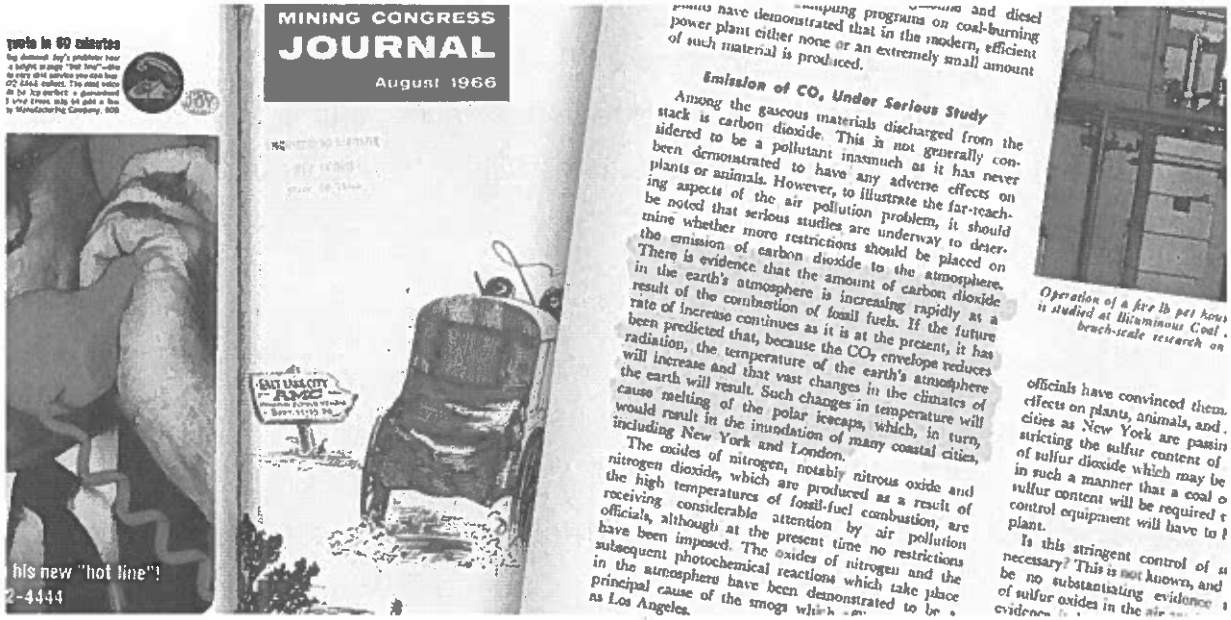
"It pretty well described a version of what we know today as climate change," said Cherry. "Increases in average air temperatures, melting of polar ice caps, rising of sea levels. It's all in there."

In a discussion piece immediately following Garvey's article, Peabody Coal combustion engineer James R. Jones noted that the coal industry was merely "buying time" before more air pollution regulations came into effect. "We are in favor of cleaning up our air," he wrote. "Everyone can point to examples in his own community where something should be done. Our aim is to have control that does not precede the technical knowledge for compliance."

Climate change is not Cherry's area of study, but he was struck by how the tone of the articles differed from the way many fossil fuel companies talk about climate change today. Rather than engage in denial, the articles offered a fairly straightforward acknowledgment of the emerging science. (This reporter is also a writer for UT's Tickle College of Engineering, where Cherry teaches.)

As Cherry did some of his own digging, he soon realized his discovery could be the first

evidence that the coal industry was aware of the impending climate crisis more than half a century ago — a finding that could open mining companies to the type of litigation that the oil industry is now facing.


MINING CONGRESS
JOURNAL
August 1966

his new "hot line"!
2-4444

Emission of CO_2 Under Serious Study

Among the gaseous materials discharged from the stack is carbon dioxide. This is not generally considered to be a pollutant inasmuch as it has never been demonstrated to have any adverse effects on plants or animals. However, to illustrate the far-reaching aspects of the air pollution problem, it should be noted that serious studies are underway to determine whether more restrictions should be placed on the emission of carbon dioxide to the atmosphere. There is evidence that the amount of carbon dioxide in the earth's atmosphere is increasing rapidly as a result of the combustion of fossil fuels. If the future rate of increase continues as it is at the present, it has been predicted that, because the CO_2 envelope reduces radiation, the temperature of the earth's atmosphere will increase and that vast changes in the climates of the earth will result. Such changes in temperature will cause melting of the polar icecaps, which, in turn, would result in the inundation of many coastal cities, including New York and London.

The oxides of nitrogen, notably nitrous oxide and nitrogen dioxide, which are produced as a result of the high temperatures of fossil-fuel combustion, are receiving considerable attention by air pollution officials, although at the present time no restrictions have been imposed. The oxides of nitrogen and the subsequent photochemical reactions which take place in the atmosphere have been demonstrated to be principal cause of the smogs which

officials have convinced them
effects on plants, animals, and
cities as New York are passin
stricting the sulfur content of
of sulfur dioxide which may be
in such a manner that a coal o
sulfur content will be required
control equipment will have to
plant.

Is this stringent control of s
necessary? This is not known, and
be no substantiating evidence
of sulfur oxides in the

COURTESY OF CHRIS CHERRY

A 1966 issue of the Mining Congress Journal suggested that rising levels of greenhouse gases could lead to "vast changes in the climates of the earth."

Decades Of Denial

While Peabody Energy, the largest private-sector coal company in the world and the largest producer of coal in the U.S., now acknowledges climate change on its website, it has been directly and indirectly involved in obfuscating climate science for decades. It funded dozens of trade, lobbying and front groups that peddled climate misinformation, as The Guardian reported in 2016.

As recently as 2015, Peabody Energy argued that carbon dioxide was a "benign gas essential for all life."

> **"Increases in average air temperatures,**

melting of polar ice caps, rising of sea levels. It's all in there.

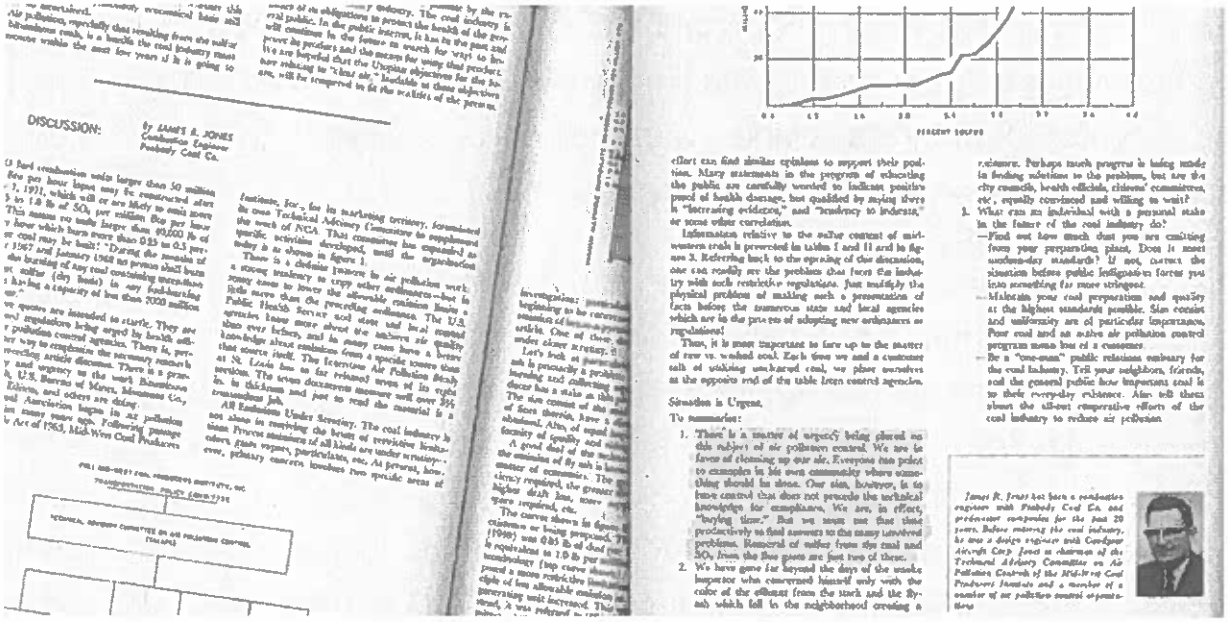
—Chris Cherry, a professor at the University of Tennessee, Knoxville

"While the benefits of carbon dioxide are proven, the alleged risks of climate change are contrary to observed data, are based on admitted speculation, and lack adequate scientific basis," the company wrote in a letter that year to the White House Council on Environmental Quality.

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At the heart of big coal's denial campaign was Fred Palmer, who served as Peabody's senior vice president of government relations from 2001 to 2015. In 1997, Palmer founded the Greening Earth Society, a now-defunct industry front group that argued that burning fossil fuels was good for the planet. The group was based in the same office as the Western Fuels Association, a consortium of coal suppliers and coal-fired utilities that Palmer also ran.

"Every time you turn your car on and you burn fossil fuels and you put CO2 into the air, you're doing the work of the Lord," Palmer told a Danish documentary team in 1997. "That's the ecological system we live in."



DISCUSSION:

by JAMES R. JONES
Combustion Engineer
Peabody Coal Co.

COURTESY OF CHRIS CHERRY

A discussion piece in the same 1966 issue of the Mining Congress Journal said the coal industry was merely "buying time" before more air pollution regulations went into effect.

Asked for comment, a Peabody spokesperson told HuffPost: "Peabody recognizes that climate change is occurring and that human activity, including the use of fossil fuels, contributes to greenhouse gas emissions. We also recognize that coal is essential to affordable, reliable energy and will continue to play a significant role in the global energy mix for the foreseeable future. Peabody views technology as vital to advancing global climate change solutions, and the company supports advanced coal technologies to drive continuous improvement toward the ultimate goal of near-zero emissions from coal."

Palmer, who did not respond to HuffPost's request for comment, continues to carry the torch. He now works as an energy policy adviser to The Heartland Institute, a Chicago-based think tank whose climate denial is so severe that even Exxon Mobil abandoned funding it and its climate denial efforts a decade ago. In 2011, leaked memos showed that the institute paid contrarian scientists like Craig Idso, founder of the Center for the Study of Carbon Dioxide and Global Change, $11,600 a month to promote carbon dioxide as beneficial to the environment.

The group sits at the heart of a broader right-wing misinformation network funded in large part by hedge fund billionaire Robert Mercer and his daughter, Rebekah, both Republican

mega-donors who backed President Donald Trump and financed projects such as Breitbart News and Cambridge Analytica, the data firm considered key to Trump's 2016 win. Palmer's daughter, Downey Magallanes, was a top policy adviser at Trump's Interior Department before joining oil giant BP in September 2018.

All of this was taking place well after climate change had become a commonly understood idea in the scientific community. A 1965 report from President Lyndon Johnson's Science Advisory Committee was the first from the White House to address climate change (and is likely what precipitated the Mining Congress Journal article). "The climate changes that may be produced by the increased CO2 content could be deleterious from the point of view of human beings," it warned. In 1988, NASA scientist James Hansen testified to Congress about what was then known as the "greenhouse effect." And in 1992, the United Nations established the Framework Convention on Climate Change, an international treaty to begin addressing the problem.

But as this consensus emerged, so too did a wave of industry-funded climate denial via vast, shadowy networks of front groups, public relations campaigns and scientists for hire.

Pulling Back The Curtain

In 2015, journalists at InsideClimate News, the Los Angeles Times and Columbia University exposed internal Exxon Mobil documents showing that the company's scientists had a deep understanding of climate change even as Exxon worked publicly to downplay that science.

Twenty state attorneys general launched an "Exxon Knew" campaign, which eventually led to communities across the country filing at least 14 legal challenges against Exxon and other fossil fuel companies. One lawsuit, from the New York state attorney general's office, went to trial on Oct. 22 and focuses on how the company accounted for the costs of potential future regulations on climate change. The Massachusetts attorney general filed another suit on Oct. 24, this time claiming the company had engaged in deceptive advertising and misled investors about the systemic financial risks to its business posed by fossil fuel-driven climate change. Earlier this month, two of Hawaii's biggest municipalities sued Exxon and other big oil companies to recoup the costs of adapting to rising seas and more violent storms.

Evidence of what fossil fuel companies knew about climate change and when is critical to

the legal strategy of those seeking damages for carbon dioxide emissions. If fossil fuel companies were aware of their products' harmful effects on the planet, they could be held liable for damages.

> **They fought the hardest because they had the biggest existential threat.**
>
> —Kert Davies, founder and director of the Climate Investigations Center

Legal liability boils down to four factors, said David Bookbinder, chief counsel for the Niskanen Center, which is representing counties in Colorado that have filed suit: one, whether the defendants knew that their products would cause climate change; two, what they told or did not tell the public about the consequences of using their products; three, the extent of injuries caused by climate change; and four, whether the defendants' actions have led to a portion of those injuries. What the plaintiffs in these suits can prove remains to be seen.

What we do know is that coal, when burned, has by far the biggest climate footprint of any fossil fuel, producing more carbon dioxide per unit than oil or gas. In the U.S. alone, coal produced 65% of the power sector's planet-warming emissions. The 1966 article in the Mining Congress Journal certainly raises questions about what the coal industry knew at the time.

Robert Brulle, a professor emeritus of sociology and environmental science at Drexel University, authored a recent paper that suggests the coal industry must have known quite a bit, given how prominently it positioned itself in the climate denial movement.

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Brulle researched 12 major groups and coalitions that argued against mandatory regulation of carbon dioxide from 1989 to 2015 — which he calls the "climate change countermovement." That countermovement included 2,000 different businesses, political or

social groups, as well as other organizations, but Brulle found that 179 core organizations belonged to multiple coalitions. Coal companies and predominantly coal-burning utilities were the most prevalent. He describes oil and gas companies as "more of a marginal player" by comparison.

"The coal mining industry — the utilities that were burning it for electricity, along with the railroads who were hauling it — and manufacturing industries like steel were the first corporate forces to become climate deniers and try to block action on climate policy," said Kert Davies, founder and director of the Climate Investigations Center. "They fought the hardest because they had the biggest existential threat."

Where Do We Go From Here?

In the aftermath of the 1973 oil embargo, Exxon and other oil giants leased large parcels of land for coal mining with the goal of manufacturing synthetic fuels and lowering U.S. dependence on the Middle East.

Some previously released documents show that Exxon's scientists began advising that the world phase out coal as a fuel as early as 1979. In one scenario, the Exxon scientists concluded that non-fossil fuels would need to be substituted for coal beginning in the 1990s to keep carbon dioxide levels below atmospheric concentrations of 440 parts per million. In 1999, Exxon merged with Mobil, and by 2002, Exxon Mobil had dumped its coal assets.

Meanwhile, the coal industry tried to reinvent itself with the concept of "clean coal." This as-yet-undelivered promise that carbon capture and other technological advances could lower coal's environmental impact has been around for decades but resurged in the early 2000s as regulations seemed imminent.

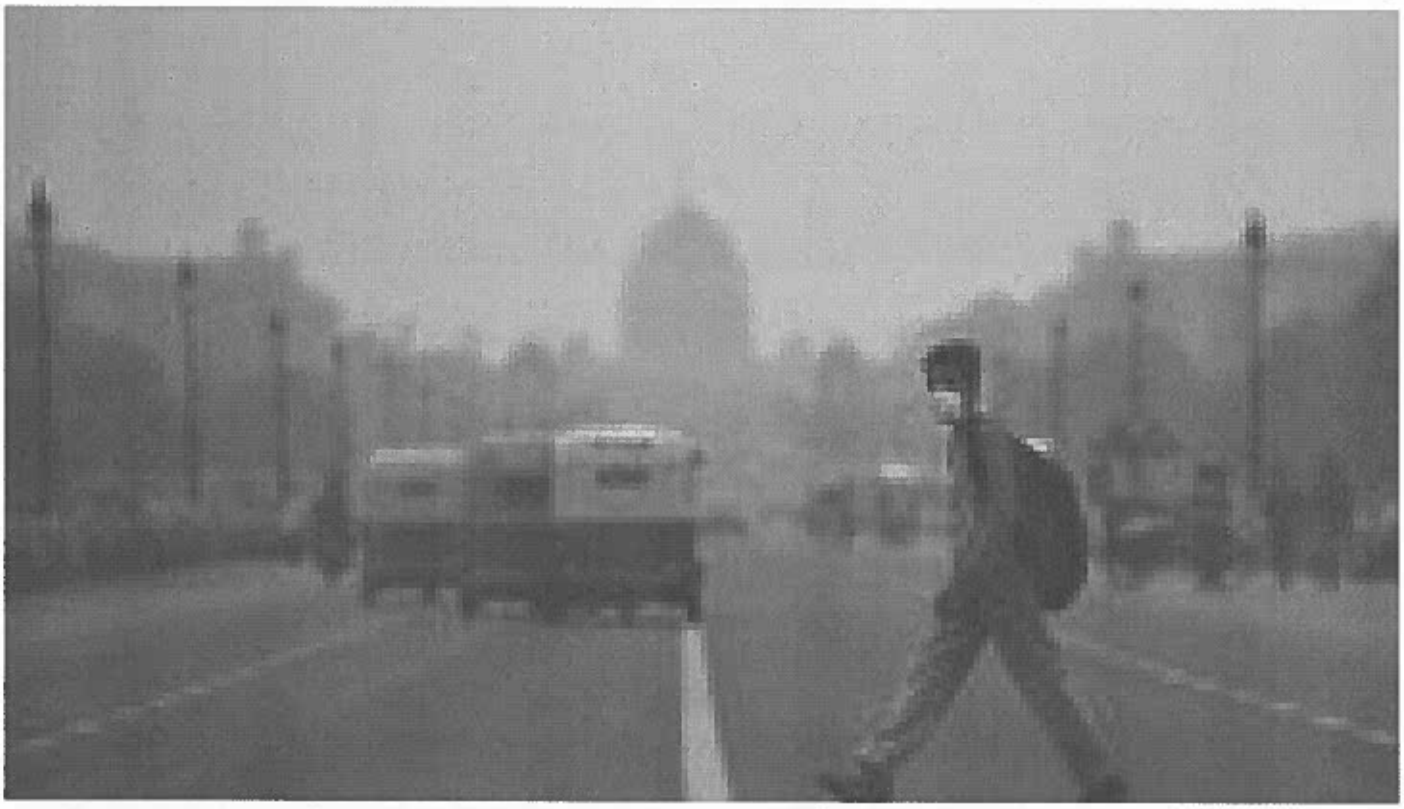
The biggest proponent of this idea was the American Coalition for Clean Coal Electricity, a coal front group that spent $35 million on public relations campaigns in 2008 alone, seeking to influence the election. A year later, ACCCE was caught sending Congress fraudulent letters opposing federal climate legislation and pretending to be from veterans, women's and civil rights groups. The incident led many members to leave the organization, but Peabody remains a member to this day.

"Its whole mission was to stop climate regulations but pretend that they were in favor of clean coal, which, of course, doesn't exist," said Davies.

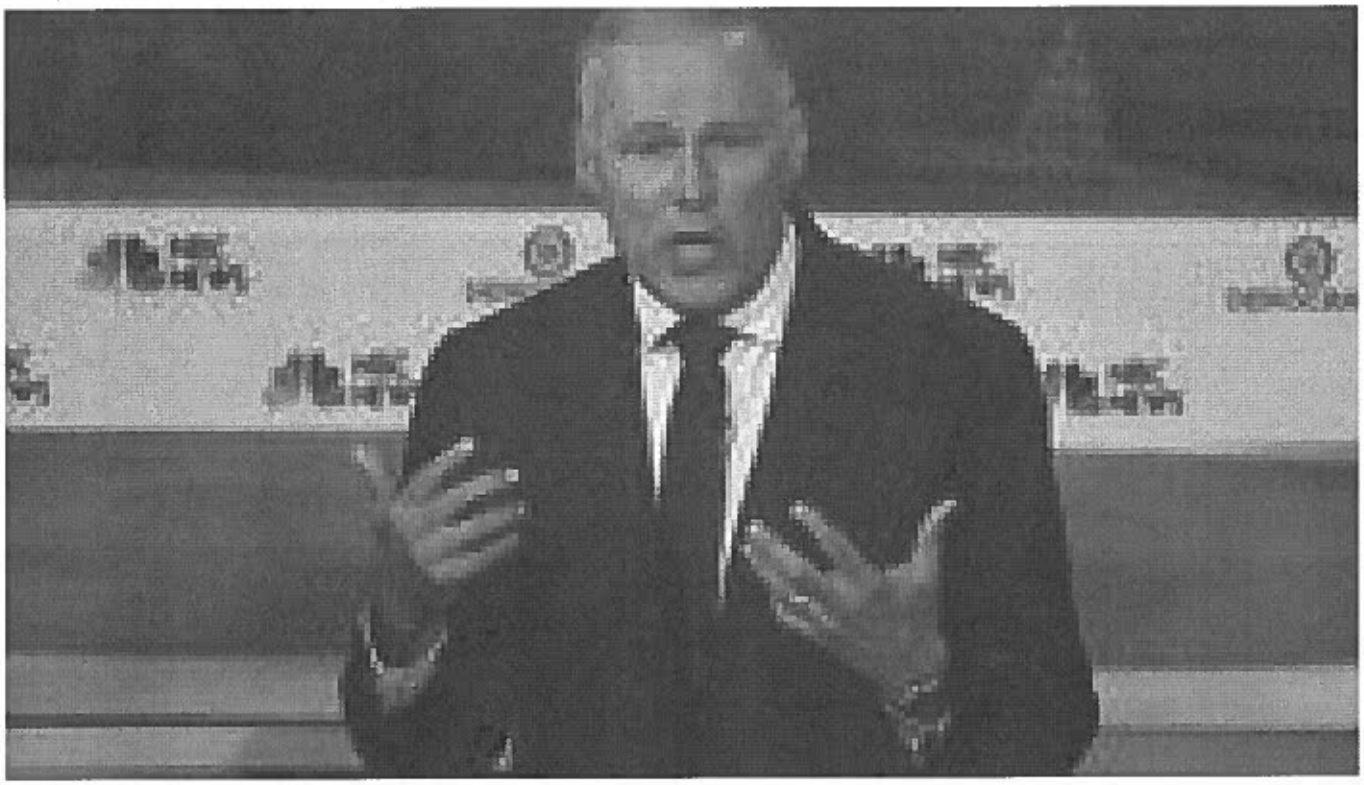
Peabody Energy filed for bankruptcy protection in 2016, the same year carbon dioxide levels hit 400 parts per million. Eight other coal companies have filed for bankruptcy this year. Even as the Trump administration has promised a coal resurgence and rolled back Obama-era regulations, the industry's profitability continues to experience a downward slide. If the slogan "Coal Knew" ever does take off, it's unclear who'll be left to sue.

Illustration by Rebecca Zisser, with photos from Getty.

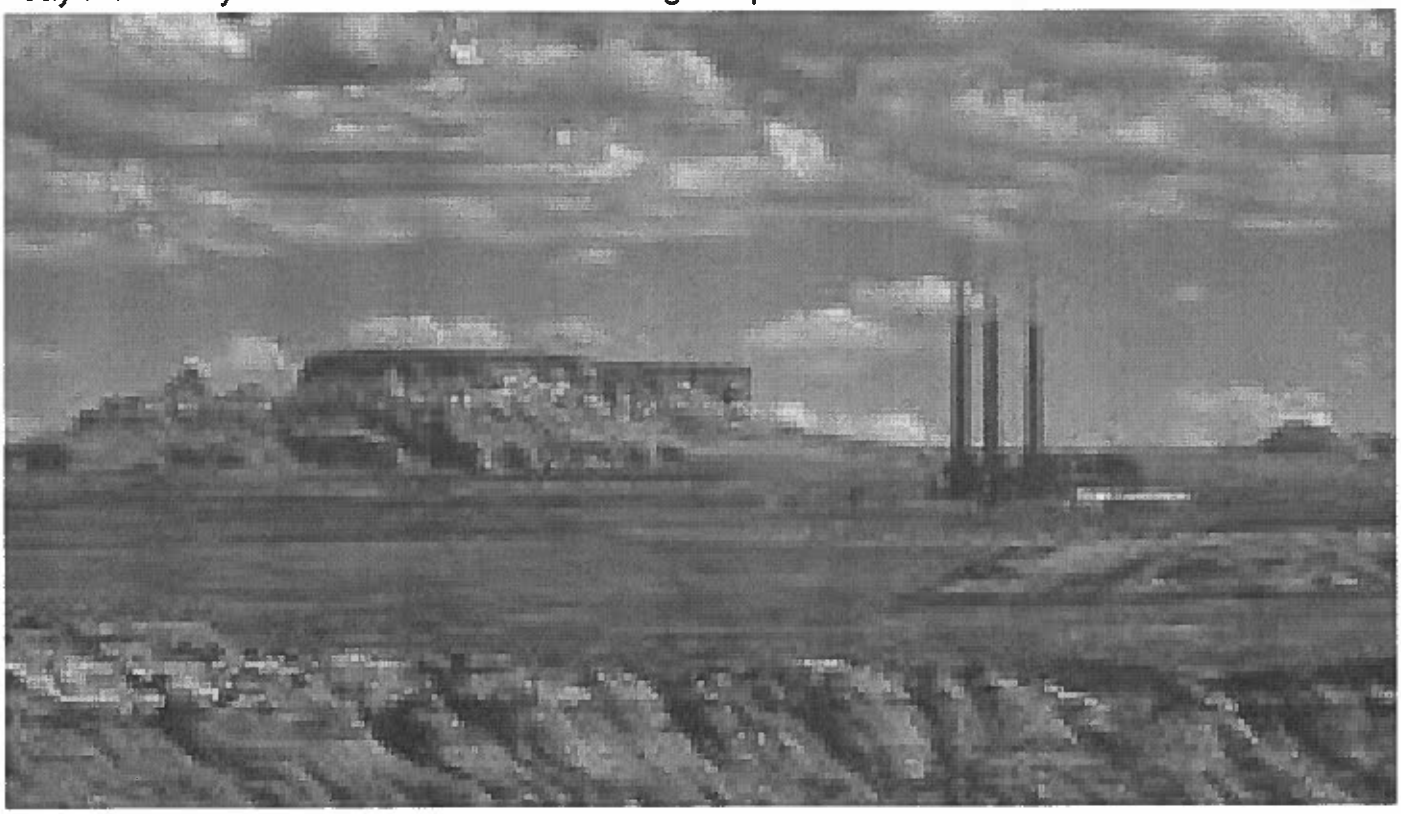
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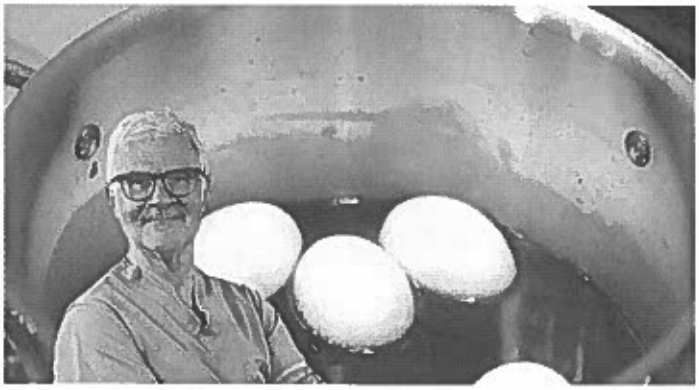
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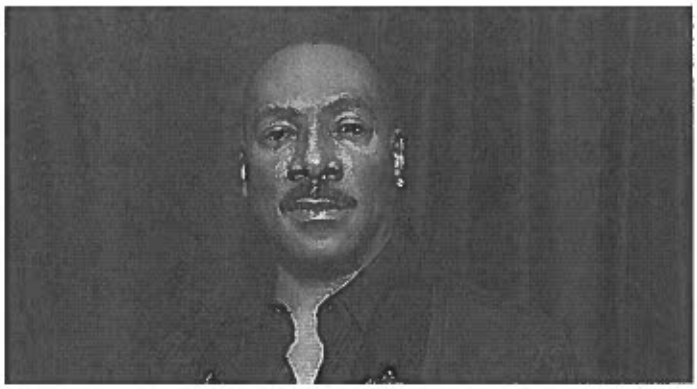
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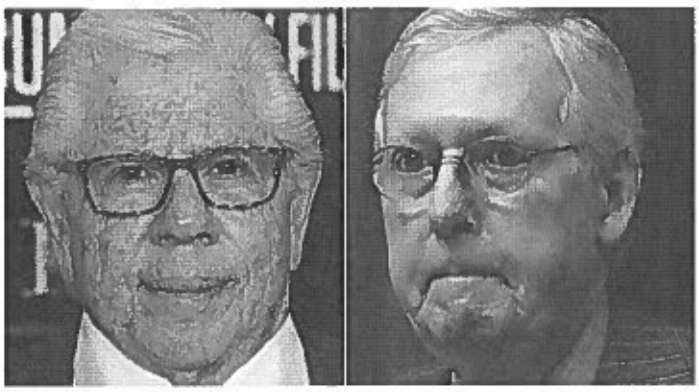
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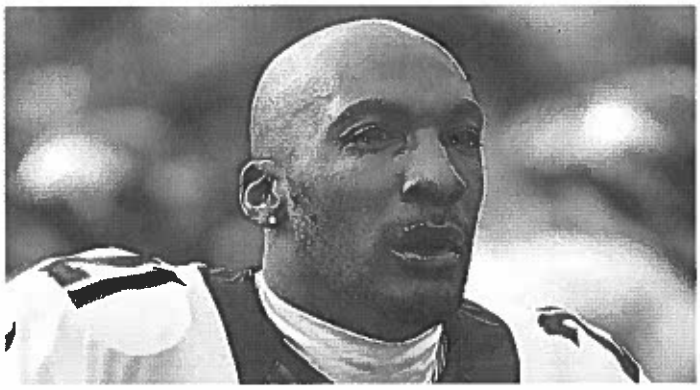
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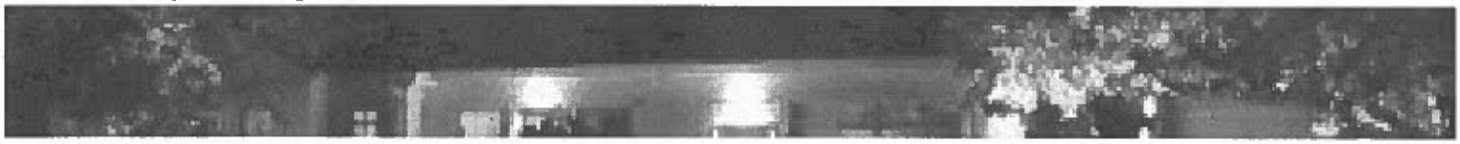
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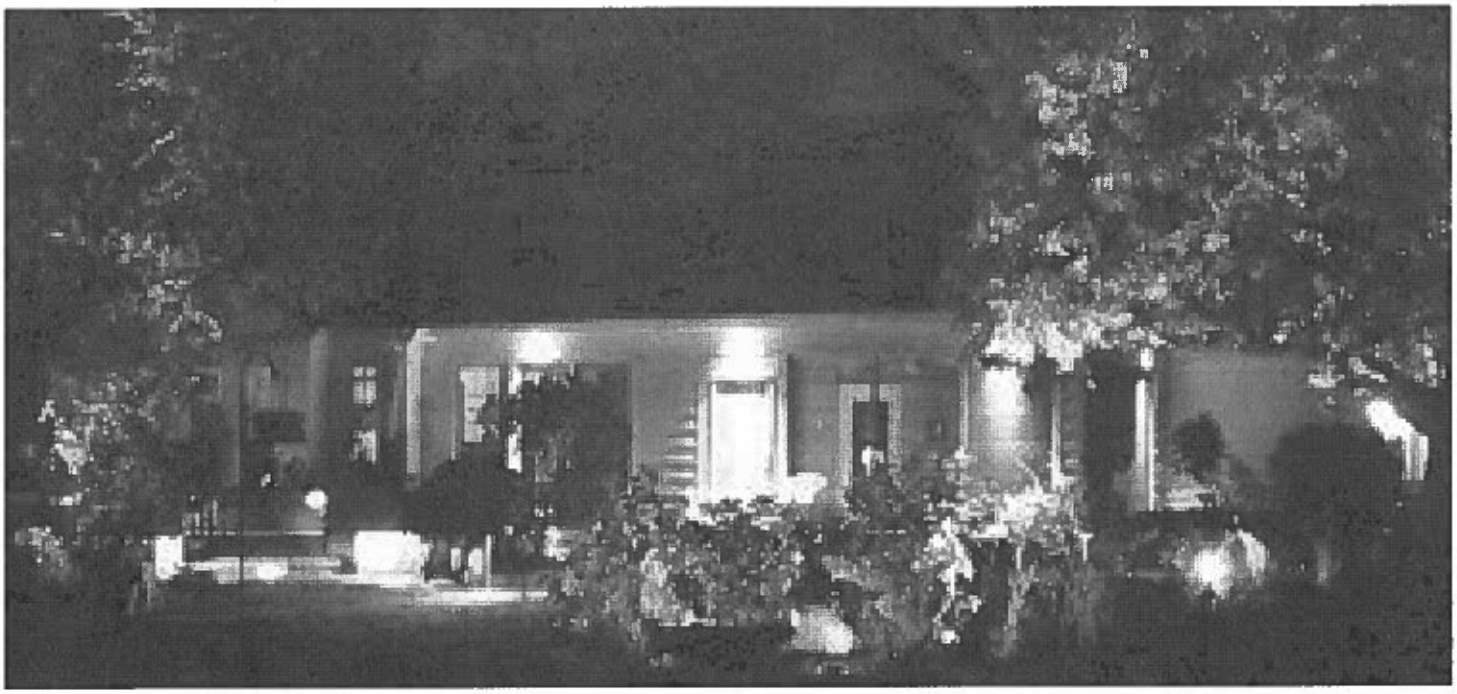
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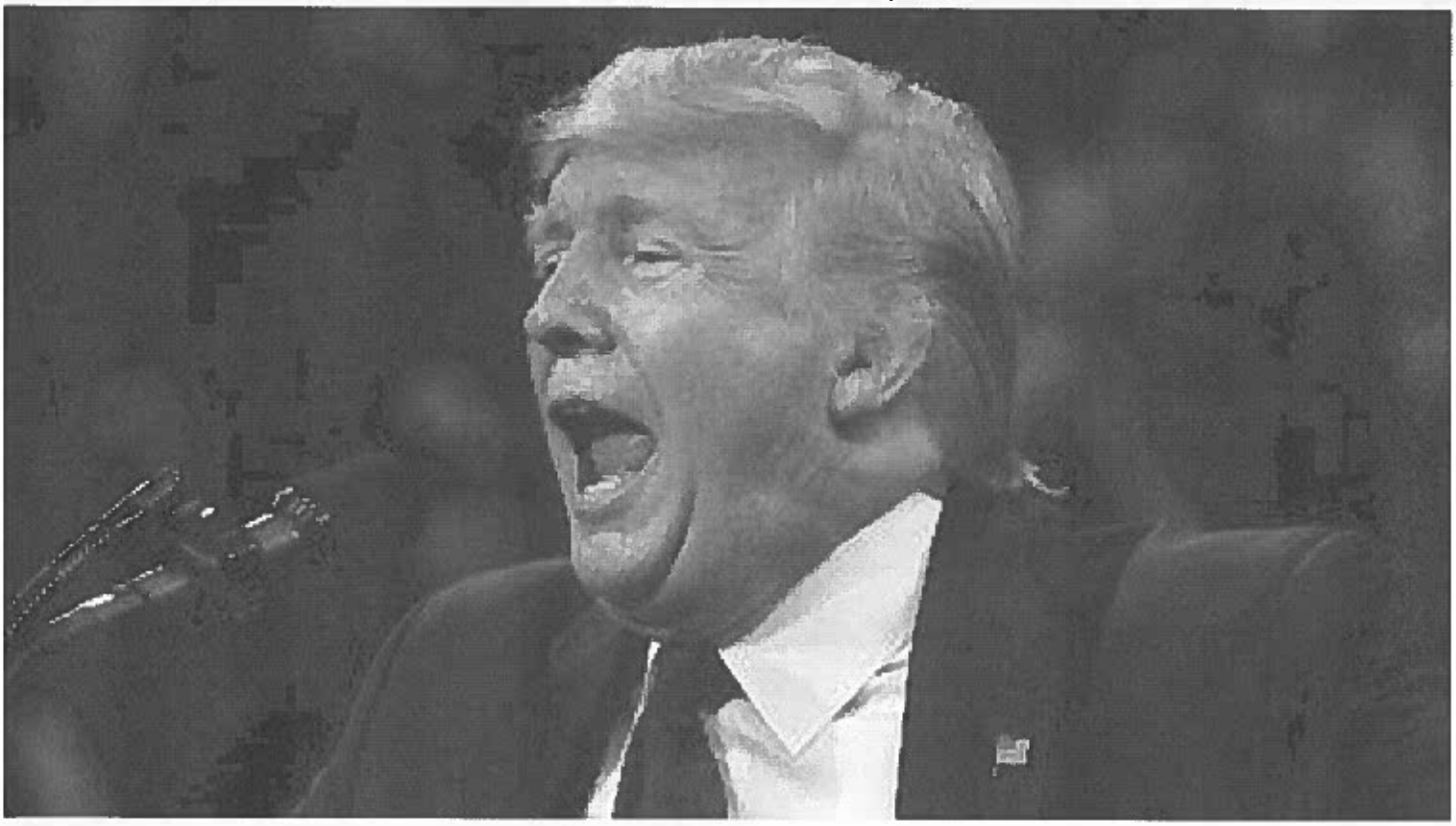


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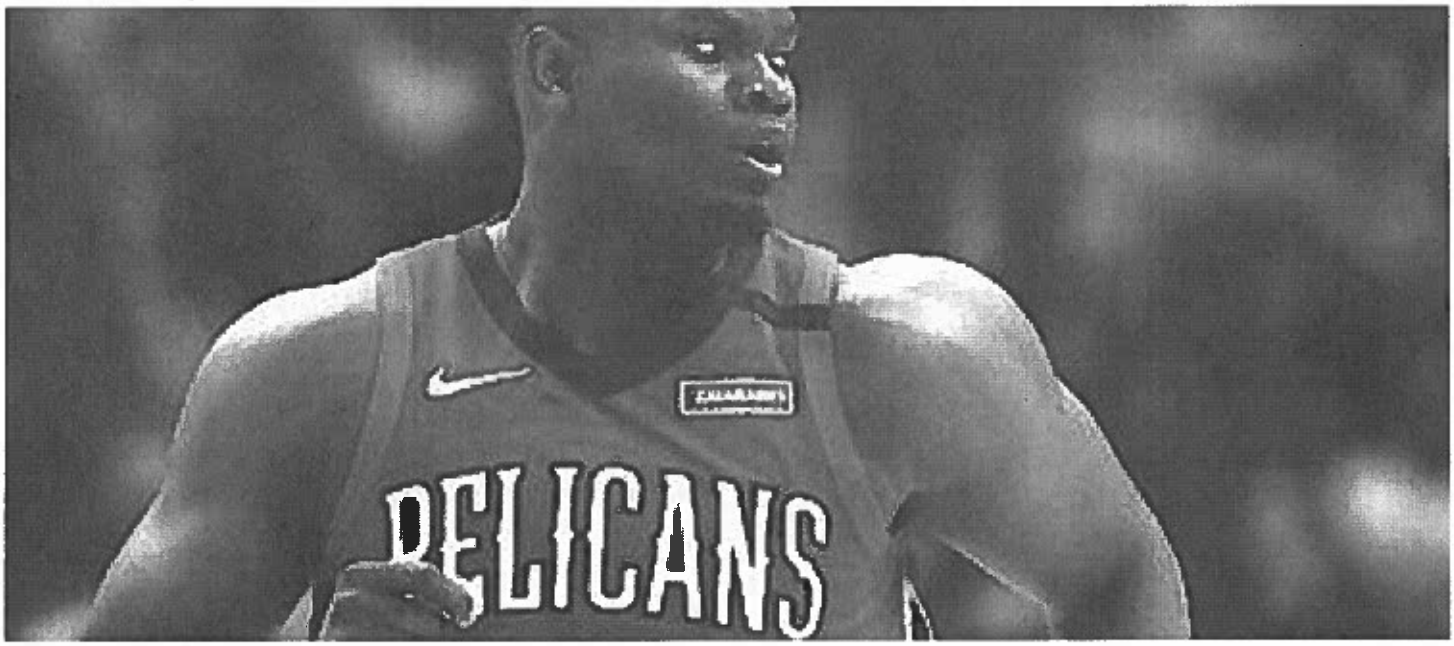
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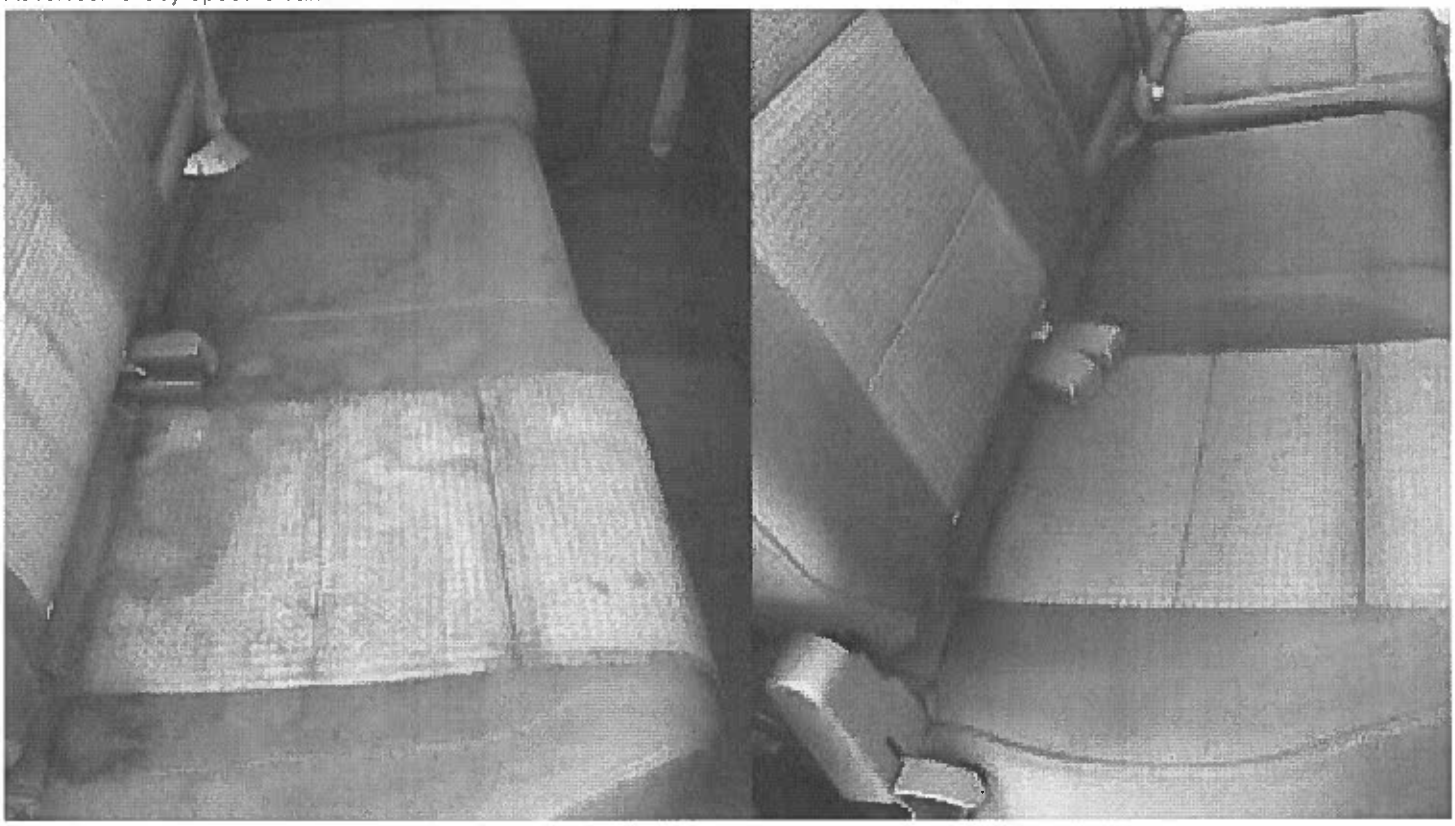
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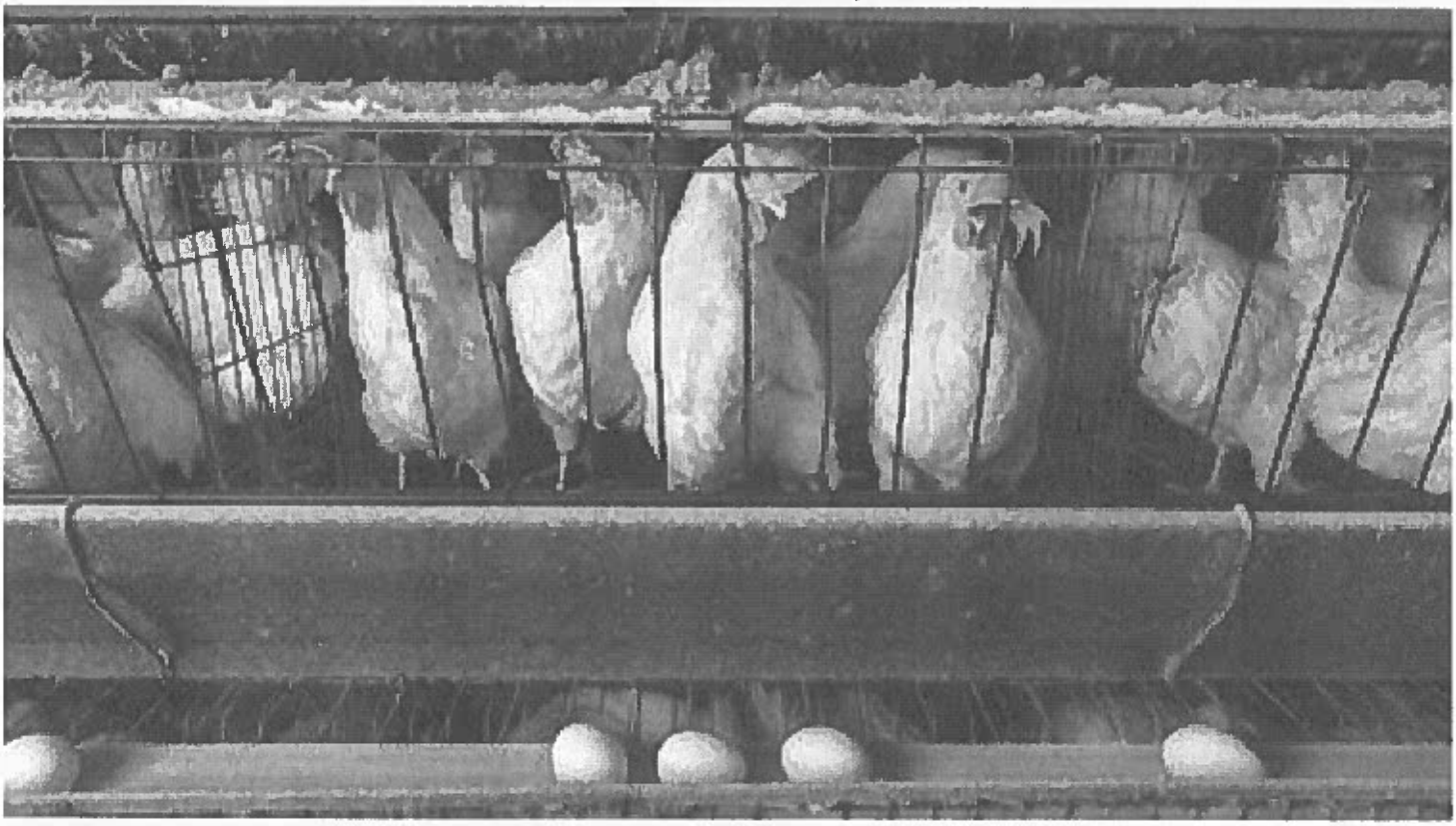


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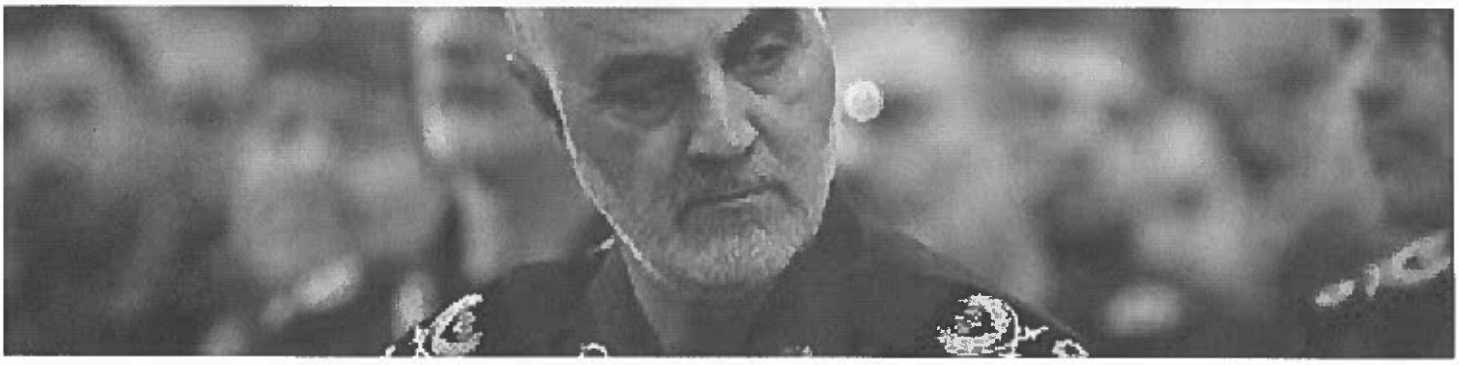


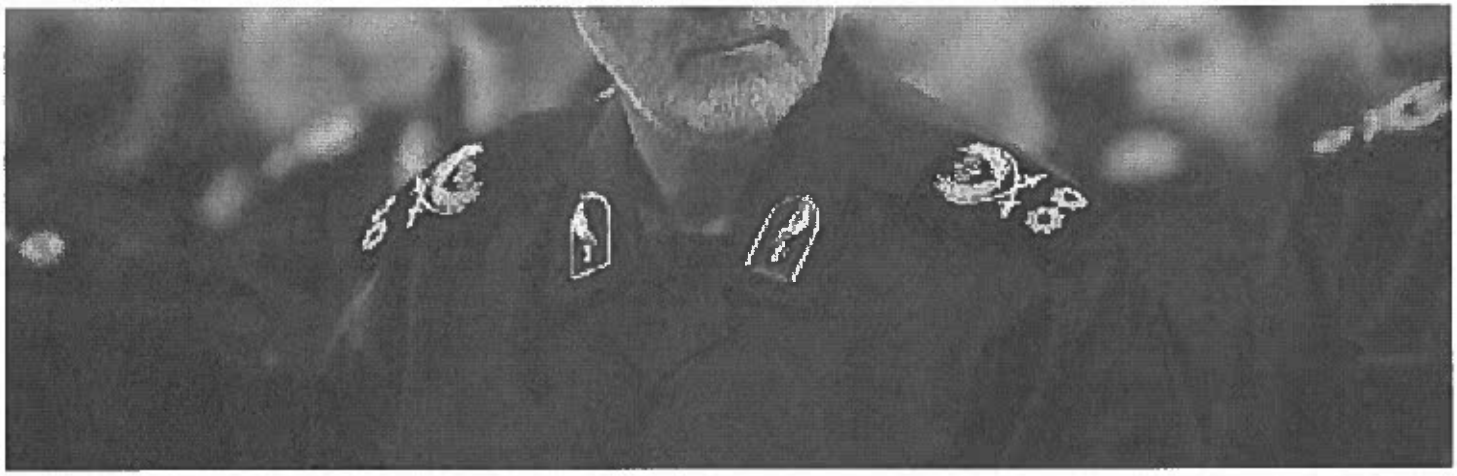


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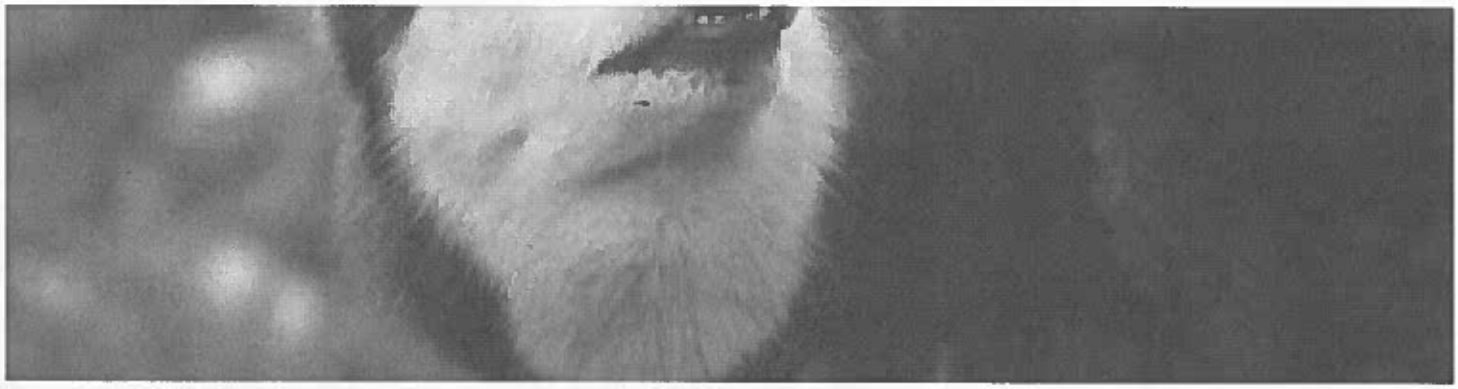


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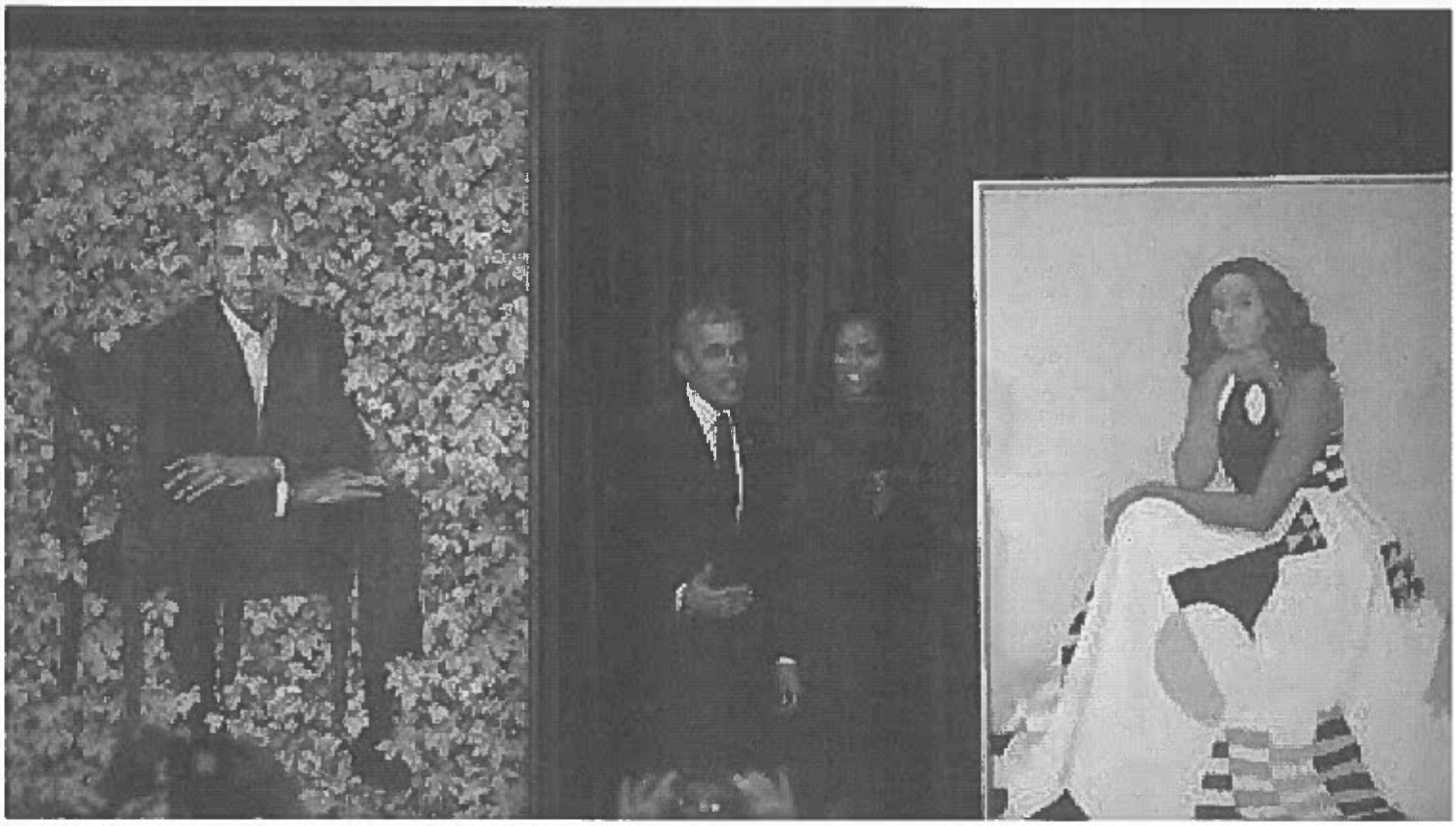


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Murray Energy Holdings Co.

Case No. 19-56885

case info

+ Case Navigation

+ Quick Links

Case Background Important Information & Dates Parties Debtors

Case Background

On October 29, 2019, Murray Energy Holdings Co. and 98 affiliated debtors (collectively, the "Debtors") each filed a voluntary petition for relief under Chapter 11 of the United States Bankruptcy Code in the United States Bankruptcy Court for the Southern District of Ohio, Western Division. The cases are pending before the Honorable John E. Hoffman Jr and are jointly administered under Case No. 19-56885.

Important Information & Dates

Deadline to File Claims

The Bankruptcy Court has set the following deadlines for filing proofs of claim:

- General Bar Date: March 9, 2020, at 5:00 p.m., prevailing Eastern Time
- Governmental Bar Date: April 27, 2020, at 5:00 p.m., prevailing Eastern

Time

Click on "Submit a Claim" above to download the applicable proof of claim form and for more information regarding filing a claim against the Debtors. Please click here to download the Bar Date Order and here to download the Bar Date Notice.

Sale

On January 9, 2020, the the Bankruptcy Court entered an order approving the bidding procedures in connection with the sale of all or substantially all of the Debtor's assets.

Please take note of the following important dates related to the sale:

- Preliminary Bid Deadline: February 4, 2020, at 4:00 p.m., prevailing Eastern Time
- Final Bid Deadline: March 16, 2020, at 4:00 p.m., prevailing Eastern Time
- Auction (if necessary): March 26, 2020, at 10:00 a.m., prevailing Eastern Time
- Sale Objection Deadline: May 26, 2020, at 4:00 p.m., prevailing Eastern Time
- Sale Hearing: June 2, 2020, at 10:00 a.m., prevailing Eastern Time

Please click below to view all documents related to the sale:

Sale Documents

Plan & Disclosure Statement

On December 3, 2019, the Debtors filed their Joint Plan of Reorganization and the Disclosure Statement related thereto. The Bankruptcy Court will hold a hearing to consider approval of the Disclosure Statement on March 12, 2020 at 10:00 a.m. (prevailing Eastern Time)

Please click below to view all documents related to the Debtors' Plan & Disclosure Statement:

Plan & Disclosure Statement

Meeting of Creditors

The Meeting of Creditors was held on December 20, 2019 at 10:00 a.m. (ET) at the following location:

John Weld Peck Federal
Building
550 Main Street
Room 1-109
Cincinnati, OH 45202

First Day Hearing

A hearing on the Debtors' First Day Motions was held on October 30, 2019 at 3:00 p.m. (ET) before the Honorable John E. Hoffman Jr., United States Bankruptcy Court for the District of Southern District of Ohio, Western Division, in Courtroom 1 at United States Bankruptcy Court, 221 East Fourth Street, Atrium Two, Suite 800, Cincinnati, OH 45202.

Please click below to view and download the Debtors' First Day Motions and Orders:

First Day Motions

First Day Orders

Formation Meeting for Official Committee of Unsecured Creditors

The United States Trustee held a meeting to form a Committee on Thursday, November 7, 2019.

For additional information about the formation meeting, please click here

Dates

October

February

29
2019
Petition Date

—

☐ Voluntary Peti...

☐ Add to Calendar

6
2020
Omnibus Hearing

10:00 a.m. (ET)

☐ Amended Order ...

☐ Add to Calendar

March
9
2020
General Bar Date

5:00 p.m. (ET)

☐ Order (I) Sett...

☐ Add to Calendar

+ SHOW ALL DATES

- Parties

Debtors' Counsel

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Kirkland & Ellis International LLP
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Chicago, IL 60654

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Kim Martin Lewis
Alexandra S. Horwitz

United States Trustee and Court Information

Office of the United States Trustee

J.W. Peck Federal Building
550 Main Street, Suite 4-812
Cincinnati, OH 45202
https://www.justice.gov/ust-regions-...
Phone: 513.684.6988

U.S. Bankruptcy Court, Southern District of Ohio

221 East Fourth Street
Atrium Two Suite 800
Cincinnati, OH 45202
https://www.ohsb.uscourts.gov/
Phone: 513-684-2572

- Debtors

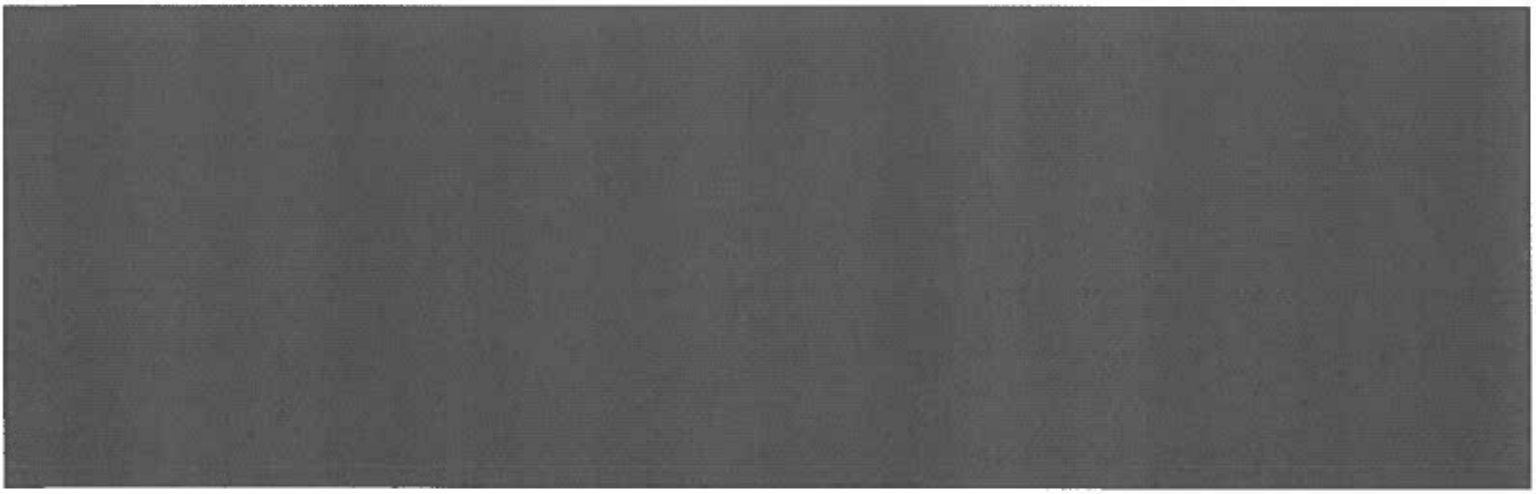
Case Number	Debtor Name	Petition Date
19-56885	Murray Energy Holdings Co.	October 29, 2019
19-56886	AMCA Coal Leasing, Inc.	October 29, 2019
19-56889	AmCoal Holdings, Inc.	October 29, 2019
19-56893	American Compliance Coal, Inc.	October 29, 2019
19-56897	American Energy Corporation	October 29, 2019

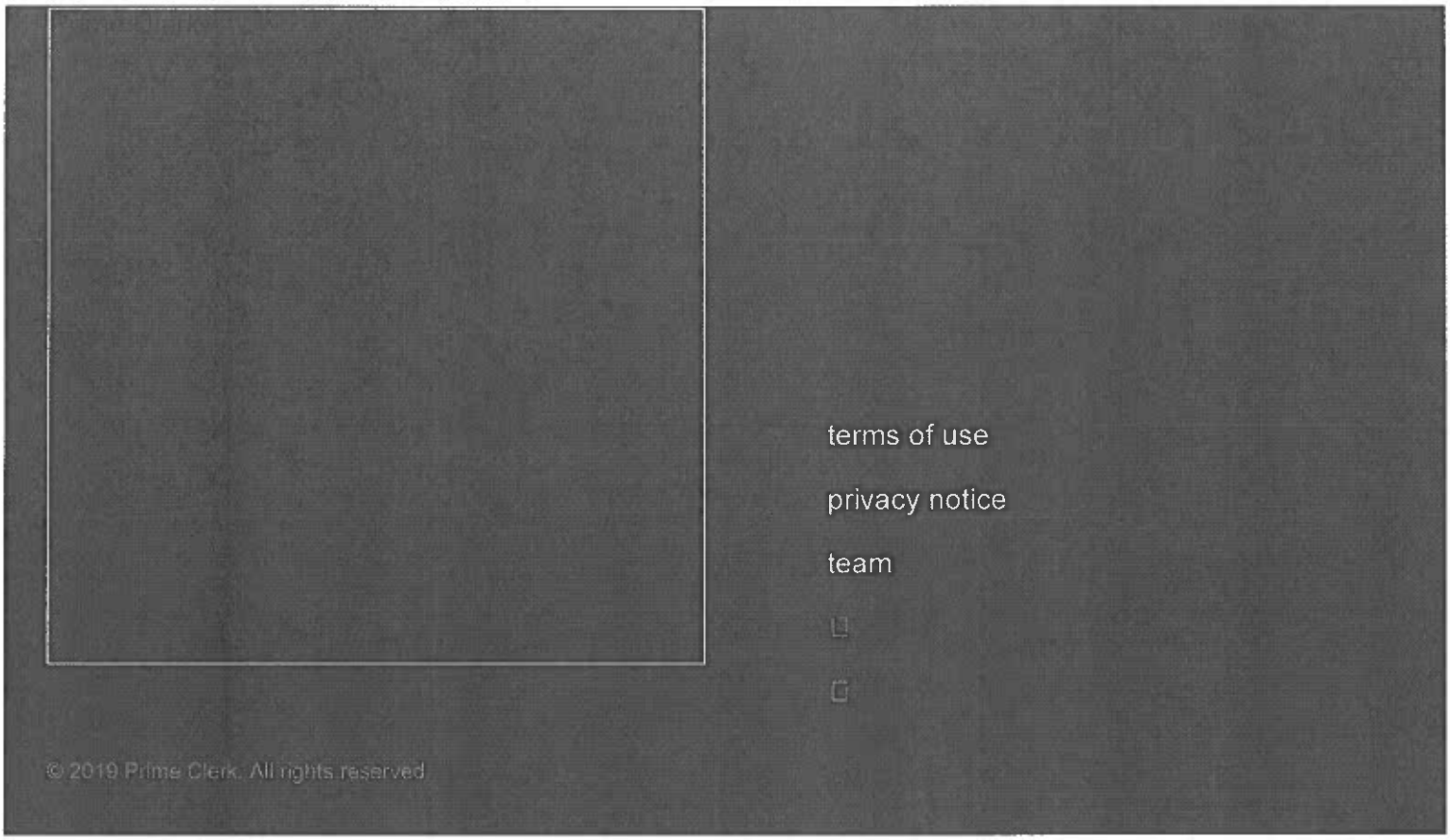
19-56901	American Equipment & Machine, Inc.	October 29, 2019
19-56903	American Mine Services, Inc.	October 29, 2019
19-56907	American Natural Gas, Inc.	October 29, 2019
19-56912	AmericanHocking Energy, Inc.	October 29, 2019
19-56916	AmericanMountaineer Energy, Inc.	October 29, 2019
19-56920	AmericanMountaineer Properties, Inc.	October 29, 2019
19-56925	Anchor Longwall And Rebuild, Inc.	October 29, 2019
19-56929	Andalex Resources Management, Inc.	October 29, 2019
19-56932	Andalex Resources, Inc.	October 29, 2019
19-56940	Belmont Coal, Inc.	October 29, 2019
19-56945	Belmont County Broadcast Studio, Inc.	October 29, 2019
19-56949	Canterbury Coal Company	October 29, 2019
19-56953	CCC Land Resources LLC	October 29, 2019
19-56956	CCC RCPC LLC	October 29, 2019
19-56887	Central Ohio Coal Company	October 29, 2019
19-56890	Coal Resources Holdings Co.	October 29, 2019
19-56892	Coal Resources, Inc.	October 29, 2019
19-56894	Consolidated Land Company	October 29, 2019
19-56898	Consolidation Coal Company	October 29, 2019
19-56902	Corporate Aviation Services, Inc.	October 29, 2019
19-56904	Eighty-Four Mining Company	October 29, 2019
19-56908	Empire Dock, Inc.	October 29, 2019
19-56911	Energy Resources, Inc.	October 29, 2019
19-56915	Energy Transportation, Inc.	October 29, 2019
19-56919	Genwal Resources, Inc.	October 29, 2019
19-56922	Kanawha Transportation Center, Inc.	October 29, 2019

19-56926	KenAmerican Resources, Inc.	October 29, 2019
19-56930	Keystone Coal Mining Corporation	October 29, 2019
19-56935	Maple Creek Mining, Inc.	October 29, 2019
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19-56961	OhioAmerican Energy, Incorporated	October 29, 2019

19-56964	Oneida Coal Company, Inc.	October 29, 2019
19-56967	PennAmerican Coal L.P.	October 29, 2019
19-56970	PennAmerican Coal, Inc.	October 29, 2019
19-56973	Pennsylvania Transloading, Inc.	October 29, 2019
19-56975	Pinski Corp.	October 29, 2019
19-56978	Pleasant Farms, Inc.	October 29, 2019
19-56980	Premium Coal, Inc.	October 29, 2019
19-56974	Southern Ohio Coal Company	October 29, 2019
19-56976	Spring Church Coal Company	October 29, 2019
19-56977	Sunburst Resources, Inc.	October 29, 2019
19-56979	T D K Coal Sales, Incorporated	October 29, 2019
19-56895	The American Coal Company	October 29, 2019
19-56899	The American Coal Sales Company	October 29, 2019
19-56905	The Franklin County Coal Company	October 29, 2019
19-56909	The Harrison County Coal Company	October 29, 2019
19-56913	The Marion County Coal Company	October 29, 2019
19-56917	The Marshall County Coal Company	October 29, 2019
19-56921	The Mclean County Coal Company	October 29, 2019
19-56923	The Meigs County Coal Company	October 29, 2019
19-56927	The Monongalia County Coal Company	October 29, 2019
19-56931	The Muhlenberg County Coal Company, LLC	October 29, 2019
19-56934	The Muskingum County Coal Company	October 29, 2019
19-56937	The Ohio County Coal Company	October 29, 2019
19-56884	The Ohio Valley Coal Company	October 29, 2019
19-56943	The Oklahoma Coal Company	October 29, 2019
19-56947	The Washington County Coal Company	October 29, 2019

19-56951	The Western Kentucky Coal Company, LLC	October 29, 2019
19-56954	Twin Rivers Towing Company	October 29, 2019
19-56957	UMCO Energy, Inc.	October 29, 2019
19-56959	UtahAmerican Energy, Inc.	October 29, 2019
19-56960	West Ridge Resources, Inc.	October 29, 2019
19-56962	West Virginia Resources, Inc.	October 29, 2019
19-56963	Western Kentucky Coal Resources, LLC	October 29, 2019
19-56965	Western Kentucky Consolidated Resources, LLC	October 29, 2019
19-56966	Western Kentucky Land Holding, LLC	October 29, 2019
19-56968	Western Kentucky Rail Loadout, LLC	October 29, 2019
19-56969	Western Kentucky Resources Financing, LLC	October 29, 2019
19-56971	Western Kentucky Resources, LLC	October 29, 2019
19-56972	Western Kentucky River Loadout, LLC	October 29, 2019
19-56936	Avonmore Rail Loading, Inc.	October 29, 2019
19-56981	Murray Global Commodities, Inc.	October 29, 2019
19-57017	Murray Energy Corporation	October 29, 2019




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COAL GIANT PROVIDED SECRET FINANCING TO GROUP CHALLENGING CLIMATE LAWSUITS

Lee Fang

December 17 2019, 12:17 p.m.

DONATE 12



The Tennessee Valley Authority Paradise Fossil Plant, a generating station that used to burn coal mined by Murray Energy Holdings Co., the largest privately owned U.S. coal company, in Paradise, Ky., on Oct. 30, 2019. Photo: Luke Sharrett/Bloomberg via Getty Images

IN 2018, a new group appeared seemingly out of nowhere and

immediately took aim at the recent wave of lawsuits filed by state attorneys general designed to hold major fossil fuel companies responsible for allegedly misleading investors and customers about the true risk of carbon pollution.

"The global warming lobby has gone too far this time," declared the innocuously named group, Government Accountability and Oversight, in a video posted on its website. GAO claimed that the lawsuits, which target Exxon Mobil, Shell Oil, and Chevron, among other corporations, represent a form of government overreach and that prosecutors are colluding with activist interest groups in an unethical manner.

GAO, which is run as a for-profit company and foundation, does not disclose its donors nor does it provide much information about its origins. But on Saturday, a bankruptcy court in southern Ohio released a filing revealing that the organization received three donations totaling $300,000 from Murray Energy, the largest privately held coal-mining company in the United States. The first payment was made on June 7, 2018, just one month after GAO announced its intention to "expose" the litigation effort against energy companies.

That a secretive group working to defend the fossil fuel industry is financed by Murray Energy may come as no surprise.

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Bob Murray, the billionaire founder of Murray Energy, a prolific GOP donor, and early supporter of President Donald Trump, is an outspoken critic of environmental regulations and activist groups. Murray's influence over the administration, including the push to unravel Environmental Protection Agency rules on carbon emissions and exit the Paris climate accords, is well documented. Even the current chief of the EPA, Andrew Wheeler, is a former lobbyist for Murray.

GAO and Murray Energy did not immediately respond to a request for comment. The company has provided over $3.8 million in campaign contributions to a range of federal politicians over the last five years, according to the Federal Election Commission. That figure, however, appears to be only part of the story in terms of the company's influence over the political debate.

In October, following a precipitous drop in coal demand, Murray's company filed for Chapter 11 bankruptcy protection, forcing the firm to disclose its recent history of payments to outside political entities. As part of the company's restructuring process, it filed a statement of financial affairs, which lists creditors and liabilities, as well as a list of recent charitable donations and grants, which revealed the payments to GAO, among many other new revelations about the coal company's hidden hand in the climate change debate.

Murray Energy showered donations to several think tanks focused on questioning the link between human activity and global warming, providing grants to groups such as the Heartland Institute, which once sponsored billboards comparing those who accept climate change to the Unabomber. The Ohio-based coal giant gave $30,000 to the Heartland Institute in March of last year, shortly after the group announced a campaign to save coal companies on the brink of closure, followed by another $100,00 in contributions in the months that followed.

Other think tanks listed in the filing as having received money from Murray Energy include the Committee for a Constructive Tomorrow, a group that claimed "there is no scientific consensus though that global warming is man-caused"; the Competitive Enterprise

[redacted] Murray Energy showered donations to several think tanks focused on

Institute, which briefs lawmakers on how the science behind climate change is a "hoax"; the Cato Institute, the Charles Koch-founded think tank that has long sponsored prominent climate change deniers; and the Center for the Study of Carbon Dioxide and Global Change, which argues for the "many benefits" of increasing carbon emissions. ("Atmospheric carbon dioxide is the *elixir of life*," one pamphlet reads. Emphasis in the original.)

questioning the link between human activity and global warming.

The filing lists nearly a dozen similar payments to right-wing organizations that do not disclose donors. Murray Energy provided $130,000 to "Hardworking Ohioians Inc.," a mysterious for-profit group, which revealed no information about its donors, tied closely to Ohio House Speaker Larry Householder, and aired advertisements last year to maintain the Republican majority in the legislature. Another $50,000 was spent in support of FreedomWorks, a grassroots group that mobilizes public support for rolling back EPA regulations. Judicial Watch, a GOP-aligned investigative nonprofit, is also a beneficiary of Murray Energy money.

"The bankruptcy filing confirms what environmentalists have long suspected about Murray Energy's connections to a network of special-interest groups that have worked to manufacture doubt about climate change and attack climate scientists and activists," said David Anderson, communications and policy manager for the Energy and Policy Institute, a watchdog group.

Bankruptcy filings have provided a unique opportunity for the public to better understand the political agenda of powerful corporate interests, which typically shroud sensitive donations through nondisclosing entities. The sudden collapse earlier this year of Cloud Peak Energy, a Wyoming-based coal firm, revealed several donations to climate change denial groups. In 2015, The

Intercept reported on another wave of coal bankruptcies, which revealed ties between coal firms to a subterranean network of groups dedicated to blocking environmental reform.

The bankruptcy of Alpha Natural Resources three years ago, for instance, showed secret payments to Chris Horner, a former lobbyist who had hounded climate scientists in an attempt to discredit their work. The disclosure was the first time Horner and his nonprofit, the Free Market Environmental Law Clinic, had been directly tied to the fossil fuel industry.

Horner is now onto new projects. Along with several other lawyers, he is a co-founder of Government Accountability and Oversight.

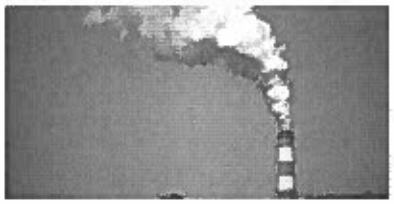
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WITH JEREMY SCAHILL

IN THE UNITED STATES BANKRUPTCY COURT
FOR THE SOUTHERN DISTRICT OF OHIO
WESTERN DIVISION

In re:	)	Chapter 11
MURRAY ENERGY HOLDINGS CO., *et al.*,[1]	)	Case No. 19-56885 (JEH)
	)	Judge John E. Hoffman, Jr.
Debtors.	)	(Jointly Administered)

GLOBAL NOTES, METHODOLOGY, AND SPECIFIC DISCLOSURES REGARDING THE DEBTORS' SCHEDULES OF ASSETS AND LIABILITIES AND STATEMENTS OF FINANCIAL AFFAIRS

INTRODUCTION

Murray Energy Holdings Co. and its debtor affiliates, as debtors and debtors in possession in the above-captioned chapter 11 cases (collectively, the "Debtors"), with the assistance of their advisors, have filed their respective Schedules of Assets and Liabilities (the "Schedules") and Statements of Financial Affairs (the "Statements," and together with the Schedules, the "Schedules and Statements") with the United States Bankruptcy Court for the Southern District of Ohio (the "Court"), under section 521 of title 11 of the United States Code, 11 U.S.C. §§ 101–1532 (the "Bankruptcy Code"), Rule 1007 of the Federal Rules of Bankruptcy Procedure (the "Bankruptcy Rules"), and Rule 1007-1 of the Bankruptcy Local Rules for the Southern District of Ohio (the "Local Rules").

These *Global Notes, Methodology, and Specific Disclosures Regarding the Debtors' Schedules of Assets and Liabilities and Statements of Financial Affairs* (the "Global Notes") pertain to, are incorporated by reference in, and comprise an integral part of all of the Debtors' Schedules and Statements. The Global Notes should be referred to, considered, and reviewed in connection with any review of the Schedules and Statements.

The Schedules and Statements do not purport to represent financial statements prepared in accordance with Generally Accepted Accounting Principles in the United States ("GAAP"), nor are they intended to be fully reconciled with the financial statements of each Debtor. Additionally, the Schedules and Statements contain unaudited information that is subject to further review and

[1] Due to the large number of Debtors in these chapter 11 cases, a complete list of the Debtors and the last four digits of their federal tax identification numbers is not provided herein. Such information may be obtained on the website of the Debtors' claims and noticing agent at https://cases.primeclerk.com/MurrayEnergy. The location of Debtor Murray Energy Holdings Co.'s principal place of business and the Debtors' service address in these chapter 11 cases is 46226 National Road, St. Clairsville, Ohio 43950.

potential adjustment and reflects the Debtors' reasonable efforts to report the assets and liabilities of each Debtor on an unconsolidated basis.

The Debtors and their agents, attorneys, and advisors do not guarantee or warrant the accuracy or completeness of the data that is provided herein and shall not be liable for any loss or injury arising out of or caused in whole or in part by the acts, errors, or omissions, whether negligent or otherwise, in procuring, compiling, collecting, interpreting, reporting, communicating, or delivering the information contained herein. While reasonable efforts have been made to provide accurate and complete information herein, inadvertent errors or omissions may exist. The Debtors and their agents, attorneys, and advisors expressly do not undertake any obligation to update, modify, revise, or re-categorize the information provided herein, or to notify any third party should the information be updated, modified, revised, or re-categorized. In no event shall the Debtors or their agents, attorneys, and advisors be liable to any third party for any direct, indirect, incidental, consequential, or special damages (including damages arising from the disallowance of a potential claim against the Debtors or damages to business reputation, lost business, or lost profits), whether foreseeable or not and however caused, even if the Debtors or their agents, attorneys, and advisors are advised of the possibility of such damages.

In preparing the Schedules and Statements, the Debtors relied on financial data derived from their books and records that was available at the time of such preparation. Although the Debtors have made reasonable, good faith efforts to collect, compile, and ensure the accuracy and completeness of the Schedules and Statements, subsequent information or discovery may result in material changes to the Schedules and Statements. As a result, inadvertent errors or omissions may exist. For the avoidance of doubt, the Debtors reserve their rights to amend and supplement the Schedules and Statements as may be necessary or appropriate.

Mr. Robert D. Moore, Chief Executive Officer, and Chief Financial Officer of Murray Energy Holdings Co. has signed each of the Schedules and Statements. Mr. Moore is an authorized signatory for each of the Debtors. In reviewing and signing the Schedules and Statements, Mr. Moore necessarily has relied upon the efforts, statements, and representations of various personnel employed by the Debtors and their advisors. Mr. Moore has not (and could not have) personally verified the accuracy of each statement and representation contained in the Schedules and Statements, including statements and representations concerning amounts owed to creditors, classification of such amounts, and creditor addresses.

Global Notes and Overview of Methodology

1. **Description of Cases.** On October 29, 2019 (the "Petition Date"), the Debtors filed voluntary petitions for relief under chapter 11 of the Bankruptcy Code. The Debtors are operating their business and managing their property as debtors-in-possession pursuant to sections 1107(a) and 1108 of the Bankruptcy Code. On November 1, 2019, an order [Docket No. 112] was entered directing joint administration of these chapter 11 cases. Notwithstanding the joint administration of the Debtors' cases for procedural purposes, each Debtor has filed its own Schedules and Statements. On November 7, 2019, the United States Trustee appointed an official committee of unsecured creditors in the Debtors' bankruptcy cases [Docket No. 168]. No request for the appointment of a trustee or examiner has been made in these chapter 11 cases. The liability information provided

herein represents the liability data of the Debtors as of the Petition Date, except as otherwise noted. The asset information provided herein represents the asset data of the Debtors as of September 30, 2019, except as otherwise noted.

2. **Global Notes Control.** These Global Notes pertain to and comprise an integral part of each of the Schedules and Statements and should be referenced in connection with any review thereof. In the event that the Schedules and Statements conflict with these Global Notes, the Global Notes shall control.

3. **Reservation of Rights.** Reasonable efforts have been made to prepare and file complete and accurate Schedules and Statements, but inadvertent errors or omissions may exist. The Debtors reserve all rights to: (i) amend or supplement the Schedules and Statements from time to time, in all respects, as may be necessary or appropriate, including the right to amend the Schedules and Statements with respect to the description, designation, or Debtor against which any claim against a Debtor ("Claim")[2] is asserted; (ii) dispute or otherwise assert offsets or defenses to any Claim reflected in the Schedules and Statements as to amount, liability, priority, status, or classification; (iii) subsequently designate any Claim as "disputed," "contingent," or "unliquidated;" or (iv) object to the extent, validity, enforceability, priority, or avoidability of any Claim (regardless of whether such Claim is designated in the Schedules and Statements as "disputed," "contingent," or "unliquidated"). Any failure to designate a Claim in the Schedules and Statements as "disputed," "contingent," or "unliquidated" does not constitute an admission by the Debtors that such Claim or amount is not "disputed," "contingent," or "unliquidated." Listing a Claim does not constitute an admission of liability by the Debtor against which the Claim is listed or against any of the Debtors. Furthermore, nothing contained in the Schedules and Statements shall constitute a waiver of rights with respect to the Debtors' chapter 11 cases, including, but not limited to, issues involving Claims, substantive consolidation, defenses, equitable subordination, and/or causes of action arising under the provisions of chapter 5 of the Bankruptcy Code and any other relevant non-bankruptcy laws to recover assets or avoid transfers. Any specific reservation or rights contained elsewhere in the Global Notes does not limit in any respect the general reservation of rights contained in this paragraph. Notwithstanding the foregoing, the Debtors shall not be required to update the Schedules and Statements.

   (a) **No Admission.** Nothing contained in the Schedules and Statements is intended or should be construed as an admission or stipulation of the validity of any Claim against the Debtors, any assertion made therein or herein, or a waiver of the Debtors' rights to dispute any Claim or assert any cause of action or defense against any party.

   (b) **Recharacterization.** Notwithstanding the Debtors' reasonable efforts to properly characterize, classify, categorize, or designate certain Claims, assets, executory contracts, unexpired leases, and other items reported in the Schedules and Statements, the Debtors may nevertheless have improperly characterized,

[2] For the purposes of these Global Notes, the term Claim shall have the meaning as defined under section 101(5) of the Bankruptcy Code.

classified, categorized, designated, or omitted certain items due to the complexity and size of the Debtors' businesses. Accordingly, the Debtors reserve all rights to recharacterize, reclassify, recategorize, redesignate, add, or delete items reported in the Schedules and Statements at a later time as is necessary or appropriate as additional information becomes available, including, but not limited to, whether contracts or leases listed herein were deemed executory or unexpired as of the Petition Date and remain executory and unexpired postpetition.

(c) **Classifications.** Listing (i) a Claim on Schedule D as "secured," (ii) a Claim on Schedule E/F as "priority," (iii) a Claim on Schedule E/F as "unsecured," or (iv) a contract on Schedule G as "executory" or "unexpired," does not constitute an admission by the Debtors of the legal rights of the claimant or a waiver of the Debtors' rights to recharacterize or reclassify such Claims or contracts or to setoff of such Claims.

(d) **Claims Description.** Schedules D and E/F permit each of the Debtors to designate a Claim as "disputed," "contingent," and/or "unliquidated." Any failure to designate a Claim on a given Debtor's Schedules and Statements as "disputed," "contingent," or "unliquidated" does not constitute an admission by that Debtor that such amount is not "disputed," "contingent," or "unliquidated," or that such Claim is not subject to objection. The Debtors reserve all of their rights to dispute, or assert offsets or defenses to, any Claim reflected on their respective Schedules and Statements on any grounds, including liability or classification. Additionally, the Debtors expressly reserve all of their rights to subsequently designate such Claims as "disputed," "contingent," or "unliquidated." Moreover, listing a Claim does not constitute an admission of liability by the Debtors. The Debtors reserve all rights to amend their Schedules and Statements as necessary and appropriate, including, but not limited to, with respect to Claim description and designation.

(e) **Estimates and Assumptions.** The preparation of the Schedules and Statements required the Debtors to make reasonable estimates and assumptions with respect to the reported amounts of assets and liabilities, the amount of contingent assets and contingent liabilities on the date of the Schedules and Statements, and the reported amounts of revenues and expenses during the applicable reporting periods. Actual results could differ from such estimates.

(f) **Causes of Action.** Despite their reasonable efforts to identify all known assets, the Debtors may not have listed all of their causes of action or potential causes of action against third parties as assets in the Schedules and Statements, including causes of action that are required to be kept confidential and causes of action arising under the provisions of chapter 5 of the Bankruptcy Code and any other relevant non-bankruptcy laws to recover assets or avoid transfers. The Debtors reserve all of their rights with respect to any cause of action (including avoidance actions), controversy, right of setoff, cross-claim, counterclaim, or recoupment and any claim on contracts or for breaches of duties imposed by law or in equity, demand, right, action, lien, indemnity, guaranty, suit, obligation, liability, damage, judgment, account, defense, power, privilege, license, and franchise of any kind or

character whatsoever, known, unknown, fixed or contingent, matured or unmatured, suspected or unsuspected, liquidated or unliquidated, disputed or undisputed, secured or unsecured, assertable directly or derivatively, whether arising before, on, or after the Petition Date, in contract or in tort, at law or in equity, or pursuant to any other theory of law (collectively, "Causes of Action") they may have, and neither these Global Notes nor the Schedules and Statements shall be deemed a waiver of any claims or Causes of Action or in any way prejudice or impair the assertion of such claims or Causes of Action.

(g) **Intellectual Property Rights.** Exclusion of certain intellectual property shall not be construed as an admission that such intellectual property rights have been abandoned, terminated, assigned, expired by their terms, or otherwise transferred pursuant to a sale, acquisition, or other transaction. Conversely, inclusion of certain intellectual property shall not be construed to be an admission that such intellectual property rights have not been abandoned, have not been terminated or otherwise expired by their terms, or have not been assigned or otherwise transferred pursuant to a sale, acquisition, or other transaction. The Debtors have made every effort to attribute intellectual property to the rightful Debtor owner; however, in some instances intellectual property owned by one Debtor may, in fact, be owned by another. Accordingly, the Debtors reserve all of their rights with respect to the legal status of any and all such intellectual property rights.

(h) **Insiders.** For purposes of the Schedules and Statements, the Debtors defined "insiders" pursuant to section 101(31) of the Bankruptcy Code as: (i) directors; (ii) officers; (iii) persons in control of the Debtors; (iv) relatives of the Debtors' directors, officers, or persons in control of the Debtors; and (v) Debtor affiliates of the foregoing. Persons listed as "insiders" have been included for informational purposes only and, by including them in the Schedules and Statements, shall not constitute an admission that those persons are insiders for purposes of section 101(31) of the Bankruptcy Code. Moreover, the Debtors do not take any position with respect to: (i) any insider's control of the Debtors; (ii) the management responsibilities or functions of any such insider; (iii) the decision making or corporate authority of any such insider; or (iv) whether the Debtors or any such insider could successfully argue that he or she is not an "insider" under applicable law or with respect to any theories of liability or for any other purpose.

In the circumstance where the Schedules and Statements require information regarding "insiders," the Debtors have included information with respect to certain individuals who served as officers and directors, as the case may be, during the relevant time periods. Such individuals may no longer serve in such capacities. For purposes of the Schedules and Statements, the listing of a person as an "insider," including by virtue of any such party serving as an officer or director of the Debtors, is not intended to be, nor should it be, construed as an admission of any fact that any such person is in fact an "insider," and all rights, claims, and defenses are hereby expressly reserved. Information regarding the individuals listed as "insiders" in the Schedules and Statements has been included for informational purposes only and such information may not be used for the purposes

of determining control of the Debtors, the extent to which any individual exercised management responsibilities or functions, corporate decision-making authority over the Debtors, whether such individual is in fact an insider for purposes of the Bankruptcy Code, or whether such individual could successfully argue that he or she is not an insider under applicable law, including the Bankruptcy Code and federal securities laws, or with respect to any theories of liability or any other purpose.

4. **Methodology.**

(a) **Confidential Information.** There may be instances in the Schedules and Statements where the Debtors deemed it necessary and appropriate to redact from the public record information such as names, addresses, or amounts. Typically, the Debtors have used this approach because of a confidentiality agreement between the Debtors and a third party, for the protection of sensitive commercial information, or for the privacy of an individual. In addition, the Court has authorized the filing of employee addresses under seal. *See* [Docket No. 110]

(b) **Umbrella or Master Agreements.** Contracts and leases listed in the Schedules and Statements may be umbrella or master agreements that cover relationships with some or all of the Debtors. Where relevant, such agreements have been listed in the Schedules and Statements only of the Debtor entity that signed the original umbrella or master agreement. Other Debtors, however, may be liable together with such Debtor on account of such agreements and the Debtors reserve all rights to amend the Schedules and Statements to reflect changes regarding the liability of the Debtors with respect to such agreements, if appropriate.

(c) **Executory Contracts.** Although the Debtors have made reasonable efforts to attribute an executory contract to its rightful Debtor, in certain instances, the Debtors may have inadvertently failed to do so due to the complexity and size of the Debtors' businesses. Accordingly, the Debtors reserve all rights with respect to the named parties of any and all executory contracts, including the right to amend Schedule G for any Debtor.

(d) **Duplication.** Certain of the Debtors' assets, liabilities, and prepetition payments may properly be disclosed in multiple parts of the Statements and Schedules. To the extent these disclosures would be duplicative, the Debtors have determined to only list such assets, liabilities, and prepetition payments once.

(e) **Net Book Value of Assets and Liabilities.** Unless otherwise indicated, liabilities on the Debtors' Schedules and Statements reflect net book values as of the Petition Date and assets reflect net book values as of September 30, 2019. The book values of certain assets may materially differ from their fair market values and/or the Debtors' enterprise valuation, if any, that may be prepared in connection with the disclosure statement to the Debtors' chapter 11 plan. For the avoidance of doubt, nothing contained in the Schedules and Statements is indicative of the Debtors' enterprise value.

Book values of assets prepared in accordance with GAAP generally do not reflect the current performance of the assets or the impact of the industry environment and may differ materially from the actual value and/or performance of the underlying assets.

(f) **Undetermined Amounts.** The description of an amount as "undetermined" is not intended to reflect upon the materiality of such amount.

(g) **Unliquidated Amounts.** Amounts that could not be fairly quantified by the Debtors are scheduled as "unliquidated."

(h) **Totals.** All totals that are included in the Schedules and Statements represent totals of all known amounts. To the extent there are unknown or undetermined amounts, the actual total may be different than the listed total.

(i) **Inventories; Property and Equipment.** Inventories consist of materials, supplies, and coal inventory. These inventories are valued at the lower of cost or market. Coal inventory costs include labor, supplies, equipment, operating overhead, and transportation costs incurred prior to the transfer of title to customers. Property, plant, equipment, and mine development are recorded at cost or at fair value at the date of acquisition in the case of acquired businesses, and are presented net of accumulated depreciation and amortization. Property, plant, and equipment are aggregated in the Debtors' books and records and cannot be segregated easily into the categories required by the Schedules and Statements. All inventories, as well as all property and equipment, are presented without consideration of any statutory or consensual liens.

(j) **Coal Reserves.** The Debtors have not analyzed the current market value of their owned or leased coal reserves. Except where otherwise noted, the Debtors have reported the book value of all owned pieces of real property, including coal reserves, in Schedule A/B. Certain unexpired coal reserve leases of the Debtors as of the Petition Date that may constitute executory contracts or unexpired leases within the meaning of Bankruptcy Code section 365 are also included in Schedule G, and to the extent that there was an amount outstanding under a coal reserve lease, such as royalties payable, as of the Petition Date, the amount owed to the lessor of the coal reserves has been listed on Schedule E/F.

(k) **Liabilities.** The Debtors have sought to allocate liabilities between the prepetition and postpetition periods based on the information and research conducted in connection with the preparation of the Schedules and Statements. As additional information becomes available and further research is conducted, the allocation of liabilities between the prepetition and postpetition periods may change. Accordingly, the Debtors reserve all of their rights to amend, supplement, or otherwise modify the Schedules and Statements as is necessary or appropriate.

(l) **Paid Claims.** The Debtors were authorized (but not directed) to pay certain outstanding prepetition Claims pursuant to various orders entered by the Court.

Accordingly, certain outstanding liabilities that have been reduced by postpetition payments made on account of prepetition liabilities have been designated as either contingent or unliquidated. To the extent the Debtors pay any of the Claims listed in the Schedules and Statements pursuant to any orders entered by the Court, the Debtors reserve all of their rights to amend or supplement the Schedules and Statements or take other action as is necessary or appropriate to avoid over-payment of or duplicate payments for any such liabilities.

(m) **Intercompany Payables and Receivables.** Intercompany payables and receivables between the Debtors are reported as of October 31, 2019, and are set forth on Schedule E/F or Schedule A/B, Part 11, Questions 71 and 77, as applicable.

As described more fully in the Debtor's *Motion for Entry of Interim and Final Orders (I) Authorizing the Debtors to (A) Continue to Operate their Cash Management System, (B) Maintain Existing Business Forms, (C) Perform Intercompany Transactions and Pay Prepetition Obligations Related Thereto, and (II) Granting Related Relief* [Docket No. 13] (the "Cash Management Motion"), the Debtors engage in a range of intercompany transactions in the ordinary course of business. Pursuant to the final order granting the relief requested in the Cash Management Motion [Docket No. 389] (the "Cash Management Order"), the Court has granted the Debtors authority to continue the intercompany transactions in the ordinary course of business. Thus, intercompany balances as of the Petition Date, as set forth in Schedule E/F or Schedule A/B, Part 11, Question 71 or 77 may not accurately reflect current positions.

The listing by the Debtors of any account between a Debtor and another Debtor is a statement of what appears in a particular Debtor's books and records and does not reflect any admission or conclusion of the Debtors regarding the allowance, classification, characterization, validity, or priority of such account. The Debtors take no position in these Schedules and Statements as to whether such accounts would be allowed as a Claim, an Interest, or not allowed at all. The Debtors reserve all rights with respect to such accounts.

(n) **Guarantees and Other Secondary Liability Claims.** The Debtors have exercised reasonable efforts to locate and identify guarantees of their executory contracts, unexpired leases, secured financings, and other such agreements. Where guarantees have been identified, they have been included in the relevant Schedules E/F, G, and H for the affected Debtor. The Debtors may have inadvertently omitted guarantees embedded in their contractual agreements and may identify additional guarantees as they continue to review their books and records and contractual agreements. The Debtors reserve their rights, but are not required, to amend the Schedules and Statements if additional guarantees are identified.

(o) **Excluded Assets and Liabilities.** The Debtors have excluded certain categories of assets, tax accruals, and liabilities from the Schedules and Statements, including

goodwill, accrued salaries, employee benefit accruals, and accrued accounts payable. The Debtors also have excluded rejection damage for Claims of counterparties to executory contracts and unexpired leases that may or may not be rejected, to the extent such damage Claims exist. The Debtors have also excluded certain unbilled receivables and allowances for doubtful accounts. The Debtors also have excluded potential pneumoconiosis and worker's compensation claims to maintain the privacy of the claimants. In addition, certain immaterial assets and liabilities may have been excluded.

The Court has authorized (but not directed) the Debtors to pay, in their discretion, certain outstanding Claims on a postpetition basis. As discussed below, prepetition liabilities that the Debtors have paid postpetition or those which the Debtors plan to pay in accordance this authorization may not be listed in the Schedules and Statements.

Liabilities for which the Debtors are attempting to determine creditor information, including approximately $4.5 million of royalty liabilities held in suspense, may be excluded from the Schedules.

(p) **Liens.** Property and equipment listed in the Schedules and Statements are presented without consideration of any liens that may attach (or have attached) to such property and equipment.

(q) **Currency.** Unless otherwise indicated, all amounts are reflected in U.S. Dollars. Currency conversions are generally as of the Petition Date.

(r) **Setoffs.** The Debtors periodically incur certain setoffs in the ordinary course of business.

Setoffs in the ordinary course can result from various items including, but not limited to, intercompany transactions, pricing discrepancies, returns, warranties, credits, refunds, negotiations, and/or disputes between Debtors and their vendors or customers regarding regulatory or governmental impositions costs incurred by Debtors, and other disputes between the Debtors and their customers and/or suppliers. These normal setoffs are consistent with the ordinary course of business in the Debtors' industry and can be particularly voluminous, making it unduly burdensome and costly for the Debtors to list such ordinary course setoffs. Therefore, although such setoffs and other similar rights may have been accounted for when scheduling certain amounts, these ordinary course setoffs are not independently accounted for, and as such, are or may be excluded from the Debtors' Schedules and Statements.

In addition, some amounts listed in the Schedules and Statements may have been affected by setoffs or nettings by third parties of which the Debtors are not yet aware and/or of which the Debtors have approved to effectuate in the claims process of their chapter 11 cases. The Debtors reserve all rights to challenge any setoff and/or recoupment rights that may be asserted.

(s) **Unknown Debtors.** In certain instances, certain contracts or other relevant documents may not specify a particular Debtor or Debtors or may include the incorrect legal entity as the contractual counterparty. In these instances, responses have been listed in the appropriate Statement or Schedule at Murray Energy Corporation out of an abundance of caution.

5. **Specific Schedules Disclosures.**

Schedules Summary. Except as otherwise noted, the asset and liability information provided herein represents the Debtors' liabilities as of the Petition Date and the Debtors' assets as of September 30, 2019.

For financial reporting purposes, the Debtors ordinarily prepare consolidated financial statements. Unlike the consolidated financial statements, the Schedules reflect the assets and liabilities of each Debtor on a nonconsolidated basis, except where otherwise indicated. Accordingly, the totals listed in the Schedules will likely differ, at times materially, from the consolidated financial reports prepared by the Debtors for financial reporting purposes or otherwise.

The Schedules do not purport to represent financial statements prepared in accordance with GAAP, nor are they intended to be fully reconciled with the financial statements of each Debtor. Certain write-downs, impairments, and other accounting adjustments may not be reflected in the Schedules. Additionally, the Schedules contain unaudited information that is subject to further review and potential adjustment, and reflect the Debtors' reasonable best efforts to report the assets and liabilities of each Debtor on an unconsolidated basis. Moreover, given, among other things, the uncertainty surrounding the collection and ownership of certain assets and the valuation and nature of certain liabilities, to the extent that a Debtor shows more assets than liabilities, this is not an admission that the Debtor was solvent as of the Petition Date or at any time before the Petition Date. Likewise, to the extent a Debtor shows more liabilities than assets, this is not an admission that the Debtor was insolvent as of the Petition Date or at any time before the Petition Date.

(a) **Schedule A/B, Parts 1 and 2 – Cash and Cash Equivalents; Deposits and Prepayments.** Details with respect to the Debtors' cash management system and bank accounts are provided in the Cash Management Motion and the Cash Management Order. Bank account balances listed are as of end of day on October 28, 2019, and may vary from book balances.

(a) **Schedule A/B, Part 3 – Accounts Receivable.** Accounts receivable detail may include credit balances with customers, as maintained in the Debtors' books and records.

(b) **Schedule A/B, Part 4 – Investments; Non-Publicly Traded Stock and Interests in Incorporated and Unincorporated Businesses, Including Any Interest in an LLC, Partnership, or Joint Venture**. Equity interests in subsidiaries and affiliates primarily arise from common stock ownership or member or partnership interests. For purposes of these Schedules, the Debtors have listed an undetermined value for the equity interests of all subsidiaries and affiliates. Nothing in these Schedules is an admission or conclusion of the Debtors regarding the value of such

subsidiary and affiliate equity interests, which, under certain fair market or enterprise valuation analyses, may have value. The book values of certain assets may materially differ from their fair market values and/or the Debtors' enterprise valuation that may be prepared in connection with a disclosure statement.

Book values of assets prepared in accordance with GAAP generally do not reflect the current performance of the assets or the impact of the industry environment and may differ materially from the actual value and/or performance of the underlying assets. As such, the value listed in these Schedules and Statements cannot be, and was not, used to determine the Debtors' enterprise valuation.

(c) **Schedule A/B, Part 7 – Office Furniture, Fixtures, and Equipment; and Collectibles.** Due to volume, individual fixed asset schedules have not been included in Part 7. However, those fixed asset schedules are available upon request.

(d) **Schedule A/B, Part 8 – Machinery, Equipment, and Vehicles; Automobiles, vans, trucks, motorcycles, trailers, and titled farm vehicles.** Certain *de minimis* amounts related to automobiles may be reported in Question 50. Due to volume, individual fixed asset schedules have not been included in Part 8; however, those fixed asset schedules are available upon request.

(e) **Schedule A/B, Part 9 – Real Property.** The Debtors may have listed certain assets as real property when such assets are in fact personal property, or the Debtors may have listed certain assets as personal property when such assets are in fact real property. Buildings and land improvements are listed on Schedule A/B, Part 9, independent of whether the real property to which the building or land improvement is connected is Debtor-owned property. The Debtors reserve all of their rights to re-categorize and/or recharacterize such asset holdings to the extent the Debtors determine that such holdings were improperly listed.

(f) **Schedule A/B, Part 11 – All Other Assets.**

Interests in Insurance Policies or Annuities. The Debtors have listed all of their insurance policies in Question 73 at each Debtor, irrespective of whether each Debtor is specifically named in any given policy. The Debtors believe that there is little or no cash value to the vast majority of such insurance policies. Such policies have all been included on Schedule A/B, Part 11, with values listed as "undetermined."

Other Property of Any Kind Not Already Listed. The listing by the Debtors of any account between a Debtor and another Debtor is a statement of what appears in a particular Debtor's books and records and does not reflect any admission or conclusion of the Debtors regarding the allowance, classification, characterization, validity, or priority of such account. The Debtors take no position in these Schedules and Statements as to whether such accounts would be allowed as a Claim, an Interest, or not allowed at all. The Debtors and all parties in interest reserve all rights with respect to such accounts.

(g) **Schedule D – Creditors Who Have Claims Secured by Property.** Except as otherwise agreed pursuant to a stipulation or order entered by the Court, the Debtors reserve their rights to dispute or challenge the validity, perfection, or immunity from avoidance of any lien purported to be granted or perfected in any specific asset to a secured creditor listed on Schedule D. Moreover, although the Debtors have scheduled Claims of various creditors as secured Claims, the Debtors reserve all rights to dispute or challenge the secured nature of any such creditor's Claim or the characterization of the structure of any such transaction or any document or instrument related to such creditor's Claim. The Debtors have not included parties that may believe their Claims are secured through setoff rights, inchoate statutory lien rights, or other lien rights created by the laws of the various jurisdictions in which the Debtors operate. Various Debtors are borrowers, and certain of the other Debtors are guarantors, under prepetition secured funded debt obligations. Although there are numerous beneficial holders of such debt, only the administrative agents have been listed for purposes of Schedule D, where applicable. The amounts outstanding under the Debtors' prepetition secured debt reflect approximate amounts as of the Petition Date.

Descriptions provided on Schedule D are intended only to be a summary. Reference to the applicable loan agreements and related documents is necessary for a complete description of the collateral and the nature, extent, and priority of any liens.

After the Petition Date, the Debtors have obtained court approval to enter into a senior secured, superpriority postpetition financing facility in the aggregate principal amount of up to $440 million (the "DIP Facility"), consisting of (a) $350 million of new money term loans and (b) a $90 million last-out incremental term loan facility pursuant to the Superpriority Secured Debtor-in-Possession Credit and Guaranty Agreement. Certain of the Debtors' prepetition debt was refinanced or converted into the DIP Facility.

(h) **Schedule E/F – Creditors Who Have Unsecured Claims.**

Part 1 – Creditors with Priority Unsecured Claims. Under the *Final Order (I) Authorizing the Payment of Certain Prepetition and Postpetition Taxes and Fees and (II) Granting Related Relief* [Docket No. 329] (the "Tax Order"), the Court granted the Debtors authority to pay the prepetition Claims of regulatory authorities on account of taxes and fees. The amounts accrued and payable on account of such Claims may not be reflected on Schedule E/F.

Under the *Final Order (I) Authorizing the Debtors to Pay Certain Prepetition Claims of (A) Critical Vendors, (B) Lien Claimants, (C) Shippers, (D) 503(B)(9) Claimants, and (E) Royalty and Leasehold Claimants, (II) Confirming Administrative Expense Priority Status of Outstanding Orders, and (III) Granting Related Relief* [Docket No. 358] (the "Vendor Order"), the Court granted the Debtors authority to pay the prepetition Claims of certain Trade Claimants, as defined in the Vendor Order. To the extent the Claim of a Trade Claimant may be

paid under the Vendor Order, but remains outstanding at the time of the filing of the Schedules, such Claim may be listed in the Schedules as a contingent Claim.

Under the *Final Order (I) Authorizing the Debtors to (A) Pay Prepetition Wages, Salaries, Other Compensation, and Reimbursable Expenses and (B) Continue Employee Benefits Programs, and (II) Granting Related Relief* [Docket No. 334] (the "Wages Order"), the Court granted the Debtors authority to pay or honor certain prepetition obligations for employee wages, salaries, and other compensation, reimbursable employee expenses, and employee medical and similar benefits. The Debtors have not listed on Schedule E/F any wage or wage-related obligations for which the Debtors have been granted authority to pay pursuant to any order that has been entered by the Court. The Debtors believe that all such Claims have been, or will be, satisfied in the ordinary course during their chapter 11 cases pursuant to the authority granted in the Wages Order.

The listing of a claim on Schedule E/F, Part 1, does not constitute an admission by the Debtors that such claim or any portion thereof is entitled to priority status.

Part 2 – Creditors with Nonpriority Unsecured Claims. The listing by the Debtors of any account between a Debtor and another Debtor is a statement of what appears in a particular Debtor's books and records and does not reflect any admission or conclusion of the Debtors regarding the allowance, classification, characterization, validity, or priority of such account. The Debtors take no position in these Schedules and Statements as to whether such accounts would be allowed as a Claim, an Interest, or not allowed at all. The Debtors and all parties in interest reserve all rights with respect to such accounts.

Various Debtors are borrowers, and certain of the other Debtors are guarantors, under prepetition funded obligations. Although the Debtors generally allocate individual liabilities to particular Debtors, in certain cases, it would be a time-consuming and inefficient use of estate resources, or impracticable, to assign a given liability to a particular Debtor. To the extent the liability could not be attributed to a specific Debtor, the liability has been listed on Schedule E/F, Part 2, of Murray Energy Corporation. Although there are numerous beneficial holders of such debt, only the administrative agents and indenture trustees, as applicable, have been listed for purposes of Schedule E/F, where applicable.

The Claims of individual creditors for, among other things, goods, products, services, or taxes are listed as the amounts entered on the Debtors' books and records and may not reflect credits, allowances, or other adjustments due from such creditors to the Debtors. The Debtors reserve all of their rights with regard to such credits, allowances, and other adjustments, including the right to assert Claims objections and/or setoffs with respect to the same. The Claims identified in these Schedules and Statements arose or were incurred on various dates. In certain instances, the date on which a Claim arose is an open issue of fact. Although reasonable efforts have been made to identify the date each Claim was incurred or arose, determining the date upon which each Claim in these Schedules and

Statements was incurred or arose would be unduly burdensome and cost prohibitive. In addition, Claims listed in these Schedules and Statements have been aggregated by creditor and may include several dates of incurrence for the aggregate balance listed. As such, Schedule E/F, where applicable, may not include the date that each Claim arose or was incurred for every Claim listed thereon.

Schedule E/F does not include certain deferred charges, deferred liabilities, accruals, or general reserves. Such amounts are, however, reflected on the Debtors' books and records as required in accordance with GAAP. Such accruals are general estimates of liabilities and do not represent specific Claims as of the Petition Date. The Debtors have made every effort to include as contingent, unliquidated, or disputed the Claim of any vendor not included on the Debtors' open accounts payable that is associated with an account that has an accrual or receipt not invoiced.

Schedule E/F reflects certain prepetition amounts owing to counterparties to executory contracts and unexpired leases. Such prepetition amounts, however, may be paid in connection with the assumption or assumption and assignment of an executory contract or unexpired lease. In addition, Schedule E/F does not include claims that may arise in connection with the rejection of any executory contracts and unexpired leases, if any, that may be or have been rejected.

Where applicable, the amounts listed in Schedule F take into account credits and overpayments owed to the Debtors.

As of the time of filing of the Schedules and Statements, the Debtors have not received all invoices for payables, expenses, and other liabilities that may have accrued prior to the Petition Date. Accordingly, the information contained in Schedules D and E/F may be incomplete. The Debtors reserve their rights, but undertakes no obligations, to amend Schedules D and E/F if, or when, the Debtors receive such invoices.

(i) **Schedule G – Executory Contracts and Unexpired Leases.** Although reasonable efforts have been made to ensure the accuracy of Schedule G regarding executory contracts and unexpired leases, inadvertent errors, omissions, or over-inclusion may have occurred in preparing Schedule G. Certain of the instruments reflected on Schedule G may contain renewal options, guarantees of payments, options to purchase, rights of first refusal, and other miscellaneous rights. Such rights, powers, duties, and obligations are not separately set forth on Schedule G. In the ordinary course of business, the Debtors may have issued numerous purchase orders for goods, supplies, product, services, and related items which, to the extent that such purchase orders constitute executory contracts, may not be listed individually on Schedule G. Omission of a contract or agreement from Schedule G does not constitute an admission that such omitted contract or agreement is not an executory contract or unexpired lease. The Debtors hereby expressly reserve the right to assert that any instrument listed on Schedule G is an executory contract within the meaning of section 365 of the Bankruptcy Code. The Debtors reserve

all of their rights, claims, and causes of action with respect to Claims associated with any contracts and agreements listed on Schedule G, including their right to dispute or challenge the characterization or the structure of any transaction, document, or instrument (including any intercompany agreement) related to a creditor's Claim. The Debtors further reserve all of their rights to alter or amend these Schedules to the extent that additional information regarding the Debtor obligor to such executory contracts or unexpired leases becomes available.

Certain confidentiality, hold harmless, and non-compete agreements may not be listed on Schedule G. In addition, agreements and underlying documentation related to the Debtors' prepetition debt are not included in Schedule G. The Debtors reserve all of their rights with respect to such agreements.

Certain of the contracts and agreements listed on Schedule G may consist of several parts, including, purchase orders, amendments, restatements, waivers, letters, and other documents that may not be listed on Schedule G or that may be listed as a single entry.

Certain confidential settlement agreements with individual counterparties have been excluded from Schedule G in order to maintain the privacy of those counterparties.

The contracts, agreements, and leases listed on Schedule G may have expired or may have been modified, amended, or supplemented from time to time by various amendments, restatements, waivers, estoppel certificates, letters, memoranda, and other documents, instruments, and agreements that may not be listed therein despite the Debtors' use of reasonable efforts to identify such documents. Further, unless otherwise specified on Schedule G, the Debtors have made reasonable efforts to ensure that each executory contract or unexpired lease listed thereon shall include all exhibits, schedules, riders, modifications, declarations, amendments, supplements, attachments, restatements, or other agreements made directly or indirectly by any agreement, instrument, or other document that in any manner affects such executory contract or unexpired lease, without respect to whether such agreement, instrument, or other document is listed thereon. In some cases, the same supplier or provider appears multiple times on Schedule G. This multiple listing is intended to reflect distinct agreements between the applicable Debtor and such supplier or provider.

(j) **Schedule H – Co-Debtors.** For purposes of Schedule H, only the administrative agents and indenture trustees are listed as co-Debtors on Schedule H. The Debtors have not listed any litigation-related co-Debtors on Schedule H. Instead, all such listings can be found on the Debtors' Schedules E/F.

6. **Specific Statements Disclosures**.

(a) **Statements, Part 1, Question 1 – Gross Revenue from Business.** Revenue reported for purposes of disclosing gross revenue from business in Question 1 is through October 31, 2019.

(b) **Statements, Part 1, Question 2 – Non-Business Revenue.** Revenue reported for purposes of disclosing non-business revenue in Question 2 is through October 31, 2019.

(c) **Statements, Part 2, Question 3 – Certain Payments or Transfers of Property Made within 90 days.** In Question 3, disbursements made on account of multiple invoices may be reflected as a single payment. In addition, certain disbursements in Question 3, including, but not limited to, disbursements made on account of legal services, may have provided a benefit to an insider of the Debtors.

All disbursements listed in Question 3 are made through the Debtors' cash management system, more fully described in the Cash Management Motion. Dates listed in Question 3 reflect the dates upon which the Debtor transferred funds to the relevant payee or disbursing agent. Certain disbursements may be excluded from Question 3, including regular payroll, expense reimbursements to employees, payroll funding, payments to benefits providers, payments on behalf of non-affiliate companies, disbursement to retained professionals (reported elsewhere), and certain *de minimis* regional disbursements.

(d) **Statements, Part 2, Question 4 – Payments and Transfers to Insiders.** Individual payments to Debtor affiliates are not reflected in Question 4 due to their complexity and voluminous nature. The Debtors have reported net annual intercompany positions in Question 4, while intercompany payables and receivables as of the Petition Date can be found on Schedule E/F and Schedule A/B. In addition, certain disbursements in Question 4, including, but not limited to, the disbursements to Corporate Aviation Services, Inc., are over inclusive as such disbursements may also be general business expenses.

As described more fully in the Cash Management Motion, the Murray Energy Corporation concentration account directly funds disbursement accounts utilized to pay payroll and employee obligations. All employee-related disbursements in Question 4 are listed under Murray Energy Corporation.

(e) **Statements, Part 6, Question 11 – Payments Related to Bankruptcy.** All disbursements listed in Question 11 were initiated and disbursed by Murray Energy Corporation but were for the benefit of all Debtors. Entities listed in Question 11 may also have payments not related to bankruptcy work listed in Question 3.

(f) **Statements, Part 6, Question 13 – Transfers Not Already Listed on This Statement.** The Debtors do not take any position with respect to whether transfers identified in the response to Question 13 in the Statements are made in the ordinary

course of business. Certain transfers listed in this response are included solely out of an abundance of caution.

Transfers pursuant to confidential settlement agreements with individual counterparties have been excluded from Statement 13 to protect the privacy of those individual counterparties.

(g) **Statements, Part 7, Question 14 – Previous Addresses.** The Debtors have listed previous addresses of office locations only in Question 14.

(h) **Statements, Part 9, Question 17 – Employees' Participation in Pension or Profit-Sharing Plans.** The Debtors have provided details about their 401(k) plan in Question 17 for Debtor entities that have employee participants. Murray Energy Corporation is the plan administrator for the Debtors' 401(k) plan but does not employ any individuals.

(i) **Statements, Part 10, Question 20 – Off-premises Storage.** The Debtors have listed their primary off-premises storage facilities in Question 20. Additional facilities storing *de minimis* property may have been inadvertently omitted from Question 20.

(j) **Statements, Part 11, Question 21 – Property the Debtor Holds or Controls That the Debtor Does Not Own.** Property owned by affiliates or insiders is excluded from responses to Question 21.

(k) **Statements, Part 12, Question 23 – Notices of Potential Environmental Liabilities.** The Debtors historically have operated in several locations across Ohio, Pennsylvania, West Virginia, Kentucky, Alabama, Illinois, and Utah. At some locations, the Debtors no longer have any active operations and may no longer have relevant records, or the records may no longer be complete or reasonably accessible or reviewable. In some cases, statutory document retention periods have passed. Further, some individuals who once possessed responsive information are no longer employed by the Debtors. For all these reasons, it may not be possible to identify and supply the requested information for all of the requested information that is responsive to Questions 22–24. The Debtors have generally provided responsive information for matters and issues that have arisen during the period January 2016 through October 2019, including matters and issues that the Debtors consider to have been resolved. This timeframe is generally consistent with requirements in state and federal coal mining regulations to include environmental violations from the previous three-year period in Surface Mining Control and Reclamation Act coal mining permit applications, revisions, and renewals. This response does not include sites or proceedings related to non-environmental laws, such as mining or occupational safety and health laws or transportation laws. This response also does not include notices issued to previous owners of property now owned by the Debtors. Finally, this response is also limited to identifying circumstances in which governmental agencies have alleged in writing that particular operations of the Debtors are in violation of environmental laws and

proceedings that have resulted from alleged violations of environmental laws. This response also does not cover (i) periodic information requests, investigations, or inspections from governmental units concerning compliance with environmental laws or (ii) routine reports and submissions concerning permitted discharges resulting from routine operations where such reports and submissions were made in compliance with regulatory requirements, such as monthly discharge monitoring reports. This response assumes that any responsive information provided in response to Statements, Part 12, Question 22, is also deemed to have been provided in response to Statements, Part 12, Questions 23–24, as appropriate.

The United States Environmental Protection Agency, Region 4 (the "EPA") has provided notices to the Debtors regarding their compliance with the Consent Agreement and Final Order, Docket No. SDWA-04-2012-1007(b) (the "CA/FO"). Such notices are not listed in Question 23. On June 15, 2017, the EPA provided notice to the Debtors that it was closing the CA/FO based on the Debtors' compliance with the CA/FO.

(l) **Statements, Part 13, Question 26(b) – Books, Records, and Financial Statements.** The Debtors have listed Ernst and Young, LLP, the external auditor of their financial statements, in response to Question 26(b). Firms that may have performed other audits (e.g. royalty audits) are not listed in response to Question 26(b).

(m) **Statements, Part 13, Question 26(d) – Books, Records, and Financial Statements.** The Debtors financials have historically been reported on a consolidated basis at Murray Energy Corporation, so their response to Question 26(d) is listed at that Debtor. The Debtors have attempted to list parties that have had access to the Debtors' financial statements through diligence processes in Question 26(d); however, some such parties may have been omitted.

(n) **Statements, Part 13, Question 27 – Inventories.** Responses to Question 27 are limited to supplies inventory and exclude periodic coal inventories, shop inventories, and other *de minimis* inventories.

[*Remainder of page intentionally left blank*]

Fill in this information to identify the case:

Debtor name Murray Energy Corporation

United States Bankruptcy Court for the: Southern District of Ohio, Western Division

Case number (If known): 19-57017 (JEH)

☐ Check if this is an amended filing

Official Form 207

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy 04/19

The debtor must answer every question. If more space is needed, attach a separate sheet to this form. On the top of any additional pages, write the debtor's name and case number (if known).

Part 1: Income

1. **Gross revenue from business**

☒ None

Identify the beginning and ending dates of the debtor's fiscal year, which may be a calendar year			Sources of revenue Check all that apply	Gross revenue (before deductions and exclusions)
From the beginning of the fiscal year to filing date:	From ____ MM / DD / YYYY	to Filing date	☐ Operating a business ☐ Other ____	$____
For prior year:	From ____ MM / DD / YYYY	to ____ MM / DD / YYYY	☐ Operating a business ☐ Other ____	$____
For the year before that:	From ____ MM / DD / YYYY	to ____ MM / DD / YYYY	☐ Operating a business ☐ Other ____	$____

2. **Non-business revenue**

Include revenue regardless of whether that revenue is taxable. *Non-business income* may include interest, dividends, money collected from lawsuits, and royalties. List each source and the gross revenue for each separately. Do not include revenue listed in line 1.

☐ None See Attached Rider

			Description of sources of revenue	Gross revenue from each source (before deductions and exclusions)
From the beginning of the fiscal year to filing date:	From ____ MM / DD / YYYY	to Filing date	____	$____
For prior year:	From ____ MM / DD / YYYY	to ____ MM / DD / YYYY	____	$____
For the year before that:	From ____ MM / DD / YYYY	to ____ MM / DD / YYYY	____	$____

Debtor Murray Energy Corporation (Name) Case number (if known) 19-57017 (JEH)

Part 2: List Certain Transfers Made Before Filing for Bankruptcy

3. Certain payments or transfers to creditors within 90 days before filing this case

List payments or transfers—including expense reimbursements—to any creditor, other than regular employee compensation, within 90 days before filing this case unless the aggregate value of all property transferred to that creditor is less than $6,825. (This amount may be adjusted on 4/01/22 and every 3 years after that with respect to cases filed on or after the date of adjustment.)

☐ None

	Creditor's name and address	Dates	Total amount or value	Reasons for payment or transfer *Check all that apply*
3.1.	See Attached Rider Creditor's name Street City State ZIP Code		$	☐ Secured debt ☐ Unsecured loan repayments ☐ Suppliers or vendors ☐ Services ☐ Other
3.2.	Creditor's name Street City State ZIP Code		$	☐ Secured debt ☐ Unsecured loan repayments ☐ Suppliers or vendors ☐ Services ☐ Other

4. Payments or other transfers of property made within 1 year before filing this case that benefited any insider

List payments or transfers, including expense reimbursements, made within 1 year before filing this case on debts owed to an insider or guaranteed or cosigned by an insider unless the aggregate value of all property transferred to or for the benefit of the insider is less than $6,825. (This amount may be adjusted on 4/01/22 and every 3 years after that with respect to cases filed on or after the date of adjustment.) Do not include any payments listed in line 3. *Insiders* include officers, directors, and anyone in control of a corporate debtor and their relatives; general partners of a partnership debtor and their relatives; affiliates of the debtor and insiders of such affiliates; and any managing agent of the debtor. 11 U.S.C. § 101(31).

☐ None

	Insider's name and address	Dates	Total amount or value	Reasons for payment or transfer
4.1.	See Attached Rider Insider's name Street City State ZIP Code **Relationship to debtor**		$	
4.2.	Insider's name Street City State ZIP Code **Relationship to debtor**		$	

Debtor Murray Energy Corporation (Name) Case number (if known) 19-57017 (JEH)

5. Repossessions, foreclosures, and returns

List all property of the debtor that was obtained by a creditor within 1 year before filing this case, including property repossessed by a creditor, sold at a foreclosure sale, transferred by a deed in lieu of foreclosure, or returned to the seller. Do not include property listed in line 6.

☒ None

	Creditor's name and address	Description of the property	Date	Value of property
5.1.	Creditor's name Street City State ZIP Code			$
5.2.	Creditor's name Street City State ZIP Code			$

6. Setoffs

List any creditor, including a bank or financial institution, that within 90 days before filing this case set off or otherwise took anything from an account of the debtor without permission or refused to make a payment at the debtor's direction from an account of the debtor because the debtor owed a debt.

☒ None

Creditor's name and address	Description of the action creditor took	Date action was taken	Amount
Creditor's name Street City State ZIP Code	Last 4 digits of account number: XXXX– _ _ _ _		$

Part 3: Legal Actions or Assignments

7. Legal actions, administrative proceedings, court actions, executions, attachments, or governmental audits

List the legal actions, proceedings, investigations, arbitrations, mediations, and audits by federal or state agencies in which the debtor was involved in any capacity—within 1 year before filing this case.

☐ None

	Case title / Case number	Nature of case	Court or agency's name and address	Status of case
7.1.	See Attached Rider Case number		Name Street City State ZIP Code	☐ Pending ☐ On appeal ☐ Concluded
7.2.	Case title Case number		Court or agency's name and address Name Street City State ZIP Code	☐ Pending ☐ On appeal ☐ Concluded

Debtor Murray Energy Corporation (Name) Case number (if known) 19-57017 (JEH)

8. Assignments and receivership

List any property in the hands of an assignee for the benefit of creditors during the 120 days before filing this case and any property in the hands of a receiver, custodian, or other court-appointed officer within 1 year before filing this case.

☒ None

Custodian's name and address	Description of the property	Value
Custodian's name Street City State ZIP Code	Case title Case number Date of order or assignment	$

Court name and address: Name, Street, City State ZIP Code

Part 4: Certain Gifts and Charitable Contributions

9. List all gifts or charitable contributions the debtor gave to a recipient within 2 years before filing this case unless the aggregate value of the gifts to that recipient is less than $1,000

☐ None

	Recipient's name and address	Description of the gifts or contributions	Dates given	Value
9.1.	See Attached Rider Recipient's name Street City State ZIP Code Recipient's relationship to debtor			$
9.2.	Recipient's name Street City State ZIP Code Recipient's relationship to debtor			$

Part 5: Certain Losses

10. All losses from fire, theft, or other casualty within 1 year before filing this case.

☒ None

Description of the property lost and how the loss occurred	Amount of payments received for the loss If you have received payments to cover the loss, for example, from insurance, government compensation, or tort liability, list the total received. List unpaid claims on Official Form 106A/B (*Schedule A/B: Assets – Real and Personal Property*).	Date of loss	Value of property lost
			$

Debtor Murray Energy Corporation (Name) Case number (if known) 19-57017 (JEH)

Part 6: Certain Payments or Transfers

11. Payments related to bankruptcy

List any payments of money or other transfers of property made by the debtor or person acting on behalf of the debtor within 1 year before the filing of this case to another person or entity, including attorneys, that the debtor consulted about debt consolidation or restructuring, seeking bankruptcy relief, or filing a bankruptcy case.

☐ None

Who was paid or who received the transfer?	If not money, describe any property transferred	Dates	Total amount or value
11.1. See Attached Rider Address Street City State ZIP Code Email or website address Who made the payment, if not debtor?			$
11.2. Address Street City State ZIP Code Email or website address Who made the payment, if not debtor?			$

12. Self-settled trusts of which the debtor is a beneficiary

List any payments or transfers of property made by the debtor or a person acting on behalf of the debtor within 10 years before the filing of this case to a self-settled trust or similar device.
Do not include transfers already listed on this statement.

☒ None

Name of trust or device	Describe any property transferred	Dates transfers were made	Total amount or value
Trustee			$

Debtor Murray Energy Corporation (Name) Case number (if known) 19-57017 (JEH)

13. Transfers not already listed on this statement

List any transfers of money or other property—by sale, trade, or any other means—made by the debtor or a person acting on behalf of the debtor within 2 years before the filing of this case to another person, other than property transferred in the ordinary course of business or financial affairs. Include both outright transfers and transfers made as security. Do not include gifts or transfers previously listed on this statement.

☒ None

	Who received transfer?	Description of property transferred or payments received or debts paid in exchange	Date transfer was made	Total amount or value
13.1.	_____	_____	_____	$_____
	Address	_____		
	_____ Street			
	_____ City State ZIP Code			
	Relationship to debtor			
	_____			
	Who received transfer?	_____	_____	$_____
13.2.	_____	_____		
	Address			
	_____ Street			
	_____ City State ZIP Code			
	Relationship to debtor			
	_____			

Part 7: Previous Locations

14. Previous addresses

List all previous addresses used by the debtor within 3 years before filing this case and the dates the addresses were used.

☒ Does not apply

	Address	Dates of occupancy
14.1.	_____ Street _____ _____ City State ZIP Code	From _____ To _____
14.2.	_____ Street _____ _____ City State ZIP Code	From _____ To _____

Debtor Murray Energy Corporation (Name) Case number (if known) 19-57017 (JEH)

Part 8: Health Care Bankruptcies

15. Health Care bankruptcies

Is the debtor primarily engaged in offering services and facilities for:

— diagnosing or treating injury, deformity, or disease, or

— providing any surgical, psychiatric, drug treatment, or obstetric care?

☒ No. Go to Part 9.

☐ Yes. Fill in the information below.

	Facility name and address	Nature of the business operation, including type of services the debtor provides	If debtor provides meals and housing, number of patients in debtor's care
15.1.	Facility name Street City State ZIP Code	Location where patient records are maintained (if different from facility address). If electronic, identify any service provider. How are records kept? *Check all that apply:* ☐ Electronically ☐ Paper	
15.2.	Facility name Street City State ZIP Code	Location where patient records are maintained (if different from facility address). If electronic, identify any service provider. How are records kept? *Check all that apply:* ☐ Electronically ☐ Paper	

Part 9: Personally Identifiable Information

16. Does the debtor collect and retain personally identifiable information of customers?

☒ No.

☐ Yes. State the nature of the information collected and retained. _____

Does the debtor have a privacy policy about that information?

☐ No

☐ Yes

17. Within 6 years before filing this case, have any employees of the debtor been participants in any ERISA, 401(k), 403(b), or other pension or profit-sharing plan made available by the debtor as an employee benefit?

☐ No. Go to Part 10.

Yes. Does the debtor serve as plan administrator?

☒ No. Go to Part 10.

☐ Yes. Fill in below:

Name of plan	Employer Identification number of the plan
Murray Energy Corporation Savings and Security Plan	EIN: 34-1956752

Has the plan been terminated?

☒ No

☐ Yes

Debtor Murray Energy Corporation (Name) Case number (if known) 19-57017 (JEH)

Part 10: Certain Financial Accounts, Safe Deposit Boxes, and Storage Units

18. Closed financial accounts

Within 1 year before filing this case, were any financial accounts or instruments held in the debtor's name, or for the debtor's benefit, closed, sold, moved, or transferred?

Include checking, savings, money market, or other financial accounts; certificates of deposit; and shares in banks, credit unions, brokerage houses, cooperatives, associations, and other financial institutions.

☒ None

	Financial institution name and address	Last 4 digits of account number	Type of account	Date account was closed, sold, moved, or transferred	Last balance before closing or transfer
18.1.	Name Street City State ZIP Code	XXXX–___ ___ ___ ___	☐ Checking ☐ Savings ☐ Money market ☐ Brokerage ☐ Other_____	_____	$_____
18.2.	Name Street City State ZIP Code	XXXX–___ ___ ___ ___	☐ Checking ☐ Savings ☐ Money market ☐ Brokerage ☐ Other_____	_____	$_____

19. Safe deposit boxes

List any safe deposit box or other depository for securities, cash, or other valuables the debtor now has or did have within 1 year before filing this case.

☒ None

Depository institution name and address	Names of anyone with access to it	Description of the contents	Does debtor still have it?
Name Street City State ZIP Code	Address		☐ No ☐ Yes

20. Off-premises storage

List any property kept in storage units or warehouses within 1 year before filing this case. Do not include facilities that are in a part of a building in which the debtor does business.

☒ None

Facility name and address	Names of anyone with access to it	Description of the contents	Does debtor still have it?
Name Street City State ZIP Code	Address		☐ No ☐ Yes

Debtor Murray Energy Corporation (Name) Case number (if known) 19-57017 (JEH)

Part 11: Property the Debtor Holds or Controls That the Debtor Does Not Own

21. Property held for another

List any property that the debtor holds or controls that another entity owns. Include any property borrowed from, being stored for, or held in trust. Do not list leased or rented property.

☒ None

Owner's name and address	Location of the property	Description of the property	Value
Name Street City State ZIP Code			$

Part 12: Details About Environmental Information

For the purpose of Part 12, the following definitions apply:

- *Environmental law* means any statute or governmental regulation that concerns pollution, contamination, or hazardous material, regardless of the medium affected (air, land, water, or any other medium).
- *Site* means any location, facility, or property, including disposal sites, that the debtor now owns, operates, or utilizes or that the debtor formerly owned, operated, or utilized.
- *Hazardous material* means anything that an environmental law defines as hazardous or toxic, or describes as a pollutant, contaminant, or a similarly harmful substance.

Report all notices, releases, and proceedings known, regardless of when they occurred.

22. Has the debtor been a party in any judicial or administrative proceeding under any environmental law? Include settlements and orders.

☒ No
☐ Yes. Provide details below.

Case title Case number	Court or agency name and address	Nature of the case	Status of case
	Name Street City State ZIP Code		☐ Pending ☐ On appeal ☐ Concluded

23. Has any governmental unit otherwise notified the debtor that the debtor may be liable or potentially liable under or in violation of an environmental law?

☒ No
☐ Yes. Provide details below.

Site name and address	Governmental unit name and address	Environmental law, if known	Date of notice
Name Street City State ZIP Code	Name Street City State ZIP Code		

Debtor Murray Energy Corporation (Name) Case number (if known) 19-57017 (JEH)

24. **Has the debtor notified any governmental unit of any release of hazardous material?**

☒ No

☐ Yes. Provide details below.

Site name and address	Governmental unit name and address	Environmental law, if known	Date of notice
Name Street City State ZIP Code	Name Street City State ZIP Code		

Part 13: Details About the Debtor's Business or Connections to Any Business

25. **Other businesses in which the debtor has or has had an interest**

List any business for which the debtor was an owner, partner, member, or otherwise a person in control within 6 years before filing this case. Include this information even if already listed in the Schedules.

☐ None

	Business name and address	Describe the nature of the business	Employer Identification number Do not include Social Security number or ITIN.
25.1.	See Attached Rider Name Street City State ZIP Code		EIN: __ __ – __ __ __ __ __ __ __ Dates business existed From _____ To _____
25.2.	Name Street City State ZIP Code		EIN: __ __ – __ __ __ __ __ __ __ Dates business existed From _____ To _____
25.3.	Name Street City State ZIP Code		EIN: __ __ – __ __ __ __ __ __ __ Dates business existed From _____ To _____

Debtor Murray Energy Corporation (Name) Case number (if known) 19-57017 (JEH)

26. Books, records, and financial statements

26a. List all accountants and bookkeepers who maintained the debtor's books and records within 2 years before filing this case.

☐ None

	Name and address	Dates of service
26a.1.	See Attached Rider	From _____ To _____
26a.2.	Name Street City State ZIP Code	From _____ To _____

26b. List all firms or individuals who have audited, compiled, or reviewed debtor's books of account and records or prepared a financial statement within 2 years before filing this case.

☐ None

	Name and address	Dates of service
26b.1.	ERNST & YOUNG LLP 950 MAIN AVENUE SUITE 1800 CLEVELAND, OH 44113	From 12/31/2008 To Present
26b.2.	Name Street City State ZIP Code	From _____ To _____

26c. List all firms or individuals who were in possession of the debtor's books of account and records when this case is filed.

☐ None

	Name and address	If any books of account and records are unavailable, explain why
26c.1.	See Attached Rider	

Debtor Murray Energy Corporation Case number (if known) 19-57017 (JEH)

	Name and address	If any books of account and records are unavailable, explain why
26c.2.	Name Street City State ZIP Code	

26d. List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

☐ None

	Name and address
26d.1.	See Attached Rider

	Name and address
26d.2.	Name Street City State ZIP Code

27. **Inventories**

Have any inventories of the debtor's property been taken within 2 years before filing this case?

☒ No

☐ Yes. Give the details about the two most recent inventories.

Name of the person who supervised the taking of the inventory	Date of inventory	The dollar amount and basis (cost, market, or other basis) of each inventory
		$

	Name and address of the person who has possession of inventory records
27.1	Name Street City State ZIP Code

Debtor Murray Energy Corporation (Name) Case number (if known) 19-57017 (JEH)

Name of the person who supervised the taking of the inventory	Date of inventory	The dollar amount and basis (cost, market, or other basis) of each inventory
		$

Name and address of the person who has possession of inventory records

27.2. Name
Street
City State ZIP Code

28. **List the debtor's officers, directors, managing members, general partners, members in control, controlling shareholders, or other people in control of the debtor at the time of the filing of this case.**

Name	Address	Position and nature of any interest	% of interest, if any
See Attached Rider			

29. **Within 1 year before the filing of this case, did the debtor have officers, directors, managing members, general partners, members in control of the debtor, or shareholders in control of the debtor who no longer hold these positions?**

☐ No
☒ Yes. Identify below.

Name	Address	Position and nature of any interest	Period during which position or interest was held
See Attached Rider			From ____ To ____
			From ____ To ____
			From ____ To ____
			From ____ To ____

30. **Payments, distributions, or withdrawals credited or given to insiders**

Within 1 year before filing this case, did the debtor provide an insider with value in any form, including salary, other compensation, draws, bonuses, loans, credits on loans, stock redemptions, and options exercised?

☐ No
☒ Yes. Identify below.

Name and address of recipient	Amount of money or description and value of property	Dates	Reason for providing the value
30.1. See Attached Rider (Name) Street City State ZIP Code Relationship to debtor			

Debtor Murray Energy Corporation (Name) Case number (if known) 19-57017 (JEH)

	Name and address of recipient			
30.2	Name Street City State ZIP Code Relationship to debtor			

31. **Within 6 years before filing this case, has the debtor been a member of any consolidated group for tax purposes?**

☒ No

☐ Yes. Identify below.

Name of the parent corporation	Employer Identification number of the parent corporation
	EIN: __ __ - __ __ __ __ __ __ __

32. **Within 6 years before filing this case, has the debtor as an employer been responsible for contributing to a pension fund?**

☒ No

☐ Yes. Identify below.

Name of the pension fund	Employer Identification number of the pension fund
	EIN: __ __ - __ __ __ __ __ __ __

Part 14: Signature and Declaration

WARNING – Bankruptcy fraud is a serious crime. Making a false statement, concealing property, or obtaining money or property by fraud in connection with a bankruptcy case can result in fines up to $500,000 or imprisonment for up to 20 years, or both. 18 U.S.C. §§ 152, 1341, 1519, and 3571.

I have examined the information in this *Statement of Financial Affairs* and any attachments and have a reasonable belief that the information is true and correct.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 12/13/2019 (MM / DD / YYYY)

✘ /s/ Robert D. Moore
Signature of individual signing on behalf of the debtor

Printed name Robert D. Moore

Position or relationship to debtor Authorized Signatory

Are additional pages to *Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy* (Official Form 207) attached?

☐ No

☒ Yes

Debtor Name: Murray Energy Corporation

Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 1, Question 2: Non-business revenue

From Date	To Date	Description of sources of revenue	Gross Revenue
01/01/2019	10/31/2019	Interest Income	$1,630,296.46
01/01/2019	10/31/2019	Interest Income - Intercompany	$151,016,850.00
01/01/2019	10/31/2019	Management Services - Intercompany	$2,011,111.00
01/01/2019	10/31/2019	Miscellaneous Other Income	$148,173.85
01/01/2019	10/31/2019	Rental Revenue	$29,000.00
01/01/2018	12/31/2018	Equipment Sale	$195,109.00
01/01/2018	12/31/2018	Gain on Retirement of Debt, Net	$113,140,020.93
01/01/2018	12/31/2018	Interest Income	$920,209.25
01/01/2018	12/31/2018	Interest Income - Intercompany	$178,338,143.87
01/01/2018	12/31/2018	Miscellaneous Other Income, Including Refunds and Rebates	$309,892.29
01/01/2018	12/31/2018	Rental Revenue	$636.00
01/01/2017	12/31/2017	Coal Contract Buyout	$17,500,000.00
01/01/2017	12/31/2017	Interest Income	$106,431.87
01/01/2017	12/31/2017	Interest Income - Intercompany	$174,716,400.00
01/01/2017	12/31/2017	Rental Revenue	$806.79

Debtor Name: Murray Energy Corporation

Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 3: Certain payments or transfers to creditors within 90 days before filing this case

Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
A C E WELDING INC PO BOX 101 ENTERPRISE, WV 26568	225791	08/05/2019	Suppliers or vendors	$18,445.00
	231526	10/16/2019	Suppliers or vendors	$3,250.00
	231570	10/17/2019	Suppliers or vendors	$21,850.00
			SUBTOTAL	$43,545.00
A G LUCAS CONSULTING 187 KINGS CREEK RD WEIRTON, WV 26062	ACH	09/13/2019	Services	$1,225.00
			SUBTOTAL	$1,225.00
A SEBULSKY STEEL INC 130 SOUTH SUGAR STREET ST. CLAIRSVILLE, OH 43950	225581	08/05/2019	Suppliers or vendors	$29,584.50
	226470	08/13/2019	Suppliers or vendors	$42,672.20
	228717	09/06/2019	Suppliers or vendors	$2,240.00
	228718	09/06/2019	Suppliers or vendors	$7,260.00
	229911	09/26/2019	Suppliers or vendors	$27,225.00
	231492	10/15/2019	Suppliers or vendors	$27,225.00
			SUBTOTAL	$136,206.70
A W CHESTERTON CO 414 INDUSTRIAL PARK RD BEAVER, WV 25813	225799	08/05/2019	Suppliers or vendors	$7,079.11
			SUBTOTAL	$7,079.11
A. REED EXCAVATING LLC 52912 STATE ROUTE 145 BEALLSVILLE, OH 43716	225825	08/05/2019	Services	$65,800.00
	226811	08/19/2019	Services	$10,800.00
	227188	08/19/2019	Services	$53,300.00
	228479	09/06/2019	Services	$21,600.00
	229027	09/06/2019	Services	$19,200.00
	231481	10/11/2019	Services	$21,850.00
	231532	10/16/2019	Services	$16,025.00
			SUBTOTAL	$208,575.00
A-1 LAWN CARE LLC PO BOX 242 SHINNSTON, WV 26431	228511	09/06/2019	Services	$2,544.00
			SUBTOTAL	$2,544.00
A2O MARINE INC PO BOX 3215 CLARKSVILLE, IN 47131	227154	08/19/2019	Suppliers or vendors	$2,133.38
	228074	08/28/2019	Suppliers or vendors	$1,643.30
	228075	08/28/2019	Suppliers or vendors	$865.16
			SUBTOTAL	$4,641.84

Debtor Name: Murray Energy Corporation

Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 3: Certain payments or transfers to creditors within 90 days before filing this case

Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
AAA MINE SERVICE 18 MOUNTAIN VIEW DRIVE HAZARD, KY 41701	225634	08/05/2019	Suppliers or vendors	$13,944.00
	228786	09/06/2019	Suppliers or vendors	$14,404.00
			SUBTOTAL	$28,348.00
AC POWER TECH, INC. PO BOX B MONESSEN, PA 15062	226933	08/19/2019	Suppliers or vendors	$88,265.00
	227866	08/28/2019	Suppliers or vendors	$13,927.76
			SUBTOTAL	$102,192.76
ACF GROUP LLC 120 MINE STREET ALLISON, PA 15413	225852	08/05/2019	Services	$11,300.00
	227224	08/19/2019	Services	$38,562.00
	227225	08/19/2019	Services	$29,875.00
	231634	10/18/2019	Services	$8,474.03
	Wire	10/28/2019	Services	$45,350.00
			SUBTOTAL	$133,561.03
ADELL L WHITE 41469 STARCHER RD POMEROY, OH 45769	225917	08/05/2019	Other - Royalty	$6.08
	229113	09/10/2019	Other - Royalty	$7.26
			SUBTOTAL	$13.34
ADP, INC PO BOX 842875 BOSTON, MA 02284-2875	225925	08/13/2019	Services	$214.86
	225926	08/13/2019	Services	$4,446.73
	227278	08/23/2019	Services	$193.26
	228218	09/06/2019	Services	$214.86
	228219	09/06/2019	Services	$4,762.19
	229165	09/20/2019	Services	$193.26
	230429	10/07/2019	Services	$214.86
	230842	10/11/2019	Services	$2,487.87
			SUBTOTAL	$12,727.89
ADVANCE MINING SERVICES 838 THIRD STREET OAKMONT, PA 15139	225621	08/05/2019	Suppliers or vendors	$3,733.91
	225622	08/05/2019	Suppliers or vendors	$4,648.10
	225623	08/05/2019	Suppliers or vendors	$744.00
	225624	08/05/2019	Suppliers or vendors	$6,000.80
	225625	08/05/2019	Suppliers or vendors	$3,268.20
	225626	08/05/2019	Suppliers or vendors	$2,636.11
	227848	08/28/2019	Suppliers or vendors	$4,503.42
	227849	08/28/2019	Suppliers or vendors	$8,514.05

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 3: Certain payments or transfers to creditors within 90 days before filing this case

Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
ADVANCE MINING SERVICES 838 THIRD STREET OAKMONT, PA 15139	227850	08/28/2019	Suppliers or vendors	$3,586.66
	227851	08/28/2019	Suppliers or vendors	$14,636.20
	227852	08/28/2019	Suppliers or vendors	$22,202.10
	227853	08/28/2019	Suppliers or vendors	$1,799.85
	227854	08/28/2019	Suppliers or vendors	$1,043.50
	228777	09/06/2019	Suppliers or vendors	$4,423.51
	228778	09/06/2019	Suppliers or vendors	$1,193.10
	228779	09/06/2019	Suppliers or vendors	$851.40
	228780	09/06/2019	Suppliers or vendors	$684.50
	231593	10/18/2019	Suppliers or vendors	$1,278.95
			SUBTOTAL	$85,748.36
ADVANCED DISPOSAL SERVICES SOLID WASTE OF PA, INC.-L6 PO BOX 74008047 CHICAGO, IL 60674-8047	227517	08/23/2019	Services	$481.45
	229519	09/20/2019	Services	$517.93
			SUBTOTAL	$999.38
ADVIZEX TECHNOLOGIES, LLC / 774019 PO BOX 72130 CLEVELAND, OH 44192-0002	ACH	08/19/2019	Suppliers or vendors	$5,241.18
			SUBTOTAL	$5,241.18
AFLAC INSURANCE CO. 1706 WILMINGTON ROAD NEW CASTLE, PA 16105	226172	08/13/2019	Services	$511.62
	226173	08/13/2019	Services	$1,029.89
	226174	08/13/2019	Services	$231.16
	226175	08/13/2019	Services	$24.48
	226176	08/13/2019	Services	$503.04
	226177	08/13/2019	Services	$114.36
	227544	08/23/2019	Services	$511.62
	227545	08/23/2019	Services	$1,029.89
	227546	08/23/2019	Services	$255.34
	227547	08/23/2019	Services	$503.04
	227548	08/23/2019	Services	$24.48
	227550	08/23/2019	Services	$83.46
	228437	09/06/2019	Services	$511.62
	228438	09/06/2019	Services	$1,029.89
	228439	09/06/2019	Services	$255.34
	228440	09/06/2019	Services	$24.48
	228441	09/06/2019	Services	$439.02
	228442	09/06/2019	Services	$135.36

Debtor Name: Murray Energy Corporation

Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 3: Certain payments or transfers to creditors within 90 days before filing this case

Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
AFLAC INSURANCE CO. 1706 WILMINGTON ROAD NEW CASTLE, PA 16105	229554	09/20/2019	Services	$511.62
	229555	09/20/2019	Services	$1,029.89
	229556	09/20/2019	Services	$255.34
	229557	09/20/2019	Services	$24.48
	229558	09/20/2019	Services	$463.50
	229559	09/20/2019	Services	$152.88
	230174	10/03/2019	Services	$135.36
			SUBTOTAL	$9,791.16
AG-PRO OHIO LLC PO BOX 95 BOSTON, GA 31626	225469	08/02/2019	Suppliers or vendors	$2,362.76
	226843	08/19/2019	Suppliers or vendors	$905.61
	227645	08/23/2019	Suppliers or vendors	$827.69
	229708	09/20/2019	Suppliers or vendors	$719.08
	231261	10/11/2019	Suppliers or vendors	$1,606.05
			SUBTOTAL	$6,421.19
AIR COMM CORPORATION 4840 S 35TH STREET PHOENIX, AZ 85040	226260	08/13/2019	Suppliers or vendors	$3,734.66
			SUBTOTAL	$3,734.66
AIR TECHNOLOGIES PO BOX 73278 CLEVELAND, OH 44193	226938	08/19/2019	Suppliers or vendors	$5,981.59
	228788	09/06/2019	Suppliers or vendors	$1,268.86
	228789	09/06/2019	Suppliers or vendors	$629.21
	228790	09/06/2019	Suppliers or vendors	$716.70
			SUBTOTAL	$8,596.36
AIRCRAFT PERFORMANCE GROUP INC. 4348 WOODLANDS BLVD, SUITE 200 CASTLE ROCK, CO 80104	229690	09/20/2019	Suppliers or vendors	$868.73
			SUBTOTAL	$868.73
AIRGAS USA LLC PO BOX 734445 CHICAGO, IL 60673-4445	ACH	08/30/2019	Suppliers or vendors	$4,894.90
	ACH	09/13/2019	Suppliers or vendors	$2,361.67
	231575	10/17/2019	Suppliers or vendors	$7,230.78
	231576	10/17/2019	Suppliers or vendors	$11,072.44
			SUBTOTAL	$25,559.79

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 3: Certain payments or transfers to creditors within 90 days before filing this case

Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
AK IRRIGATION, LLC DBA CONSERVA IRRIGATION 10855 FANCHER ROAD WESTERVILLE, OH 43082	229462	09/20/2019	Suppliers or vendors	$780.00
			SUBTOTAL	$780.00
ALFORD CURD ALLEN 7910 JUDGE BLVD. LOUISVILLE, KY 40219	229992	09/26/2019	Other - Royalty	$109.04
			SUBTOTAL	$109.04
ALL WATER SYSTEMS 1475 AIRBRAKE AVENUE TURTLE CREEK, PA 15145	227145	08/19/2019	Suppliers or vendors	$6,279.35
			SUBTOTAL	$6,279.35
ALLEGHENY BELTING INC 491 JAPP RD APT #1 SUMMERHILL, PA 15958	227159	08/19/2019	Suppliers or vendors	$13,899.00
	228080	08/28/2019	Suppliers or vendors	$4,998.00
			SUBTOTAL	$18,897.00
ALLEGHENY MINERAL CORP. PO BOX 1022 KITTANNING, PA 16201	225642	08/05/2019	Suppliers or vendors	$9,930.25
	225643	08/05/2019	Suppliers or vendors	$1,482.17
	226477	08/13/2019	Suppliers or vendors	$10,436.14
	226478	08/13/2019	Suppliers or vendors	$8,920.20
	226479	08/13/2019	Suppliers or vendors	$8,970.59
	226480	08/13/2019	Suppliers or vendors	$12,932.82
	226481	08/13/2019	Suppliers or vendors	$30,339.98
	227879	08/28/2019	Suppliers or vendors	$8,448.36
	227880	08/28/2019	Suppliers or vendors	$4,728.98
	227881	08/28/2019	Suppliers or vendors	$4,397.07
	227882	08/28/2019	Suppliers or vendors	$8,451.31
	228794	09/06/2019	Suppliers or vendors	$11,692.23
	228795	09/06/2019	Suppliers or vendors	$9,987.22
	228796	09/06/2019	Suppliers or vendors	$4,776.63
	228797	09/06/2019	Suppliers or vendors	$1,450.22
	228798	09/06/2019	Suppliers or vendors	$10,326.35
	228799	09/06/2019	Suppliers or vendors	$25,952.76
	230342	10/04/2019	Suppliers or vendors	$30,416.93
	230343	10/04/2019	Suppliers or vendors	$29,110.48
	230344	10/04/2019	Suppliers or vendors	$5,941.61
	230345	10/04/2019	Suppliers or vendors	$26,777.57
	230346	10/04/2019	Suppliers or vendors	$13,876.96

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
ALLEGHENY MINERAL CORP. PO BOX 1022 KITTANNING, PA 16201	230347	10/04/2019	Suppliers or vendors	$18,786.14
	231382	10/11/2019	Suppliers or vendors	$14,629.19
	231383	10/11/2019	Suppliers or vendors	$11,571.67
	231384	10/11/2019	Suppliers or vendors	$6,071.30
	231385	10/11/2019	Suppliers or vendors	$5,965.37
	231386	10/11/2019	Suppliers or vendors	$20,848.11
	231387	10/11/2019	Suppliers or vendors	$41,523.85
	231502	10/16/2019	Suppliers or vendors	$14,386.49
	231503	10/16/2019	Suppliers or vendors	$21,803.25
	231504	10/16/2019	Suppliers or vendors	$3,033.54
	231505	10/16/2019	Suppliers or vendors	$14,429.59
	231506	10/16/2019	Suppliers or vendors	$8,263.08
	231507	10/16/2019	Suppliers or vendors	$18,825.36
	231674	10/22/2019	Suppliers or vendors	$8,712.05
	231675	10/22/2019	Suppliers or vendors	$10,094.71
	231676	10/22/2019	Suppliers or vendors	$3,074.28
	231677	10/22/2019	Suppliers or vendors	$3,031.86
	231678	10/22/2019	Suppliers or vendors	$13,755.42
	231679	10/22/2019	Suppliers or vendors	$19,793.20
	Wire	10/28/2019	Suppliers or vendors	$39,062.86
			SUBTOTAL	$577,008.15
ALLEGHENY SURVEYS INC PO BOX 438 BIRCH RIVER, WV 26610	228055	08/28/2019	Suppliers or vendors	$14,237.96
	228974	09/06/2019	Suppliers or vendors	$7,531.92
			SUBTOTAL	$21,769.88
ALLIANCE CONSULTING INC. 124 PHILPOTT LANE BEAVER, WV 25813-9502	226165	08/13/2019	Suppliers or vendors	$7,798.38
	226774	08/19/2019	Suppliers or vendors	$730.30
	226775	08/19/2019	Suppliers or vendors	$5,114.27
	226776	08/19/2019	Suppliers or vendors	$49,402.30
	226777	08/19/2019	Suppliers or vendors	$6,732.23
	226778	08/19/2019	Suppliers or vendors	$5,100.00
	231137	10/11/2019	Suppliers or vendors	$145.74
	231138	10/11/2019	Suppliers or vendors	$1,242.66
	231139	10/11/2019	Suppliers or vendors	$16,980.28
	231140	10/11/2019	Suppliers or vendors	$739.76
	231141	10/11/2019	Suppliers or vendors	$3,267.70
			SUBTOTAL	$97,253.62

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ALLIED HOSTS LLC DBA FAIRFIELD INN & SUITES PO BOX 8615 SOUTH CHARLESTON, WV 25303	226271	08/13/2019	Suppliers or vendors	$2,340.23
			SUBTOTAL	$2,340.23
ALMA J. PENDERGRASS- FAJARDO KHAYMANTA FAJARDO 2500 NE 201 AVENUE UNIT 15 FAIRVIEW, OR 97024	226095	08/13/2019	Other - Royalty	$1,210.36
	229991	09/26/2019	Other - Royalty	$199.60
			SUBTOTAL	$1,409.96
ALMONO, LP C/O OXFORD DEVELOPMENT COMPANY 301 GRANT STREET, SUITE 4500 PITTSBURGH, PA 15219	227552	08/23/2019	Suppliers or vendors	$24,420.00
	230012	09/26/2019	Suppliers or vendors	$9,900.00
			SUBTOTAL	$34,320.00
ALRO STEEL DEPT 771478 PO BOX 77000 DETROIT, MI 48277-1478	228046	08/28/2019	Suppliers or vendors	$161.23
			SUBTOTAL	$161.23
AMBER COLVIN 22 EAST ORANGE STREET, APT 102B ELIZABETHTOWN, PA 17022	229587	09/20/2019	Other - Royalty	$358.65
			SUBTOTAL	$358.65
AMEREN IP PO BOX 88034 CHICAGO, IL 60680-1034	225994	08/13/2019	Other - Utilities	$3,638.54
	229309	09/20/2019	Other - Utilities	$3,949.66
	230938	10/11/2019	Other - Utilities	$4,281.54
			SUBTOTAL	$11,869.74
AMERICAN ELECTRIC POWER PO BOX 371496 PITTSBURGH, PA 15250-7496	225307	08/02/2019	Other - Utilities	$48.66
	225308	08/02/2019	Other - Utilities	$28.94
	225309	08/02/2019	Other - Utilities	$34.84
	225310	08/02/2019	Other - Utilities	$71.56
	225311	08/02/2019	Other - Utilities	$29.45
	225312	08/02/2019	Other - Utilities	$139.94
	225313	08/02/2019	Other - Utilities	$187.69
	225314	08/02/2019	Other - Utilities	$12.00
	225315	08/02/2019	Other - Utilities	$862,447.61
	225316	08/02/2019	Other - Utilities	$16.94
	225317	08/02/2019	Other - Utilities	$44.73

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
AMERICAN ELECTRIC POWER PO BOX 371496 PITTSBURGH, PA 15250-7496	225318	08/02/2019	Other - Utilities	$68.24
	225319	08/02/2019	Other - Utilities	$472.17
	225320	08/02/2019	Other - Utilities	$68.90
	225321	08/02/2019	Other - Utilities	$77.56
	225322	08/02/2019	Other - Utilities	$59.57
	225323	08/02/2019	Other - Utilities	$378.48
	225324	08/02/2019	Other - Utilities	$50.62
	225325	08/02/2019	Other - Utilities	$19.99
	225326	08/02/2019	Other - Utilities	$19.81
	225930	08/13/2019	Other - Utilities	$12,844.62
	225931	08/13/2019	Other - Utilities	$8,406.03
	225932	08/13/2019	Other - Utilities	$256.59
	225933	08/13/2019	Other - Utilities	$60.21
	225934	08/13/2019	Other - Utilities	$8,343.33
	225935	08/13/2019	Other - Utilities	$519.92
	225936	08/13/2019	Other - Utilities	$3,657.03
	225937	08/13/2019	Other - Utilities	$748.21
	225938	08/13/2019	Other - Utilities	$28.96
	226615	08/19/2019	Other - Utilities	$761.20
	227236	08/21/2019	Other - Utilities	$174.51
	227237	08/21/2019	Other - Utilities	$202.61
	227238	08/21/2019	Other - Utilities	$445,827.34
	227239	08/21/2019	Other - Utilities	$34.69
	227240	08/21/2019	Other - Utilities	$730.15
	227241	08/21/2019	Other - Utilities	$16.34
	227242	08/21/2019	Other - Utilities	$145.19
	227243	08/21/2019	Other - Utilities	$16.68
	227244	08/21/2019	Other - Utilities	$41.69
	227245	08/21/2019	Other - Utilities	$340.43
	227246	08/21/2019	Other - Utilities	$173.86
	227247	08/21/2019	Other - Utilities	$125.91
	227248	08/21/2019	Other - Utilities	$74.88
	227249	08/21/2019	Other - Utilities	$18.78
	227250	08/21/2019	Other - Utilities	$69.02
	227251	08/21/2019	Other - Utilities	$7,747.50
	227252	08/21/2019	Other - Utilities	$19.72
	227253	08/21/2019	Other - Utilities	$16.77
	227254	08/21/2019	Other - Utilities	$326.90
	227255	08/21/2019	Other - Utilities	$9.16
	227256	08/21/2019	Other - Utilities	$517,454.04

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AMERICAN ELECTRIC POWER PO BOX 371496 PITTSBURGH, PA 15250-7496	227257	08/21/2019	Other - Utilities	$148.42
	227258	08/21/2019	Other - Utilities	$581,161.92
	227259	08/21/2019	Other - Utilities	$32.35
	227260	08/21/2019	Other - Utilities	$534,347.24
	227261	08/21/2019	Other - Utilities	$59.82
	227262	08/21/2019	Other - Utilities	$19.28
	227263	08/21/2019	Other - Utilities	$144.05
	227264	08/21/2019	Other - Utilities	$72.18
	227265	08/21/2019	Other - Utilities	$19.49
	227266	08/21/2019	Other - Utilities	$70.84
	227267	08/21/2019	Other - Utilities	$1,830.07
	227268	08/21/2019	Other - Utilities	$196.90
	227269	08/21/2019	Other - Utilities	$191.82
	227270	08/21/2019	Other - Utilities	$1,423.24
	228173	09/03/2019	Other - Utilities	$53.18
	228174	09/03/2019	Other - Utilities	$28.73
	228175	09/03/2019	Other - Utilities	$68.72
	228176	09/03/2019	Other - Utilities	$34.25
	228177	09/03/2019	Other - Utilities	$29.25
	228178	09/03/2019	Other - Utilities	$12.00
	228179	09/03/2019	Other - Utilities	$854,934.85
	228180	09/03/2019	Other - Utilities	$457.01
	228181	09/03/2019	Other - Utilities	$64.72
	228182	09/03/2019	Other - Utilities	$106.04
	228183	09/03/2019	Other - Utilities	$353.15
	228184	09/03/2019	Other - Utilities	$67.97
	228185	09/03/2019	Other - Utilities	$37.65
	228186	09/03/2019	Other - Utilities	$4,752.50
	229190	09/20/2019	Other - Utilities	$12,038.93
	229191	09/20/2019	Other - Utilities	$7,427.11
	229192	09/20/2019	Other - Utilities	$213.14
	229193	09/20/2019	Other - Utilities	$35.40
	229194	09/20/2019	Other - Utilities	$429,033.77
	229195	09/20/2019	Other - Utilities	$66.27
	229196	09/20/2019	Other - Utilities	$41.32
	229197	09/20/2019	Other - Utilities	$594,093.26
	229198	09/20/2019	Other - Utilities	$27.72
	229199	09/20/2019	Other - Utilities	$16.74
	229200	09/20/2019	Other - Utilities	$19.28
	229201	09/20/2019	Other - Utilities	$7,948.01

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AMERICAN ELECTRIC POWER PO BOX 371496 PITTSBURGH, PA 15250-7496	229202	09/20/2019	Other - Utilities	$412.36
	229203	09/20/2019	Other - Utilities	$9.16
	229204	09/20/2019	Other - Utilities	$148.17
	229205	09/20/2019	Other - Utilities	$470.52
	229206	09/20/2019	Other - Utilities	$6,714.40
	229207	09/20/2019	Other - Utilities	$739.67
	229208	09/20/2019	Other - Utilities	$4,027.14
	229209	09/20/2019	Other - Utilities	$71.32
	229210	09/20/2019	Other - Utilities	$129.20
	229211	09/20/2019	Other - Utilities	$73.16
	229212	09/20/2019	Other - Utilities	$19.74
	229213	09/20/2019	Other - Utilities	$220.18
	229214	09/20/2019	Other - Utilities	$1,647.40
	229215	09/20/2019	Other - Utilities	$788.64
	229216	09/20/2019	Other - Utilities	$19.56
	229217	09/20/2019	Other - Utilities	$27.55
	229835	09/23/2019	Other - Utilities	$501,549.72
	229836	09/23/2019	Other - Utilities	$520,918.60
	229837	09/23/2019	Other - Utilities	$19.21
	229912	09/26/2019	Other - Utilities	$196.90
	229913	09/26/2019	Other - Utilities	$12.00
	229914	09/26/2019	Other - Utilities	$159.81
	229915	09/26/2019	Other - Utilities	$516.02
	229916	09/26/2019	Other - Utilities	$198.00
	229917	09/26/2019	Other - Utilities	$74.44
	229918	09/26/2019	Other - Utilities	$19.28
	229919	09/26/2019	Other - Utilities	$145.54
	229920	09/26/2019	Other - Utilities	$53.77
	229921	09/26/2019	Other - Utilities	$164.17
	229922	09/26/2019	Other - Utilities	$339.78
	229923	09/26/2019	Other - Utilities	$16.60
	229924	09/26/2019	Other - Utilities	$17.26
	229925	09/26/2019	Other - Utilities	$68.75
	229926	09/26/2019	Other - Utilities	$45.82
	229927	09/26/2019	Other - Utilities	$195.04
	229928	09/26/2019	Other - Utilities	$1,423.87
	229929	09/26/2019	Other - Utilities	$4,762.17
	230075	10/03/2019	Other - Utilities	$55.04
	230076	10/03/2019	Other - Utilities	$29.22
	230077	10/03/2019	Other - Utilities	$57.06

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AMERICAN ELECTRIC POWER PO BOX 371496 PITTSBURGH, PA 15250-7496	230078	10/03/2019	Other - Utilities	$29.98
	230079	10/03/2019	Other - Utilities	$29.76
	230080	10/03/2019	Other - Utilities	$451.15
	230081	10/03/2019	Other - Utilities	$843,287.55
	230082	10/03/2019	Other - Utilities	$396.47
	230083	10/03/2019	Other - Utilities	$74.79
	230084	10/03/2019	Other - Utilities	$114.49
	230085	10/03/2019	Other - Utilities	$341.64
	230086	10/03/2019	Other - Utilities	$37.90
	230087	10/03/2019	Other - Utilities	$660.43
	230088	10/03/2019	Other - Utilities	$778.43
	230089	10/03/2019	Other - Utilities	$20.72
	230090	10/03/2019	Other - Utilities	$32.27
	230843	10/11/2019	Other - Utilities	$11,413.58
	230844	10/11/2019	Other - Utilities	$8,518.58
	230845	10/11/2019	Other - Utilities	$12.40
	230846	10/11/2019	Other - Utilities	$64.84
	230847	10/11/2019	Other - Utilities	$6,701.91
	230848	10/11/2019	Other - Utilities	$469.26
	230849	10/11/2019	Other - Utilities	$3,616.67
	231821	10/24/2019	Other - Utilities	$431,697.98
	231822	10/24/2019	Other - Utilities	$33.84
	231823	10/24/2019	Other - Utilities	$731.24
	231824	10/24/2019	Other - Utilities	$116.25
	231825	10/24/2019	Other - Utilities	$138.85
	231826	10/24/2019	Other - Utilities	$18.78
	231827	10/24/2019	Other - Utilities	$61.11
	231828	10/24/2019	Other - Utilities	$46.69
	231829	10/24/2019	Other - Utilities	$423.10
	231830	10/24/2019	Other - Utilities	$17.02
	231831	10/24/2019	Other - Utilities	$16.52
	231832	10/24/2019	Other - Utilities	$164.17
	231833	10/24/2019	Other - Utilities	$66.63
	231834	10/24/2019	Other - Utilities	$338.45
	231835	10/24/2019	Other - Utilities	$43.21
	231836	10/24/2019	Other - Utilities	$866,548.26
	231837	10/24/2019	Other - Utilities	$564,238.52
	231838	10/24/2019	Other - Utilities	$524.35
	231839	10/24/2019	Other - Utilities	$451,638.36
	231840	10/24/2019	Other - Utilities	$147.70

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AMERICAN ELECTRIC POWER PO BOX 371496 PITTSBURGH, PA 15250-7496	231841	10/24/2019	Other - Utilities	$16.67
	231842	10/24/2019	Other - Utilities	$9.14
	231843	10/24/2019	Other - Utilities	$19.79
	231844	10/24/2019	Other - Utilities	$36.10
	231845	10/24/2019	Other - Utilities	$475,769.08
	231846	10/24/2019	Other - Utilities	$18.78
	231847	10/24/2019	Other - Utilities	$16.19
	231848	10/24/2019	Other - Utilities	$6,045.96
	231849	10/24/2019	Other - Utilities	$68.38
	231850	10/24/2019	Other - Utilities	$73.01
	231851	10/24/2019	Other - Utilities	$132.14
	231852	10/24/2019	Other - Utilities	$73.87
	231853	10/24/2019	Other - Utilities	$19.70
	231854	10/24/2019	Other - Utilities	$261.12
	231855	10/24/2019	Other - Utilities	$1,744.47
	231856	10/24/2019	Other - Utilities	$194.33
	231857	10/24/2019	Other - Utilities	$1,207.90
	231858	10/24/2019	Other - Utilities	$4,987.57
			SUBTOTAL	$9,636,462.85
AMERICAN ENERGY SERVICES, INC. DBA BENS RUN PRODUCTION, LLC. 1105 SCHROCK RD, SUITE 602 COLUMBUS, OH 43229	227459	08/23/2019	Other - Royalty	$215.44
	229973	09/26/2019	Other - Royalty	$217.83
			SUBTOTAL	$433.27
AMERICAN MINE POWER, INC. 584 RAGLAND ROAD BECKLEY, WV 25801	227133	08/19/2019	Suppliers or vendors	$200.00
	227134	08/19/2019	Suppliers or vendors	$6,547.97
	227135	08/19/2019	Suppliers or vendors	$1,030.00
	227136	08/19/2019	Suppliers or vendors	$32,845.00
	227137	08/19/2019	Suppliers or vendors	$26,582.00
	228040	08/28/2019	Suppliers or vendors	$5,500.00
	228041	08/28/2019	Suppliers or vendors	$24,081.00
	228042	08/28/2019	Suppliers or vendors	$2,550.00
	228043	08/28/2019	Suppliers or vendors	$11,010.74
	228044	08/28/2019	Suppliers or vendors	$1,080.08
	228958	09/06/2019	Suppliers or vendors	$7,995.00
	228959	09/06/2019	Suppliers or vendors	$9,792.50
	228960	09/06/2019	Suppliers or vendors	$6,154.66
	228961	09/06/2019	Suppliers or vendors	$8,130.00

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AMERICAN MINE POWER, INC. 584 RAGLAND ROAD BECKLEY, WV 25801	228962	09/06/2019	Suppliers or vendors	$11,904.00
	228963	09/06/2019	Suppliers or vendors	$6,213.00
	231524	10/16/2019	Suppliers or vendors	$1,650.00
	231565	10/17/2019	Suppliers or vendors	$1,650.00
			SUBTOTAL	$164,915.95
AMERICAN MINE RESEARCH INC PO BOX 234 ROCKY GAP, VA 24366	228057	08/28/2019	Suppliers or vendors	$12,574.67
	228058	08/28/2019	Suppliers or vendors	$14,942.07
	228059	08/28/2019	Suppliers or vendors	$1,365.20
	229125	09/12/2019	Suppliers or vendors	$8,801.36
	229126	09/12/2019	Suppliers or vendors	$23,594.54
	229127	09/12/2019	Suppliers or vendors	$15,354.47
			SUBTOTAL	$76,632.31
AMERICAN PRODUCERS SUPPLY CO., INC. 119 SECOND ST. PO BOX 1050 MARIETTA, OH 45750	226663	08/19/2019	Suppliers or vendors	$563.47
	226946	08/19/2019	Suppliers or vendors	$15,815.97
	226947	08/19/2019	Suppliers or vendors	$1,849.05
	226948	08/19/2019	Suppliers or vendors	$7,361.05
	226949	08/19/2019	Suppliers or vendors	$12,535.00
	226950	08/19/2019	Suppliers or vendors	$6,839.50
	226951	08/19/2019	Suppliers or vendors	$198.00
	226952	08/19/2019	Suppliers or vendors	$9,274.11
	227883	08/28/2019	Suppliers or vendors	$19,086.85
	227884	08/28/2019	Suppliers or vendors	$712.85
	227885	08/28/2019	Suppliers or vendors	$5,131.46
	227886	08/28/2019	Suppliers or vendors	$7,402.98
	227887	08/28/2019	Suppliers or vendors	$17,324.17
	227888	08/28/2019	Suppliers or vendors	$150.47
	227889	08/28/2019	Suppliers or vendors	$184.88
	228800	09/06/2019	Suppliers or vendors	$11,418.53
	228801	09/06/2019	Suppliers or vendors	$940.02
	228802	09/06/2019	Suppliers or vendors	$3,272.56
	228803	09/06/2019	Suppliers or vendors	$9,082.25
	228804	09/06/2019	Suppliers or vendors	$14,855.37
	228805	09/06/2019	Suppliers or vendors	$16.72
	228806	09/06/2019	Suppliers or vendors	$68.54
	230348	10/04/2019	Suppliers or vendors	$2,360.77

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AMERICAN PRODUCERS SUPPLY CO., INC. 119 SECOND ST. PO BOX 1050 MARIETTA, OH 45750	230349	10/04/2019	Suppliers or vendors	$34.11
	230350	10/04/2019	Suppliers or vendors	$420.00
	230351	10/04/2019	Suppliers or vendors	$4,510.57
	230352	10/04/2019	Suppliers or vendors	$199.18
	230353	10/04/2019	Suppliers or vendors	$1,360.60
	230354	10/04/2019	Suppliers or vendors	$490.11
	231508	10/16/2019	Suppliers or vendors	$11,790.32
	231680	10/22/2019	Suppliers or vendors	$506.04
			SUBTOTAL	$165,755.50
AMERICAN TELEPHONE COMPANY LLC DBA WINDSTREAM PO BOX 9001013 LOUISVILLE, KY 40290-1013	228541	09/06/2019	Other - Utilities	$0.05
			SUBTOTAL	$0.05
AMERICAN TIRE INC 2901 CHAPLINE STREET WHEELING, WV 26003	ACH	08/30/2019	Suppliers or vendors	$2,273.75
			SUBTOTAL	$2,273.75
AMERICAN WATERWAYS OPERATORS 801 NORTH QUINCY STREET ARLINGTON, VA 22203	226784	08/19/2019	Other - Regulatory/Tax	$106.58
			SUBTOTAL	$106.58
AMERIGAS PROPANE LP PO BOX 371473 PITTSBURGH, PA 15250-7473	230157	10/03/2019	Other - Utilities	$102.72
	231057	10/11/2019	Other - Utilities	$162.64
			SUBTOTAL	$265.36
AMERITAS LIFE INSURANCE CORP. PO BOX 82590 LINCOLN, NE 68501-2590	228281	09/06/2019	Services	$17,600.00
			SUBTOTAL	$17,600.00
AMHERST MADISON, INC. 2 PORT AMHERST DRIVE CHARLESTON, WV 25306-6699	226116	08/13/2019	Suppliers or vendors	$210,142.04
	226751	08/19/2019	Suppliers or vendors	$58,958.84
	227494	08/23/2019	Suppliers or vendors	$21,509.25
	229486	09/20/2019	Suppliers or vendors	$26,113.08
	230637	10/07/2019	Suppliers or vendors	$652.45
	230638	10/07/2019	Suppliers or vendors	$78,231.61
	231089	10/11/2019	Suppliers or vendors	$63,043.59
			SUBTOTAL	$458,650.86

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
AMTRAC OF OHIO, INC. PO BOX 508 DALTON, OH 44618	226616	08/19/2019	Suppliers or vendors	$21,831.10
	227760	08/28/2019	Suppliers or vendors	$2,130.00
	230850	10/11/2019	Suppliers or vendors	$13,659.09
			SUBTOTAL	$37,620.19
ANDERSON EXCAVATING LLC 343 WILLIAMS RD MORGANTOWN, WV 26501	228097	08/28/2019	Suppliers or vendors	$21,600.00
	228098	08/28/2019	Suppliers or vendors	$111,691.97
	228099	08/28/2019	Suppliers or vendors	$126,733.70
	228100	08/28/2019	Suppliers or vendors	$108,990.00
	228101	08/28/2019	Suppliers or vendors	$46,076.00
	229015	09/06/2019	Suppliers or vendors	$135,404.00
	230423	10/04/2019	Suppliers or vendors	$40,981.25
	231622	10/18/2019	Suppliers or vendors	$24,440.00
			SUBTOTAL	$615,916.92
ANDY BACK DBA AFFORDABLE CLEANING 1848 KINOKA ROAD PATOKA, IL 62875	225973	08/13/2019	Suppliers or vendors	$1,530.00
	227327	08/23/2019	Suppliers or vendors	$1,800.00
	229268	09/20/2019	Suppliers or vendors	$3,400.00
	230893	10/11/2019	Suppliers or vendors	$1,700.00
			SUBTOTAL	$8,430.00
ANGELA F BALL 34719 BALL RUN ROAD POMEROY, OH 45769	225920	08/05/2019	Other - Royalty	$7.86
	229116	09/10/2019	Other - Royalty	$7.68
			SUBTOTAL	$15.54
ANNA B LOCKHART 2445 COLUMBUS-LANCASTER RD NW LT 50 LANCASTER, OH 43130	225916	08/05/2019	Other - Royalty	$6.08
	229112	09/10/2019	Other - Royalty	$7.26
	230733	10/07/2019	Other - Royalty	$6.42
			SUBTOTAL	$19.76
ANNA B. TAYLOR MAY 3824 EAST DEVONSHIRE LANE BLOOMINGTON, IN 47408	227442	08/23/2019	Other - Royalty	$181.65
			SUBTOTAL	$181.65

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ANNA BRUCE TAYLOR KOSTELNIK 3649 WATER WORKS ROAD WINCHESTER, KY 40391	229957	09/26/2019	Other - Royalty	$184.24
			SUBTOTAL	$184.24
ANTHONY J. & ASHLEY N. GREGOR 41470 BROWN ROAD BETHESDA, OH 43719	229300	09/20/2019	Suppliers or vendors	$8,000.00
			SUBTOTAL	$8,000.00
APPALACHIAN AGGREGATES LLC PO BOX 743836 ATLANTA, GA 30374-3836	225851	08/05/2019	Suppliers or vendors	$13,708.25
			SUBTOTAL	$13,708.25
APPALACHIAN RAILCAR SERVICES INC PO BOX 800 ELEANOR, WV 25070	226163	08/13/2019	Services	$6,949.05
	228428	09/06/2019	Services	$21,851.93
			SUBTOTAL	$28,800.98
APPALACHIAN TIRE PRODUCTS,INC. PO BOX 10057 STATION C CHARLESTON, WV 25357	228060	08/28/2019	Suppliers or vendors	$58,234.35
	228061	08/28/2019	Suppliers or vendors	$11,501.00
	228062	08/28/2019	Suppliers or vendors	$29,163.26
	228063	08/28/2019	Suppliers or vendors	$49,575.26
	228064	08/28/2019	Suppliers or vendors	$52,453.97
	228065	08/28/2019	Suppliers or vendors	$41,568.25
	228066	08/28/2019	Suppliers or vendors	$2,916.55
	228975	09/06/2019	Suppliers or vendors	$6,092.20
	228976	09/06/2019	Suppliers or vendors	$2,428.00
	228977	09/06/2019	Suppliers or vendors	$14,757.94
	228978	09/06/2019	Suppliers or vendors	$11,979.95
	228979	09/06/2019	Suppliers or vendors	$4,347.00
	228980	09/06/2019	Suppliers or vendors	$23,073.00
			SUBTOTAL	$308,090.73

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APPLIED INDUSTRIAL TECHNOLOGIES INC 22510 NETWORK PLACE CHICAGO, IL 60673-1225	227761	08/28/2019	Suppliers or vendors	$9,111.39
	227762	08/28/2019	Suppliers or vendors	$171.71
	227763	08/28/2019	Suppliers or vendors	$4,723.79
	227764	08/28/2019	Suppliers or vendors	$3,855.32
	227765	08/28/2019	Suppliers or vendors	$1,384.62
	227766	08/28/2019	Suppliers or vendors	$267.27
	231584	10/18/2019	Suppliers or vendors	$65.18
			SUBTOTAL	$19,579.28
AQUA FILTER FRESH INC 1 COMMERCE DR PITTSBURGH, PA 15239	226126	08/13/2019	Suppliers or vendors	$387.10
	227505	08/23/2019	Suppliers or vendors	$417.10
	228400	09/06/2019	Suppliers or vendors	$303.10
	229497	09/20/2019	Suppliers or vendors	$990.20
	231104	10/11/2019	Suppliers or vendors	$453.10
			SUBTOTAL	$2,550.60
AQUATIC RESOURCES MANAGEMENT LLC 2554 PALUMBO DRIVE LEXINGTON, KY 40509	226207	08/13/2019	Suppliers or vendors	$10,802.10
	229632	09/20/2019	Suppliers or vendors	$3,106.00
	229633	09/20/2019	Suppliers or vendors	$881.37
	231207	10/11/2019	Suppliers or vendors	$9,934.10
			SUBTOTAL	$24,723.57
ARAMARK UNIFORM SERVICES INC AUS WEST LOCKBOX PO BOX 101179 PASADENA, CA 91189-1179	225991	08/13/2019	Suppliers or vendors	$6,359.56
	226660	08/19/2019	Suppliers or vendors	$3,734.41
	228282	09/06/2019	Suppliers or vendors	$9,477.41
	229305	09/20/2019	Suppliers or vendors	$6,525.52
	230487	10/07/2019	Suppliers or vendors	$3,579.84
	230933	10/11/2019	Suppliers or vendors	$6,905.70
			SUBTOTAL	$36,582.44
ARINC DIRECT PO BOX 951273 DALLAS, TX 75395-1273	230031	09/26/2019	Suppliers or vendors	$50.00
			SUBTOTAL	$50.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
ARKADIN INC SCHERERS CONFERENCING PO BOX 347261 PITTSBURGH, PA 15251-4261	228269	09/06/2019	Other - Utilities	$519.46
	230107	10/03/2019	Other - Utilities	$2,437.81
	230891	10/11/2019	Other - Utilities	$126.15
			SUBTOTAL	$3,083.42
ARM CAMCO LLC 667 INDUSTRIAL PARK ROAD EBENSBURG, PA 15931	229044	09/06/2019	Suppliers or vendors	$10,949.00
	229045	09/06/2019	Suppliers or vendors	$4,635.00
	229046	09/06/2019	Suppliers or vendors	$1,595.00
			SUBTOTAL	$17,179.00
ARTHUR E LEWIS JR AELEWIS RAILCAR MANAGEMENT SERVICES 5070 PLEASANT VALLEY RD LANCASTER, OH 43130	226230	08/13/2019	Services	$1,102.49
	231231	10/11/2019	Services	$7,672.79
			SUBTOTAL	$8,775.28
ASAP AUTO CARE 112 16TH STREET WHEELING, WV 26003	226184	08/13/2019	Services	$740.86
	226791	08/19/2019	Services	$279.86
	227554	08/23/2019	Services	$991.72
	227555	08/23/2019	Services	$921.06
	228104	08/28/2019	Services	$2,415.89
	228443	09/06/2019	Services	$4,683.64
	228444	09/06/2019	Services	$1,822.04
	229563	09/20/2019	Services	$3,360.98
	229564	09/20/2019	Services	$2,854.17
	229565	09/20/2019	Services	$685.52
	230681	10/07/2019	Services	$267.42
	230682	10/07/2019	Services	$3,777.80
	231164	10/11/2019	Services	$1,570.17
	231165	10/11/2019	Services	$530.81
	231166	10/11/2019	Services	$877.27
			SUBTOTAL	$25,779.21
ASSOCIATED ENGINEERS, INC. 2740 NORTH MAIN STREET MADISONVILLE, KY 42431	228785	09/06/2019	Suppliers or vendors	$18,060.00
			SUBTOTAL	$18,060.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
ASTON CARTER INC 3689 COLLECTION CENTER DRIVE CHICAGO, IL 60693	229047	09/06/2019	Suppliers or vendors	$1,560.33
			SUBTOTAL	$1,560.33
AT & T PO BOX 105503 ATLANTA, GA 30348-5503	Credit Card	08/27/2019	Other - Utilities	$4,152.84
	Credit Card	10/18/2019	Other - Utilities	$4,179.02
			SUBTOTAL	$8,331.86
AT & T PO BOX 5011 CAROL STREAM, IL 60197-5011	229674	09/20/2019	Other - Utilities	$1,936.17
			SUBTOTAL	$1,936.17
AT & T PO BOX 9005 CAROL STREAM, IL 60197-9005	228491	09/06/2019	Other - Utilities	$3,912.40
	230029	09/26/2019	Other - Utilities	$3,912.40
			SUBTOTAL	$7,824.80
AT&T GLOBAL NETWORK SERVICES LLC P.O. BOX 5091 CAROL STREAM, IL 60197-5091	227560	08/23/2019	Other - Utilities	$2,821.11
	230020	09/26/2019	Other - Utilities	$2,821.11
			SUBTOTAL	$5,642.22
AT&T MOBILITY 871034403 & 823083809 PO BOX 6463 CAROL STREAM, IL 60197-6463	Credit Card	08/27/2019	Other - Utilities	$3,390.53
	Credit Card	09/19/2019	Other - Utilities	$2,751.07
	Credit Card	10/18/2019	Other - Utilities	$3,134.29
			SUBTOTAL	$9,275.89
AT&T MOBILITY PO BOX 6463 CAROL STREAM, IL 60197-6463	226785	08/19/2019	Suppliers or vendors	$6,138.77
	Credit Card	08/27/2019	Suppliers or vendors	$2,242.01
	Credit Card	09/19/2019	Suppliers or vendors	$6,138.77
	Credit Card	10/18/2019	Suppliers or vendors	$5,800.55
			SUBTOTAL	$20,320.10
AT&T TELECONFERENCE SERVICES PO BOX 5002 CAROL STREAM, IL 60197-5002	227639	08/23/2019	Other - Utilities	$133.82
	230041	09/26/2019	Other - Utilities	$336.73
			SUBTOTAL	$470.55

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
AT&T P.O. BOX 5014 CAROL STREAM, IL 60197-5014	Credit Card	08/27/2019	Other - Utilities	$150.60
	Credit Card	09/19/2019	Other - Utilities	$55.00
	230186	10/03/2019	Other - Utilities	$95.60
	Credit Card	10/18/2019	Other - Utilities	$55.00
			SUBTOTAL	$356.20
AT&T PO BOX 105262 ATLANTA, GA 30348-5262	Credit Card	08/27/2019	Other - Utilities	$1,414.51
	Credit Card	09/19/2019	Other - Utilities	$451.76
	Credit Card	10/18/2019	Other - Utilities	$1,369.84
			SUBTOTAL	$3,236.11
AT&T PO BOX 5019 CAROL STREAM, IL 60197-5019	225365	08/02/2019	Other - Utilities	$17,661.74
	225366	08/02/2019	Other - Utilities	$50,676.05
	226664	08/19/2019	Other - Utilities	$6,390.00
	227341	08/23/2019	Other - Utilities	$955.58
	Credit Card	08/27/2019	Other - Utilities	$3,211.15
	Credit Card	08/28/2019	Other - Utilities	$43,179.72
	228190	09/03/2019	Other - Utilities	$64,758.07
	228287	09/06/2019	Other - Utilities	$50,067.05
	228288	09/06/2019	Other - Utilities	$36,702.95
	228289	09/06/2019	Other - Utilities	$18,663.74
	Credit Card	09/19/2019	Other - Utilities	$9,006.23
	229313	09/20/2019	Other - Utilities	$58,735.01
	229314	09/20/2019	Other - Utilities	$6,390.00
	229937	09/26/2019	Other - Utilities	$36,702.95
	229938	09/26/2019	Other - Utilities	$784.06
	230947	10/11/2019	Other - Utilities	$6,390.00
	230948	10/11/2019	Other - Utilities	$51,130.45
	230949	10/11/2019	Other - Utilities	$58,834.41
	Credit Card	10/18/2019	Other - Utilities	$27,999.35
			SUBTOTAL	$548,238.51

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AT&T PO BOX 5080 CAROL STREAM, IL 60197-5080	ACH	08/21/2019	Other - Utilities	$205.01
	Credit Card	08/27/2019	Other - Utilities	$2,488.14
	ACH	09/18/2019	Other - Utilities	$202.14
	Credit Card	09/19/2019	Other - Utilities	$1,330.77
	Credit Card	10/18/2019	Other - Utilities	$2,814.82
	ACH	10/21/2019	Other - Utilities	$202.14
			SUBTOTAL	$7,243.02
AT&T PO BOX 5094 CAROL STREAM, IL 60197-5094	227566	08/23/2019	Other - Utilities	$1.32
	227567	08/23/2019	Other - Utilities	$47.53
	227568	08/23/2019	Other - Utilities	$1,101.82
	229606	09/20/2019	Other - Utilities	$930.30
	229607	09/20/2019	Other - Utilities	$47.48
	229608	09/20/2019	Other - Utilities	$1.32
			SUBTOTAL	$2,129.77
ATLAS VAN LINES, INC. PO BOX 952340 ST. LOUIS, MO 63195-2340	227342	08/23/2019	Suppliers or vendors	$11,493.98
	229317	09/20/2019	Suppliers or vendors	$53,593.10
			SUBTOTAL	$65,087.08
AUDREY BUTCHER 5229 HIGHWAY 11-E PINEY FLATS, TN 37686	227465	08/23/2019	Other - Royalty	$128.84
			SUBTOTAL	$128.84
AUTHORITY OF THE BOROUGH OF CHARLER PO BOX 645255 PITTSBURGH, PA 15264-5250	226743	08/19/2019	Other - Utilities	$244.80
	229466	09/20/2019	Other - Utilities	$244.80
			SUBTOTAL	$489.60
AV COMPANY INC P.O. BOX 910 HUNDRED, WV 26575	226771	08/19/2019	Suppliers or vendors	$620.48
	229539	09/20/2019	Suppliers or vendors	$265.92
	231135	10/11/2019	Suppliers or vendors	$443.20
			SUBTOTAL	$1,329.60
AVI FOODSYSTEMS, INC. 2590 ELM ROAD NE WARREN, OH 44483-2997	225400	08/02/2019	Suppliers or vendors	$160.00
	226080	08/13/2019	Suppliers or vendors	$2,050.00
			SUBTOTAL	$2,210.00

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AVIALL INC PO BOX 842267 DALLAS, TX 75284-2267	227333	08/23/2019	Suppliers or vendors	$52.79
	229294	09/20/2019	Suppliers or vendors	$500.20
			SUBTOTAL	$552.99
B & H FOTO & ELECTRONICS CORP. REMITTANCE PROCESSING CENTER PO BOX 28072 NEW YORK, NY 10087-8072	Credit Card	08/27/2019	Suppliers or vendors	$1,977.90
			SUBTOTAL	$1,977.90
B & N ENTERPRISES OF SOMERSET LLC 427 SUNSHINE AVE. CENTRAL CITY, PA 15926	ACH	08/30/2019	Suppliers or vendors	$5,875.00
			SUBTOTAL	$5,875.00
B H & S CONSTRUCTION CO., INC. PO BOX 214 MORRISTOWN, OH 43759	225367	08/02/2019	Suppliers or vendors	$7,506.00
	226666	08/19/2019	Suppliers or vendors	$4,950.00
	227343	08/23/2019	Suppliers or vendors	$4,860.00
	228290	09/06/2019	Suppliers or vendors	$14,550.00
	229318	09/20/2019	Suppliers or vendors	$9,660.00
	229319	09/20/2019	Suppliers or vendors	$10,858.27
	230498	10/07/2019	Suppliers or vendors	$9,750.00
	230950	10/11/2019	Suppliers or vendors	$9,540.00
			SUBTOTAL	$71,674.27
BABST, CALLAND, CLEMENTS TWO GATEWAY CENTER PITTSBURGH, PA 15022	ACH	08/07/2019	Services	$28,507.50
	230062	10/01/2019	Services	$11,229.00
	230063	10/01/2019	Services	$20,506.34
	230064	10/01/2019	Services	$328.50
	230065	10/01/2019	Services	$22,177.50
	230066	10/01/2019	Services	$19,719.04
	230067	10/01/2019	Services	$53,094.81
	230068	10/01/2019	Services	$61,332.08
	231122	10/11/2019	Services	$6,493.50
	231123	10/11/2019	Services	$4,062.29
	231124	10/11/2019	Services	$328.50
	231125	10/11/2019	Services	$28,327.50
	231126	10/11/2019	Services	$28,037.57
	231127	10/11/2019	Services	$17,287.70
	ACH	10/25/2019	Services	$80,000.00
			SUBTOTAL	$381,431.83

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BAILEY & GLASSER LLP 209 CAPITAL ST CHARLESTON, WV 25301	226840	08/19/2019	Services	$1,175.50
	229703	09/20/2019	Services	$405.00
	229704	09/20/2019	Services	$1,260.50
			SUBTOTAL	$2,841.00
BAKER & SONS EQUIPMENT CO 45381 ST. RT. 145 LEWISVILLE, OH 43754	226007	08/13/2019	Suppliers or vendors	$478.19
	230499	10/07/2019	Suppliers or vendors	$734.10
	230951	10/11/2019	Suppliers or vendors	$58.24
			SUBTOTAL	$1,270.53
BANK OF AMERICA, N.A. BANC OF AMERICA LEASING & CAPITAL, PO BOX 100918 ATLANTA, GA 30384-0918	225440	08/02/2019	Suppliers or vendors	$26,000.00
	229568	09/20/2019	Suppliers or vendors	$26,000.00
	231167	10/11/2019	Suppliers or vendors	$26,000.00
			SUBTOTAL	$78,000.00
BANK OF NEW YORK MELLON CORPORATE TRUST DEPARTMENT PO BOX 392013 PITTSBURGH, PA 15251-9013	228193	09/04/2019	Services	$14,000.00
			SUBTOTAL	$14,000.00
BARBARA G STADELMAN 3175 RUSSELL CAVE RD. LEXINGTON, KY 40511	227584	08/23/2019	Other - Royalty	$218.91
	230027	09/26/2019	Other - Royalty	$196.96
			SUBTOTAL	$415.87
BBU SERVICE OF WV, LLC PO BOX 169 KENNA, WV 25248	229435	09/20/2019	Suppliers or vendors	$11,243.09
			SUBTOTAL	$11,243.09
BEARCOM PO BOX 670354 DALLAS, TX 75267-0354	228139	08/28/2019	Suppliers or vendors	$740.00
	228140	08/28/2019	Suppliers or vendors	$822.46
	228141	08/28/2019	Suppliers or vendors	$581.77
	228142	08/28/2019	Suppliers or vendors	$1,322.75
	231234	10/11/2019	Suppliers or vendors	$1,619.00
			SUBTOTAL	$5,085.98
BEARING DISTRIBUTORS, INC. PO BOX 6128 CLEVELAND, OH 44101-1128	ACH	09/13/2019	Suppliers or vendors	$3,031.33
			SUBTOTAL	$3,031.33

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BEARING SERVICE CO. OF PENNSYLVANIA P.O. BOX 536091 PITTSBURGH, PA 15253-5902	225640	08/05/2019	Suppliers or vendors	$6,071.50
			SUBTOTAL	$6,071.50
BEATTYVILLE WATERWORKS PO BOX 307 BEATTYVILLE, KY 41311	229458	09/20/2019	Other - Utilities	$8.27
	231062	10/11/2019	Other - Utilities	$134.07
			SUBTOTAL	$142.34
BECKER WHOLESALE MINE SUPPLY LLC ATTN: ACCOUNTS RECEIVABLE PO BOX 1688 ABINGDON, VA 24212	225715	08/05/2019	Suppliers or vendors	$50,748.84
	225716	08/05/2019	Suppliers or vendors	$29,689.33
	225717	08/05/2019	Suppliers or vendors	$41,382.00
			SUBTOTAL	$121,820.17
BEELMAN LOGISTICS LLC PO BOX 954389 ST LOUIS, MO 63195-4389	230488	10/07/2019	Suppliers or vendors	$2,309.00
			SUBTOTAL	$2,309.00
BEGLEY AUTO PARTS, INC. 15 EAST MAIN PO BOX 606 BEATTYVILLE, KY 41311	226094	08/13/2019	Suppliers or vendors	$154.17
	226737	08/19/2019	Suppliers or vendors	$375.24
	227436	08/23/2019	Suppliers or vendors	$103.07
	229455	09/20/2019	Suppliers or vendors	$235.96
	231059	10/11/2019	Suppliers or vendors	$461.24
			SUBTOTAL	$1,329.68

Debtor Name: Murray Energy Corporation

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
BELLAIRE HARBOR SERVICE, LLC PO BOX 29 BELLAIRE, OH 43906	225921	08/06/2019	Suppliers or vendors	$77,055.00
	225922	08/06/2019	Suppliers or vendors	$18,490.00
	225923	08/06/2019	Suppliers or vendors	$980.00
	227271	08/21/2019	Suppliers or vendors	$77,775.00
	227272	08/21/2019	Suppliers or vendors	$22,745.00
	227273	08/21/2019	Suppliers or vendors	$812.00
	228225	09/06/2019	Suppliers or vendors	$3,153.00
	228721	09/06/2019	Suppliers or vendors	$79,542.75
	228722	09/06/2019	Suppliers or vendors	$35,095.00
	228723	09/06/2019	Suppliers or vendors	$7,954.00
			SUBTOTAL	$323,601.75
BELMONT COUNTY CLERK OF COURTS 121 EAST MAIN STREET ST. CLAIRSVILLE, OH 43950	228199	09/05/2019	Other - Regulatory/Tax	$18.50
	228200	09/05/2019	Other - Regulatory/Tax	$18.50
	228201	09/05/2019	Other - Regulatory/Tax	$18.50
	228202	09/05/2019	Other - Regulatory/Tax	$18.50
	228203	09/05/2019	Other - Regulatory/Tax	$18.50
	228204	09/05/2019	Other - Regulatory/Tax	$18.50
	228205	09/05/2019	Other - Regulatory/Tax	$18.50
	228206	09/05/2019	Other - Regulatory/Tax	$18.50
	228207	09/05/2019	Other - Regulatory/Tax	$18.50
	228208	09/05/2019	Other - Regulatory/Tax	$18.50
	228209	09/05/2019	Other - Regulatory/Tax	$18.50
	228210	09/05/2019	Other - Regulatory/Tax	$18.50
	228211	09/05/2019	Other - Regulatory/Tax	$18.50
	228212	09/05/2019	Other - Regulatory/Tax	$18.50
			SUBTOTAL	$259.00
BELMONT COUNTY RECORDER COURTHOUSE 101 W. MAIN ST. ST. CLAIRSVILLE, OH 43950	226009	08/13/2019	Other - Regulatory/Tax	$120.00
			SUBTOTAL	$120.00
BELMONT COUNTY TREASURER 101 WEST MAIN STREET ST. CLAIRSVILLE, OH 43950-1260	229941	09/26/2019	Other - Regulatory/Tax	$15.25
			SUBTOTAL	$15.25
BELMONT COUNTY WATER & SEWER DISTRI PO BOX 457 ST. CLAIRSVILLE, OH 43950	226008	08/13/2019	Other - Utilities	$249.88
	226959	08/19/2019	Other - Utilities	$29,377.50

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
BELMONT COUNTY WATER & SEWER DISTRI PO BOX 457 ST. CLAIRSVILLE, OH 43950	227344	08/23/2019	Other - Utilities	$6,437.70
	229320	09/20/2019	Other - Utilities	$1,468.89
	229321	09/20/2019	Other - Utilities	$3,133.16
	229940	09/26/2019	Other - Utilities	$6,733.69
	230355	10/04/2019	Other - Utilities	$8,682.73
			SUBTOTAL	$56,083.55
BELMONT EQUIPMENT SALES 46049 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	ACH	08/07/2019	Suppliers or vendors	$65.00
	ACH	08/30/2019	Suppliers or vendors	$64.98
	230500	10/07/2019	Suppliers or vendors	$79.98
	230952	10/11/2019	Suppliers or vendors	$153.93
			SUBTOTAL	$363.89
BELMONT HILLS COUNTRY CLUB PO BOX 219 ST. CLAIRSVILLE, OH 43950	226010	08/13/2019	Suppliers or vendors	$614.13
	229322	09/20/2019	Suppliers or vendors	$845.65
			SUBTOTAL	$1,459.78
BELMONT HOSPITALITY LLC DBA MICROTEL INN & SUITES ST.CLAIRS 51128 NATIONAL ROAD E. ST.CLAIRSVILLE, OH 43950	228487	09/06/2019	Suppliers or vendors	$1,108.69
			SUBTOTAL	$1,108.69
BELMONT MILLS INC 400 SOUTH JEFFERSON STREET BELMONT, OH 43718	227334	08/23/2019	Suppliers or vendors	$170.39
	227335	08/23/2019	Suppliers or vendors	$390.79
	229296	09/20/2019	Suppliers or vendors	$358.02
	230069	10/02/2019	Suppliers or vendors	$4,839.04
	230484	10/07/2019	Suppliers or vendors	$5,597.01
	230485	10/07/2019	Suppliers or vendors	$1,372.80
	230918	10/11/2019	Suppliers or vendors	$480.25
			SUBTOTAL	$13,208.30
BELT TECH INC PO BOX 608 BLUEFIELD, VA 24605	225792	08/05/2019	Suppliers or vendors	$109,336.67
			SUBTOTAL	$109,336.67
BENESCH, FRIEDLANDR, COPLN, ARONOFF 2300 BP TOWER, 200 PUBLIC SQUARE CLEVELAND, OH 44114	ACH	08/07/2019	Services	$28,810.90

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
BENESCH, FRIEDLANDR, COPLN, ARONOFF 2300 BP TOWER, 200 PUBLIC SQUARE CLEVELAND, OH 44114	ACH	08/30/2019	Services	$140,664.42
	230486	10/07/2019	Services	$62,112.07
	230924	10/11/2019	Services	$17,571.85
	230925	10/11/2019	Services	$2,580.60
	230926	10/11/2019	Services	$4,136.25
	230927	10/11/2019	Services	$2,785.00
	230928	10/11/2019	Services	$9,952.50
	230929	10/11/2019	Services	$211,321.29
	ACH	10/25/2019	Services	$250,000.00
			SUBTOTAL	$729,934.88
BENJAMIN J HAYS 141 JANETTE DR ST HELENA IS, SC 29920	227581	08/23/2019	Other - Royalty	$160.55
			SUBTOTAL	$160.55
BENJAMIN J. HAYS, AGENT 141 JANETTE DRIVE ST. HELENA ISLAND, SC 29920	229986	09/26/2019	Other - Royalty	$118.81
			SUBTOTAL	$118.81
BENNOC, INC. PO BOX 208 MORRISTOWN, OH 43759	225653	08/05/2019	Suppliers or vendors	$2,197.50
	225654	08/05/2019	Suppliers or vendors	$3,267.18
	225655	08/05/2019	Suppliers or vendors	$5,005.55
	225656	08/05/2019	Suppliers or vendors	$2,317.50
	226960	08/19/2019	Suppliers or vendors	$5,635.00
	226961	08/19/2019	Suppliers or vendors	$25,512.79
	226962	08/19/2019	Suppliers or vendors	$33,668.59
	227891	08/28/2019	Suppliers or vendors	$5,230.36
	227892	08/28/2019	Suppliers or vendors	$21,223.68
	227893	08/28/2019	Suppliers or vendors	$29,434.93
	228824	09/06/2019	Suppliers or vendors	$9,548.92
	228825	09/06/2019	Suppliers or vendors	$4,500.00
	228826	09/06/2019	Suppliers or vendors	$7,154.40
	228827	09/06/2019	Suppliers or vendors	$1,365.00
	228828	09/06/2019	Suppliers or vendors	$12,506.50
	230118	10/03/2019	Suppliers or vendors	$32,494.67
	230119	10/03/2019	Suppliers or vendors	$4,500.00
	230120	10/03/2019	Suppliers or vendors	$10,454.60
	230121	10/03/2019	Suppliers or vendors	$3,126.20
	230122	10/03/2019	Suppliers or vendors	$44,911.37

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
BENNOC, INC. PO BOX 208 MORRISTOWN, OH 43759	230123	10/03/2019	Suppliers or vendors	$2,563.26
	231392	10/11/2019	Suppliers or vendors	$8,100.00
	231393	10/11/2019	Suppliers or vendors	$4,909.05
	231394	10/11/2019	Suppliers or vendors	$4,523.68
	231395	10/11/2019	Suppliers or vendors	$26,628.43
			SUBTOTAL	$310,779.16
BENWOOD MUNICIPAL UTILITIES & SERVI PO BOX 26 BENWOOD, WV 26031	226178	08/13/2019	Other - Utilities	$30,592.47
	229560	09/20/2019	Other - Utilities	$31,014.43
	231158	10/11/2019	Other - Utilities	$1,604.72
			SUBTOTAL	$63,211.62
BERNARD TWIGG GENERAL RECEIVER OF MARSHALL COUNTY PO BOX 459 MOUNDSVILLE, WV 26041	226847	08/19/2019	Suppliers or vendors	$300.00
	226848	08/19/2019	Suppliers or vendors	$251.00
	226849	08/19/2019	Suppliers or vendors	$251.00
			SUBTOTAL	$802.00
BEST WESTERN VENTURE INN 627 SOUTH SECOND STREET CENTRAL CITY, KY 42330	225368	08/02/2019	Suppliers or vendors	$434.44
	228292	09/06/2019	Suppliers or vendors	$325.83
			SUBTOTAL	$760.27
BILLSON TOWING CO., INC. 11341 SR 170 NEGLEY, OH 44441	226127	08/13/2019	Suppliers or vendors	$1,200.00
	227506	08/23/2019	Suppliers or vendors	$19,996.94
	229498	09/20/2019	Suppliers or vendors	$26,396.00
	230644	10/07/2019	Suppliers or vendors	$1,905.00
			SUBTOTAL	$49,497.94
BINGAMON PSD C/0 WESBANCO 329 PIKE STREET SHINNSTON, WV 26431	226186	08/13/2019	Other - Utilities	$3,523.12
	226795	08/19/2019	Other - Utilities	$2,308.78
	229573	09/20/2019	Other - Utilities	$2,749.04
	229574	09/20/2019	Other - Utilities	$1,899.12
	231172	10/11/2019	Other - Utilities	$4,165.92
	231173	10/11/2019	Other - Utilities	$2,126.79
			SUBTOTAL	$16,772.77

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
BINGHAM GREENEBAUM DOLL LLP 3913 SOLUTIONS CENTER CHICAGO, IL 60677-3009	ACH	08/07/2019	Services	$8,841.82
	230716	10/07/2019	Services	$8,506.79
	231221	10/11/2019	Services	$4,886.47
	ACH	10/25/2019	Services	$3,589.32
			SUBTOTAL	$25,824.40
BJW PRINTING & OFFICE SUPPLY PO BOX 1309 BECKLEY, WV 25802	226160	08/13/2019	Suppliers or vendors	$84.23
	231134	10/11/2019	Suppliers or vendors	$228.56
			SUBTOTAL	$312.79
BLACK, BALLARD & MCDONALD 108 S 9TH ST MT. VERNON, IL 62864	230489	10/07/2019	Services	$5,521.00
	230935	10/11/2019	Services	$1,564.00
	ACH	10/25/2019	Services	$2,493.80
			SUBTOTAL	$9,578.80
BLANC PRINTING CO 630 BALDWIN ST BRIDGEVILLE, PA 15017	226136	08/13/2019	Suppliers or vendors	$198.27
	226137	08/13/2019	Suppliers or vendors	$1,994.65
	227513	08/23/2019	Suppliers or vendors	$719.84
	228407	09/06/2019	Suppliers or vendors	$2,530.28
	228408	09/06/2019	Suppliers or vendors	$2,546.54
	228409	09/06/2019	Suppliers or vendors	$1,274.82
	230648	10/07/2019	Suppliers or vendors	$519.43
			SUBTOTAL	$9,783.83
BLANK ROME LLP ATTN:CASH RECEIPTS ONE LOGAN SQUARE 130 N 18TH ST PHILADELPHIA, PA 19103-6998	226124	08/13/2019	Services	$4,566.50
	231101	10/11/2019	Services	$9,974.10
			SUBTOTAL	$14,540.60
BLUE MARBLE GEOGRAPHICS 22 CARRIAGE LANE HALLOWELL, ME 04347	230768	10/07/2019	Suppliers or vendors	$1,098.00
			SUBTOTAL	$1,098.00
BMG MARINE INC 1263 CHARTIERS AVE MC KEES ROCKS, PA 15136	226187	08/13/2019	Suppliers or vendors	$6,000.00
			SUBTOTAL	$6,000.00

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BOART LONGYEAR DRILLING SERV, INC. SDS12-0734 PO BOX 86 MINNEAPOLIS, MN 55486-0734	229323	09/20/2019	Suppliers or vendors	$115,895.75
			SUBTOTAL	$115,895.75
BODEC, INC. 90 EAST 1300 SOUTH PRICE, UT 84501	226963	08/19/2019	Suppliers or vendors	$3,181.00
			SUBTOTAL	$3,181.00
BOLEA OIL PRODUCTS INC 1209 4TH AVE CORAOPOLIS, PA 15108	ACH	09/06/2019	Suppliers or vendors	$22,885.49
	ACH	09/20/2019	Suppliers or vendors	$19,645.67
	ACH	10/11/2019	Suppliers or vendors	$4,260.83
			SUBTOTAL	$46,791.99
BOOKCLIFF SALES, INC. 42 SOUTH CARBON AVENUE PO BOX 1010 PRICE, UT 84501	230501	10/07/2019	Suppliers or vendors	$19,221.74
	230771	10/08/2019	Suppliers or vendors	$2,497.95
	231396	10/11/2019	Suppliers or vendors	$5,003.68
	231510	10/16/2019	Suppliers or vendors	$60.85
	231544	10/17/2019	Suppliers or vendors	$616.37
			SUBTOTAL	$27,400.59
BOWEN ENGINEERING CORP 8802 N MERIDIAN ST INDIANAPOLIS, IN 46260-5380	228427	09/06/2019	Suppliers or vendors	$16,700.67
			SUBTOTAL	$16,700.67
BOWLES RICE LLP PO BOX 1386 CHARLESTON, WV 25325-1386	227418	08/23/2019	Services	$277.63
	227419	08/23/2019	Services	$65,994.86
	230566	10/07/2019	Services	$495.00
	230567	10/07/2019	Services	$52,621.35
			SUBTOTAL	$119,388.84
BRAKE SUPPLY CO., INC. 4280 PAYSPHERE CIRCLE CHICAGO, IL 60674	227894	08/28/2019	Suppliers or vendors	$75,142.19
	228832	09/06/2019	Suppliers or vendors	$2,057.38
	228833	09/06/2019	Suppliers or vendors	$17,167.20
			SUBTOTAL	$94,366.77

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
BREATHING AIR SYSTEMS A DIVISION OF SUB-AQUATICS, INC. 8855 E BROAD ST REYNOLDSBURG, OH 43068	226805	08/19/2019	Suppliers or vendors	$1,636.06
			SUBTOTAL	$1,636.06
BRIDGEPORT SUPPLY COMPANY PO BOX 68 BRIDGEPORT, OH 43912	230810	10/09/2019	Suppliers or vendors	$2,361.58
	231262	10/11/2019	Suppliers or vendors	$864.22
			SUBTOTAL	$3,225.80
BRIGHT HOUSE NETWORKS LLC PO BOX 790450 ST. LOUIS, MO 63179-0450	Credit Card	08/27/2019	Suppliers or vendors	$841.36
	Credit Card	10/18/2019	Suppliers or vendors	$263.37
			SUBTOTAL	$1,104.73
BROOKVILLE EQUIPMENT CORPORATION PO BOX 645781 PITTSBURGH, PA 15264-5255	ACH	08/19/2019	Suppliers or vendors	$8,396.62
	ACH	09/13/2019	Suppliers or vendors	$2,584.65
			SUBTOTAL	$10,981.27
BROOKVILLE SERVICES LLC PO BOX 645781 PITTSBURGH, PA 15264-5255	ACH	08/19/2019	Suppliers or vendors	$11,400.00
	ACH	09/13/2019	Suppliers or vendors	$5,514.50
			SUBTOTAL	$16,914.50
BROWN & ROBERTS, INC. 1 WESTRIDGE ROAD HARRISBURG, IL 62946	225992	08/13/2019	Suppliers or vendors	$3,692.25
			SUBTOTAL	$3,692.25
BROWNSVILLE MUNICIPAL AUTHORITY 7 JACKSON ST. BROWNSVILLE, PA 15417	228458	09/06/2019	Other - Utilities	$475.76
	230180	10/03/2019	Other - Utilities	$452.92
			SUBTOTAL	$928.68
BRUCE ALLEN DAVIS 7510 FAIRFIELD DRIVE FAIRVIEW, PA 16415	227439	08/23/2019	Other - Royalty	$355.04
	229955	09/26/2019	Other - Royalty	$369.65
			SUBTOTAL	$724.69
BRUNO ENGINEERING, P.C. PO BOX 1767 PRICE, UT 84501	228834	09/06/2019	Suppliers or vendors	$13,500.00
			SUBTOTAL	$13,500.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
BRUNO'S PLUMBING 1622 SOUTH 2300 EAST PRICE, UT 84501	227100	08/19/2019	Suppliers or vendors	$889.58
	228015	08/28/2019	Suppliers or vendors	$2,424.14
			SUBTOTAL	$3,313.72
BUCHANAN PUMP SERVICE & SUPPLY COMPANY, INC. PO BOX 827 POUND, VA 24279	ACH	08/07/2019	Suppliers or vendors	$3,427.00
	231441	10/11/2019	Suppliers or vendors	$11,326.00
	231442	10/11/2019	Suppliers or vendors	$11,326.00
	231443	10/11/2019	Suppliers or vendors	$17,775.87
	231523	10/16/2019	Suppliers or vendors	$38,335.20
			SUBTOTAL	$82,190.07
BUCKEYE CONTROLS & AUTOMATION 3306 ASHBY LANE RICHFIELD, OH 44286	228543	09/06/2019	Suppliers or vendors	$441.13
			SUBTOTAL	$441.13
BUCKEYE PEST MANAGEMENT, INC. 210 WEST MAIN STREET, BOX 327 ST. CLAIRSVILLE, OH 43950	ACH	08/19/2019	Suppliers or vendors	$347.68
	ACH	08/30/2019	Suppliers or vendors	$129.88
	ACH	09/13/2019	Suppliers or vendors	$414.57
	230502	10/07/2019	Suppliers or vendors	$327.11
	230503	10/07/2019	Suppliers or vendors	$47.70
	230504	10/07/2019	Suppliers or vendors	$55.00
	230953	10/11/2019	Suppliers or vendors	$141.52
	230954	10/11/2019	Suppliers or vendors	$480.00
	230955	10/11/2019	Suppliers or vendors	$182.32
	230956	10/11/2019	Suppliers or vendors	$32.18
			SUBTOTAL	$2,157.96
BUCKEYE REC PO BOX 200 RIO GRANDE, OH 45674-0200	228367	09/06/2019	Other - Utilities	$60.00
	229950	09/26/2019	Other - Utilities	$30.00
	230155	10/03/2019	Other - Utilities	$30.00
			SUBTOTAL	$120.00
BUCKLEY ASSOCIATES, INC. 636 ALPHA DRIVE RIDC IND. PARK PO BOX 111344 PITTSBURGH, PA 15238	ACH	08/07/2019	Suppliers or vendors	$26,156.37
	ACH	08/30/2019	Suppliers or vendors	$2,575.00
			SUBTOTAL	$28,731.37

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
BULLDOG OFFICE PRODUCTS INC 500 GLASS RD PITTSBURGH, PA 15205	226147	08/13/2019	Suppliers or vendors	$107.43
	226148	08/13/2019	Suppliers or vendors	$464.78
	226149	08/13/2019	Suppliers or vendors	$752.78
	226150	08/13/2019	Suppliers or vendors	$459.72
	227523	08/23/2019	Suppliers or vendors	$493.78
	227524	08/23/2019	Suppliers or vendors	$152.20
	227525	08/23/2019	Suppliers or vendors	$326.60
	227526	08/23/2019	Suppliers or vendors	$564.96
	228415	09/06/2019	Suppliers or vendors	$988.75
	228416	09/06/2019	Suppliers or vendors	$973.56
	228417	09/06/2019	Suppliers or vendors	$312.72
	228418	09/06/2019	Suppliers or vendors	$1,576.76
	228419	09/06/2019	Suppliers or vendors	$509.98
	229525	09/20/2019	Suppliers or vendors	$20.32
	229526	09/20/2019	Suppliers or vendors	$1,439.76
	229527	09/20/2019	Suppliers or vendors	$1,740.47
	229528	09/20/2019	Suppliers or vendors	$1,478.28
	230654	10/07/2019	Suppliers or vendors	$2,247.43
	230655	10/07/2019	Suppliers or vendors	$1,966.74
	230656	10/07/2019	Suppliers or vendors	$2,306.77
	230657	10/07/2019	Suppliers or vendors	$516.32
	231118	10/11/2019	Suppliers or vendors	$36.90
	231119	10/11/2019	Suppliers or vendors	$49.95
			SUBTOTAL	$19,486.96
BUNNER & SONS CONTRACTING LLC 317 CLEVELAND AVENUE FAIRMONT, WV 26554	225816	08/05/2019	Suppliers or vendors	$118,500.00
	229014	09/06/2019	Suppliers or vendors	$13,000.00
			SUBTOTAL	$131,500.00
BURNS DRILLING & EXCAVATING BOX 41 WIND RIDGE, PA 15380	228081	08/28/2019	Suppliers or vendors	$1,422.50
			SUBTOTAL	$1,422.50
BURNS INDUSTRIAL EQUIPMENT PO BOX 951734 CLEVELAND, OH 44193	228108	08/28/2019	Suppliers or vendors	$8,618.53
	228109	08/28/2019	Suppliers or vendors	$9,884.53
			SUBTOTAL	$18,503.06

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
BURRELL MINING PRODUCTS UTAH INC 2400 LEECHBURGH RD, STE 221 NEW KENSINGTON, PA 15068-4620	ACH	09/13/2019	Suppliers or vendors	$23,321.02
			SUBTOTAL	$23,321.02
BUSINESS WIRE INC DEPT 34182 PO BOX 39000 SAN FRANCISCO, CA 94139	225467	08/02/2019	Suppliers or vendors	$3,866.00
	227641	08/23/2019	Suppliers or vendors	$3,000.00
	228538	09/06/2019	Suppliers or vendors	$6,866.00
			SUBTOTAL	$13,732.00
C. B. P. ENGINEERING CORP. 185 PLUMPTON AVENUE WASHINGTON, PA 15301	231571	10/17/2019	Suppliers or vendors	$1,203.35
			SUBTOTAL	$1,203.35
C.I.S. INVESTMENTS, LLC PO BOX 820 BIXBY, OK 74008	227456	08/23/2019	Other - Royalty	$1,008.63
	229970	09/26/2019	Other - Royalty	$1,026.25
			SUBTOTAL	$2,034.88
CADENA GLOBAL LTD. 2 CELANDINE WALK HIGHFIELD WIGAN WN3 6AZ UNITED KINGDOM	Wire	09/17/2019	Suppliers or vendors	$450,399.65
			SUBTOTAL	$450,399.65
CAMPBELL TRANSPORTATION CO INC PO BOX 931696 CLEVELAND, OH 44193	226146	08/13/2019	Suppliers or vendors	$103,702.40
	229524	09/20/2019	Suppliers or vendors	$117,172.05
	230653	10/07/2019	Suppliers or vendors	$130,625.00
	231117	10/11/2019	Suppliers or vendors	$345,690.17
			SUBTOTAL	$697,189.62
CANDLEWOOD SUITES ST.CLAIRSVILLE 67689 MALL RING ROAD ST.CLAIRSVILLE, OH 43950	229651	09/20/2019	Suppliers or vendors	$226.50
			SUBTOTAL	$226.50
CAPITAL HOTEL GROUP LLC DBA HOLIDAY INN HOTELS & SUITES PO BOX 8615 CHARLESTON, WV 25303	226284	08/13/2019	Services	$134.47
			SUBTOTAL	$134.47

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CAPITAL ONE EQUIPMENT FINANCE PO BOX 3071 HICKSVILLE, NY 11802-3071	ACH	08/22/2019	Suppliers or vendors	$16,590.31
	ACH	09/26/2019	Suppliers or vendors	$16,590.31
			SUBTOTAL	$33,180.62
CARDINAL BUSINESS FORMS PO BOX 6771 WHEELING, WV 26003	225328	08/02/2019	Suppliers or vendors	$165.10
			SUBTOTAL	$165.10
CARDINAL NATURAL GAS COMPANY PO BOX 94608 CLEVELAND, OH 44101-4608	230042	09/26/2019	Other - Utilities	$43.00
			SUBTOTAL	$43.00
CARL E. FOX 875 NORTH 900 EAST PRICE, UT 84501	229428	09/20/2019	Suppliers or vendors	$1,425.00
	231037	10/11/2019	Suppliers or vendors	$2,412.71
			SUBTOTAL	$3,837.71
CARLSON SOFTWARE 33 E. 2ND STREET MAYSVILLE, KY 41056	227346	08/23/2019	Other - Utilities	$2,770.00
	230957	10/11/2019	Other - Utilities	$27,071.47
			SUBTOTAL	$29,841.47
CAROL A MOURNING 600 GRANT STREET MIDDLEPORT, OH 45760	225910	08/05/2019	Other - Royalty	$9.48
			SUBTOTAL	$9.48
CAROL A TAYLOR MOUNTAIN STATE TRAINING LLC 875 JIM KENNEDY RD FAIRMONT, WV 26554	228484	09/06/2019	Suppliers or vendors	$1,500.00
	228485	09/06/2019	Suppliers or vendors	$2,000.00
	230707	10/07/2019	Suppliers or vendors	$1,500.00
	230708	10/07/2019	Suppliers or vendors	$500.00
			SUBTOTAL	$5,500.00
CAROL ANN STONE 217 HOOD AVENUE WINCHESTER, KY 40391	229985	09/26/2019	Other - Royalty	$117.62
			SUBTOTAL	$117.62
CAROLYN KETCHKA 432 FALLOW DRIVE GREENFIELD, IN 46140	225896	08/05/2019	Other - Royalty	$0.96
	229091	09/10/2019	Other - Royalty	$1.15
			SUBTOTAL	$2.11

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CAROLYN L MCGUIRE 1230 EAST FRANCIS ROAD NEW LENOX, IL 60451	229691	09/20/2019	Other - Royalty	$48.89
			SUBTOTAL	$48.89
CARON/EAST INC. 429 N MECHANIC ST CUMBERLAND, MD 21502-2223	228401	09/06/2019	Suppliers or vendors	$6,625.00
			SUBTOTAL	$6,625.00
CARROLL TOWNSHIP AUTHORITY 128 BAIRD ST. MONONGAHELA, PA 15065	226255	08/13/2019	Suppliers or vendors	$83,544.00
	228530	09/06/2019	Suppliers or vendors	$70.00
	228531	09/06/2019	Suppliers or vendors	$70.00
	228532	09/06/2019	Suppliers or vendors	$70.00
	228533	09/06/2019	Suppliers or vendors	$70.00
	228534	09/06/2019	Suppliers or vendors	$70.00
	228535	09/06/2019	Suppliers or vendors	$70.00
	230194	10/03/2019	Suppliers or vendors	$72.31
	230195	10/03/2019	Suppliers or vendors	$72.31
	230196	10/03/2019	Suppliers or vendors	$72.31
	230197	10/03/2019	Suppliers or vendors	$72.31
	230198	10/03/2019	Suppliers or vendors	$72.31
	230199	10/03/2019	Suppliers or vendors	$72.31
	230200	10/03/2019	Suppliers or vendors	$70.00
			SUBTOTAL	$84,467.86
CARROLL TOWNSHIP TAX COLLECTOR 104 MAPLE AVENUE MONOGAHELA, PA 15063	230383	10/04/2019	Other - Regulatory/Tax	$2,335.58
	230990	10/11/2019	Other - Regulatory/Tax	$1,636.65
			SUBTOTAL	$3,972.23
CASEY A POZELL POZELL & COMPANY PO BOX 67 GLEN DALE, WV 26038	226158	08/13/2019	Suppliers or vendors	$14,050.00
	226767	08/19/2019	Suppliers or vendors	$16,795.00
	227534	08/23/2019	Suppliers or vendors	$7,495.00
	229535	09/20/2019	Suppliers or vendors	$5,385.00
	231132	10/11/2019	Suppliers or vendors	$78,890.00
			SUBTOTAL	$122,615.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CASTLE COUNTRY HYDRAULIC & SUPPLY 1755 SOUTH HIGHWAY 10 PO BOX 1035 PRICE, UT 84501	226966	08/19/2019	Suppliers or vendors	$13,641.73
	227896	08/28/2019	Suppliers or vendors	$10,799.35
	228835	09/06/2019	Suppliers or vendors	$4,377.33
			SUBTOTAL	$28,818.41
CATERPILLAR FINANCIAL SERVICES CORPORATION PO BOX 730681 DALLAS, TX 75373-0681	ACH	08/01/2019	Suppliers or vendors	$190,517.82
	ACH	08/09/2019	Suppliers or vendors	$4,529.44
	ACH	08/16/2019	Suppliers or vendors	$107,243.43
	ACH	09/03/2019	Suppliers or vendors	$71,656.66
	ACH	09/05/2019	Suppliers or vendors	$118,861.16
	ACH	09/09/2019	Suppliers or vendors	$4,529.44
	ACH	09/16/2019	Suppliers or vendors	$107,243.43
	ACH	10/02/2019	Suppliers or vendors	$195,047.26
			SUBTOTAL	$799,628.64
CATHERINE C. TAYLOR 1210 STAMPING GROUND ROAD GEORGETOWN, KY 40324	227458	08/23/2019	Other - Royalty	$174.84
	229972	09/26/2019	Other - Royalty	$162.12
			SUBTOTAL	$336.96
CATHERINE CASTO 2729 MAYFAIR ROAD AKRON, OH 44312-5411	225892	08/05/2019	Other - Royalty	$1.62
			SUBTOTAL	$1.62
CATHERINE H. STERCHI 3919 WEST 89TH STREET PRAIRIE VILLAGE, KS 66207	227476	08/23/2019	Other - Royalty	$115.53
			SUBTOTAL	$115.53
CATHERINE R PARSONS 492 AINSLEYS RIDGE TRIADELPHIA, WV 26059	226228	08/13/2019	Services	$5,704.00
	229653	09/20/2019	Services	$6,293.00
	231228	10/11/2019	Services	$5,406.00
	231879	10/25/2019	Services	$4,530.00
			SUBTOTAL	$21,933.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CATTRELL COMPANIES INC 906 FRANKLIN ST PO BOX 367 TORONTO, OH 43964	225450	08/02/2019	Suppliers or vendors	$699.60
	227585	08/23/2019	Suppliers or vendors	$1,970.00
	228488	09/06/2019	Suppliers or vendors	$825.00
	229635	09/20/2019	Suppliers or vendors	$3,800.00
			SUBTOTAL	$7,294.60
CAUDILL CHIPPING, INC. 35887 SR 324 DUNDAS, OH 45634	225898	08/05/2019	Other - Royalty	$94.45
	229093	09/10/2019	Other - Royalty	$97.16
	230609	10/07/2019	Other - Royalty	$94.88
			SUBTOTAL	$286.49
CB MINING, INC. CAT FINANCIAL COMMERCIAL ACCT. PO BOX 5 MURRYSVILLE, PA 15668	225785	08/05/2019	Suppliers or vendors	$20,071.92
	225786	08/05/2019	Suppliers or vendors	$128,394.62
	225787	08/05/2019	Suppliers or vendors	$72,663.54
	225788	08/05/2019	Suppliers or vendors	$99,184.18
	225789	08/05/2019	Suppliers or vendors	$256,150.98
	225790	08/05/2019	Suppliers or vendors	$3,260.40
	226587	08/13/2019	Suppliers or vendors	$298,540.94
	226588	08/13/2019	Suppliers or vendors	$301,548.00
	226589	08/13/2019	Suppliers or vendors	$74,062.19
	226590	08/13/2019	Suppliers or vendors	$40,685.91
	226591	08/13/2019	Suppliers or vendors	$36,400.00
	226592	08/13/2019	Suppliers or vendors	$89,674.16
	227138	08/19/2019	Suppliers or vendors	$52,504.65
	227139	08/19/2019	Suppliers or vendors	$41,312.75
	227140	08/19/2019	Suppliers or vendors	$8,118.02
	227141	08/19/2019	Suppliers or vendors	$206,875.69
	227142	08/19/2019	Suppliers or vendors	$31,602.57
	227143	08/19/2019	Suppliers or vendors	$24,170.35
	227144	08/19/2019	Suppliers or vendors	$341.13
	227755	08/28/2019	Suppliers or vendors	$20,949.40
	227756	08/28/2019	Suppliers or vendors	$20,262.20
	227757	08/28/2019	Suppliers or vendors	$95,947.00
	227758	08/28/2019	Suppliers or vendors	$207,201.21
	227759	08/28/2019	Suppliers or vendors	$10,715.00
	228967	09/06/2019	Suppliers or vendors	$23,466.18
	228968	09/06/2019	Suppliers or vendors	$86,781.26

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CB MINING, INC. CAT FINANCIAL COMMERCIAL ACCT. PO BOX 5 MURRYSVILLE, PA 15668	228969	09/06/2019	Suppliers or vendors	$23,268.38
	228970	09/06/2019	Suppliers or vendors	$87,536.28
	228971	09/06/2019	Suppliers or vendors	$99,723.76
	228972	09/06/2019	Suppliers or vendors	$16,586.00
	228973	09/06/2019	Suppliers or vendors	$1,119.14
	230804	10/09/2019	Suppliers or vendors	$13,371.52
	230805	10/09/2019	Suppliers or vendors	$3,655.39
	230806	10/09/2019	Suppliers or vendors	$4,224.00
	231525	10/16/2019	Suppliers or vendors	$12,928.80
	231566	10/17/2019	Suppliers or vendors	$17,500.00
	231567	10/17/2019	Suppliers or vendors	$757.51
	231568	10/17/2019	Suppliers or vendors	$17,322.76
	231569	10/17/2019	Suppliers or vendors	$6,484.82
	231649	10/18/2019	Suppliers or vendors	$3,978.02
	231650	10/18/2019	Suppliers or vendors	$27,450.97
			SUBTOTAL	$2,586,791.60
CB TRUCKING INC PO BOX 7 PENTRESS, WV 26544	227507	08/23/2019	Suppliers or vendors	$22,095.00
	228402	09/06/2019	Suppliers or vendors	$5,290.00
	229499	09/20/2019	Suppliers or vendors	$41,278.00
	230645	10/07/2019	Suppliers or vendors	$14,467.00
	231105	10/11/2019	Suppliers or vendors	$11,665.00
			SUBTOTAL	$94,795.00
CDW DIRECT LLC PO BOX 75723 CHICAGO, IL 60675	225369	08/02/2019	Suppliers or vendors	$15,845.26
	226011	08/13/2019	Suppliers or vendors	$9,661.56
	226668	08/19/2019	Suppliers or vendors	$3,131.39
	227347	08/23/2019	Suppliers or vendors	$6,570.71
	Credit Card	08/27/2019	Suppliers or vendors	$4,204.49
	228294	09/06/2019	Suppliers or vendors	$15,036.91
	229328	09/20/2019	Suppliers or vendors	$12,850.91
	230506	10/07/2019	Suppliers or vendors	$6,785.21
	230958	10/11/2019	Suppliers or vendors	$1,787.94
	Credit Card	10/18/2019	Suppliers or vendors	$423.13
			SUBTOTAL	$76,297.51

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CEDAR HILLS STORAGE 350 N CEDAR HILLS DRIVE PO BOX 520 PRICE, UT 84501	ACH	08/19/2019	Suppliers or vendors	$156.00
	230507	10/07/2019	Suppliers or vendors	$156.00
	230959	10/11/2019	Suppliers or vendors	$156.00
			SUBTOTAL	$468.00
CENTRAL PENNSYLVANIA NEWSPAPERS LLC DBA OBSERVER-REPORTER 122 S. MAIN STREET WASHINGTON, PA 15301-0506	231266	10/11/2019	Suppliers or vendors	$195.65
			SUBTOTAL	$195.65
CENTRAL SUPPLY COMPANY PO BOX 741866 ATLANTA, GA 30374-1866	231476	10/11/2019	Suppliers or vendors	$12,104.37
	231477	10/11/2019	Suppliers or vendors	$6,787.20
	231696	10/22/2019	Suppliers or vendors	$10,223.59
			SUBTOTAL	$29,115.16
CENTRIFUGAL & MECHANICAL INDUSTRIES 24703 NETWORK PLACE CHICAGO, IL 60673-1247	226967	08/19/2019	Suppliers or vendors	$970.00
	228836	09/06/2019	Suppliers or vendors	$17,039.50
	ACH	10/17/2019	Suppliers or vendors	$33,355.90
	231683	10/22/2019	Suppliers or vendors	$16,944.40
			SUBTOTAL	$68,309.80
CENTURY HOSPITALITY ST CLAIRSVILLE DBA HAWTHORN ST CLAIRSVILLE 51110 NATIONAL ROAD EAST ST. CLAIRSVILLE, OH 43950	226250	08/13/2019	Suppliers or vendors	$864.08
	231247	10/11/2019	Suppliers or vendors	$678.92
			SUBTOTAL	$1,543.00
CENTURYTEL OF ALABAMA DBA CENTURYLINK PO BOX 4300 CAROL STREAM, IL 60197-4300	Credit Card	10/18/2019	Other - Utilities	$252.63
			SUBTOTAL	$252.63
CERTIFIED LABORATORIES 23261 NETWORK PLACE CHICAGO, IL 60673-1232	ACH	08/30/2019	Suppliers or vendors	$4,710.22
			SUBTOTAL	$4,710.22
CESO INC. 3601 RIGBY ROAD, SUITE 30 MIAMISBURG, OH 45342	227222	08/19/2019	Suppliers or vendors	$10,852.10
	227223	08/19/2019	Suppliers or vendors	$2,985.40

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CESO INC. 3601 RIGBY ROAD, SUITE 30 MIAMISBURG, OH 45342	228163	08/28/2019	Suppliers or vendors	$1,741.20
	228164	08/28/2019	Suppliers or vendors	$4,360.20
			SUBTOTAL	$19,938.90
CHAMPION MINE SUPPLY, INC. PO BOX 550 CHAMPION, PA 15622-0550	225657	08/05/2019	Suppliers or vendors	$1,149.00
	225658	08/05/2019	Suppliers or vendors	$1,453.36
	225659	08/05/2019	Suppliers or vendors	$3,651.20
	225660	08/05/2019	Suppliers or vendors	$1,069.90
	225661	08/05/2019	Suppliers or vendors	$2,108.18
	225662	08/05/2019	Suppliers or vendors	$2,037.61
	227897	08/28/2019	Suppliers or vendors	$1,807.74
	227898	08/28/2019	Suppliers or vendors	$1,461.42
	227899	08/28/2019	Suppliers or vendors	$3,534.00
	227900	08/28/2019	Suppliers or vendors	$264.50
	227901	08/28/2019	Suppliers or vendors	$415.85
	228837	09/06/2019	Suppliers or vendors	$3,385.90
	228838	09/06/2019	Suppliers or vendors	$234.80
	228839	09/06/2019	Suppliers or vendors	$2,237.70
	228840	09/06/2019	Suppliers or vendors	$1,541.20
	228841	09/06/2019	Suppliers or vendors	$1,200.00
	228842	09/06/2019	Suppliers or vendors	$2,038.55
			SUBTOTAL	$29,590.91
CHARLENE H PARK 30 WILDWOOD DR CARMEL, IN 46032	230023	09/26/2019	Other - Royalty	$135.88
			SUBTOTAL	$135.88
CHARLES E SHESTAK 399 TREASURE LAKE DUBOIS, PA 15801	225468	08/02/2019	Suppliers or vendors	$3,977.63
	226264	08/13/2019	Suppliers or vendors	$3,867.01
	227643	08/23/2019	Suppliers or vendors	$3,795.05
	229707	09/20/2019	Suppliers or vendors	$2,550.00
	230764	10/07/2019	Suppliers or vendors	$3,375.40
	231260	10/11/2019	Suppliers or vendors	$2,019.76
			SUBTOTAL	$19,584.85
CHARLES L CARNES 107 VALLEY MANOR LANE, APT 7 PINE GROVE, WV 26419	228548	09/06/2019	Suppliers or vendors	$2,000.00
			SUBTOTAL	$2,000.00

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CHARLES M WALTON MOUNDSVILLE ECHO LLC PO BOX 369 MOUNDSVILLE, WV 26041	228404	09/06/2019	Suppliers or vendors	$245.08
	228405	09/06/2019	Suppliers or vendors	$223.96
	229506	09/20/2019	Suppliers or vendors	$73.08
	231110	10/11/2019	Suppliers or vendors	$113.16
			SUBTOTAL	$655.28
CHARLES R AND DEBBIE D SHEEDY 12471 WAYNESBURG PIKE ROAD CAMERON, WV 26033	229726	09/20/2019	Suppliers or vendors	$6,000.00
			SUBTOTAL	$6,000.00
CHARLES W WENDT 3582 WAYNESBURG PIKE MOUNDSVILLE, WV 26041	227651	08/23/2019	Suppliers or vendors	$1,000.00
	227652	08/23/2019	Suppliers or vendors	$4,500.00
			SUBTOTAL	$5,500.00
CHARLESTON BLUEPRINT, INC. 1203 VIRGINIA ST E CHARLESTON, WV 25301	227508	08/23/2019	Suppliers or vendors	$352.00
			SUBTOTAL	$352.00
CHARLOTTE C BUXTON IRREV FAMILY GST EXEMPT SHARE PO BOX 363 MT. STERLING, KY 40353	227617	08/23/2019	Other - Royalty	$409.72
	230039	09/26/2019	Other - Royalty	$435.05
			SUBTOTAL	$844.77
CHARLOTTE CLAY BUXTON 4910 INDIAN LANE NW WASHINGTON, NC 20016	227444	08/23/2019	Other - Royalty	$177.35
			SUBTOTAL	$177.35
CHARTER COMMUNICATIONS P.O. BOX 790086 ST LOUIS, MO 63179-0086	Credit Card	08/27/2019	Other - Utilities	$175.77
	Credit Card	09/19/2019	Other - Utilities	$175.77
			SUBTOTAL	$351.54
CHASTAIN & ASSOCIATES LLC 114 EAST MAIN STREET BENTON, IL 62812	226237	08/13/2019	Services	$4,329.68
	229669	09/20/2019	Services	$4,241.74
	230738	10/07/2019	Services	$3,447.37
			SUBTOTAL	$12,018.79
CHEMSTREAM, INC. 511 RAILROAD AVENUE HOMER CITY, PA 15748	ACH	08/19/2019	Suppliers or vendors	$18,420.48

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CHEMSTREAM, INC. 511 RAILROAD AVENUE HOMER CITY, PA 15748	ACH	08/30/2019	Suppliers or vendors	$64,431.82
	230360	10/04/2019	Suppliers or vendors	$1,667.08
	230361	10/04/2019	Suppliers or vendors	$3,521.39
	230362	10/04/2019	Suppliers or vendors	$9,290.37
	230363	10/04/2019	Suppliers or vendors	$5,345.20
	230364	10/04/2019	Suppliers or vendors	$19,525.50
	230365	10/04/2019	Suppliers or vendors	$55,261.44
	230366	10/04/2019	Suppliers or vendors	$6,547.20
	231397	10/11/2019	Suppliers or vendors	$758.00
	231398	10/11/2019	Suppliers or vendors	$1,543.58
			SUBTOTAL	$186,312.06
CHERIE L WILLIAMSON 39012 SR 124 POMEROY, OH 45769	225914	08/05/2019	Other - Royalty	$23.57
	229110	09/10/2019	Other - Royalty	$22.79
			SUBTOTAL	$46.36
CHISLER BROTHERS CONTRACTING LLC PO BOX 101 PENTRESS, WV 26544	228083	08/28/2019	Suppliers or vendors	$90,000.00
	228084	08/28/2019	Suppliers or vendors	$1,000.00
	230046	09/27/2019	Suppliers or vendors	$63,380.00
	230416	10/04/2019	Suppliers or vendors	$5,400.00
	230417	10/04/2019	Suppliers or vendors	$850.00
	230661	10/07/2019	Suppliers or vendors	$6,000.00
			SUBTOTAL	$166,630.00
CHOICE SERVICES, INC. 220 S 3RD ST STEUBENVILLE, OH 43952	ACH	08/19/2019	Suppliers or vendors	$2,685.92
	ACH	09/13/2019	Suppliers or vendors	$176.28
	230508	10/07/2019	Suppliers or vendors	$2,314.22
	230960	10/11/2019	Suppliers or vendors	$353.22
			SUBTOTAL	$5,529.64
CHRISTOPHER D CATES CLEAN GREEN PORTA POTTIES LLC 6771 STATE ROUTE 370 EAST SEBREE, KY 42455	228276	09/06/2019	Suppliers or vendors	$404.15
			SUBTOTAL	$404.15
CINTAS CORPORATION #013 PO BOX 740855 CINCINNATI, OH 45274-0855	226072	08/13/2019	Suppliers or vendors	$1,564.50
	226073	08/13/2019	Suppliers or vendors	$919.08

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CINTAS CORPORATION #013 PO BOX 740855 CINCINNATI, OH 45274-0855	226713	08/19/2019	Suppliers or vendors	$832.22
	226714	08/19/2019	Suppliers or vendors	$459.54
	227084	08/19/2019	Suppliers or vendors	$12,272.55
	227408	08/23/2019	Suppliers or vendors	$1,555.26
	227409	08/23/2019	Suppliers or vendors	$764.76
	228001	08/28/2019	Suppliers or vendors	$6,492.15
	228350	09/06/2019	Suppliers or vendors	$781.82
	228351	09/06/2019	Suppliers or vendors	$614.78
	229417	09/20/2019	Suppliers or vendors	$2,518.35
	229418	09/20/2019	Suppliers or vendors	$1,456.52
	230556	10/07/2019	Suppliers or vendors	$138.40
	230557	10/07/2019	Suppliers or vendors	$155.24
	231027	10/11/2019	Suppliers or vendors	$3,022.59
	231028	10/11/2019	Suppliers or vendors	$1,223.38
			SUBTOTAL	$34,771.14
CINTAS CORPORATION #259 PO BOX 630910 CINCINNATI, OH 45263-0910	228012	08/28/2019	Suppliers or vendors	$3,562.72
			SUBTOTAL	$3,562.72
CINTAS CORPORATION #731 PO BOX 88005 CHICAGO, IL 60680-1005	226074	08/13/2019	Suppliers or vendors	$314.77
	226715	08/19/2019	Suppliers or vendors	$149.14
	227410	08/23/2019	Suppliers or vendors	$149.14
	228002	08/28/2019	Suppliers or vendors	$6,400.64
	228352	09/06/2019	Suppliers or vendors	$298.28
	229419	09/20/2019	Suppliers or vendors	$298.28
	230558	10/07/2019	Suppliers or vendors	$190.74
	231029	10/11/2019	Suppliers or vendors	$276.18
			SUBTOTAL	$8,077.17
CINTAS CORPORATION PO BOX 630910 CINCINNATI, OH 45263-0910	226121	08/13/2019	Suppliers or vendors	$505.62
	226122	08/13/2019	Suppliers or vendors	$881.42
	226580	08/13/2019	Suppliers or vendors	$291.48
	226581	08/13/2019	Suppliers or vendors	$11,333.29
	226582	08/13/2019	Suppliers or vendors	$3,338.85
	226583	08/13/2019	Suppliers or vendors	$8,572.31
	226584	08/13/2019	Suppliers or vendors	$4,736.93
	226585	08/13/2019	Suppliers or vendors	$16,488.93
	226586	08/13/2019	Suppliers or vendors	$23,823.33

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CINTAS CORPORATION PO BOX 630910 CINCINNATI, OH 45263-0910	226754	08/19/2019	Suppliers or vendors	$662.86
	226755	08/19/2019	Suppliers or vendors	$446.96
	227502	08/23/2019	Suppliers or vendors	$1,002.63
	227503	08/23/2019	Suppliers or vendors	$464.52
	228047	08/28/2019	Suppliers or vendors	$2,744.70
	228048	08/28/2019	Suppliers or vendors	$7,005.17
	228049	08/28/2019	Suppliers or vendors	$20,064.61
	228050	08/28/2019	Suppliers or vendors	$25,786.53
	228051	08/28/2019	Suppliers or vendors	$32,100.24
	228052	08/28/2019	Suppliers or vendors	$57,496.07
	228053	08/28/2019	Suppliers or vendors	$40,097.01
	228054	08/28/2019	Suppliers or vendors	$3,057.26
	228397	09/06/2019	Suppliers or vendors	$301.23
	228398	09/06/2019	Suppliers or vendors	$929.04
	228966	09/06/2019	Suppliers or vendors	$768.00
	229494	09/20/2019	Suppliers or vendors	$1,401.98
	229495	09/20/2019	Suppliers or vendors	$929.04
	230641	10/07/2019	Suppliers or vendors	$464.52
	231098	10/11/2019	Suppliers or vendors	$1,365.86
	231099	10/11/2019	Suppliers or vendors	$929.04
			SUBTOTAL	$267,989.43
CINTAS FIRST AID & SAFETY, LOC 199 PO BOX 631025 CINCINNATI, OH 45263-1025	226551	08/13/2019	Suppliers or vendors	$1,340.24
	226552	08/13/2019	Suppliers or vendors	$2,072.43
	226553	08/13/2019	Suppliers or vendors	$3,913.60
	226554	08/13/2019	Suppliers or vendors	$2,760.43
	226555	08/13/2019	Suppliers or vendors	$9,433.73
	226556	08/13/2019	Suppliers or vendors	$314.82
	226557	08/13/2019	Suppliers or vendors	$1,054.56
	227085	08/19/2019	Suppliers or vendors	$109.86
	227086	08/19/2019	Suppliers or vendors	$258.15
	227087	08/19/2019	Suppliers or vendors	$1,550.61
	228003	08/28/2019	Suppliers or vendors	$449.85
	228004	08/28/2019	Suppliers or vendors	$2,057.17
	228005	08/28/2019	Suppliers or vendors	$228.88
			SUBTOTAL	$25,544.33
CINTAS PO BOX 630921 CINCINNATI, OH 45263-0921	226102	08/13/2019	Suppliers or vendors	$1,493.94
	226566	08/13/2019	Suppliers or vendors	$1,766.36

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CINTAS PO BOX 630921 CINCINNATI, OH 45263-0921	226567	08/13/2019	Suppliers or vendors	$798.26
	226568	08/13/2019	Suppliers or vendors	$908.17
	226744	08/19/2019	Suppliers or vendors	$761.77
	227115	08/19/2019	Suppliers or vendors	$2,814.72
	227116	08/19/2019	Suppliers or vendors	$2,175.64
	227487	08/23/2019	Suppliers or vendors	$1,286.56
	228380	09/06/2019	Suppliers or vendors	$830.21
	229469	09/20/2019	Suppliers or vendors	$2,397.13
	230626	10/07/2019	Suppliers or vendors	$258.83
	231073	10/11/2019	Suppliers or vendors	$2,288.79
			SUBTOTAL	$17,780.38
CIT GROUP/CAPITAL FINANCE INC CHURCH STREET STATION PO BOX 4339 NEW YORK, NY 10261-4339	228284	09/06/2019	Services	$35,090.00
	230941	10/11/2019	Services	$35,090.00
			SUBTOTAL	$70,180.00
CITY OF CAMERON 44 MAIN ST CAMERON, WV 26033	226197	08/13/2019	Other - Utilities	$146.52
	229610	09/20/2019	Other - Utilities	$177.30
	230188	10/03/2019	Other - Utilities	$61.92
	231193	10/11/2019	Other - Utilities	$87.50
			SUBTOTAL	$473.24
CITY OF CENTRALIA 222 SOUTH POPLAR PO BOX 569 CENTRALIA, IL 62801	225974	08/13/2019	Other - Utilities	$264.94
	230895	10/11/2019	Other - Utilities	$145.62
			SUBTOTAL	$410.56
CITY OF MANNINGTON 206 MAIN STREET MANNINGTON, WV 26582	226810	08/19/2019	Other - Regulatory/Tax	$301.18
	229625	09/20/2019	Other - Regulatory/Tax	$321.74
	231199	10/11/2019	Other - Regulatory/Tax	$331.96
			SUBTOTAL	$954.88
CITY OF MILLERSBURG-GF PO BOX 265 MILLERSBURG, KY 40348-0265	225454	08/02/2019	Other - Regulatory/Tax	$50.00
			SUBTOTAL	$50.00
CITY OF WHEELING - WATER DEPT. 1500 CHAPLINE STREET, ROOM 112 WHEELING, WV 26003	225396	08/02/2019	Other - Utilities	$44.57

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CITY OF WHEELING - WATER DEPT. 1500 CHAPLINE STREET, ROOM 112 WHEELING, WV 26003	226717	08/19/2019	Other - Utilities	$296.74
	228357	09/06/2019	Other - Utilities	$23.49
	229423	09/20/2019	Other - Utilities	$353.97
	231031	10/11/2019	Other - Utilities	$409.98
			SUBTOTAL	$1,128.75
CITY OF WHEELING 1500 CHAPLINE STREET WHEELING, WV 26003	225354	08/02/2019	Other - Regulatory/Tax	$16.50
			SUBTOTAL	$16.50
CIUNI & PANICHI, INC. 25201 CHAGRIN BOULEVARD CLEVELAND, OH 44122-5683	ACH	09/09/2019	Services	$26,750.00
	ACH	10/08/2019	Services	$55,170.00
	ACH	10/15/2019	Services	$17,100.00
	Wire	10/28/2019	Services	$119,825.00
			SUBTOTAL	$218,845.00
CIVIL & ENV. CONSULTANTS, INC. PO BOX 644246 PITTSBURGH, PA 15264-4246	228295	09/06/2019	Suppliers or vendors	$276.50
			SUBTOTAL	$276.50
CLARK F GILLIAN CLARK GILLIAN TRAINING 1089 OLD GRANDVIEW RD BEAVER, WV 25813	227565	08/23/2019	Suppliers or vendors	$500.00
			SUBTOTAL	$500.00
CLASSIC MOTORS, INC. 120 SOUTH MAIN RICHFIELD, UT 84701	226562	08/13/2019	Suppliers or vendors	$86,346.00
			SUBTOTAL	$86,346.00
CLAUDIA T. PUCKETT 2527 BECKNERVILLE ROAD WINCHESTER, KY 40391	227492	08/23/2019	Other - Royalty	$177.47
	229999	09/26/2019	Other - Royalty	$184.82
			SUBTOTAL	$362.29
CLAY BATTELLE PSD 186 BUCKEYE RD CORE, WV 26541	225442	08/02/2019	Other - Utilities	$898.02
	228460	09/06/2019	Other - Utilities	$983.92
	230182	10/03/2019	Other - Utilities	$1,195.75
			SUBTOTAL	$3,077.69

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CLAYTON ENGINEERING COMPANY PO BOX 6649 WHEELING, WV 26003	226866	08/19/2019	Suppliers or vendors	$3,769.47
			SUBTOTAL	$3,769.47
CLEAN WATER FUND COMMONWEALTH OF PA DEPARTMENT OF EP 131 BROADVIEW ROAD NEW STANTON, PA 15672	226205	08/13/2019	Other - Regulatory/Tax	$2,000.00
	229629	09/20/2019	Other - Regulatory/Tax	$3,500.00
	231203	10/11/2019	Other - Regulatory/Tax	$2,000.00
			SUBTOTAL	$7,500.00
CLEARWAVE COMMUNICATION PO BOX 808 HARRISBURG, IL 62946	Credit Card	08/27/2019	Other - Utilities	$2,433.55
	Credit Card	09/19/2019	Other - Utilities	$1,750.35
			SUBTOTAL	$4,183.90
CLEVELAND BROTHERS EQUIPMENT CO INC PO BOX 417094 BOSTON, MA 02241-7094	226968	08/19/2019	Suppliers or vendors	$2,533.74
	226969	08/19/2019	Suppliers or vendors	$21,300.47
	227902	08/28/2019	Suppliers or vendors	$6,512.39
	227903	08/28/2019	Suppliers or vendors	$16,000.46
	227904	08/28/2019	Suppliers or vendors	$14,658.49
	227905	08/28/2019	Suppliers or vendors	$53,165.16
	227906	08/28/2019	Suppliers or vendors	$4,936.68
	227907	08/28/2019	Suppliers or vendors	$333.98
	228843	09/06/2019	Suppliers or vendors	$42,017.01
	231643	10/18/2019	Suppliers or vendors	$808.47
			SUBTOTAL	$162,266.85
CLIMATECH INC 200 BILMAR DR PITTSBURGH, PA 15205	228078	08/28/2019	Suppliers or vendors	$1,734.20
	228079	08/28/2019	Suppliers or vendors	$4,582.83
			SUBTOTAL	$6,317.03

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CLINT G FABRY FABCO CONSULTANT 66305 BELMONT MORRISTOWN RD BELMONT, OH 43718	226128	08/13/2019	Services	$1,350.00
	226129	08/13/2019	Services	$1,350.00
	229501	09/20/2019	Services	$3,150.00
	230646	10/07/2019	Services	$900.00
	231107	10/11/2019	Services	$3,150.00
			SUBTOTAL	$9,900.00
CLOUSTON METHODIST CEMETERY ASSOC. CLOUSTON ROAD US 250 CAMERON, WV 26033	229145	09/16/2019	Suppliers or vendors	$90,500.00
			SUBTOTAL	$90,500.00
CME ENGINEERING PO BOX 644872 PITTSBURGH, PA 15264-4872	227895	08/28/2019	Suppliers or vendors	$7,300.00
	228293	09/06/2019	Suppliers or vendors	$4,796.64
	229324	09/20/2019	Suppliers or vendors	$30,000.00
	229325	09/20/2019	Suppliers or vendors	$17,001.68
	230356	10/04/2019	Suppliers or vendors	$1,045.60
	230357	10/04/2019	Suppliers or vendors	$18,531.20
	230358	10/04/2019	Suppliers or vendors	$1,002.50
	230359	10/04/2019	Suppliers or vendors	$31,383.38
	230505	10/07/2019	Suppliers or vendors	$3,200.00
			SUBTOTAL	$114,261.00
CNX LAND C/O STEPTOE & JOHNSON 1233 MAIN STREET #3000 WHEELING, WV 26003	ACH	08/06/2019	Suppliers or vendors	$533,159.54
	ACH	10/02/2019	Suppliers or vendors	$204,323.50
			SUBTOTAL	$737,483.04
COAL AGE, INC. PO BOX 70 HICO, WV 25854-0070	226482	08/13/2019	Suppliers or vendors	$75,540.25
	226970	08/19/2019	Suppliers or vendors	$16,489.00
	226971	08/19/2019	Suppliers or vendors	$9,995.60
	227908	08/28/2019	Suppliers or vendors	$309.42
	227909	08/28/2019	Suppliers or vendors	$11,446.00
	227910	08/28/2019	Suppliers or vendors	$12,759.35
	228844	09/06/2019	Suppliers or vendors	$5,723.00
			SUBTOTAL	$132,262.62

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
COAL CENTRIFUGE SERVICE, INC. (CCS) 26108 NETWORK PLACE CHICAGO, IL 60673-1247	226972	08/19/2019	Suppliers or vendors	$14,058.30
	226973	08/19/2019	Suppliers or vendors	$6,390.00
	228845	09/06/2019	Suppliers or vendors	$18,568.00
	228846	09/06/2019	Suppliers or vendors	$15,810.57
	228847	09/06/2019	Suppliers or vendors	$6,517.71
	228848	09/06/2019	Suppliers or vendors	$254.00
	228849	09/06/2019	Suppliers or vendors	$26,208.50
	ACH	10/17/2019	Suppliers or vendors	$107,572.00
			SUBTOTAL	$195,379.08
COAL SOURCE LLC ROBIN R HOLMES 5174 ROBERTS RDG RD MOUNDSVILLE, WV 26041	226257	08/13/2019	Suppliers or vendors	$5,160.00
	226258	08/13/2019	Suppliers or vendors	$36,120.00
	229701	09/20/2019	Suppliers or vendors	$5,332.00
	229702	09/20/2019	Suppliers or vendors	$30,743.00
			SUBTOTAL	$77,355.00
COALFIELD SERVICES, INC. 3203 PEPPERS FERRY ROAD WYTHEVILLE, VA 24382	228016	08/28/2019	Suppliers or vendors	$5,507.92
	228950	09/06/2019	Suppliers or vendors	$18,265.54
			SUBTOTAL	$23,773.46
COASTAL DRILLING EAST, LLC 130 MEADOW RIDGE ROAD, STE 24 MT. MORRIS, PA 15349	225741	08/05/2019	Suppliers or vendors	$30,385.95
	225742	08/05/2019	Suppliers or vendors	$44,750.82
	226558	08/13/2019	Suppliers or vendors	$75,503.64
	226559	08/13/2019	Suppliers or vendors	$287,358.39
	226560	08/13/2019	Suppliers or vendors	$243,889.72
	227094	08/19/2019	Suppliers or vendors	$154,780.36
	227095	08/19/2019	Suppliers or vendors	$108,538.20
	227096	08/19/2019	Suppliers or vendors	$217,637.85
	227097	08/19/2019	Suppliers or vendors	$159,920.35
	228008	08/28/2019	Suppliers or vendors	$132,873.00
	228009	08/28/2019	Suppliers or vendors	$103,963.71
	228010	08/28/2019	Suppliers or vendors	$193,815.32
	228011	08/28/2019	Suppliers or vendors	$769,378.07
	228944	09/06/2019	Suppliers or vendors	$100,723.20
	228945	09/06/2019	Suppliers or vendors	$278,706.40
	228946	09/06/2019	Suppliers or vendors	$422,143.83
	230153	10/03/2019	Suppliers or vendors	$60,000.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
COASTAL DRILLING EAST, LLC 130 MEADOW RIDGE ROAD, STE 24 MT. MORRIS, PA 15349	230154	10/03/2019	Suppliers or vendors	$168,000.00
	230841	10/11/2019	Suppliers or vendors	$105,000.00
	231438	10/11/2019	Suppliers or vendors	$91,980.00
	231522	10/16/2019	Suppliers or vendors	$6,000.00
	231563	10/17/2019	Suppliers or vendors	$105,000.00
	231602	10/18/2019	Suppliers or vendors	$75,000.00
			SUBTOTAL	$3,935,348.81
CODALE ELECTRIC SUPPLY INC P.O. BOX 740525 LOS ANGELES, CA 90074-0525	ACH	08/07/2019	Suppliers or vendors	$8,079.18
			SUBTOTAL	$8,079.18
CODY & JOYCE BOOTHE 10597 SR 218 CROWN CITY, OH 45623	225857	08/05/2019	Other - Royalty	$48.13
	229054	09/10/2019	Other - Royalty	$45.84
	230570	10/07/2019	Other - Royalty	$37.84
			SUBTOTAL	$131.81
COEN MARKETS INC. 1000 PHILADELPHIA ST. CANNONSBURG, PA 15317	226261	08/13/2019	Suppliers or vendors	$1,513.96
	230763	10/07/2019	Suppliers or vendors	$430.13
			SUBTOTAL	$1,944.09
COGENCY GLOBAL INC 10 E 40TH STREET 10TH FL NEW YORK, NY 10016	ACH	10/15/2019	Services	$29,318.97
	ACH	10/17/2019	Services	$46,406.88
	ACH	10/23/2019	Services	$2,900.43
			SUBTOTAL	$78,626.28
COHEN & GRIGSBY, PC 625 LIBERTY AVENUE PITTSBURGH, PA 15222-3152	ACH	08/30/2019	Services	$6,895.52
	ACH	10/25/2019	Services	$40,000.00
			SUBTOTAL	$46,895.52
COLLETTI MARINE SURVEYORS & CRANE INSPECTION INC 944 WESTERN AVE HICKORY, PA 15340	229697	09/20/2019	Suppliers or vendors	$2,040.00
			SUBTOTAL	$2,040.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
COLONIAL LIFE & ACCIDENT INS CO BILLING CONTROL NUMBER E7540834 PO BOX 903 COLUMBIA, SC 29202-0903	226649	08/19/2019	Services	$50.00
	228272	09/06/2019	Services	$50.00
	230897	10/11/2019	Services	$50.00
			SUBTOTAL	$150.00
COLUMBIA GAS OF OHIO PO BOX 742510 CINCINNATI, OH 45274-2510	225360	08/02/2019	Other - Utilities	$132.52
	225987	08/13/2019	Other - Utilities	$30.03
	226659	08/19/2019	Other - Utilities	$30.03
	227337	08/23/2019	Other - Utilities	$43.03
	228280	09/06/2019	Other - Utilities	$131.81
	229301	09/20/2019	Other - Utilities	$30.03
	229302	09/20/2019	Other - Utilities	$30.64
	229935	09/26/2019	Other - Utilities	$41.69
	229936	09/26/2019	Other - Utilities	$132.29
	230930	10/11/2019	Other - Utilities	$30.64
			SUBTOTAL	$632.71
COLUMBIA GAS TRANSMISSION PNC BANK N A 700 LOUISIANA STREET HOUSTON, TX 77002-2700	ACH	08/02/2019	Other - Utilities	$708,583.42
	ACH	08/16/2019	Other - Utilities	$100,000.00
	ACH	09/06/2019	Other - Utilities	$808,583.42
	ACH	10/07/2019	Other - Utilities	$99,528.99
	ACH	10/11/2019	Other - Utilities	$708,583.42
			SUBTOTAL	$2,425,279.25
COMBINED INSURANCE COMPANY OF AMERI 5277 PAYSPHERE CIRCLE CHICAGO, IL 60674-0052	226117	08/13/2019	Suppliers or vendors	$1,166.67
	226118	08/13/2019	Suppliers or vendors	$3,426.18
	226119	08/13/2019	Suppliers or vendors	$2,547.01
	226120	08/13/2019	Suppliers or vendors	$4,598.12
	226610	08/16/2019	Suppliers or vendors	$1,155.27
	226611	08/16/2019	Suppliers or vendors	$4,608.44
	226612	08/16/2019	Suppliers or vendors	$4,328.47
	227495	08/23/2019	Suppliers or vendors	$3,426.18
	227496	08/23/2019	Suppliers or vendors	$3,168.74
	227497	08/23/2019	Suppliers or vendors	$3,251.93
	228389	09/06/2019	Suppliers or vendors	$1,105.10
	228390	09/06/2019	Suppliers or vendors	$3,383.17

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
COMBINED INSURANCE COMPANY OF AMERI 5277 PAYSPHERE CIRCLE CHICAGO, IL 60674-0052	228391	09/06/2019	Suppliers or vendors	$3,035.38
	228392	09/06/2019	Suppliers or vendors	$4,656.10
	228393	09/06/2019	Suppliers or vendors	$4,405.43
	229487	09/20/2019	Suppliers or vendors	$1,105.10
	229488	09/20/2019	Suppliers or vendors	$3,383.17
	229489	09/20/2019	Suppliers or vendors	$3,157.70
	229490	09/20/2019	Suppliers or vendors	$4,734.17
	229491	09/20/2019	Suppliers or vendors	$4,505.42
	230161	10/03/2019	Suppliers or vendors	$1,105.10
	230162	10/03/2019	Suppliers or vendors	$3,289.08
	230163	10/03/2019	Suppliers or vendors	$3,077.23
	230164	10/03/2019	Suppliers or vendors	$4,668.72
	230165	10/03/2019	Suppliers or vendors	$4,271.65
	231090	10/11/2019	Suppliers or vendors	$1,105.10
	231091	10/11/2019	Suppliers or vendors	$2,985.18
	231092	10/11/2019	Suppliers or vendors	$458.74
	231093	10/11/2019	Suppliers or vendors	$4,271.65
			SUBTOTAL	$90,380.20
COMBS EQUIPMENT GROUP LLC PO BOX 573 PINEVILLE, KY 40965	225850	08/05/2019	Suppliers or vendors	$29,080.00
	228156	08/28/2019	Suppliers or vendors	$2,675.00
			SUBTOTAL	$31,755.00
COMCAST PO BOX 70219 PHILADELPHIA, PA 19176-0219	Credit Card	08/27/2019	Other - Utilities	$1,361.31
	Credit Card	08/28/2019	Other - Utilities	$829.75
	Credit Card	09/19/2019	Other - Utilities	$1,366.34
	Credit Card	10/18/2019	Other - Utilities	$1,218.59
			SUBTOTAL	$4,775.99
COMDOC 21146 NETWORK PLACE CHICAGO, IL 60673-1211	227588	08/23/2019	Suppliers or vendors	$763.30
	230192	10/03/2019	Suppliers or vendors	$763.30
			SUBTOTAL	$1,526.60
COMMERCIAL PRINTING INC. 119 SOUTH MAIN ST. GREENVILLE, KY 42345	228277	09/06/2019	Suppliers or vendors	$297.33
			SUBTOTAL	$297.33

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COMMONWEALTH OF PA 400 WATERFRONT DRIVE PITTSBURGH, PA 15222-4745	229636	09/20/2019	Other - Regulatory/Tax	$3,500.00
			SUBTOTAL	$3,500.00
COMMONWEALTH OF PA PA DEPT OF EPA/BUR. OF CLEAN WATER PO BOX 8466 HARRISBURG, PA 17105-8466	227599	08/23/2019	Other - Regulatory/Tax	$100.00
	227600	08/23/2019	Other - Regulatory/Tax	$2,550.00
			SUBTOTAL	$2,650.00
COMMONWEALTH OF PENNSYLVANIA 25 TECHNOLOGY DRIVE COAL CENTER, PA 15423	226212	08/13/2019	Other - Regulatory/Tax	$2,500.00
			SUBTOTAL	$2,500.00
COMMONWEALTH OF PENNSYLVANIA ATTN: CHAPTER 302 ANNUAL SERVICE FE PO BOX 8467 HARRISBURG, PA 17105-8467	225446	08/02/2019	Other - Regulatory/Tax	$65.00
	225447	08/02/2019	Other - Regulatory/Tax	$250.00
			SUBTOTAL	$315.00
COMMONWEALTH OF PENNSYLVANIA PA DEPT OF EPA 25 TECHNOLOGY DRIVE COAL CENTER, PA 15423	230329	10/03/2019	Other - Regulatory/Tax	$5,750.00
			SUBTOTAL	$5,750.00
COMPLIANCE MANAGEMENT INT 1350 WELSH ROAD, SUITE 200 NORTH WALES, PA 19454	226086	08/13/2019	Suppliers or vendors	$18,450.00
			SUBTOTAL	$18,450.00
COMPRESSOR-PUMP & SERVICE INC 3333 WEST 2400 SOUTH SALT LAKE CITY, UT 84119	ACH	08/30/2019	Suppliers or vendors	$17,715.43
			SUBTOTAL	$17,715.43
CONGLETON BROS., INC. PO BOX 167 BEATTYVILLE, KY 41311	226101	08/13/2019	Suppliers or vendors	$53.07
	231072	10/11/2019	Suppliers or vendors	$311.53
			SUBTOTAL	$364.60
CONN-WELD INDUSTRIES, INC. PO BOX 5329 PRINCETON, WV 24740	225663	08/05/2019	Suppliers or vendors	$93,935.31
	225664	08/05/2019	Suppliers or vendors	$1,224.30
	225665	08/05/2019	Suppliers or vendors	$5,454.49

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CONN-WELD INDUSTRIES, INC. PO BOX 5329 PRINCETON, WV 24740	225666	08/05/2019	Suppliers or vendors	$55,296.49
	225667	08/05/2019	Suppliers or vendors	$16,744.29
	227911	08/28/2019	Suppliers or vendors	$9,841.56
	227912	08/28/2019	Suppliers or vendors	$1,765.20
			SUBTOTAL	$184,261.64
CONSOL MINING COMPANY LLC 1000 CONSOL ENERGY DRIVE, SUITE 100 CANONSBURG, PA 15317	ACH	08/01/2019	Suppliers or vendors	$1,000.00
	ACH	08/27/2019	Suppliers or vendors	$154,394.59
	ACH	09/03/2019	Suppliers or vendors	$1,000.00
	ACH	09/17/2019	Suppliers or vendors	$154,394.59
	ACH	10/02/2019	Suppliers or vendors	$1,000.00
	ACH	10/16/2019	Suppliers or vendors	$103,705.59
			SUBTOTAL	$415,494.77
CONSOLIDATED COMMUNICATIONS PO BOX 580028 CHARLOTTE, NC 28258-0028	227558	08/23/2019	Other - Utilities	$726.43
	227559	08/23/2019	Other - Utilities	$366.32
	229595	09/20/2019	Other - Utilities	$726.43
	229596	09/20/2019	Other - Utilities	$366.32
			SUBTOTAL	$2,185.50
CONSOLIDATED STEEL INC P.O. BOX 110 POUNDING MILL, VA 24637	228981	09/06/2019	Suppliers or vendors	$12,631.92
			SUBTOTAL	$12,631.92
CONVEYOR SPECIALTIES, INC. 29 KEARNS SPUR BENTLEYVILLE, PA 15314	225668	08/05/2019	Suppliers or vendors	$2,028.00
	225669	08/05/2019	Suppliers or vendors	$15,520.00
	225670	08/05/2019	Suppliers or vendors	$6,430.00
	226978	08/19/2019	Suppliers or vendors	$23,931.00
	227915	08/28/2019	Suppliers or vendors	$2,500.00
	227916	08/28/2019	Suppliers or vendors	$19,321.00
	231512	10/16/2019	Suppliers or vendors	$9,344.00
	231684	10/22/2019	Suppliers or vendors	$2,846.00
			SUBTOTAL	$81,920.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CORBETT CAUDILL 35887 SR 324 DUNDAS, OH 45634	225858	08/05/2019	Other - Royalty	$94.45
	229055	09/10/2019	Other - Royalty	$97.16
	230571	10/07/2019	Other - Royalty	$94.88
			SUBTOTAL	$286.49
CORINTH WATER DISTRICT 20219 CORINTH ROAD PITTSBURG, IL 62974	226662	08/19/2019	Other - Utilities	$44.80
	229307	09/20/2019	Other - Utilities	$30.98
	230936	10/11/2019	Other - Utilities	$30.82
			SUBTOTAL	$106.60
CORNERSTONE SOLUTIONS GROUP INC 12647 OLIVE BLVD. SUITE 560 ST LOUIS, MO 63141	227563	08/23/2019	Suppliers or vendors	$2,520.00
	229602	09/20/2019	Suppliers or vendors	$2,520.00
	231188	10/11/2019	Suppliers or vendors	$2,520.00
			SUBTOTAL	$7,560.00
CORPORATE AIRCRAFT ASSOCIATION PO BOX 1745 FORNEY, TX 75126	Credit Card	08/27/2019	Suppliers or vendors	$1,500.00
			SUBTOTAL	$1,500.00
CORPORATE LODGING CONSULTANTS PO BOX 534722 ATLANTA, GA 30353-4722	ACH	08/02/2019	Services	$12,382.93
	ACH	08/09/2019	Services	$22,169.83
	ACH	08/19/2019	Services	$21,621.58
	ACH	08/23/2019	Services	$13,963.05
	ACH	08/30/2019	Services	$20,647.40
	ACH	09/06/2019	Services	$17,993.36
	ACH	09/17/2019	Services	$8,937.75
	ACH	09/20/2019	Services	$3,730.65
	ACH	10/07/2019	Services	$14,264.43
	ACH	10/17/2019	Services	$3,920.05
			SUBTOTAL	$139,631.03
CORPORATION OF THE PRESIDING BISHOP CHURCH OF JESUS CHRIST OF LATTER DA NATURAL RES 12TH FL 50 E N TEMPLE SALT LAKE CITY, UT 84150	230470	10/07/2019	Other - Royalty	$1,250.00
			SUBTOTAL	$1,250.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
COST CLEANING INC P.O. BOX 225 EIGHTY FOUR, PA 15330	226181	08/13/2019	Services	$4,500.00
	226182	08/13/2019	Services	$3,500.00
	226183	08/13/2019	Services	$1,717.00
	226790	08/19/2019	Services	$400.00
	229561	09/20/2019	Services	$3,500.00
	229562	09/20/2019	Services	$1,717.00
	231162	10/11/2019	Services	$3,500.00
	231163	10/11/2019	Services	$1,717.00
			SUBTOTAL	$20,551.00
CRANE 1 SERVICES INC PO BOX 88989 MILWAUKEE, WI 53288-8989	228076	08/28/2019	Suppliers or vendors	$2,940.00
			SUBTOTAL	$2,940.00
CROWN BATTERY MFG. CO. SLOT 302191 PO BOX 639612 CINCINNATI, OH 45263-9612	228045	08/28/2019	Suppliers or vendors	$7,304.50
	228964	09/06/2019	Suppliers or vendors	$1,356.00
	228965	09/06/2019	Suppliers or vendors	$4,934.60
			SUBTOTAL	$13,595.10
CROWN PRODUCTS & SERVICES INC 319 S GILLETTE AVE STE 303 GILLETTE, WY 82716	228110	08/28/2019	Suppliers or vendors	$6,343.26
	228111	08/28/2019	Suppliers or vendors	$10,350.00
	228112	08/28/2019	Suppliers or vendors	$22,712.00
	228113	08/28/2019	Suppliers or vendors	$43,232.98
	228114	08/28/2019	Suppliers or vendors	$4,717.44
	228115	08/28/2019	Suppliers or vendors	$675.00
	229616	09/20/2019	Suppliers or vendors	$4,800.00
	229617	09/20/2019	Suppliers or vendors	$5,688.56
			SUBTOTAL	$98,519.24

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CRYSTAL SPRINGS WATER COMPANY PO BOX 660579 DALLAS, TX 75266-0579	226012	08/13/2019	Suppliers or vendors	$3,216.82
	226013	08/13/2019	Suppliers or vendors	$745.12
	226014	08/13/2019	Suppliers or vendors	$679.89
	229329	09/20/2019	Suppliers or vendors	$829.98
	229330	09/20/2019	Suppliers or vendors	$68.81
	230509	10/07/2019	Suppliers or vendors	$338.14
	230961	10/11/2019	Suppliers or vendors	$871.22
	230962	10/11/2019	Suppliers or vendors	$547.14
			SUBTOTAL	$7,297.12
CS1 INDUSTRIAL SUPPLY LLC 144 LAMPLIGHTER DRIVE MORGANTOWN, WV 26508	228117	08/28/2019	Suppliers or vendors	$11,609.20
			SUBTOTAL	$11,609.20
CSE CORPORATION DEPARTMENT L 578 P PITTSBURGH, PA 15264-0578	226015	08/13/2019	Suppliers or vendors	$1,166.00
	227917	08/28/2019	Suppliers or vendors	$170,100.00
			SUBTOTAL	$171,266.00
CSI CORPORATE SECURITY & INVESTIGAT 3645 BRODHEAD RD MONACA, PA 15061	227531	08/23/2019	Services	$1,227.17
	229532	09/20/2019	Services	$2,825.00
			SUBTOTAL	$4,052.17
CT CORPORATION SYSTEM PO BOX 4349 CAROL STREAM, IL 60197-4349	228220	09/06/2019	Services	$271.15
	228221	09/06/2019	Services	$271.15
	228222	09/06/2019	Services	$271.15
			SUBTOTAL	$813.45
CULLIGAN OF DOVER PO BOX 2932 WICHITA, KS 67201-2932	226669	08/19/2019	Suppliers or vendors	$193.95
	229331	09/20/2019	Suppliers or vendors	$193.95
			SUBTOTAL	$387.90
CUMBERLAND TOWNSHIP TAX COLLECTOR 100 MUNICIPAL ROAD CARMICHAELS, PA 15320	226217	08/13/2019	Other - Regulatory/Tax	$468.07
	226218	08/13/2019	Other - Regulatory/Tax	$54.00
			SUBTOTAL	$522.07

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
CUSTOM ENGINEERING, INC. 656 HALL STREET PO BOX 320 CLAY, KY 42404-0320	228851	09/06/2019	Suppliers or vendors	$9,600.00
			SUBTOTAL	$9,600.00
CUTTING SYSTEMS INC 15593 BROOKPARK RD BROOK PARK, OH 44142	227184	08/19/2019	Suppliers or vendors	$1,933.44
			SUBTOTAL	$1,933.44
CW SERVICES, INC. PO BOX 203 RUSH, KY 41168	225671	08/05/2019	Suppliers or vendors	$114,050.00
			SUBTOTAL	$114,050.00
CYBERALERT, LLC FOOT OF BROAD STREET STE 202 STRATFORD, CT 06615	227569	08/23/2019	Services	$498.00
	230695	10/07/2019	Services	$498.00
			SUBTOTAL	$996.00
CYLINDER EXCHANGE LLC 330 HARPER PARK DR SUITE E BECKLEY, WV 25801	229039	09/06/2019	Suppliers or vendors	$7,250.00
	229040	09/06/2019	Suppliers or vendors	$10,295.75
	231534	10/16/2019	Suppliers or vendors	$24,000.00
			SUBTOTAL	$41,545.75
CYNTHIA JEAN GILLILAND 17341 E 670 ROAD GEROGETOWN, IL 61846	226281	08/13/2019	Other - Royalty	$4,908.11
			SUBTOTAL	$4,908.11
CYNTHIA LYNN TAYLOR 1630 TAZEWELL DRIVE LEXINGTON, KY 40504	227455	08/23/2019	Other - Royalty	$236.65
	229969	09/26/2019	Other - Royalty	$246.45
			SUBTOTAL	$483.10
D & G MACHINE CO., INC. PO BOX 31 MANNINGTON, WV 26582	225672	08/05/2019	Suppliers or vendors	$4,489.72
	225673	08/05/2019	Suppliers or vendors	$1,607.25
	225674	08/05/2019	Suppliers or vendors	$17,887.44
	225675	08/05/2019	Suppliers or vendors	$26,483.60
	225676	08/05/2019	Suppliers or vendors	$15,809.36
	226979	08/19/2019	Suppliers or vendors	$4,705.63
	226980	08/19/2019	Suppliers or vendors	$9,627.18
	226981	08/19/2019	Suppliers or vendors	$2,146.02

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
D & G MACHINE CO., INC. PO BOX 31 MANNINGTON, WV 26582	228852	09/06/2019	Suppliers or vendors	$5,400.00
	228853	09/06/2019	Suppliers or vendors	$15,943.71
	228854	09/06/2019	Suppliers or vendors	$25,995.36
	228855	09/06/2019	Suppliers or vendors	$123,160.73
	228856	09/06/2019	Suppliers or vendors	$75,978.64
	230051	09/27/2019	Suppliers or vendors	$24,533.46
	230052	09/27/2019	Suppliers or vendors	$39,088.83
	231399	10/11/2019	Suppliers or vendors	$22,405.85
	231400	10/11/2019	Suppliers or vendors	$3,957.77
			SUBTOTAL	$419,220.55
D & M WELDING INC PO BOX 2073 FAIRMONT, WV 26555-2073	227168	08/19/2019	Suppliers or vendors	$11,582.00
			SUBTOTAL	$11,582.00
D & T ENTERPRISES 704 THRU DRIVE POUNDING MILL, VA 24637	229008	09/06/2019	Suppliers or vendors	$938.36
			SUBTOTAL	$938.36
D&D TRANSPORT INC DBA BEN'S COURIER P.O. BOX 325 MARIANNA, PA 15345	226814	08/19/2019	Services	$6,345.00
	227579	08/23/2019	Services	$460.00
	227580	08/23/2019	Services	$3,585.00
	229630	09/20/2019	Services	$695.00
	229631	09/20/2019	Services	$4,220.00
	230700	10/07/2019	Services	$705.00
	230701	10/07/2019	Services	$355.00
	230702	10/07/2019	Services	$7,220.00
	231205	10/11/2019	Services	$525.00
	231206	10/11/2019	Services	$2,785.00
			SUBTOTAL	$26,895.00
D&J SALES & SERVICE 38175 CADIZ PIEDMONT RD CADIZ, OH 43907	230483	10/07/2019	Suppliers or vendors	$1,180.00
			SUBTOTAL	$1,180.00

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D&W CONTRACTORS LLC 2344 DAYBROOK ROAD FAIRVIEW, WV 26570	227182	08/19/2019	Services	$14,000.00
	227183	08/19/2019	Services	$17,895.00
	228107	08/28/2019	Services	$25,100.00
	229024	09/06/2019	Services	$7,400.00
	231623	10/18/2019	Services	$9,275.00
	Wire	10/28/2019	Services	$8,500.00
			SUBTOTAL	$82,170.00
D. CAMERON HAYS 3819 DYLAN PLACE LEXINGTON, KY 40514	227475	08/23/2019	Other - Royalty	$115.53
			SUBTOTAL	$115.53
DALE L LITTLE 39988 GRUESER ROAD POMEROY, OH 45769	225877	08/05/2019	Other - Royalty	$55.11
	229073	09/10/2019	Other - Royalty	$50.63
	230589	10/07/2019	Other - Royalty	$44.21
			SUBTOTAL	$149.95
DALLAS C KEMP TRUST HEIDI KEMP TRUSTEE 41440 BROWN ROAD BETHESDA, OH 43719	228495	09/06/2019	Suppliers or vendors	$4,500.00
	229645	09/20/2019	Suppliers or vendors	$3,500.00
			SUBTOTAL	$8,000.00
DALLAS R. & BILLI R. KEMP 64121 GARRETT ROAD BETHESDA, OH 43719	230061	10/01/2019	Suppliers or vendors	$4,500.00
			SUBTOTAL	$4,500.00
DAPCO, INC. 11500 NEBO ROAD NEBO, KY 42441	226483	08/13/2019	Suppliers or vendors	$160.56
	226484	08/13/2019	Suppliers or vendors	$544.96
	228857	09/06/2019	Suppliers or vendors	$356.51
			SUBTOTAL	$1,062.03
DARIUS PAZEMIS 5224 STRAWBERRY LANE WILLOUGHBY, OH 44094	225881	08/05/2019	Other - Royalty	$14.71
			SUBTOTAL	$14.71

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DASSAULT FALCON JET CORP. PO BOX 416357 BOSTON, MA 02241-6357	226200	08/13/2019	Suppliers or vendors	$10,020.95
	227572	08/23/2019	Suppliers or vendors	$24,874.32
	228475	09/06/2019	Suppliers or vendors	$1,359.40
	229619	09/20/2019	Suppliers or vendors	$28,554.03
	230698	10/07/2019	Suppliers or vendors	$176.51
			SUBTOTAL	$64,985.21
DATE MINING SERVICES, LLC 1400 SOUTH MAIN STREET HARRISBURG, IL 62946	227870	08/28/2019	Suppliers or vendors	$3,638.00
	227871	08/28/2019	Suppliers or vendors	$5,400.00
	227872	08/28/2019	Suppliers or vendors	$18,697.50
	231380	10/11/2019	Suppliers or vendors	$83,910.42
			SUBTOTAL	$111,645.92
DATE MINING SUPPLY, LLC 1400 SOUTH MAIN STREET HARRISBURG, IL 62946	228118	08/28/2019	Suppliers or vendors	$773.13
	228119	08/28/2019	Suppliers or vendors	$3,391.15
	228120	08/28/2019	Suppliers or vendors	$1,150.00
	228121	08/28/2019	Suppliers or vendors	$28,682.14
	231652	10/18/2019	Suppliers or vendors	$1,260.34
			SUBTOTAL	$35,256.76
DAVID &/OR LINDA OWENS 34046 BALL RUN ROAD POMEROY, OH 45769	225880	08/05/2019	Other - Royalty	$101.00
	229076	09/10/2019	Other - Royalty	$95.96
	230592	10/07/2019	Other - Royalty	$81.63
			SUBTOTAL	$278.59
DAVID A NAUGLE 304 WINDSOR CIRCLE WASHINGTON, PA 15301	228537	09/06/2019	Services	$591.75
	230759	10/07/2019	Services	$1,098.50
	231253	10/11/2019	Services	$591.75
			SUBTOTAL	$2,282.00
DAVID D PRICE 38736 SR 143 POMEROY, OH 45769	225883	08/05/2019	Other - Royalty	$44.39
	229078	09/10/2019	Other - Royalty	$43.32
	230595	10/07/2019	Other - Royalty	$36.19
			SUBTOTAL	$123.90
DAVID J BLAKE 39302 CR 72 FLUSHING, OH 43977	226254	08/13/2019	Services	$5,839.64

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
DAVID J BLAKE 39302 CR 72 FLUSHING, OH 43977	228529	09/06/2019	Services	$5,657.00
	229700	09/20/2019	Services	$6,648.00
	230758	10/07/2019	Services	$4,844.00
	231252	10/11/2019	Services	$2,336.00
			SUBTOTAL	$25,324.64
DAVID P DOWLER 1518 POWELL ST. MIDDLEPORT, OH 45760	225911	08/05/2019	Other - Royalty	$33.29
	229107	09/10/2019	Other - Royalty	$26.07
	230721	10/07/2019	Other - Royalty	$24.06
			SUBTOTAL	$83.42
DAVID W SCHRACK 37 UPPER STULLS RUN ROAD CAMERON, WV 26033	226286	08/13/2019	Suppliers or vendors	$1,000.00
			SUBTOTAL	$1,000.00
DAVIS ELECTRIC COMPANY, INC. PO BOX 1997 FAIRMONT, WV 26555-1997	225677	08/05/2019	Suppliers or vendors	$33,586.66
	225678	08/05/2019	Suppliers or vendors	$45,121.70
	225679	08/05/2019	Suppliers or vendors	$19,463.38
	226982	08/19/2019	Suppliers or vendors	$40,262.11
	226983	08/19/2019	Suppliers or vendors	$24,171.42
	226984	08/19/2019	Suppliers or vendors	$39,862.88
	227918	08/28/2019	Suppliers or vendors	$3,160.00
	227919	08/28/2019	Suppliers or vendors	$9,867.09
	227920	08/28/2019	Suppliers or vendors	$44,621.58
	227921	08/28/2019	Suppliers or vendors	$19,454.96
	227922	08/28/2019	Suppliers or vendors	$25,781.38
	230045	09/27/2019	Suppliers or vendors	$4,408.71
	230428	10/07/2019	Suppliers or vendors	$17,000.00
	231401	10/11/2019	Suppliers or vendors	$25,229.18
	231402	10/11/2019	Suppliers or vendors	$18,277.38
	231403	10/11/2019	Suppliers or vendors	$27,222.87
	231404	10/11/2019	Suppliers or vendors	$5,648.40
	231489	10/14/2019	Suppliers or vendors	$4,000.00
	231513	10/16/2019	Suppliers or vendors	$3,850.00
	231596	10/18/2019	Suppliers or vendors	$9,500.00
			SUBTOTAL	$420,489.70

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
DDC HOTELS INC DRURY INN & SUITES EVANSVILLE EAST 100 CROSS POINTE BLVD EVANSVILLE, IN 47715	231230	10/11/2019	Suppliers or vendors	$1,115.51
			SUBTOTAL	$1,115.51
DDC HOTELS INC DRURY INN AND SUITES MT VERNON 145 NORTH 44TH STREET MOUNT VERNON, IL 62864	225452	08/02/2019	Services	$460.88
	226215	08/13/2019	Services	$2,650.06
	231212	10/11/2019	Services	$5,862.84
			SUBTOTAL	$8,973.78
DDC HOTELS INC. DRURY INN & SUITES-BIRMINGHAM SE 3510 GRANDVIEW PARKWAY BIRMINGHAM, AL 35243	231272	10/11/2019	Suppliers or vendors	$1,046.97
			SUBTOTAL	$1,046.97
DDC HOTELS, INC. DRURY INN & SUITES- BIRMINGHAM SW 160 STATE FARM PARKWAY BIRMINGHAM, AL 35209	226270	08/13/2019	Services	$24,106.78
	226845	08/19/2019	Services	$14,734.77
	227649	08/23/2019	Services	$3,326.40
	229713	09/20/2019	Services	$68,073.49
			SUBTOTAL	$110,241.44
DDP AND ASSOCIATES 855 EAST COOKE ROAD COLUMBUS, OH 43224	227348	08/23/2019	Services	$11,126.96
			SUBTOTAL	$11,126.96
DEANNA SUE LUCAS PO BOX 131 CHAUNCEY, OH 45719	225912	08/05/2019	Other - Royalty	$33.29
	229108	09/10/2019	Other - Royalty	$26.07
	230722	10/07/2019	Other - Royalty	$24.06
			SUBTOTAL	$83.42
DEAN'S WATER SERVICE INC 950 JESSOP PL WASHINGTON, PA 15301	231462	10/11/2019	Suppliers or vendors	$1,770.00
	231527	10/16/2019	Suppliers or vendors	$20,820.00
			SUBTOTAL	$22,590.00

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DEARING COMPRESSOR & PUMP COMPANY PO BOX 6044 YOUNGSTOWN, OH 44501	225808	08/05/2019	Suppliers or vendors	$10,702.48
			SUBTOTAL	$10,702.48
DEBBIE D SHEEDY 12471 WAYNESBURG PIKE ROAD CAMERON, WV 26033	229729	09/20/2019	Suppliers or vendors	$95,000.00
			SUBTOTAL	$95,000.00
DEBRA D BLAKE GERALD H BLAKE II 993 CLOUSTON RD CAMERON, WV 26033	229144	09/16/2019	Suppliers or vendors	$222,500.00
			SUBTOTAL	$222,500.00
DELATTRE CORP 505 HUDSON AVENUE MONONGAHELA, PA 15063	227521	08/23/2019	Suppliers or vendors	$2,336.25
			SUBTOTAL	$2,336.25
DELAWARE SEC. OF STATE V# 51-600027 STATE OF DELAWARE DIV. OF CORPORATION PO BOX 5509 BINGHAMTON, NY 13902-5509	ACH	10/28/2019	Other - Regulatory/Tax	$7,243.95
			SUBTOTAL	$7,243.95
DELL MARKETING LP C/O DELL USA LP PO BOX 643561 PITTSBURGH, PA 15264-3561	225352	08/02/2019	Suppliers or vendors	$4,074.06
	226645	08/19/2019	Suppliers or vendors	$4,190.45
	227326	08/23/2019	Suppliers or vendors	$24,416.25
	228268	09/06/2019	Suppliers or vendors	$7,161.19
	229264	09/20/2019	Suppliers or vendors	$5,447.00
	230476	10/07/2019	Suppliers or vendors	$2,468.28
	230888	10/11/2019	Suppliers or vendors	$1,999.86
			SUBTOTAL	$49,757.09
DELOITTE MANAGEMENT SERVICES LP C/O T04567U PO BOX 4567 STU A TORONTO, ON M5W 0J1 CANADA	ACH	10/28/2019	Services	$59,219.09
			SUBTOTAL	$59,219.09

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DELTA MANAGEMENT SOLUTIONS LLC 724 CARLTON DRIVE OWENSBORO, KY 42303	ACH	08/31/2019	Suppliers or vendors	$57,077.55
	ACH	09/24/2019	Suppliers or vendors	$24,229.10
			SUBTOTAL	$81,306.65
DELTA PUMP & SYSTEMS, INC. ROUTE 519 BOX 338 EIGHTY FOUR, PA 15330	226600	08/14/2019	Suppliers or vendors	$2,785.00
	226601	08/14/2019	Suppliers or vendors	$3,762.00
	226602	08/14/2019	Suppliers or vendors	$7,564.00
	226603	08/14/2019	Suppliers or vendors	$6,029.00
	226604	08/14/2019	Suppliers or vendors	$6,500.00
			SUBTOTAL	$26,640.00
DELTA RIGGING & TOOLS, INC. 125 MCCARTY STREET HOUSTON, TX 77029	226922	08/19/2019	Suppliers or vendors	$18,287.29
	227847	08/28/2019	Suppliers or vendors	$20,325.21
	230339	10/04/2019	Suppliers or vendors	$8,383.71
			SUBTOTAL	$46,996.21
DERRICK MANUFACTURING CORP 590 DUKE RD BUFFALO, NY 14225	227152	08/19/2019	Suppliers or vendors	$12,572.57
	227153	08/19/2019	Suppliers or vendors	$3,144.06
	230808	10/09/2019	Suppliers or vendors	$20,781.56
	230832	10/10/2019	Suppliers or vendors	$4,206.76
	231573	10/17/2019	Suppliers or vendors	$6,282.37
			SUBTOTAL	$46,987.32
DESKO ENTERPRISES, INC. 162 TUDOR MANOR ROAD LATROBE, PA 15650	ACH	08/09/2019	Suppliers or vendors	$5,136.88
	ACH	10/07/2019	Suppliers or vendors	$5,136.88
	ACH	10/15/2019	Suppliers or vendors	$5,129.92
	ACH	10/21/2019	Suppliers or vendors	$4,504.92
			SUBTOTAL	$19,908.60

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DICKIE MCCAMEY & CHILCOTE P.C. TWO PPG PLACE SUITE 400 PITTSBURGH, PA 15222-5402	ACH	08/30/2019	Services	$33,811.90
	230683	10/07/2019	Services	$10,259.00
	230684	10/07/2019	Services	$1,355.50
	230685	10/07/2019	Services	$1,239.50
	230686	10/07/2019	Services	$61.00
	230687	10/07/2019	Services	$4,598.00
	ACH	10/25/2019	Services	$50,000.00
			SUBTOTAL	$101,324.90
DINOSAUR TIRE SERVICE 200 EAST MAIN STREET PO BOX 853 PRICE, UT 84501-0853	228858	09/06/2019	Suppliers or vendors	$30,789.19
	230070	10/02/2019	Suppliers or vendors	$9,040.35
	230367	10/04/2019	Suppliers or vendors	$2,856.64
	230510	10/07/2019	Suppliers or vendors	$6,648.88
	231597	10/18/2019	Suppliers or vendors	$2,636.73
			SUBTOTAL	$51,971.79
DINSMORE & SHOHL LLP PO BOX 639038 CINCINNATI, OH 45263-9038	226608	08/16/2019	Services	$7,068.14
	226670	08/19/2019	Services	$16,267.55
	226671	08/19/2019	Services	$7,014.98
	226672	08/19/2019	Services	$46,607.49
	226673	08/19/2019	Services	$17,736.05
	226674	08/19/2019	Services	$7,455.00
	226675	08/19/2019	Services	$2,250.00
	226676	08/19/2019	Services	$10,052.50
	227349	08/23/2019	Services	$39,590.85
	229332	09/20/2019	Services	$30,398.10
	229333	09/20/2019	Services	$115.00
	229334	09/20/2019	Services	$61,303.15
	229335	09/20/2019	Services	$28,263.80
	229336	09/20/2019	Services	$52.50
	229337	09/20/2019	Services	$28,963.55
	ACH	10/25/2019	Services	$183,697.13
			SUBTOTAL	$486,835.79

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DIRECTV PO BOX 5006 CAROL STREAM, IL 60197-5006	228450	09/06/2019	Other - Utilities	$360.00
	Credit Card	09/19/2019	Other - Utilities	$360.00
	229572	09/20/2019	Other - Utilities	$1,055.63
	Credit Card	10/18/2019	Other - Utilities	$385.85
			SUBTOTAL	$2,161.48
DIRT DESIGNS 1 LLC 68249 MORRISTOWN-FLUSHING RD. BELMONT, OH 43718	225680	08/05/2019	Suppliers or vendors	$1,622.50
	225681	08/05/2019	Suppliers or vendors	$84,380.00
	226985	08/19/2019	Suppliers or vendors	$49,120.00
	226986	08/19/2019	Suppliers or vendors	$16,630.00
	227923	08/28/2019	Suppliers or vendors	$87,615.00
	227924	08/28/2019	Suppliers or vendors	$25,525.00
	228296	09/06/2019	Suppliers or vendors	$1,950.00
	228859	09/06/2019	Suppliers or vendors	$90,284.50
	230368	10/04/2019	Suppliers or vendors	$31,670.00
	231405	10/11/2019	Suppliers or vendors	$21,550.00
	231546	10/17/2019	Suppliers or vendors	$61,170.00
			SUBTOTAL	$471,517.00
DISH NETWORK DEPT 0063 PO BOX 94063 PALATINE, IL 60094-4063	225362	08/02/2019	Other - Utilities	$1,237.20
	225363	08/02/2019	Other - Utilities	$1,172.52
	Credit Card	08/28/2019	Other - Utilities	$107.69
	228283	09/06/2019	Other - Utilities	$1,335.96
	230939	10/11/2019	Other - Utilities	$1,399.56
	230940	10/11/2019	Other - Utilities	$814.32
			SUBTOTAL	$6,067.25
DIVERSIFIED AIR SYSTEMS, INC. 4760 VAN EPPS ROAD BROOKLYN HEIGHTS, OH 44131	226473	08/13/2019	Suppliers or vendors	$33,254.20
	226474	08/13/2019	Suppliers or vendors	$6,645.15
	226475	08/13/2019	Suppliers or vendors	$1,545.75
	226924	08/19/2019	Suppliers or vendors	$3,915.28
	226925	08/19/2019	Suppliers or vendors	$4,403.25
	227855	08/28/2019	Suppliers or vendors	$9,062.76
	227856	08/28/2019	Suppliers or vendors	$3,711.90
	227857	08/28/2019	Suppliers or vendors	$27,525.10
	227858	08/28/2019	Suppliers or vendors	$24,006.89
	227859	08/28/2019	Suppliers or vendors	$4,991.90

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
DIVERSIFIED AIR SYSTEMS, INC. 4760 VAN EPPS ROAD BROOKLYN HEIGHTS, OH 44131	228782	09/06/2019	Suppliers or vendors	$9,656.35
	ACH	10/01/2019	Suppliers or vendors	$58,759.78
	230478	10/07/2019	Suppliers or vendors	$15,050.10
	231377	10/11/2019	Suppliers or vendors	$25,000.00
	231378	10/11/2019	Suppliers or vendors	$2,088.85
	231379	10/11/2019	Suppliers or vendors	$500.00
	231673	10/22/2019	Suppliers or vendors	$2,365.73
	Wire	10/28/2019	Suppliers or vendors	$2,883.38
			SUBTOTAL	$235,366.37
DNW EQUIPMENT NASH REBUILD CORPORATION PO BOX 68 LAFFERTY, OH 43951	227221	08/19/2019	Suppliers or vendors	$2,836.05
	228159	08/28/2019	Suppliers or vendors	$4,926.35
			SUBTOTAL	$7,762.40
DOMINION ENERGY WEST VIRGINIA PO BOX 26783 RICHMOND, VA 23261-6783	225441	08/02/2019	Other - Utilities	$906.04
	226794	08/19/2019	Other - Utilities	$625.98
	228451	09/06/2019	Other - Utilities	$1,604.18
	228452	09/06/2019	Other - Utilities	$11.32
	230013	09/26/2019	Other - Utilities	$61.10
	230014	09/26/2019	Other - Utilities	$625.98
	230015	09/26/2019	Other - Utilities	$22.75
	231170	10/11/2019	Other - Utilities	$487.10
	231171	10/11/2019	Other - Utilities	$625.98
			SUBTOTAL	$4,970.43
DONALD AND LARAYNE M LAFFERTY 176 SEVEN PINES ROAD MANNINGTON, WV 26582	226851	08/19/2019	Suppliers or vendors	$175,000.00
			SUBTOTAL	$175,000.00
DONNA G. CONLEY PO BOX 323 IRVINE, KY 40336	227478	08/23/2019	Other - Royalty	$517.10
	229990	09/26/2019	Other - Royalty	$661.86
			SUBTOTAL	$1,178.96
DONNA M DAVIDSON 33956 PARKINSON ROAD MIDDLEPORT, OH 45760-9749	225915	08/05/2019	Other - Royalty	$6.08
	230732	10/07/2019	Other - Royalty	$6.42
			SUBTOTAL	$12.50

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DONNELLEY FINANCIAL LLC PO BOX 842282 BOSTON, MA 02284-2282	229695	09/20/2019	Services	$2,949.38
			SUBTOTAL	$2,949.38
DONOVAN MARINE INC PO BOX 1979 MEMPHIS, TN 38101	226168	08/13/2019	Suppliers or vendors	$3,859.06
	226782	08/19/2019	Suppliers or vendors	$2,980.55
	229546	09/20/2019	Suppliers or vendors	$2,660.77
			SUBTOTAL	$9,500.38
DORIS MERTZ 34770 BALL RUN ROAD POMEROY, OH 45769	225878	08/05/2019	Other - Royalty	$13.22
	229074	09/10/2019	Other - Royalty	$11.59
	230590	10/07/2019	Other - Royalty	$11.31
			SUBTOTAL	$36.12
DOROTHY TURNER 37554 SR 143, BOX 172 RUTLAND, OH 45775	225889	08/05/2019	Other - Royalty	$20.07
	229084	09/10/2019	Other - Royalty	$19.27
	230601	10/07/2019	Other - Royalty	$15.42
			SUBTOTAL	$54.76
DRILLING PRODUCTS INC 250 WEST BERGER LANE SALT LAKE CITY, UT 84107	227177	08/19/2019	Suppliers or vendors	$18,543.51
	227178	08/19/2019	Suppliers or vendors	$6,027.70
			SUBTOTAL	$24,571.21
DRURY DEVELOPMENT CORP DRURY INN MARION 2706 WEST DEYOUNG MARION, IL 62959	230713	10/07/2019	Suppliers or vendors	$1,673.05
			SUBTOTAL	$1,673.05
DUQUESNE LIGHT ENERGY PO BOX 10 PITTSBURGH, PA 15230-0010	ACH	08/19/2019	Other - Utilities	$817.65
	230008	09/26/2019	Other - Utilities	$681.62
	231106	10/11/2019	Other - Utilities	$316.83
			SUBTOTAL	$1,816.10
E.D. LEWIS 100 LINCOLN HWY IMPERIAL, PA 15126	227586	08/23/2019	Suppliers or vendors	$6,016.53
			SUBTOTAL	$6,016.53

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EARTHTECH INC 966 PLEASANT HILL ROAD SOMERSET, PA 15501	226152	08/13/2019	Services	$3,975.00
	227527	08/23/2019	Services	$494.85
	227528	08/23/2019	Services	$7,330.16
	228421	09/06/2019	Services	$8,400.00
	229529	09/20/2019	Services	$8,400.00
	231121	10/11/2019	Services	$12,164.38
			SUBTOTAL	$40,764.39
EAST BANK MACHINE INC 7021 PENNSYLVANIA AVE FINLEYVILLE, PA 15332	227163	08/19/2019	Suppliers or vendors	$14,746.00
	228082	08/28/2019	Suppliers or vendors	$15,881.00
			SUBTOTAL	$30,627.00
EAST CARBON CITY 101 W. GENEVA DRIVE PO BOX 70 EAST CARBON, UT 84520	225351	08/02/2019	Other - Utilities	$165.00
	227322	08/23/2019	Other - Utilities	$45.00
	229931	09/26/2019	Other - Utilities	$45.00
			SUBTOTAL	$255.00
EAST COAST RISK MANAGEMENT LLC 40 LINCOLN WAY SUITE 201 NORTH HUNTINGDON, PA 15642	ACH	07/31/2019	Services	$4,343.11
	ACH	08/07/2019	Services	$34,231.36
	ACH	08/14/2019	Services	$13,890.90
	ACH	08/21/2019	Services	$33,061.26
	ACH	08/28/2019	Services	$12,190.81
	ACH	09/04/2019	Services	$30,719.07
	ACH	09/11/2019	Services	$8,498.58
	ACH	09/18/2019	Services	$34,082.65
	ACH	09/25/2019	Services	$6,696.41
	ACH	10/03/2019	Services	$31,920.54
	ACH	10/09/2019	Services	$9,873.87
	ACH	10/16/2019	Services	$31,366.98
	ACH	10/24/2019	Services	$7,929.84
			SUBTOTAL	$258,805.38
ECHO INDUSTRIES PO BOX 568 PRICE, UT 84501	226485	08/13/2019	Suppliers or vendors	$19,588.61
	226987	08/19/2019	Suppliers or vendors	$5,242.64
	231598	10/18/2019	Suppliers or vendors	$16,495.96
			SUBTOTAL	$41,327.21

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ECKO INC P.O. BOX 448 NORTH TAZEWELL, VA 24630	ACH	08/07/2019	Suppliers or vendors	$24,308.66
	ACH	08/19/2019	Suppliers or vendors	$38,015.81
	231528	10/16/2019	Suppliers or vendors	$27,050.00
	231529	10/16/2019	Suppliers or vendors	$2,500.00
			SUBTOTAL	$91,874.47
ECOM AMERICA LTD 1628 OAKBROOK DR GAINESVILLE, GA 30507	ACH	08/07/2019	Suppliers or vendors	$257.91
			SUBTOTAL	$257.91
EDOC SYSTEM GROUP 400-1208 WHARF STREET VICTORIA, BC V8W 3B9 CANADA	227614	08/23/2019	Suppliers or vendors	$50,770.40
			SUBTOTAL	$50,770.40
EDWARD THOMAS MORROW-MORROW HEIRSHI 125 GRANVILLE SQUARE, SUITE 400 MORGANTOWN, WV 26501	ACH	10/08/2019	Services	$33,340.00
			SUBTOTAL	$33,340.00
EDWARDS PUMP LLC PO BOX 425 CARMI, IL 62821	227486	08/23/2019	Suppliers or vendors	$1,268.21
	229467	09/20/2019	Suppliers or vendors	$51.38
	231070	10/11/2019	Suppliers or vendors	$194.78
			SUBTOTAL	$1,514.37
EFTPS - DIRECT PAYMENT ALBION RD LINCOLN, RI 02865	ACH	07/31/2019	Other - Regulatory/Tax	$6,600.30
	ACH	08/14/2019	Other - Regulatory/Tax	$690,000.00
	ACH	08/26/2019	Other - Regulatory/Tax	$55,524.09
	ACH	08/29/2019	Other - Regulatory/Tax	$569,000.00
	ACH	09/16/2019	Other - Regulatory/Tax	$861,000.00
	ACH	09/26/2019	Other - Regulatory/Tax	$3,202.67
	ACH	09/27/2019	Other - Regulatory/Tax	$604,000.00
	ACH	09/30/2019	Other - Regulatory/Tax	$516,000.00
	ACH	10/11/2019	Other - Regulatory/Tax	$147,000.00
	ACH	10/17/2019	Other - Regulatory/Tax	$17,220.00
			SUBTOTAL	$3,469,547.06
EFTPS - INTERNAL REVENUE SERVICE 324 25TH ST OGDEN, UT 84401	ACH	07/31/2019	Other - Regulatory/Tax	$2,565.15
	ACH	08/14/2019	Other - Regulatory/Tax	$60,000.00
	ACH	08/29/2019	Other - Regulatory/Tax	$15,000.00

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EFTPS - INTERNAL REVENUE SERVICE 324 25TH ST OGDEN, UT 84401	ACH	09/16/2019	Other - Regulatory/Tax	$125,000.00
	ACH	09/27/2019	Other - Regulatory/Tax	$73,000.00
	ACH	09/30/2019	Other - Regulatory/Tax	$50,000.00
	ACH	10/11/2019	Other - Regulatory/Tax	$52,500.00
			SUBTOTAL	$378,065.15
EIS ENVIROMENTAL & ENGINEERING CONS 31 NORTH MAIN STREET HELPER, UT 84526	ACH	08/19/2019	Suppliers or vendors	$1,500.00
	ACH	08/30/2019	Suppliers or vendors	$9,482.50
	ACH	09/13/2019	Suppliers or vendors	$3,617.60
	230511	10/07/2019	Suppliers or vendors	$2,665.95
			SUBTOTAL	$17,266.05
ELEANOR F. WRIGHT 1153 SOUTH MAIN STREET APT: H-2 GREENVILLE, MS 38701	227477	08/23/2019	Other - Royalty	$162.43
	229988	09/26/2019	Other - Royalty	$143.58
			SUBTOTAL	$306.01
ELEANOR P. TAYLOR MASTIN 244 TAHOMA ROAD LEXINGTON, KY 40503	227449	08/23/2019	Other - Royalty	$236.64
	229963	09/26/2019	Other - Royalty	$246.45
			SUBTOTAL	$483.09
ELECTRO CHEMICAL DEVICES INC 1500 N. KELLOGG DRIVE ANAHEIM, CA 92807	228403	09/06/2019	Suppliers or vendors	$2,021.37
			SUBTOTAL	$2,021.37
ELEMENT FLEET CORPORATION 5924 COLLECTIONS CENTER DRIVE CHICAGO, IL 60693	225465	08/02/2019	Suppliers or vendors	$124.88
			SUBTOTAL	$124.88
ELIZABETH REYNOLDS CARR CO-TRUSTEE 195 CARR LANE RICHMOND, KY 40475	227445	08/23/2019	Other - Royalty	$117.66
	229962	09/26/2019	Other - Royalty	$133.75
			SUBTOTAL	$251.41
ELLEN G. TAYLOR 24586 HARBOUR VIEW DR. PONTE VEDRA BEACH, FL 32082	229960	09/26/2019	Other - Royalty	$184.24
			SUBTOTAL	$184.24
ELLER & ASSOCIATES, INC. 6335 MITCH HAVEN DRIVE BETHEL PARK, PA 15102	225988	08/13/2019	Suppliers or vendors	$1,063.80

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ELLER & ASSOCIATES, INC. 6335 MITCH HAVEN DRIVE BETHEL PARK, PA 15102	225989	08/13/2019	Suppliers or vendors	$8,516.15
	225990	08/13/2019	Suppliers or vendors	$350.00
	230931	10/11/2019	Suppliers or vendors	$21,200.10
			SUBTOTAL	$31,130.05
ELM GROVE DODGE INC 2538 NATIONAL ROAD WHEELING, WV 26003	225356	08/02/2019	Suppliers or vendors	$6,293.78
	225357	08/02/2019	Suppliers or vendors	$673.03
	226650	08/19/2019	Suppliers or vendors	$1,117.78
	228273	09/06/2019	Suppliers or vendors	$1,259.76
	229275	09/20/2019	Suppliers or vendors	$5,158.44
	229276	09/20/2019	Suppliers or vendors	$105.84
	230899	10/11/2019	Suppliers or vendors	$649.00
	230900	10/11/2019	Suppliers or vendors	$6,145.55
			SUBTOTAL	$21,403.18
EMERY TELCOM PO BOX 629 ORANGEVILLE, UT 84537	227345	08/23/2019	Other - Utilities	$885.79
	Credit Card	08/27/2019	Other - Utilities	$1,266.69
	Credit Card	09/19/2019	Other - Utilities	$1,271.77
	229942	09/26/2019	Other - Utilities	$885.79
	Credit Card	10/18/2019	Other - Utilities	$1,273.35
			SUBTOTAL	$5,583.39
EMORY ROTHENBUHLER & SONS, INC 47126 SUNFISH CREEK RD. BEALLSVILLE, OH 43716	226614	08/19/2019	Services	$4,447.78
	227288	08/23/2019	Services	$6,453.02
	227289	08/23/2019	Services	$12,984.70
	230332	10/04/2019	Services	$3,074.80
	230446	10/07/2019	Services	$9,256.11
	230790	10/09/2019	Services	$2,142.00
	231494	10/16/2019	Services	$5,845.00
			SUBTOTAL	$44,203.41
EMORY ROTHENBUHLER & SONS, LTD 47126 SUNFISH CREEK ROAD BEALLSVILLE, OH 43716	226677	08/19/2019	Suppliers or vendors	$333,217.59
	230512	10/07/2019	Suppliers or vendors	$579,650.40
			SUBTOTAL	$912,867.99

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
ENCINA EQUIPMENT FINANCE SPV LLC 83 WOOSTER HEIGHTS ROAD SUITE 125 DANBURY, CT 06810	ACH	08/01/2019	Suppliers or vendors	$367,032.35
	ACH	09/03/2019	Suppliers or vendors	$367,032.35
	ACH	10/02/2019	Suppliers or vendors	$367,032.35
			SUBTOTAL	$1,101,097.05
ENVIRO TECHNOLOGIES INC 544 GREENTREE ROAD KITTANNING, PA 16201	226016	08/13/2019	Suppliers or vendors	$4,763.90
	227350	08/23/2019	Suppliers or vendors	$396.30
	227351	08/23/2019	Suppliers or vendors	$2,449.05
	229340	09/20/2019	Suppliers or vendors	$1,352.00
			SUBTOTAL	$8,961.25
ENVIRONMENTAL SYSTEMS RESEARCH INST PO BOX 741076 LOS ANGELES, CA 90074-1076	228370	09/06/2019	Suppliers or vendors	$1,500.00
			SUBTOTAL	$1,500.00
ENVIROSERVE INC. PO BOX 413070 SALT LAKE CITY, UT 84141-3070	228525	09/06/2019	Suppliers or vendors	$3,026.25
			SUBTOTAL	$3,026.25
ENVIRSYS LLC 8843 S IRIS CT LITTLETON, CO 80128	ACH	08/30/2019	Services	$2,150.00
			SUBTOTAL	$2,150.00
ERNST & YOUNG PITTSBURGH NATNL BANK PO BOX 640382 PITTSBURGH, PA 15264-0382	ACH	10/07/2019	Suppliers or vendors	$400,000.00
	ACH	10/11/2019	Suppliers or vendors	$221,321.00
			SUBTOTAL	$621,321.00
ESAB WELDING & CUTTING PRODUCTS PO BOX 417540 BOSTON, MA 02241-7540	226544	08/13/2019	Suppliers or vendors	$7,139.49
			SUBTOTAL	$7,139.49
EVA LOU YOHO AND WILLIAM J YOHO 691 FLAGGY MEADOW ROAD MANNINGTON, WV 26582	229724	09/20/2019	Suppliers or vendors	$135,000.00
			SUBTOTAL	$135,000.00
EVANSVILLE BOLT & NUT 1701 EAST COLUMBIA STREET EVANSVILLE, IN 47711	226926	08/19/2019	Suppliers or vendors	$3,200.43
			SUBTOTAL	$3,200.43

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
EVAPAR 9000 N. KENTUCKY AVE EVANSVILLE, IN 47725-1396	ACH	09/13/2019	Suppliers or vendors	$1,053.85
			SUBTOTAL	$1,053.85
EVELYN P BANE 11549 FORK RIDGE ROAD GLEN EASTON, WV 26039	229580	09/20/2019	Other - Royalty	$130.38
			SUBTOTAL	$130.38
EVERETT E HIGGINS PO BOX 9 SMITHFIELD, WV 26437	228547	09/06/2019	Suppliers or vendors	$2,000.00
			SUBTOTAL	$2,000.00
EVOLUTION AUTOMATION INC 660 COCHRAN MILL ROAD JEFFERSON HILLS, PA 15025	228143	08/28/2019	Suppliers or vendors	$17,793.63
			SUBTOTAL	$17,793.63
FABIAN VANCOTT 215 SOUTH STATE STREET SUITE 1200 SALT LAKE CITY, UT 84111-2323	ACH	10/25/2019	Services	$52,462.19
			SUBTOTAL	$52,462.19
FABICK MINING INC DBA FABICK MINING UNDERGROUND PO BOX 952121 ST LOUIS, MO 63195-2121	228133	08/28/2019	Suppliers or vendors	$20,296.46
			SUBTOTAL	$20,296.46
FAIRMONT LODGING LLC HOLIDAY INN EXPRESS & SUITES 2256 LANDING LANE FAIRMONT, WV 26554	225466	08/02/2019	Services	$142.60
	227640	08/23/2019	Services	$330.00
	231254	10/11/2019	Services	$908.60
			SUBTOTAL	$1,381.20
FAIRMONT STATE UNIVERSITY 1201 LOCUST AVE FAIRMONT, WV 26554	226757	08/19/2019	Suppliers or vendors	$2,100.00
			SUBTOTAL	$2,100.00
FALLOWFIELD TWP. TAX COLLECTOR 9 MEMORIAL DRIVE CHARLEROI, PA 15022	226697	08/19/2019	Other - Regulatory/Tax	$132.73
			SUBTOTAL	$132.73

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
FARNHAM & PFILE COMPANY INC 1200 MARONDA WAY STE 403B MONESSEN, PA 15062-1079	226188	08/13/2019	Suppliers or vendors	$2,555.16
	228461	09/06/2019	Suppliers or vendors	$7,394.11
	229577	09/20/2019	Suppliers or vendors	$2,645.16
	230692	10/07/2019	Suppliers or vendors	$7,394.11
			SUBTOTAL	$19,988.54
FASTFOX COURIER SERVICE PO BOX 61 MARION, IL 62959	226723	08/19/2019	Services	$12,350.00
	229429	09/20/2019	Services	$2,395.00
			SUBTOTAL	$14,745.00
FAUPEL FAMILY TRUST PO BOX 22319 LEXINGTON, KY 40522	227440	08/23/2019	Other - Royalty	$452.21
	229956	09/26/2019	Other - Royalty	$483.35
			SUBTOTAL	$935.56
FAYE E BROWN 41400 MT. HOREB RD. BETHESDA, OH 43719	228501	09/06/2019	Suppliers or vendors	$3,000.00
			SUBTOTAL	$3,000.00
FAYETTE PARTS SERVICE - NAPA PO BOX 645174 PITTSBURGH, PA 15264-5174	ACH	08/30/2019	Suppliers or vendors	$2,588.67
	ACH	09/13/2019	Suppliers or vendors	$858.99
			SUBTOTAL	$3,447.66
FE GENERATION CORP PO BOX 3687 AKRON, OH 44309-3687	229714	09/20/2019	Suppliers or vendors	$10,000.00
	231269	10/11/2019	Suppliers or vendors	$10,000.00
	Wire	10/28/2019	Suppliers or vendors	$40,000.00
			SUBTOTAL	$60,000.00
FEDEX CUSTOM CRITICAL PO BOX 645135 PITTSBIRGH, PA 15264-5135	226766	08/19/2019	Services	$2,179.74
			SUBTOTAL	$2,179.74

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
FEDEX FREIGHT WEST PO BOX 10306 PALATINE, IL 60055-0306	225370	08/02/2019	Services	$208.15
	226018	08/13/2019	Services	$1,458.43
	226678	08/19/2019	Services	$1,450.42
	227353	08/23/2019	Services	$207.98
	228297	09/06/2019	Services	$1,017.28
	229342	09/20/2019	Services	$690.39
	230513	10/07/2019	Services	$669.67
	230966	10/11/2019	Services	$1,108.58
			SUBTOTAL	$6,810.90
FEDEX FREIGHT PO BOX 223125 PITTSBURGH, PA 15251-2125	225402	08/02/2019	Services	$579.72
	225403	08/02/2019	Services	$199.48
	228363	09/06/2019	Services	$207.98
	230564	10/07/2019	Services	$319.59
			SUBTOTAL	$1,306.77
FEDEX PO BOX 371461 PITTSBURGH, PA 15250-7461	225401	08/02/2019	Services	$3,859.62
	226081	08/13/2019	Services	$113.12
	226082	08/13/2019	Services	$2,024.43
	227415	08/23/2019	Services	$5,176.05
	228358	09/06/2019	Services	$30.60
	228359	09/06/2019	Services	$950.14
	228360	09/06/2019	Services	$3,000.87
	229425	09/20/2019	Services	$348.77
	229426	09/20/2019	Services	$5,194.29
	230562	10/07/2019	Services	$200.57
	230563	10/07/2019	Services	$6,501.11
	231035	10/11/2019	Services	$172.03
	231036	10/11/2019	Services	$3,190.71
			SUBTOTAL	$30,762.31
FEIRICH MAGER GREEN RYAN 2001 WEST MAIN ST PO BOX 1570 CARBONDALE, IL 62903-1570	225993	08/13/2019	Services	$3,212.01
	229306	09/20/2019	Services	$1,612.60
			SUBTOTAL	$4,824.61

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
FEMCO HOLDINGS LLC FEMCO MACHINE 1000 GAMMA DRIVE, SUITE 600 PITTSBURGH, PA 15238	227206	08/19/2019	Suppliers or vendors	$3,415.04
			SUBTOTAL	$3,415.04
FENNER DUNLOP AMERICAS PO BOX 347625 PITTSBURGH, PA 15251-4625	226974	08/19/2019	Suppliers or vendors	$8,715.14
	226975	08/19/2019	Suppliers or vendors	$25,498.50
	226976	08/19/2019	Suppliers or vendors	$44,799.78
	226977	08/19/2019	Suppliers or vendors	$51,552.99
	227913	08/28/2019	Suppliers or vendors	$13,297.35
	227914	08/28/2019	Suppliers or vendors	$20,177.94
	228850	09/06/2019	Suppliers or vendors	$15,383.58
	231511	10/16/2019	Suppliers or vendors	$21,960.03
			SUBTOTAL	$201,385.31
FIFTH THIRD MCCF	ACH	08/20/2019	Services	$2,562.31
	ACH	09/20/2019	Services	$2,562.31
			SUBTOTAL	$5,124.62
FILTER SERVICE AND TESTING CORP PO BOX 1466 PRICE, UT 84501	229136	09/13/2019	Suppliers or vendors	$38,748.37
			SUBTOTAL	$38,748.37
FIRST ENERGY SOLUTIONS CORPORATION PO BOX 3622 AKRON, OH 44309	ACH	08/15/2019	Other - Utilities	$11,401,875.12
			SUBTOTAL	$11,401,875.12
FKC-LAKESHORE 1695 ALLEN ROAD PO BOX 6690 EVANSVILLE, IN 47719	226486	08/13/2019	Suppliers or vendors	$234,950.20
	228860	09/06/2019	Suppliers or vendors	$117,475.10
	230369	10/04/2019	Suppliers or vendors	$11,898.99
	230370	10/04/2019	Suppliers or vendors	$8,250.00
	230371	10/04/2019	Suppliers or vendors	$44.00
	230372	10/04/2019	Suppliers or vendors	$21,592.56
	230373	10/04/2019	Suppliers or vendors	$139,697.50
	231406	10/11/2019	Suppliers or vendors	$3,966.33
	231407	10/11/2019	Suppliers or vendors	$357,399.82
			SUBTOTAL	$895,274.50

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
FLAHERTY SENSABAUGH BONASSO PLLC PO BOX 3843 CHARLESTON, WV 25338	226204	08/13/2019	Services	$1,035.50
	229628	09/20/2019	Services	$74.33
	ACH	10/25/2019	Services	$7,905.88
			SUBTOTAL	$9,015.71
FLORIAN TURNER BENSON 1998 BELLE AVENUE SAN CARLOS, CA 94070	227468	08/23/2019	Other - Royalty	$160.68
			SUBTOTAL	$160.68
FLSMIDTH INC - CHARLESTON OPERATIONS 16002 WINFIELD ROAD FRAZIERS BOTTOM, WV 25082	ACH	09/13/2019	Suppliers or vendors	$180,866.23
			SUBTOTAL	$180,866.23
FLSMIDTH INC DEPT. 3252 PO BOX 123252 DALLAS, TX 75312-3252	227040	08/19/2019	Suppliers or vendors	$3,289.98
	227962	08/28/2019	Suppliers or vendors	$45,520.00
	228894	09/06/2019	Suppliers or vendors	$2,326.61
	228895	09/06/2019	Suppliers or vendors	$45,000.00
	228896	09/06/2019	Suppliers or vendors	$364.58
	228897	09/06/2019	Suppliers or vendors	$100,988.82
	231646	10/18/2019	Suppliers or vendors	$2,720.64
			SUBTOTAL	$200,210.63
FLSMIDTH INC TUCSON OPERATIONS DEPT 3252 PO BOX 123252 DALLAS, TX 75312-3252	227181	08/19/2019	Suppliers or vendors	$6,938.64
			SUBTOTAL	$6,938.64
FLUID COMPONENT SERVICES A DIVISION OF RG INDUSTRIES, INC. PO BOX 62744 BALTIMORE, MD 21264	226942	08/19/2019	Suppliers or vendors	$12,752.00
	226943	08/19/2019	Suppliers or vendors	$3,772.00
	226944	08/19/2019	Suppliers or vendors	$14,625.90
	227876	08/28/2019	Suppliers or vendors	$391.00
	227877	08/28/2019	Suppliers or vendors	$2,720.00
	228791	09/06/2019	Suppliers or vendors	$1,174.00
			SUBTOTAL	$35,434.90

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
FORESTRY SUPPLIERS, INC. 205 WEST RANKIN STREET PO BOX 8397 JACKSON, MS 39284	228298	09/06/2019	Suppliers or vendors	$720.30
			SUBTOTAL	$720.30
FORQUER CONTRACTING PO BOX 123 PENTRESS, WV 26544-0123	225815	08/05/2019	Suppliers or vendors	$69,300.00
	227169	08/19/2019	Suppliers or vendors	$24,387.50
	227170	08/19/2019	Suppliers or vendors	$11,288.75
	227171	08/19/2019	Suppliers or vendors	$19,183.50
	228092	08/28/2019	Suppliers or vendors	$1,000.00
	228093	08/28/2019	Suppliers or vendors	$11,700.00
	228094	08/28/2019	Suppliers or vendors	$47,766.00
	228095	08/28/2019	Suppliers or vendors	$40,250.00
	229157	09/18/2019	Suppliers or vendors	$47,469.00
	230047	09/27/2019	Suppliers or vendors	$2,000.00
	230048	09/27/2019	Suppliers or vendors	$22,991.00
	230049	09/27/2019	Suppliers or vendors	$32,400.00
	230050	09/27/2019	Suppliers or vendors	$42,175.00
	230422	10/04/2019	Suppliers or vendors	$25,000.00
	230426	10/07/2019	Suppliers or vendors	$40,816.00
	230427	10/07/2019	Suppliers or vendors	$60,553.70
	231478	10/11/2019	Suppliers or vendors	$77,750.00
			SUBTOTAL	$576,030.45
FORT MASON MACHINE COMPANY P O BOX 729 MASONTOWN, PA 15461	227158	08/19/2019	Suppliers or vendors	$3,250.00
	228998	09/06/2019	Suppliers or vendors	$2,750.00
			SUBTOTAL	$6,000.00
FOURT INDUSTRIAL SUPPLIES INC 1761 W UNIVERSITY DR., STE 142 TEMPE, AZ 85281	228157	08/28/2019	Suppliers or vendors	$5,000.00
			SUBTOTAL	$5,000.00
FP MAILING SOLUTIONS FRANCOTYP-POSTALIA, INC. P.O. BOX 157 BEDFORD PARK, IL 60499-0157	ACH	08/19/2019	Suppliers or vendors	$81.00
			SUBTOTAL	$81.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
FRANCES ALKIRE 38461 SR 684 POMEROY, OH 45769	225855	08/05/2019	Other - Royalty	$2.24
	229052	09/10/2019	Other - Royalty	$2.52
			SUBTOTAL	$4.76
FRANCES GREEN SWINK 6615 SOUTH IRBY STREET EFFINGHAM, SC 29541	227485	08/23/2019	Other - Royalty	$162.41
	229997	09/26/2019	Other - Royalty	$143.59
			SUBTOTAL	$306.00
FRANCES POSTLETWAIT 517 POGUE RUN RD BURTON, WV 26562	225474	08/02/2019	Suppliers or vendors	$16,370.00
			SUBTOTAL	$16,370.00
FRANCIS ENTERPRISES INC PO BOX 2284 WESTOVER, WV 26502-2284	226988	08/19/2019	Suppliers or vendors	$12,974.93
	226989	08/19/2019	Suppliers or vendors	$363.83
	227925	08/28/2019	Suppliers or vendors	$12,294.70
			SUBTOTAL	$25,633.46
FRANCO A PINACCHIO 125 RANDALL AVE. FOLLANSBEE, WV 26037	229851	09/23/2019	Suppliers or vendors	$71,250.00
			SUBTOTAL	$71,250.00
FRANK H. FERREL DBA SOCRATES SOLUTIONS 57460 PINCH RUN ROAD BELLAIRE, OH 43906	225439	08/02/2019	Suppliers or vendors	$4,260.00
	226169	08/13/2019	Suppliers or vendors	$2,240.00
	228434	09/06/2019	Suppliers or vendors	$2,690.00
	229550	09/20/2019	Suppliers or vendors	$1,120.00
	229551	09/20/2019	Suppliers or vendors	$2,130.00
	230673	10/07/2019	Suppliers or vendors	$2,130.00
	230674	10/07/2019	Suppliers or vendors	$3,810.00
	231148	10/11/2019	Suppliers or vendors	$1,570.00
	231149	10/11/2019	Suppliers or vendors	$1,680.00
			SUBTOTAL	$21,630.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
FRANK RAMOS 414 PARKWAY AVE. MONESSEN, PA 15062	226821	08/19/2019	Services	$1,080.00
	228494	09/06/2019	Services	$1,680.00
	229642	09/20/2019	Services	$810.00
	230717	10/07/2019	Services	$2,250.00
	231222	10/11/2019	Services	$1,350.00
			SUBTOTAL	$7,170.00
FRANKES WOOD PRODUCTS INC 825 COLLINS AVE. MARYSVILLE, OH 43040	227201	08/19/2019	Suppliers or vendors	$3,071.68
	231582	10/17/2019	Suppliers or vendors	$2,504.68
			SUBTOTAL	$5,576.36
FRANKLIN COUNTY TITLE CO INC. 106 WEST MAIN STREET, PO BOX 577 BENTON, IL 62812	230769	10/07/2019	Suppliers or vendors	$1,353.00
			SUBTOTAL	$1,353.00
FREEPORT GAS COAL COMPANY TRUST 5301 GRANT AVE, SUITE 100 CLEVELAND, OH 44125	229609	09/20/2019	Other - Royalty	$1,000.00
			SUBTOTAL	$1,000.00
FREEPORT TERMINALS INC PO BOX 29 BUTLER, PA 16003-0029	225445	08/02/2019	Suppliers or vendors	$2,000.00
			SUBTOTAL	$2,000.00
FREEPORT TOWNSHIP COLLECTOR 860 GOLDEN OAKS ROAD NEW FREEPORT, PA 15352	229639	09/20/2019	Other - Regulatory/Tax	$51,109.63
			SUBTOTAL	$51,109.63
FREMER RECLAMATION, INC. 1915 FERMANTOWN RD BROCKWAY, PA 15824	230913	10/11/2019	Suppliers or vendors	$39,500.00
			SUBTOTAL	$39,500.00
FREY LUMBER & PALLET CORP 2883 MORGANTOWN RD SMITHFIELD, PA 15478	227160	08/19/2019	Suppliers or vendors	$7,261.50
	227161	08/19/2019	Suppliers or vendors	$11,025.00
	227162	08/19/2019	Suppliers or vendors	$18,512.40
	231621	10/18/2019	Suppliers or vendors	$25,745.84
			SUBTOTAL	$62,544.74

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
FRITZ-RUMER-COOKE CO INC PO BOX 07884 COLUMBUS, OH 43207	227146	08/19/2019	Suppliers or vendors	$10,373.39
	228067	08/28/2019	Suppliers or vendors	$1,643.50
	230072	10/02/2019	Suppliers or vendors	$89,593.50
			SUBTOTAL	$101,610.39
FRONTIER COMMUNICATIONS ATTN: SPB PO BOX 639406 CINCINNATI, OH 45263-9406	231268	10/11/2019	Other - Utilities	$8,990.00
			SUBTOTAL	$8,990.00
FRONTIER WEST VIRGINIA ATTN:ACCESS BILLING PO BOX 639459 CINCINNATI, OH 45263-9459	225444	08/02/2019	Other - Utilities	$239.62
	228470	09/06/2019	Other - Utilities	$1,150.28
	230187	10/03/2019	Other - Utilities	$1,150.28
			SUBTOTAL	$2,540.18
FRONTIER PO BOX 20550 ROCHESTER, NY 14602-0550	Credit Card	09/19/2019	Other - Utilities	$138.98
			SUBTOTAL	$138.98
FRONTIER PO BOX 740407 CINCINNATI, OH 45274-0407	227597	08/23/2019	Other - Utilities	$29,647.39
	227598	08/23/2019	Other - Utilities	$1,574.22
	Credit Card	08/27/2019	Other - Utilities	$1,292.41
	Credit Card	08/28/2019	Other - Utilities	$2,354.57
	228497	09/06/2019	Other - Utilities	$1,609.47
	Credit Card	09/19/2019	Other - Utilities	$4,792.79
	231225	10/11/2019	Other - Utilities	$26,823.57
	231226	10/11/2019	Other - Utilities	$1,574.22
	Credit Card	10/18/2019	Other - Utilities	$3,294.43
			SUBTOTAL	$72,963.07
FROST BROWN TODD, LLC PO BOX 5716 CINCINNATI, OH 42501-5716	229280	09/20/2019	Services	$22,404.00
	230481	10/07/2019	Services	$32,463.50
	230904	10/11/2019	Services	$7,383.00
			SUBTOTAL	$62,250.50
FUCHS LUBRICANTS CO. PO BOX 71735 CHICAGO, IL 60694-1735	226617	08/19/2019	Suppliers or vendors	$4,769.62
	226857	08/19/2019	Suppliers or vendors	$72,475.10
	226858	08/19/2019	Suppliers or vendors	$71,349.48

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
FUCHS LUBRICANTS CO. PO BOX 71735 CHICAGO, IL 60694-1735	226859	08/19/2019	Suppliers or vendors	$2,412.00
	226860	08/19/2019	Suppliers or vendors	$15,471.68
	226861	08/19/2019	Suppliers or vendors	$23,324.50
	226862	08/19/2019	Suppliers or vendors	$2,184.00
	226863	08/19/2019	Suppliers or vendors	$30,004.87
	226864	08/19/2019	Suppliers or vendors	$48,726.62
	226865	08/19/2019	Suppliers or vendors	$623.84
	227767	08/28/2019	Suppliers or vendors	$54,194.76
	227768	08/28/2019	Suppliers or vendors	$103,306.95
	227769	08/28/2019	Suppliers or vendors	$2,873.52
	227770	08/28/2019	Suppliers or vendors	$16,186.80
	227771	08/28/2019	Suppliers or vendors	$17,489.10
	227772	08/28/2019	Suppliers or vendors	$1,092.00
	227773	08/28/2019	Suppliers or vendors	$530.75
	227774	08/28/2019	Suppliers or vendors	$31,754.54
	227775	08/28/2019	Suppliers or vendors	$20,824.50
	227776	08/28/2019	Suppliers or vendors	$1,597.20
	229860	09/25/2019	Suppliers or vendors	$3,210.90
	229861	09/25/2019	Suppliers or vendors	$133,708.02
	229862	09/25/2019	Suppliers or vendors	$241,487.32
	229863	09/25/2019	Suppliers or vendors	$119,097.20
	229864	09/25/2019	Suppliers or vendors	$128,450.29
	229865	09/25/2019	Suppliers or vendors	$95,803.56
	229866	09/25/2019	Suppliers or vendors	$4,594.80
	229867	09/25/2019	Suppliers or vendors	$5,460.00
	229868	09/25/2019	Suppliers or vendors	$135,922.45
	229869	09/25/2019	Suppliers or vendors	$128,588.93
	229870	09/25/2019	Suppliers or vendors	$1,032.10
	229871	09/25/2019	Suppliers or vendors	$3,276.35
	229872	09/25/2019	Suppliers or vendors	$10,167.90
	229873	09/25/2019	Suppliers or vendors	$4,048.20
	231355	10/11/2019	Suppliers or vendors	$3,502.80
	231356	10/11/2019	Suppliers or vendors	$100,568.86
	231357	10/11/2019	Suppliers or vendors	$46,433.40
	231358	10/11/2019	Suppliers or vendors	$64,661.70
	231359	10/11/2019	Suppliers or vendors	$44,700.00
	231360	10/11/2019	Suppliers or vendors	$50,239.14
	231361	10/11/2019	Suppliers or vendors	$441.00
	231362	10/11/2019	Suppliers or vendors	$69,037.28
	231363	10/11/2019	Suppliers or vendors	$23,291.48

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FUCHS LUBRICANTS CO. PO BOX 71735 CHICAGO, IL 60694-1735	231364	10/11/2019	Suppliers or vendors	$18,117.90
	231658	10/22/2019	Suppliers or vendors	$66.68
	231659	10/22/2019	Suppliers or vendors	$14,928.20
	231660	10/22/2019	Suppliers or vendors	$123,079.80
	231661	10/22/2019	Suppliers or vendors	$4,527.50
	231662	10/22/2019	Suppliers or vendors	$24,913.23
	231663	10/22/2019	Suppliers or vendors	$11,659.02
	231664	10/22/2019	Suppliers or vendors	$2,210.20
	231665	10/22/2019	Suppliers or vendors	$39,513.36
	231666	10/22/2019	Suppliers or vendors	$81,246.49
	231667	10/22/2019	Suppliers or vendors	$1,740.00
	231668	10/22/2019	Suppliers or vendors	$1,038.40
			SUBTOTAL	$2,261,956.29
FUTURE FUND BOARD OF GUARDIANS 46226 NATIONAL ROAD ST.CLAIRSVILLE, OH 43950	ACH	09/09/2019	Suppliers or vendors	$22,782.50
			SUBTOTAL	$22,782.50
FYDA FREIGHTLINER PITTSBURGH INC 20 FYDA DRIVE CANNONSBURG, PA 15317	226803	08/19/2019	Suppliers or vendors	$212.48
	230693	10/07/2019	Suppliers or vendors	$46.55
			SUBTOTAL	$259.03
GAI CONSULTANTS INC 385 E WATERFRONT DRIVE PITTSBURGH, PA 15120	225424	08/02/2019	Services	$3,945.00
	227522	08/23/2019	Services	$325.00
			SUBTOTAL	$4,270.00
GALLO EQUIPMENT COMPANY 11835 SOUTH AVENUE O CHICAGO, IL 60617	225682	08/05/2019	Suppliers or vendors	$13,000.00
	225683	08/05/2019	Suppliers or vendors	$1,064.84
			SUBTOTAL	$14,064.84
GARRETT AND AMY O'NEIL BERRY, KESSLER,CRUTCHFIELD,TAYLOR,G 9860 FORK RIDGE ROAD GLEN EASTON, WV 26039	228172	08/30/2019	Suppliers or vendors	$212,500.00
			SUBTOTAL	$212,500.00
GARY FASSLER DECKHAND MANUAL PO BOX 343 TITUSVILLE, NJ 08560-1824	227607	08/23/2019	Suppliers or vendors	$437.00
			SUBTOTAL	$437.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
GATES SUPPLY COMPANY 363 RAGLAND RD BECKLEY, WV 25801	228982	09/06/2019	Suppliers or vendors	$27.15
	231572	10/17/2019	Suppliers or vendors	$676.24
	231618	10/18/2019	Suppliers or vendors	$513.91
			SUBTOTAL	$1,217.30
GAYDOS & TURNER PLLC PO BOX 585 KINGWOOD, WV 26537	226267	08/13/2019	Services	$1,175.00
	231263	10/11/2019	Services	$9,306.36
	ACH	10/25/2019	Services	$6,103.00
			SUBTOTAL	$16,584.36
GEMINI VALVE SALES & SERVICE 2 OTTER COURT RAYMOND, NH 03077	228544	09/06/2019	Suppliers or vendors	$729.39
			SUBTOTAL	$729.39
GENCO MINE SERVICE PO BOX 581 HUNTINGTON, UT 84528-1002	226487	08/13/2019	Suppliers or vendors	$1,524.63
	226990	08/19/2019	Suppliers or vendors	$38,005.88
	227926	08/28/2019	Suppliers or vendors	$11,056.57
			SUBTOTAL	$50,587.08
GENE JEFFERS 32076 WOODYARD ROAD ALBANY, OH 45710	225869	08/05/2019	Other - Royalty	$79.90
	229065	09/10/2019	Other - Royalty	$77.07
	230581	10/07/2019	Other - Royalty	$58.60
			SUBTOTAL	$215.57
GENERAL PRODUCTS & SUPPLY INC. 101 TECHNOLOGY LANE EXPORT, PA 15632	228068	08/28/2019	Suppliers or vendors	$316.76
	228069	08/28/2019	Suppliers or vendors	$997.67
	228070	08/28/2019	Suppliers or vendors	$4,448.48
	228983	09/06/2019	Suppliers or vendors	$19,600.00
	228984	09/06/2019	Suppliers or vendors	$11,356.50
			SUBTOTAL	$36,719.41
GENERAL TIRE SALES 465 NORTH 2ND AVENUE MIDDLEPORT, OH 45760	231043	10/11/2019	Suppliers or vendors	$882.70
			SUBTOTAL	$882.70
GEORGE E RECTOR 71382 SHARON ROAD BRIDGEPORT, OH 43912	226251	08/13/2019	Services	$3,593.48
	226836	08/19/2019	Services	$3,595.80

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
GEORGE E RECTOR 71382 SHARON ROAD BRIDGEPORT, OH 43912	228526	09/06/2019	Services	$1,577.72
	229692	09/20/2019	Services	$2,962.16
	231249	10/11/2019	Services	$1,568.44
			SUBTOTAL	$13,297.60
GEOSHACK OHIO LLC PO BOX 224199 DALLAS, TX 75222-4199	229343	09/20/2019	Suppliers or vendors	$16,209.99
			SUBTOTAL	$16,209.99
GERARD SPINNER DBA E & G CONSTRUCTION 18067 DEER TRAIL HILLSBORO, IL 62049	226227	08/13/2019	Services	$13,980.00
	226823	08/19/2019	Services	$13,995.00
	231227	10/11/2019	Services	$34,170.00
	229649	10/24/2019	Services	$27,960.00
			SUBTOTAL	$90,105.00
GILMAN KIRK 2125 ACKLEY PLACE COLUMBUS, OH 43219	225876	08/05/2019	Other - Royalty	$59.10
	229072	09/10/2019	Other - Royalty	$57.43
	230588	10/07/2019	Other - Royalty	$58.60
			SUBTOTAL	$175.13
GILMORE TOWNSHIP TAX COLLECTOR 119 MINNIEHILL RD NEW FREEPORT, PA 15352	226192	08/13/2019	Other - Regulatory/Tax	$54,729.60
	226193	08/13/2019	Other - Regulatory/Tax	$130.45
			SUBTOTAL	$54,860.05
GILSON ENGINEERING SALES, INC. 535 ROCHESTER ROAD PITTSBURGH, PA 15237-8099	231470	10/11/2019	Suppliers or vendors	$5,959.62
	231471	10/11/2019	Suppliers or vendors	$32,513.72
	231472	10/11/2019	Suppliers or vendors	$1,187.75
			SUBTOTAL	$39,661.09
GL SERVICES 2727 BRANDONVILLE PIKE TERA ALTA, WV 26764	226597	08/13/2019	Services	$48,500.00
	226598	08/13/2019	Services	$360,029.90
	228162	08/28/2019	Services	$53,843.24
	229043	09/06/2019	Services	$333,427.16
			SUBTOTAL	$795,800.30

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
GLAS TRUST COMPANY LLC 230 PARK AVENUE-SUITE 1000 NEW YORK, NY 10169	ACH	07/31/2019	Secured Debt	$153,452.25
	ACH	08/30/2019	Secured Debt	$44,159,427.87
			SUBTOTAL	$44,312,880.12
GLOBAL MINE SERVICE, INC. PO BOX 188 FAYETTE CITY, PA 15438-0188	225684	08/05/2019	Suppliers or vendors	$82,273.09
	225685	08/05/2019	Suppliers or vendors	$59,760.35
	225686	08/05/2019	Suppliers or vendors	$65,840.16
	225687	08/05/2019	Suppliers or vendors	$132,874.81
	225688	08/05/2019	Suppliers or vendors	$2,260.66
	225689	08/05/2019	Suppliers or vendors	$28,848.02
	225690	08/05/2019	Suppliers or vendors	$22,504.28
	226019	08/13/2019	Suppliers or vendors	$2,510.00
	226488	08/13/2019	Suppliers or vendors	$13,501.87
	226489	08/13/2019	Suppliers or vendors	$2,767.48
	226490	08/13/2019	Suppliers or vendors	$75,883.44
	226491	08/13/2019	Suppliers or vendors	$49,141.86
	226492	08/13/2019	Suppliers or vendors	$8,861.54
	226493	08/13/2019	Suppliers or vendors	$19,065.74
	226991	08/19/2019	Suppliers or vendors	$5,543.68
	226992	08/19/2019	Suppliers or vendors	$72,301.31
	226993	08/19/2019	Suppliers or vendors	$65,634.60
	226994	08/19/2019	Suppliers or vendors	$4,900.00
	226995	08/19/2019	Suppliers or vendors	$3,386.86
	226996	08/19/2019	Suppliers or vendors	$18,212.32
	227927	08/28/2019	Suppliers or vendors	$10,452.45
	227928	08/28/2019	Suppliers or vendors	$20,051.57
	227929	08/28/2019	Suppliers or vendors	$216,474.12
	227930	08/28/2019	Suppliers or vendors	$13,231.48
	227931	08/28/2019	Suppliers or vendors	$22,380.02
	227932	08/28/2019	Suppliers or vendors	$21,899.16
	227933	08/28/2019	Suppliers or vendors	$9,870.00
	228861	09/06/2019	Suppliers or vendors	$95,665.10
	228862	09/06/2019	Suppliers or vendors	$82,730.86
	228863	09/06/2019	Suppliers or vendors	$9,444.29
	228864	09/06/2019	Suppliers or vendors	$56,231.48
	228865	09/06/2019	Suppliers or vendors	$56,040.16
	228866	09/06/2019	Suppliers or vendors	$8,850.00
	228867	09/06/2019	Suppliers or vendors	$8,220.00
	228868	09/06/2019	Suppliers or vendors	$33,638.19

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
GLOBAL MINE SERVICE, INC. PO BOX 188 FAYETTE CITY, PA 15438-0188	228869	09/06/2019	Suppliers or vendors	$7,091.01
	229906	09/26/2019	Suppliers or vendors	$4,581.45
	229907	09/26/2019	Suppliers or vendors	$19,009.91
	230514	10/07/2019	Suppliers or vendors	$4,484.87
	230824	10/10/2019	Suppliers or vendors	$4,470.00
	231490	10/14/2019	Suppliers or vendors	$1,420.00
	231547	10/17/2019	Suppliers or vendors	$6,084.60
	231644	10/18/2019	Suppliers or vendors	$3,090.74
	231645	10/18/2019	Suppliers or vendors	$2,212.80
	231685	10/22/2019	Suppliers or vendors	$5,608.30
	231686	10/22/2019	Suppliers or vendors	$7,520.00
			SUBTOTAL	$1,466,824.63
GMS MINE REPAIR & MAINTENANCE PO BOX 2446 MT LAKE PARK, MD 21550	226494	08/13/2019	Suppliers or vendors	$109,171.22
	226495	08/13/2019	Suppliers or vendors	$31,988.51
	226496	08/13/2019	Suppliers or vendors	$18,262.32
	226497	08/13/2019	Suppliers or vendors	$18,602.35
	226498	08/13/2019	Suppliers or vendors	$12,500.00
	226499	08/13/2019	Suppliers or vendors	$10,270.63
	226997	08/19/2019	Suppliers or vendors	$111,167.09
	226998	08/19/2019	Suppliers or vendors	$14,124.72
	226999	08/19/2019	Suppliers or vendors	$30,549.66
	227000	08/19/2019	Suppliers or vendors	$23,437.10
	227001	08/19/2019	Suppliers or vendors	$10,333.07
	227002	08/19/2019	Suppliers or vendors	$17,220.22
	227934	08/28/2019	Suppliers or vendors	$194,344.85
	227935	08/28/2019	Suppliers or vendors	$12,245.63
	227936	08/28/2019	Suppliers or vendors	$14,261.50
	231514	10/16/2019	Suppliers or vendors	$24,900.00
			SUBTOTAL	$653,378.87
GOGO BUSINESS AVIATION INC. 11001 W 120TH AVE., SUITE 310 BROOMFIELD, CO 80021	Credit Card	08/27/2019	Services	$19,055.04
	Credit Card	10/18/2019	Services	$9,527.52
			SUBTOTAL	$28,582.56

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GOLDMAN SACHS CREDIT PARTNERS 200 WEST STREET NEW YORK, NY 10282	ACH	08/02/2019	Secured Debt	$562,500.00
	ACH	09/20/2019	Secured Debt	$562,500.00
	ACH	10/02/2019	Secured Debt	$337,500.00
	ACH	10/03/2019	Secured Debt	$3,662,064.09
	ACH	10/04/2019	Secured Debt	$21,100,000.00
	ACH	10/18/2019	Secured Debt	$14,000,000.00
			SUBTOTAL	$40,224,564.09
GORDON GOETZ JOHNSON CALDWELL PSC 121 W. 2ND STREET OWENSBORO, KY 42303	226835	08/19/2019	Services	$67.50
	228524	09/06/2019	Services	$6,457.50
	229124	09/12/2019	Services	$520.00
	229689	09/20/2019	Services	$585.00
			SUBTOTAL	$7,630.00
GOULD'S ELECTRIC MOTOR REPAIR, INC. PO BOX 100 INDORE, WV 25111-0100	ACH	08/30/2019	Suppliers or vendors	$10,302.41
			SUBTOTAL	$10,302.41
GRANDVIEW-DOOLIN PSD 120 PLUM STREET PROCTOR, WV 26055	228462	09/06/2019	Other - Utilities	$1,686.10
	230019	09/26/2019	Other - Utilities	$2,161.75
			SUBTOTAL	$3,847.85
GRANITE TELECOMMUNICATIONS CLIENT ID 311 PO BOX 983119 BOSTON, MA 02298-3119	ACH	08/19/2019	Other - Utilities	$27,059.49
	230016	09/26/2019	Other - Utilities	$11,860.77
	230017	09/26/2019	Other - Utilities	$14,247.89
			SUBTOTAL	$53,168.15
GRANVILLE HOSPITALITY GROUP LLC FAIRFIELD INN & SUITES 2500 UNIVERSITY TOWN CENTRE DRIVE MORGANTOWN, WV 26501	226209	08/13/2019	Services	$221.76
	230710	10/07/2019	Services	$2,543.99
	231210	10/11/2019	Services	$665.28
			SUBTOTAL	$3,431.03
GRAY PHYSICIANS SUPPLY, INC. 1324 GRAHAM AVENUE STE 2 WINDBER, PA 15963	226098	08/13/2019	Suppliers or vendors	$1,153.69
	226742	08/19/2019	Suppliers or vendors	$3,924.60

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GRAY PHYSICIANS SUPPLY, INC. 1324 GRAHAM AVENUE STE 2 WINDBER, PA 15963	228378	09/06/2019	Suppliers or vendors	$5,813.94
	228379	09/06/2019	Suppliers or vendors	$888.00
	229463	09/20/2019	Suppliers or vendors	$942.59
	229464	09/20/2019	Suppliers or vendors	$589.86
	230625	10/07/2019	Suppliers or vendors	$2,357.97
			SUBTOTAL	$15,670.65
GRAYMONT WESTERN US, INC. GRAYMONT CAPITAL, INC. DEPT. CH 17976 PALATINE, IL 60055-7976	228870	09/06/2019	Suppliers or vendors	$4,312.39
			SUBTOTAL	$4,312.39
GRAYSON RURAL ELECTRIC COOP CORP 109 BAGBY PARK GRAYSON, KY 41143-1203	226741	08/19/2019	Other - Utilities	$416.59
	229461	09/20/2019	Other - Utilities	$455.45
	231065	10/11/2019	Other - Utilities	$458.78
			SUBTOTAL	$1,330.82
GREATAMERICA FINANCIAL SERVICES PO BOX 660831 DALLAS, TX 75266-0831	228435	09/06/2019	Suppliers or vendors	$1,572.82
	230675	10/07/2019	Suppliers or vendors	$1,741.50
			SUBTOTAL	$3,314.32
GREENE COUNTY HOTEL ASSOC HAMPTON I HAMPTON INN WAYNESBURG 227 GREENE PLAZA WAYNESBURG, PA 15370	226210	08/13/2019	Services	$648.55
			SUBTOTAL	$648.55
GREENE COUNTY TREASURER 93 EAST HIGH STREET WAYNESBURG, PA 15370	227561	08/23/2019	Other - Regulatory/Tax	$510.00
	227562	08/23/2019	Other - Regulatory/Tax	$135.26
			SUBTOTAL	$645.26
GREENSFELDER,HEMKER & GALE PC 10 SOUTH BROADWAY, SUITE 2000 ST LOUIS, MO 63102	230923	10/11/2019	Services	$318.00
			SUBTOTAL	$318.00
GREENWELL INN & CONVENTION CENTER 655 EAST MAIN STREET PRICE, UT 84501	226020	08/13/2019	Services	$1,851.50
	227354	08/23/2019	Services	$400.00
			SUBTOTAL	$2,251.50

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GREER INDUSTRIES, INC. P.O. BOX 536221 PITTSBURGH, PA 15253-5904	225763	08/05/2019	Suppliers or vendors	$40,551.12
	225764	08/05/2019	Suppliers or vendors	$4,689.68
	226563	08/13/2019	Suppliers or vendors	$18,962.46
	226564	08/13/2019	Suppliers or vendors	$10,983.98
	226565	08/13/2019	Suppliers or vendors	$17,381.56
	228194	09/04/2019	Suppliers or vendors	$2,846.91
	228195	09/04/2019	Suppliers or vendors	$46,234.16
	228196	09/04/2019	Suppliers or vendors	$40,074.59
	228197	09/04/2019	Suppliers or vendors	$116,029.69
	230406	10/04/2019	Suppliers or vendors	$21,954.38
	230407	10/04/2019	Suppliers or vendors	$11,195.70
	230408	10/04/2019	Suppliers or vendors	$22,822.26
	230803	10/09/2019	Suppliers or vendors	$2,400.00
	231615	10/18/2019	Suppliers or vendors	$2,450.00
	231648	10/18/2019	Suppliers or vendors	$2,400.00
	Wire	10/28/2019	Suppliers or vendors	$40,966.61
			SUBTOTAL	$401,943.10
GREGORY D FOWLER DBA GDF CONSULTING LLC 1405 LETART ROAD POINT PLEASANT, WV 25550	227413	08/23/2019	Services	$19,500.00
	231032	10/11/2019	Services	$10,500.00
	231033	10/11/2019	Services	$7,500.00
			SUBTOTAL	$37,500.00
GREGORY F BOLISH SAFETY FIRST FIRE EQUIPMENT 250 FURNACE HILL ROAD DUNBAR, PA 15431	227532	08/23/2019	Suppliers or vendors	$4,864.50
	228424	09/06/2019	Suppliers or vendors	$411.75
			SUBTOTAL	$5,276.25
GREGORY S. WILLIAMS 4434 RACCOON VALLEY ROAD ALEXANDRIA, OH 43001	225410	08/02/2019	Suppliers or vendors	$440.00
	230630	10/07/2019	Suppliers or vendors	$440.00
	231616	10/18/2019	Suppliers or vendors	$2,010.00
			SUBTOTAL	$2,890.00
GROVER RIDDLE 36185 WOLFE PEN ROAD POMEROY, OH 45769	225884	08/05/2019	Other - Royalty	$33.17
	229079	09/10/2019	Other - Royalty	$41.82
	230596	10/07/2019	Other - Royalty	$36.81
			SUBTOTAL	$111.80

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
GUY CORPORATION 92 16TH ST, 2ND FLOOR WHEELING, WV 26003	226646	08/19/2019	Other - Royalty	$425.09
	229265	09/20/2019	Other - Royalty	$425.09
			SUBTOTAL	$850.18
GUY R. SARGENT 35620 WOLF PEN ROAD POMEROY, OH 45769	225886	08/05/2019	Other - Royalty	$146.63
	229081	09/10/2019	Other - Royalty	$142.81
	230598	10/07/2019	Other - Royalty	$114.12
			SUBTOTAL	$403.56
GWYNN TIRE SERVICE INC. 750 FAIRMONT AVE. FAIRMONT, WV 26554	227637	08/23/2019	Suppliers or vendors	$1,448.40
	228527	09/06/2019	Suppliers or vendors	$1,854.17
	229696	09/20/2019	Suppliers or vendors	$974.14
	230755	10/07/2019	Suppliers or vendors	$1,778.50
			SUBTOTAL	$6,055.21
H & K EQUIPMENT COMPANY INC 4200 CASTEEL DR CORAOPOLIS, PA 15108	227147	08/19/2019	Suppliers or vendors	$2,038.45
			SUBTOTAL	$2,038.45
H.I. QUALITY STEEL CASTINGS TRINITY WORKS FOUNDRY STREET, WHITTINGTON MOOR CHESTERFIELD S41 9AX UNITED KINGDOM	ACH	08/05/2019	Suppliers or vendors	$261,292.04
	Wire	09/17/2019	Suppliers or vendors	$262,686.60
			SUBTOTAL	$523,978.64
HACH COMPANY 2207 COLLECTIONS CENTER DR CHICAGO, IL 60693	227003	08/19/2019	Suppliers or vendors	$6,257.89
			SUBTOTAL	$6,257.89
HAMILTON COUNTY COLLECTOR 100 SOUTH JACKSON ST RM 4 MCLEANSBORO, IL 62859-1462	230193	10/03/2019	Other - Regulatory/Tax	$24,570.57
			SUBTOTAL	$24,570.57
HAMMOND PUBLIC SERVICE DISTRICT 59 TOWN SQUARE WELLSBURG, WV 26070	225986	08/13/2019	Other - Utilities	$90.30
	229297	09/20/2019	Other - Utilities	$90.30
	230919	10/11/2019	Other - Utilities	$90.30
			SUBTOTAL	$270.90

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
HAMPTON INN 1053 VAN VOORHIS ROAD MORGANTOWN, WV 26505	229621	09/20/2019	Suppliers or vendors	$613.76
			SUBTOTAL	$613.76
HARBAUGH POWER PRODUCTS, INC. 520 N. 7TH STREET YOUNGWOOD, PA 15697	228727	09/06/2019	Suppliers or vendors	$14,880.00
			SUBTOTAL	$14,880.00
HARDY PENCE PLLC PO BOX 2548 CHARLESTON, WV 25329	226786	08/19/2019	Services	$220.00
	226787	08/19/2019	Services	$82.50
	230680	10/07/2019	Services	$361.00
	231156	10/11/2019	Services	$275.00
	231157	10/11/2019	Services	$988.00
	ACH	10/25/2019	Services	$5,424.25
			SUBTOTAL	$7,350.75
HAROLD D SHRADER AND LOIS J SHRADER 59460 HUNTER-BETHESDA ROAD BETHESDA, OH 43719	228394	09/06/2019	Suppliers or vendors	$12,000.00
			SUBTOTAL	$12,000.00
HARRIET S RINGO C/O JOHN J RINGO POA 7 LAKE SOMERSET CIRLCE BLUFFTON, SC 29909	227573	08/23/2019	Other - Royalty	$297.84
	230024	09/26/2019	Other - Royalty	$364.29
			SUBTOTAL	$662.13
HARRINGTON & COMPANY 760 W LAYTON AVE. SALT LAKE CITY, UT 84104	230809	10/09/2019	Suppliers or vendors	$2,818.20
	231484	10/11/2019	Suppliers or vendors	$19,554.47
			SUBTOTAL	$22,372.67
HARRISON RURAL ELECTRIFICATION ASSO PO BOX 4247 CLARKSBURG, WV 26302-9955	226770	08/19/2019	Suppliers or vendors	$165.58
	229538	09/20/2019	Suppliers or vendors	$143.33
	231133	10/11/2019	Suppliers or vendors	$152.51
			SUBTOTAL	$461.42

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
HARVEY SERVICES LLC P.O BOX 133 PO BOX 133 SCENERY HILL, PA 15360	230515	10/07/2019	Suppliers or vendors	$32,300.00
	230516	10/07/2019	Suppliers or vendors	$1,000.00
			SUBTOTAL	$33,300.00
HAWKEY & KLINE CORING & DRILLING 400 LONE GROVE ROAD PO BOX 205 ST. PETER, IL 62880	226476	08/13/2019	Suppliers or vendors	$81,508.41
			SUBTOTAL	$81,508.41
HD SUPPLY FACILITIES MAINTENANCE LT USA BLUE BOOK PO BOX 9004 GURNEE, IL 60031	225798	08/05/2019	Suppliers or vendors	$1,678.83
			SUBTOTAL	$1,678.83
HEALTHSMART BENEFIT SOLUTIONS INC. SMART CASUALTY CLAIMS PO BOX 535106 ATLANTA, GA 30353-5106	ACH	08/02/2019	Services	$130,582.18
	ACH	08/08/2019	Services	$196,771.29
	ACH	08/15/2019	Services	$158,528.95
	226750	08/19/2019	Services	$1,000.00
	ACH	08/22/2019	Services	$72,936.63
	ACH	08/29/2019	Services	$572,483.42
	ACH	09/05/2019	Services	$127,623.66
	ACH	09/13/2019	Services	$134,050.64
	ACH	09/19/2019	Services	$94,940.17
	229485	09/20/2019	Services	$2,500.00
	ACH	09/27/2019	Services	$524,140.64
	ACH	10/03/2019	Services	$170,935.12
	ACH	10/10/2019	Services	$254,319.26
	ACH	10/17/2019	Services	$158,794.88
	ACH	10/24/2019	Services	$578,470.94
	ACH	10/28/2019	Services	$107,649.46
			SUBTOTAL	$3,285,727.24
HEALTHSMART BENEFIT SOLUTIONS, INC. 222 W LAS COLINAS BLVD SUITE 500N IRVING, TX 75039	ACH	08/09/2019	Services	$102,696.75
	ACH	08/14/2019	Services	$27,185.95
	ACH	08/22/2019	Services	$16,717.32
	ACH	08/26/2019	Services	$117,686.11
	ACH	09/04/2019	Services	$109,345.23

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
HEALTHSMART BENEFIT SOLUTIONS, INC. 222 W LAS COLINAS BLVD SUITE 500N IRVING, TX 75039	ACH	09/16/2019	Services	$97,903.77
	ACH	09/25/2019	Services	$122,745.88
	ACH	10/03/2019	Services	$99,477.09
	ACH	10/11/2019	Services	$158,453.03
	Wire	10/28/2019	Services	$17,824.35
			SUBTOTAL	$870,035.48
HENSON MAINTENANCE COMPANY 900 LINCOLN ST. MONONGAHELA, PA 15063	ACH	08/30/2019	Services	$2,238.00
			SUBTOTAL	$2,238.00
HERALD STAR/DAILY TIMES PO BOX 7006 WHEELING, WV 26003	225995	08/13/2019	Suppliers or vendors	$434.40
			SUBTOTAL	$434.40
HERITAGE COOPERATIVE INC 364 LISBON STREET CANFIELD, OH 44406-0369	225841	08/05/2019	Suppliers or vendors	$21,378.60
	225842	08/05/2019	Suppliers or vendors	$41,801.75
	225843	08/05/2019	Suppliers or vendors	$11,376.68
	225844	08/05/2019	Suppliers or vendors	$20,559.32
	225845	08/05/2019	Suppliers or vendors	$24,974.91
	225846	08/05/2019	Suppliers or vendors	$8,829.48
	225847	08/05/2019	Suppliers or vendors	$1,841.59
	225848	08/05/2019	Suppliers or vendors	$15,434.43
	225849	08/05/2019	Suppliers or vendors	$106,715.41
	226241	08/13/2019	Suppliers or vendors	$7,102.14
	226242	08/13/2019	Suppliers or vendors	$14,954.10
	226243	08/13/2019	Suppliers or vendors	$7,775.76
	226244	08/13/2019	Suppliers or vendors	$7,658.75
	226245	08/13/2019	Suppliers or vendors	$2,132.25
	226830	08/19/2019	Suppliers or vendors	$783.15
	226831	08/19/2019	Suppliers or vendors	$1,430.59
	226832	08/19/2019	Suppliers or vendors	$6,584.65
	226833	08/19/2019	Suppliers or vendors	$1,403.69
	227207	08/19/2019	Suppliers or vendors	$3,046.83
	227208	08/19/2019	Suppliers or vendors	$2,205.42
	227209	08/19/2019	Suppliers or vendors	$27,010.38
	227210	08/19/2019	Suppliers or vendors	$69,744.51
	227211	08/19/2019	Suppliers or vendors	$24,599.74
	227212	08/19/2019	Suppliers or vendors	$34,978.05

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
HERITAGE COOPERATIVE INC 364 LISBON STREET CANFIELD, OH 44406-0369	227213	08/19/2019	Suppliers or vendors	$39,768.93
	227214	08/19/2019	Suppliers or vendors	$1,627.98
	227215	08/19/2019	Suppliers or vendors	$8,061.29
	227216	08/19/2019	Suppliers or vendors	$3,362.42
	227217	08/19/2019	Suppliers or vendors	$38,457.52
	227218	08/19/2019	Suppliers or vendors	$90,184.36
	227219	08/19/2019	Suppliers or vendors	$2,297.05
	227619	08/23/2019	Suppliers or vendors	$3,064.02
	227620	08/23/2019	Suppliers or vendors	$9,731.23
	227621	08/23/2019	Suppliers or vendors	$7,339.57
	227622	08/23/2019	Suppliers or vendors	$3,940.99
	227624	08/23/2019	Suppliers or vendors	$3,013.27
	228144	08/28/2019	Suppliers or vendors	$17,595.95
	228145	08/28/2019	Suppliers or vendors	$27,198.53
	228146	08/28/2019	Suppliers or vendors	$65,257.21
	228147	08/28/2019	Suppliers or vendors	$20,704.74
	228148	08/28/2019	Suppliers or vendors	$31,413.73
	228149	08/28/2019	Suppliers or vendors	$61,681.51
	228150	08/28/2019	Suppliers or vendors	$5,274.03
	228151	08/28/2019	Suppliers or vendors	$1,518.61
	228152	08/28/2019	Suppliers or vendors	$30,911.65
	228153	08/28/2019	Suppliers or vendors	$83,160.76
	228154	08/28/2019	Suppliers or vendors	$2,182.87
	228155	08/28/2019	Suppliers or vendors	$1,911.06
	228519	09/06/2019	Suppliers or vendors	$5,733.83
	228520	09/06/2019	Suppliers or vendors	$1,693.42
	227623	09/11/2019	Suppliers or vendors	$87,136.95
	229675	09/20/2019	Suppliers or vendors	$20,057.61
	229676	09/20/2019	Suppliers or vendors	$7,135.07
	229677	09/20/2019	Suppliers or vendors	$3,458.22
	229838	09/23/2019	Suppliers or vendors	$6,602.36
	229839	09/23/2019	Suppliers or vendors	$18,591.03
	229840	09/23/2019	Suppliers or vendors	$96,970.84
	229841	09/23/2019	Suppliers or vendors	$186,957.23
	229842	09/23/2019	Suppliers or vendors	$54,934.06
	229843	09/23/2019	Suppliers or vendors	$92,365.95
	229844	09/23/2019	Suppliers or vendors	$108,218.22
	229845	09/23/2019	Suppliers or vendors	$14,855.84
	229846	09/23/2019	Suppliers or vendors	$29,677.98
	229847	09/23/2019	Suppliers or vendors	$12,409.02

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
HERITAGE COOPERATIVE INC 364 LISBON STREET CANFIELD, OH 44406-0369	229848	09/23/2019	Suppliers or vendors	$96,047.11
	229849	09/23/2019	Suppliers or vendors	$276,560.99
	229850	09/23/2019	Suppliers or vendors	$5,909.39
	230741	10/07/2019	Suppliers or vendors	$10,159.28
	230742	10/07/2019	Suppliers or vendors	$35,033.93
	230743	10/07/2019	Suppliers or vendors	$15,657.78
	230744	10/07/2019	Suppliers or vendors	$7,512.28
	230745	10/07/2019	Suppliers or vendors	$4,241.27
	230746	10/07/2019	Suppliers or vendors	$5,848.47
	230774	10/08/2019	Suppliers or vendors	$5,443.40
	230775	10/08/2019	Suppliers or vendors	$13,022.78
	230776	10/08/2019	Suppliers or vendors	$70,609.52
	230777	10/08/2019	Suppliers or vendors	$97,180.71
	230778	10/08/2019	Suppliers or vendors	$51,217.46
	230779	10/08/2019	Suppliers or vendors	$110,843.25
	230780	10/08/2019	Suppliers or vendors	$120,935.02
	230781	10/08/2019	Suppliers or vendors	$11,921.23
	230782	10/08/2019	Suppliers or vendors	$19,824.07
	230783	10/08/2019	Suppliers or vendors	$9,005.43
	230784	10/08/2019	Suppliers or vendors	$64,914.86
	230785	10/08/2019	Suppliers or vendors	$155,613.25
	230786	10/08/2019	Suppliers or vendors	$4,049.15
			SUBTOTAL	$2,962,329.72
HERITAGE CRYSTAL CLEAN, LLC 13621 COLLECTIONS CENTER DRIVE CHICAGO, IL 60693	225977	08/13/2019	Suppliers or vendors	$2,935.36
	227330	08/23/2019	Suppliers or vendors	$3,184.48
	228275	09/06/2019	Suppliers or vendors	$2,934.93
	229278	09/20/2019	Suppliers or vendors	$571.48
	229279	09/20/2019	Suppliers or vendors	$5,940.00
	230902	10/11/2019	Suppliers or vendors	$6,352.00
	230903	10/11/2019	Suppliers or vendors	$2,203.16
			SUBTOTAL	$24,121.41
HERMAN A ROBERTS 39422 UNION AVENUE POMEROY, OH 45769	225885	08/05/2019	Other - Royalty	$69.58
	229080	09/10/2019	Other - Royalty	$67.50
	230597	10/07/2019	Other - Royalty	$63.13
			SUBTOTAL	$200.21

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
HERRMANN ASSOCIATES INC 1000 NOBLESTOWN ROAD PITTSBURGH, OH 15205	231624	10/18/2019	Suppliers or vendors	$6,296.55
			SUBTOTAL	$6,296.55
HIGGINS HAULING COMPANY 202 HIGGINS LANE WAYNESBURG, PA 15370	228413	09/06/2019	Suppliers or vendors	$5,200.00
	228994	09/06/2019	Suppliers or vendors	$8,000.00
	228995	09/06/2019	Suppliers or vendors	$9,400.00
	228996	09/06/2019	Suppliers or vendors	$15,325.00
	228997	09/06/2019	Suppliers or vendors	$14,610.00
	230409	10/04/2019	Suppliers or vendors	$14,250.00
	230410	10/04/2019	Suppliers or vendors	$16,800.00
	230411	10/04/2019	Suppliers or vendors	$32,780.00
	230412	10/04/2019	Suppliers or vendors	$25,850.00
	230413	10/04/2019	Suppliers or vendors	$65,400.00
	230414	10/04/2019	Suppliers or vendors	$15,080.00
	230415	10/04/2019	Suppliers or vendors	$270.00
			SUBTOTAL	$222,965.00
HIGHLANDS HOSPITALITY LLC MICROTEL HIGHLANDS 85 FORT HENRY RD TRIDELPHIA, WV 26059	231238	10/11/2019	Suppliers or vendors	$1,342.88
			SUBTOTAL	$1,342.88
HIGHRIDGE WATER AUTHORTIY 17 MAPLE AVENUE BLAIRSVILLE, PA 15717	225355	08/02/2019	Other - Utilities	$46.60
	230898	10/11/2019	Other - Utilities	$55.00
			SUBTOTAL	$101.60
HILCO VALUATION SERVICES LLC 25285 NETWORK PLACE CHICAGO, IL 60673-1252	ACH	09/27/2019	Services	$68,057.43
	ACH	10/03/2019	Services	$70,000.00
			SUBTOTAL	$138,057.43
HINERMAN EXCAVATING LLC PO BOX 66 BLACKSVILLE, WV 26521	ACH	08/19/2019	Services	$21,027.75
	ACH	08/30/2019	Services	$22,500.00
	ACH	09/13/2019	Services	$7,500.00
	230418	10/04/2019	Services	$33,032.00
	230419	10/04/2019	Services	$7,996.00
			SUBTOTAL	$92,055.75

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
HISSAM FORMAN DONOVAN RITCHIE PLLC PO BOX 3983 CHARLESTON, WV 25339	229715	09/20/2019	Services	$6,008.00
			SUBTOTAL	$6,008.00
HI-TEK SECURITY SOLUTIONS 1008 DUTCH HILL ROAD MARTINS FERRY, OH 43935	225411	08/02/2019	Suppliers or vendors	$705.13
	225412	08/02/2019	Suppliers or vendors	$246.68
	230631	10/07/2019	Suppliers or vendors	$987.61
			SUBTOTAL	$1,939.42
HLS HARD-LINE SOLUTIONS, INC. PO BOX 908 DOWLING, ON P0M 1R0 CANADA	225840	08/05/2019	Suppliers or vendors	$20,099.39
			SUBTOTAL	$20,099.39
HOLIDAY INN EXPRESS & SUITES SLC 200 NORTH 2100 WEST SALT LAKE CITY, UT 84116	226246	08/13/2019	Services	$122.74
	228521	09/06/2019	Services	$122.74
	229678	09/20/2019	Services	$613.70
			SUBTOTAL	$859.18
HOLIDAY INN EXPRESS 925 WESTWOOD BLVD PRICE, UT 84501	226239	08/13/2019	Services	$5,346.32
	227618	08/23/2019	Services	$5,441.79
	228516	09/06/2019	Services	$6,930.08
	229671	09/20/2019	Services	$1,050.17
	230739	10/07/2019	Services	$95.47
	231242	10/11/2019	Services	$2,673.19
			SUBTOTAL	$21,537.02
HONEYWELL AEROSPACE PO BOX 93078 CHICAGO, IL 60673-3078	226654	08/19/2019	Suppliers or vendors	$20,067.79
	229295	09/20/2019	Suppliers or vendors	$44,320.17
	230917	10/11/2019	Suppliers or vendors	$33,894.67
			SUBTOTAL	$98,282.63
HONEYWELL 21380 NETWORK PLACE CHICAGO, IL 60673-1213	229615	09/20/2019	Suppliers or vendors	$3,844.51
	230696	10/07/2019	Suppliers or vendors	$15,709.74
			SUBTOTAL	$19,554.25

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
HOPE INDUSTRIAL SYSTEMS INC 1325 NORTHMEADOW PKWY STE 100 ROSWELL, GA 30076	228431	09/06/2019	Suppliers or vendors	$862.45
			SUBTOTAL	$862.45
HORIZON LABORATORIES INC PO BOX 995 PRICE, UT 84501	226021	08/13/2019	Suppliers or vendors	$24,996.25
	228299	09/06/2019	Suppliers or vendors	$24,984.75
	229346	09/20/2019	Suppliers or vendors	$24,992.25
			SUBTOTAL	$74,973.25
HOSPITALITY ASSOCIATES LP DBA WINGATE BY WYNDHAM ST.C/WHLG. 51130 NATIONAL ROAD EAST ST. CLAIRSVILLE, OH 43950	226266	08/13/2019	Services	$503.95
	228540	09/06/2019	Services	$302.37
	229709	09/20/2019	Services	$1,511.85
	230765	10/07/2019	Services	$403.16
			SUBTOTAL	$2,721.33
HOSPITALITY VENTURES, LLC DBA HAMPTON INN & SUITES SOUTHRIDGE PO BOX 8615 SOUTH CHARLESTON, WV 25303	228542	09/06/2019	Services	$33,308.66
			SUBTOTAL	$33,308.66
HOTEL FIVE LLC FAIRFIELD INN BEACHWOOD OH 3750 ORANGE PLACE BEACHWOOD, OH 44122	227647	08/23/2019	Services	$1,378.91
			SUBTOTAL	$1,378.91
HOYA OPTICAL LABS OF AMERICA HOYA VISION-DEPT. 2454 PO BOX 122454 DALLAS, TX 75312-2454	225457	08/02/2019	Suppliers or vendors	$43.00
	225458	08/02/2019	Suppliers or vendors	$365.50
	225459	08/02/2019	Suppliers or vendors	$1,279.00
	225460	08/02/2019	Suppliers or vendors	$148.00
	226233	08/13/2019	Suppliers or vendors	$356.50
	226827	08/19/2019	Suppliers or vendors	$12.21
	226828	08/19/2019	Suppliers or vendors	$309.50
	227610	08/23/2019	Suppliers or vendors	$1,078.00
	227611	08/23/2019	Suppliers or vendors	$1,118.58
	228512	09/06/2019	Suppliers or vendors	$2,023.00
	229662	09/20/2019	Suppliers or vendors	$304.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
HOYA OPTICAL LABS OF AMERICA HOYA VISION-DEPT. 2454 PO BOX 122454 DALLAS, TX 75312-2454	229663	09/20/2019	Suppliers or vendors	$799.50
	229664	09/20/2019	Suppliers or vendors	$186.00
	229665	09/20/2019	Suppliers or vendors	$148.00
	230729	10/07/2019	Suppliers or vendors	$1,974.00
	230730	10/07/2019	Suppliers or vendors	$2,812.50
	230731	10/07/2019	Suppliers or vendors	$2,077.50
	231236	10/11/2019	Suppliers or vendors	$229.00
	231237	10/11/2019	Suppliers or vendors	$658.00
			SUBTOTAL	$15,921.79
HUGHES OFFICE EQUIPMENT, LLC 3114 BELMONT STREET PO BOX 278 BELLAIRE, OH 43906	225464	08/02/2019	Suppliers or vendors	$23,331.52
	227628	08/23/2019	Suppliers or vendors	$3,741.66
	227629	08/23/2019	Suppliers or vendors	$5,775.09
	227630	08/23/2019	Suppliers or vendors	$2,222.74
	227631	08/23/2019	Suppliers or vendors	$3,987.00
	227632	08/23/2019	Suppliers or vendors	$3,662.33
	227633	08/23/2019	Suppliers or vendors	$1,289.00
	227634	08/23/2019	Suppliers or vendors	$1,555.13
	229685	09/20/2019	Suppliers or vendors	$2,139.02
	229686	09/20/2019	Suppliers or vendors	$3,473.93
	229687	09/20/2019	Suppliers or vendors	$3,880.74
	229688	09/20/2019	Suppliers or vendors	$37,275.22
	230749	10/07/2019	Suppliers or vendors	$4,758.94
	230750	10/07/2019	Suppliers or vendors	$4,451.06
	230751	10/07/2019	Suppliers or vendors	$30,965.81
			SUBTOTAL	$132,509.19
HULSING HOTELS VIRGINIA INC. HOLIDAY INN BRISTOL 3005 LINDEN DRIVE BRISTOL, VA 24202	226269	08/13/2019	Services	$1,322.49
	231265	10/11/2019	Services	$406.92
			SUBTOTAL	$1,729.41
HUMCO MARINE PRODUCTS INC 1074 KENRAN INDUSTRIAL BLVD ST LOUIS, MO 63137	227148	08/19/2019	Suppliers or vendors	$2,637.61
			SUBTOTAL	$2,637.61

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
HYATT REGENCY ST. LOUIS PO BOX 205327 DALLAS, TX 75320-5327	226240	08/13/2019	Services	$339.64
	228518	09/06/2019	Services	$169.82
			SUBTOTAL	$509.46
HYDE BROTHERS PRINTING & MARKETING PROFORMA PO BOX 640814 CINCINNATI, OH 45264-0814	228482	09/06/2019	Suppliers or vendors	$2,601.69
			SUBTOTAL	$2,601.69
HYDROTECH, INC 10052 COMMERCE PARK DR. CINCINNATI, OH 45246	228158	08/28/2019	Suppliers or vendors	$273.82
			SUBTOTAL	$273.82

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
ICR EQUIPMENT RENTAL & SUPPLY LLC ATTN: ACCOUNTS PAYABLE 1 COMMERCE PARKWAY BELLAIRE, OH 43906	225644	08/05/2019	Suppliers or vendors	$1,062.45
	225645	08/05/2019	Suppliers or vendors	$14,540.35
	225646	08/05/2019	Suppliers or vendors	$17,834.67
	225647	08/05/2019	Suppliers or vendors	$3,953.78
	225648	08/05/2019	Suppliers or vendors	$8,582.50
	225649	08/05/2019	Suppliers or vendors	$5,607.14
	225650	08/05/2019	Suppliers or vendors	$4,500.00
	225651	08/05/2019	Suppliers or vendors	$5,713.81
	225652	08/05/2019	Suppliers or vendors	$606.86
	226667	08/19/2019	Suppliers or vendors	$120.00
	226955	08/19/2019	Suppliers or vendors	$25,344.68
	226956	08/19/2019	Suppliers or vendors	$109.00
	226957	08/19/2019	Suppliers or vendors	$313.20
	226958	08/19/2019	Suppliers or vendors	$10,445.57
	228291	09/06/2019	Suppliers or vendors	$125.00
	228814	09/06/2019	Suppliers or vendors	$250.00
	228815	09/06/2019	Suppliers or vendors	$4,789.67
	228816	09/06/2019	Suppliers or vendors	$34,584.77
	228817	09/06/2019	Suppliers or vendors	$41,391.45
	228818	09/06/2019	Suppliers or vendors	$2,950.97
	228819	09/06/2019	Suppliers or vendors	$268.65
	228820	09/06/2019	Suppliers or vendors	$2,390.15
	228821	09/06/2019	Suppliers or vendors	$10,793.94
	228822	09/06/2019	Suppliers or vendors	$500.00
	228823	09/06/2019	Suppliers or vendors	$999.82
	231595	10/18/2019	Suppliers or vendors	$45,000.00
			SUBTOTAL	$242,778.43
IDLEWOOD INDUSTRIES, INC. 17 GEORGETOWN LANE BEAVER, PA 15009	231699	10/22/2019	Suppliers or vendors	$58,554.94
			SUBTOTAL	$58,554.94

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
ILLINOIS DEPT OF REVENUE RETAILERS' OCCUPATION TAX SPRINGFIELD, IL 62796-0001	ACH	08/20/2019	Other - Regulatory/Tax	$4,437.00
	ACH	08/22/2019	Other - Regulatory/Tax	$1,837.00
	ACH	08/28/2019	Other - Regulatory/Tax	$10,500.00
	ACH	09/20/2019	Other - Regulatory/Tax	$5,798.00
	ACH	09/23/2019	Other - Regulatory/Tax	$1,980.00
	ACH	09/26/2019	Other - Regulatory/Tax	$10,500.00
	ACH	10/21/2019	Other - Regulatory/Tax	$331.00
	ACH	10/22/2019	Other - Regulatory/Tax	$2,303.00
	ACH	10/28/2019	Other - Regulatory/Tax	$10,500.00
			SUBTOTAL	$48,186.00
IMPACT TELECOM LLC PO BOX 660344 DALLAS, TX 75266-0344	Credit Card	08/27/2019	Other - Utilities	$213.36
	Credit Card	09/19/2019	Other - Utilities	$112.88
	Credit Card	10/18/2019	Other - Utilities	$113.36
			SUBTOTAL	$439.60
INDEMNITY NATIONAL INSURANCE COMPANY JAMIE HART, CHIEF FINANCIAL OFFICER 725 COOL SPRINGS BLVD, SUITE 600 FRANKLIN, TN 37067	ACH	08/02/2019	Secured Debt	$1,250,000.00
	ACH	09/04/2019	Secured Debt	$1,250,000.00
	ACH	10/04/2019	Secured Debt	$1,250,000.00
			SUBTOTAL	$3,750,000.00
INDUSTRIAL COMMERCIAL RESIDENTIAL CONTRACTING LLC STATE ROUTE 149 PO BOX 122 NEFFS, OH 43940	225327	08/02/2019	Suppliers or vendors	$5,000.00
	226853	08/19/2019	Suppliers or vendors	$29,590.00
	226854	08/19/2019	Suppliers or vendors	$29,200.00
	226855	08/19/2019	Suppliers or vendors	$8,375.00
	226856	08/19/2019	Suppliers or vendors	$7,355.00
	228223	09/06/2019	Suppliers or vendors	$5,000.00
	228224	09/06/2019	Suppliers or vendors	$8,700.00
	228719	09/06/2019	Suppliers or vendors	$34,565.00
	228720	09/06/2019	Suppliers or vendors	$72,515.00
	230333	10/04/2019	Suppliers or vendors	$21,780.00
	230334	10/04/2019	Suppliers or vendors	$17,350.00
	230335	10/04/2019	Suppliers or vendors	$36,740.00
	231352	10/11/2019	Suppliers or vendors	$44,705.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
INDUSTRIAL COMMERCIAL RESIDENTIAL CONTRACTING LLC STATE ROUTE 149 PO BOX 122 NEFFS, OH 43940	231353	10/11/2019	Suppliers or vendors	$1,000.00
	231354	10/11/2019	Suppliers or vendors	$20,090.00
	231585	10/18/2019	Suppliers or vendors	$100,000.00
	231586	10/18/2019	Suppliers or vendors	$100,000.00
			SUBTOTAL	$541,965.00
INDUSTRIAL ELECTRIC MOTOR SERVICE 225 WEST 500 SOUTH PO BOX 485 ORANGEVILLE, UT 84537-0485	Wire	10/28/2019	Suppliers or vendors	$17,870.14
			SUBTOTAL	$17,870.14
INDUSTRIAL MAGNETICS, INC. 1385 M-75 SOUTH BOYNE CITY, MI 49712	226921	08/19/2019	Suppliers or vendors	$1,106.86
			SUBTOTAL	$1,106.86
INDUSTRIAL MINING SUPPLY INC 2500 FIVE STAR PARKWAY BESSEMER, AL 35022	231583	10/17/2019	Suppliers or vendors	$19,985.78
			SUBTOTAL	$19,985.78
INDUSTRIAL SAFETY PLUS LLC FRANCIS NICKLER 4024 GREYSTONE DRIVE MORGANTOWN, WV 26508	226142	08/13/2019	Suppliers or vendors	$840.00
	227516	08/23/2019	Suppliers or vendors	$480.00
	229518	09/20/2019	Suppliers or vendors	$1,260.00
	230651	10/07/2019	Suppliers or vendors	$1,020.00
	231115	10/11/2019	Suppliers or vendors	$1,920.00
			SUBTOTAL	$5,520.00
INDUSTRIAL SUPPLY (UTAH) 1635 SOUTH 300 WEST PO BOX 30600 SALT LAKE CITY, UT 84130	230374	10/04/2019	Suppliers or vendors	$13,128.83
			SUBTOTAL	$13,128.83

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
INDUSTRY TERMINAL & SALVAGE CO INC PO BOX 255 INDUSTRY, PA 15052	226130	08/13/2019	Suppliers or vendors	$16,946.88
	227509	08/23/2019	Suppliers or vendors	$20,288.38
	229502	09/20/2019	Suppliers or vendors	$63,775.00
	230647	10/07/2019	Suppliers or vendors	$2,996.50
	231108	10/11/2019	Suppliers or vendors	$61,100.00
			SUBTOTAL	$165,106.76
INFOQUEST LTD 2000 HENDERSON RD SUITE 300 COLUMBUS, OH 43220	226278	08/13/2019	Services	$8,295.79
	229721	09/20/2019	Suppliers or vendors	$3,828.83
			SUBTOTAL	$12,124.62
INGRAM UNITED BARGE LLC DBA INGRAM BARGE COMPANY PO BOX 198934 ATLANTA, GA 30384-8934	ACH	08/02/2019	Services	$181,706.66
	ACH	08/16/2019	Services	$211,194.04
	ACH	09/23/2019	Services	$364,598.63
	ACH	10/11/2019	Services	$371,034.09
			SUBTOTAL	$1,128,533.42
INNOVATIVE WIRELESS TECHNOLOGIES IN 1100 MAIN STREET LYNCHBURG, VA 24504	227186	08/19/2019	Services	$27,769.54
	227187	08/19/2019	Services	$26,939.45
	229025	09/06/2019	Services	$32,460.18
	229026	09/06/2019	Services	$24,656.03
	229050	09/09/2019	Services	$26,287.02
	231578	10/17/2019	Services	$26,825.81
	231579	10/17/2019	Services	$82,551.45
			SUBTOTAL	$247,489.48
INTERMOUNTAIN ELECTRONICS, INC. 1511 SOUTH HIGHWAY 6 PO BOX 914 PRICE, UT 84501	227938	08/28/2019	Suppliers or vendors	$38,912.85
			SUBTOTAL	$38,912.85
INTERMOUNTAIN ENVIRONMENTAL, INC. 601 WEST 1700 S, STE 120 LOGAN, UT 84321-8247	226069	08/13/2019	Suppliers or vendors	$1,016.50
			SUBTOTAL	$1,016.50
INTERMOUNTAIN ORIENT P.O. BOX 8288 BOISE, ID 83707	226595	08/13/2019	Suppliers or vendors	$15,126.56

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
INTERMOUNTAIN ORIENT P.O. BOX 8288 BOISE, ID 83707	228116	08/28/2019	Suppliers or vendors	$11,981.46
	229028	09/06/2019	Suppliers or vendors	$4,424.39
	230424	10/04/2019	Suppliers or vendors	$26,171.03
	231580	10/17/2019	Suppliers or vendors	$11,385.82
			SUBTOTAL	$69,089.26
INTERNATIONAL CONVEYOR & RUBBER LLC 72 INDUSTRIAL PARK ROAD BLAIRSVILLE, PA 15717	225835	08/05/2019	Suppliers or vendors	$2,758.71
	225836	08/05/2019	Suppliers or vendors	$24,465.00
	225837	08/05/2019	Suppliers or vendors	$30,533.93
	225838	08/05/2019	Suppliers or vendors	$28,025.00
	227203	08/19/2019	Suppliers or vendors	$23,013.20
	227204	08/19/2019	Suppliers or vendors	$11,254.00
	227205	08/19/2019	Suppliers or vendors	$18,310.00
	228134	08/28/2019	Suppliers or vendors	$8,763.00
	228135	08/28/2019	Suppliers or vendors	$5,035.00
	228136	08/28/2019	Suppliers or vendors	$31,334.50
	228137	08/28/2019	Suppliers or vendors	$11,246.00
	228138	08/28/2019	Suppliers or vendors	$28,140.00
	229035	09/06/2019	Suppliers or vendors	$7,675.10
	229036	09/06/2019	Suppliers or vendors	$8,425.00
	229037	09/06/2019	Suppliers or vendors	$30,405.10
	229038	09/06/2019	Suppliers or vendors	$8,738.70
	231533	10/16/2019	Suppliers or vendors	$10,453.56
			SUBTOTAL	$288,575.80
INTER-STATE TREATED MATERIAL PO BOX 99 MOUNT MORRIS, PA 15349	226500	08/13/2019	Suppliers or vendors	$6,832.98
	226501	08/13/2019	Suppliers or vendors	$16,491.00
	226502	08/13/2019	Suppliers or vendors	$13,287.80
	227939	08/28/2019	Suppliers or vendors	$5,531.46
	227940	08/28/2019	Suppliers or vendors	$7,425.40
	227941	08/28/2019	Suppliers or vendors	$12,774.60
	227942	08/28/2019	Suppliers or vendors	$15,940.50
	231515	10/16/2019	Suppliers or vendors	$18,419.76
	231516	10/16/2019	Suppliers or vendors	$17,475.20
	231548	10/17/2019	Suppliers or vendors	$6,832.98
	231599	10/18/2019	Suppliers or vendors	$15,052.80
			SUBTOTAL	$136,064.48

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
INTRALINKS PO BOX 392134 PITTSBURGH, PA 15251-9134	226071	08/13/2019	Suppliers or vendors	$1,787.78
	228348	09/06/2019	Suppliers or vendors	$1,787.78
	230555	10/07/2019	Suppliers or vendors	$1,787.78
	231485	10/11/2019	Suppliers or vendors	$20,415.04
			SUBTOTAL	$25,778.38
IPI INC 6211 FRAME RD STE A ELKVIEW, WV 25071	225428	08/02/2019	Suppliers or vendors	$1,560.00
			SUBTOTAL	$1,560.00
IPREO 1359 BROADWAY, 2ND FLOOR NEW YORK, NY 10018	226096	08/13/2019	Services	$27,500.00
			SUBTOTAL	$27,500.00
IRENE E FISHER 1711 GLENN ROAD CHATTANOOGA, TN 37405	227603	08/23/2019	Other - Royalty	$123.49
			SUBTOTAL	$123.49
IRWIN MINE & TUNNELING SUPPLY 9953 BROADWAY PO BOX 409 IRWIN, PA 15642	230497	10/07/2019	Suppliers or vendors	$14,021.57
	230796	10/09/2019	Suppliers or vendors	$8,335.00
	230822	10/10/2019	Suppliers or vendors	$4,875.16
	230823	10/10/2019	Suppliers or vendors	$4,419.35
	231388	10/11/2019	Suppliers or vendors	$2,889.72
	231389	10/11/2019	Suppliers or vendors	$14,263.18
	231390	10/11/2019	Suppliers or vendors	$2,200.00
	231391	10/11/2019	Suppliers or vendors	$1,724.75
	231491	10/14/2019	Suppliers or vendors	$13,363.82
	231509	10/16/2019	Suppliers or vendors	$7,661.00
	231543	10/17/2019	Suppliers or vendors	$1,852.36
	231642	10/18/2019	Suppliers or vendors	$956.40
	231681	10/22/2019	Suppliers or vendors	$1,700.00
	231682	10/22/2019	Suppliers or vendors	$2,321.88
			SUBTOTAL	$80,584.19
IRWIN TRANSPORTATION PRODUCTS PO BOX 409 IRWIN, PA 15642	226953	08/19/2019	Suppliers or vendors	$5,539.84
	226954	08/19/2019	Suppliers or vendors	$18,787.00
			SUBTOTAL	$24,326.84

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
IVS HYDRO, INC. PO BOX 245 WAVERLY, WV 26184	227106	08/19/2019	Suppliers or vendors	$8,438.94
	227107	08/19/2019	Suppliers or vendors	$82,222.80
	227108	08/19/2019	Suppliers or vendors	$8,168.36
			SUBTOTAL	$98,830.10
J & L PROFESSIONAL SALES INC 200 METEOR CIRCLE FREEDOM, PA 15042	ACH	08/30/2019	Suppliers or vendors	$25,651.00
			SUBTOTAL	$25,651.00
J & S TOOL, INC. 311 S COOL SPRINGS RD O'FALLON, MO 63366	225765	08/05/2019	Suppliers or vendors	$9,251.70
			SUBTOTAL	$9,251.70
J & S TRANSPORT, INC. P.O. BOX 1043 NORTH TAZEWELL, VA 24630	ACH	08/19/2019	Suppliers or vendors	$5,225.00
	ACH	08/30/2019	Suppliers or vendors	$3,850.00
	ACH	09/13/2019	Suppliers or vendors	$7,600.00
	230477	10/07/2019	Suppliers or vendors	$55,900.00
	230889	10/11/2019	Suppliers or vendors	$10,200.00
			SUBTOTAL	$82,775.00
J. ARON & COMPANY GOLDMAN SACHS INTERNATIONAL 200 WEST STREET NEW YORK, NY 10282-2198	ACH	08/02/2019	Services	$500,000.00
	ACH	08/09/2019	Services	$500,000.00
	ACH	08/16/2019	Services	$500,000.00
	ACH	08/23/2019	Services	$500,000.00
	ACH	08/30/2019	Services	$2,612,671.48
			SUBTOTAL	$4,612,671.48
J. H. DAVIS 275 QUISENBERRY LANE WINCHESTER, KY 40391	229995	09/26/2019	Other - Royalty	$101.34
			SUBTOTAL	$101.34
J.H. FLETCHER & COMPANY PO BOX 2187 HUNTINGTON, WV 25722-2187	228787	09/06/2019	Suppliers or vendors	$2,986.55
			SUBTOTAL	$2,986.55
J.J. KELLER & ASSOCIATES, INC. PO BOX 6609 CAROL STREAM, IL 60197-6609	ACH	09/13/2019	Suppliers or vendors	$242.94
			SUBTOTAL	$242.94

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JABO SUPPLY CORP. PO BOX 238 HUNTINGTON, WV 25707	227010	08/19/2019	Suppliers or vendors	$16,581.13
	227011	08/19/2019	Suppliers or vendors	$114,722.44
	227012	08/19/2019	Suppliers or vendors	$9,022.07
	227013	08/19/2019	Suppliers or vendors	$58,044.47
	227014	08/19/2019	Suppliers or vendors	$6,467.46
	227015	08/19/2019	Suppliers or vendors	$26,225.84
	227016	08/19/2019	Suppliers or vendors	$94.80
	227017	08/19/2019	Suppliers or vendors	$2,377.32
	228871	09/06/2019	Suppliers or vendors	$25,521.75
	228872	09/06/2019	Suppliers or vendors	$62,679.22
	228873	09/06/2019	Suppliers or vendors	$18,082.14
	228874	09/06/2019	Suppliers or vendors	$23,987.40
	228875	09/06/2019	Suppliers or vendors	$13,816.54
	228876	09/06/2019	Suppliers or vendors	$149.06
	228877	09/06/2019	Suppliers or vendors	$5,017.83
	228878	09/06/2019	Suppliers or vendors	$118.08
			SUBTOTAL	$382,907.55
JACK J. RONEVICH 208 GEORGIANN DRIVE ST. CLAIRSVILLE, OH 43950	226739	08/19/2019	Services	$4,900.00
	226740	08/19/2019	Services	$6,102.60
	229459	09/20/2019	Services	$2,450.00
	229460	09/20/2019	Services	$2,034.20
	230615	10/07/2019	Services	$2,034.20
	231063	10/11/2019	Services	$2,450.00
	231064	10/11/2019	Services	$2,034.20
			SUBTOTAL	$22,005.20
JACKELINE DIAZ LAMBERT 39051 HEILMAN ROAD POMEROY, OH 45769	225907	08/05/2019	Other - Royalty	$2.00
	229103	09/10/2019	Other - Royalty	$3.27
			SUBTOTAL	$5.27
JACKSON ENERGY COOPERATIVE PO BOX 790 ANNVILLE, KY 40402-0790	226738	08/19/2019	Other - Utilities	$3,914.34
	227437	08/23/2019	Other - Utilities	$1,018.53
	229456	09/20/2019	Other - Utilities	$3,725.04
	229954	09/26/2019	Other - Utilities	$1,039.25
	231060	10/11/2019	Other - Utilities	$375.06
			SUBTOTAL	$10,072.22

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JACKSON TOWNSHIP TAX COLLECTOR 2102 GOLDEN OAKS ROAD HOLBROOK, PA 15341	229599	09/20/2019	Other - Regulatory/Tax	$39,778.65
			SUBTOTAL	$39,778.65
JACQUELINE J RANIERI-MORROW HEIRSHI 125 GRANVILLE SQUARE, SUITE 400 MORGANTOWN, WV 26501	ACH	10/08/2019	Services	$33,340.00
			SUBTOTAL	$33,340.00
JAG LANDSCAPING 108 GILBOB ST. FAIRMONT, WV 26554	226213	08/13/2019	Services	$11,550.00
	226214	08/13/2019	Services	$4,350.00
	229634	09/20/2019	Services	$32,300.00
	230712	10/07/2019	Services	$19,520.00
	231211	10/11/2019	Services	$17,950.00
			SUBTOTAL	$85,670.00
JAME M MCCULLOUGH MCCULLOUGH ENTERPRISES PO BOX 403 LUMBERPORT, WV 26386	228305	09/06/2019	Suppliers or vendors	$350.00
			SUBTOTAL	$350.00
JAMES & PHYLLIS A DREHEL 37475 LEADING CREEK ROAD MIDDLEPORT, OH 45760	225860	08/05/2019	Other - Royalty	$26.18
	229057	09/10/2019	Other - Royalty	$26.45
			SUBTOTAL	$52.63
JAMES BRIAN MILLS 11 FAIRWAY DRIVE MOUNT CLARE, WV 26408	225455	08/02/2019	Services	$1,550.00
	226225	08/13/2019	Services	$950.00
	228496	09/06/2019	Services	$550.00
	229646	09/20/2019	Services	$1,250.00
			SUBTOTAL	$4,300.00
JAMES H MEHLMAN DBA MEHLMAN TRUCKING 53763 FARMINGTON ROAD BRIDGEPORT, OH 43912	227357	08/23/2019	Services	$23,500.00
	229349	09/20/2019	Services	$24,825.00
			SUBTOTAL	$48,325.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JAMES PAUL MURRAY PO BOX 525 HARRODSBURG, KY 40330	227450	08/23/2019	Other - Royalty	$880.90
	229964	09/26/2019	Other - Royalty	$867.65
			SUBTOTAL	$1,748.55
JAMES TALTON TURNER, III PO BOX 1232 GENOA, NV 89411	227474	08/23/2019	Other - Royalty	$160.64
			SUBTOTAL	$160.64
JAMES W. ROSS 1533 STONEBRIAR ROAD GREEN COVE SPRINGS, FL 32043	229994	09/26/2019	Other - Royalty	$101.34
			SUBTOTAL	$101.34
JANE L. CHRISTOPHER 6 CROSS CREEK DRIVE BIRMINGHAM, AL 35213	227480	08/23/2019	Other - Royalty	$104.07
			SUBTOTAL	$104.07
JANET A DUNHAM 960 45TH STREET NEW BOSTON, IL 61722	225861	08/05/2019	Other - Royalty	$13.32
	229058	09/10/2019	Other - Royalty	$12.85
	230574	10/07/2019	Other - Royalty	$9.77
			SUBTOTAL	$35.94
JANICE L HAUGHT 26042 SHORTLINE HWY SMITHFIELD, WV 26437	226223	08/13/2019	Suppliers or vendors	$1,000.00
			SUBTOTAL	$1,000.00
JANIE TOMPSON 1507 CYPRESS RD. OLNEY, IL 62450	226279	08/13/2019	Other - Royalty	$4,908.11
			SUBTOTAL	$4,908.11
JASON RUSK 1050 CRESWELL CIRCLE NEW ALBANY, OH 43054	ACH	08/09/2019	Services	$16,612.50
	ACH	09/11/2019	Services	$17,400.00
	ACH	10/04/2019	Services	$11,400.00
			SUBTOTAL	$45,412.50
JAY D WHARTON AND AMANDA K WHARTON 40701 FITZGERALD ROAD BETHESDA, OH 43719	229492	09/20/2019	Suppliers or vendors	$33,000.00
			SUBTOTAL	$33,000.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JAYMAR, INC. PO BOX 378 CHESHIRE, OH 45620	225868	08/05/2019	Other - Royalty	$120.43
	229064	09/10/2019	Other - Royalty	$116.92
	230580	10/07/2019	Other - Royalty	$119.86
			SUBTOTAL	$357.21
JAYSTERN LLC 412 MARKET STREET, SUITE 202 PARKERSBURG, WV 26101	227754	08/27/2019	Other - Royalty	$91,229.83
	229905	09/25/2019	Other - Royalty	$157,246.87
			SUBTOTAL	$248,476.70
JEANETTE LILLEY RT #4 BOX 180 CAMERON, WV 26033	229579	09/20/2019	Other - Royalty	$814.88
			SUBTOTAL	$814.88
JEANIE L HENTHORN HENTHORN ENVIRONMENTAL SERVICES LLC PO BOX 599 ST ALBANS, WV 25177	231116	10/11/2019	Suppliers or vendors	$11,956.26
			SUBTOTAL	$11,956.26
JEFFERY D MEADOWS 720 CIRCLE DRIVE MULLENS, WV 25882	229854	09/23/2019	Suppliers or vendors	$15,690.42
			SUBTOTAL	$15,690.42

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JEFFREY C HURT INTERNATIONAL BELT SALES LLC 29425 CHAGRIN BLVD, SUITE 300 PEPPER PIKE, OH 44122	225833	08/05/2019	Suppliers or vendors	$69,020.00
	225834	08/05/2019	Suppliers or vendors	$112,631.52
	226596	08/13/2019	Suppliers or vendors	$142,065.50
	227194	08/19/2019	Suppliers or vendors	$226,055.94
	227195	08/19/2019	Suppliers or vendors	$69,917.26
	227196	08/19/2019	Suppliers or vendors	$96,840.00
	227197	08/19/2019	Suppliers or vendors	$110,640.00
	227198	08/19/2019	Suppliers or vendors	$260,176.80
	228129	08/28/2019	Suppliers or vendors	$679,678.76
	228130	08/28/2019	Suppliers or vendors	$111,746.40
	229030	09/06/2019	Suppliers or vendors	$139,489.42
	229031	09/06/2019	Suppliers or vendors	$194,971.20
	229032	09/06/2019	Suppliers or vendors	$647,626.80
	229033	09/06/2019	Suppliers or vendors	$90,632.40
	231482	10/11/2019	Suppliers or vendors	$37,544.00
	231483	10/11/2019	Suppliers or vendors	$32,280.00
			SUBTOTAL	$3,021,316.00
JEFF'S WELDING & MACHINE LLC 2901 BENWOOD HILL RD BENWOOD, WV 26031	225793	08/05/2019	Suppliers or vendors	$32,110.35
	225794	08/05/2019	Suppliers or vendors	$119,989.53
	228071	08/28/2019	Suppliers or vendors	$13,550.90
	228072	08/28/2019	Suppliers or vendors	$14,590.00
			SUBTOTAL	$180,240.78
JELM ENTERPRISES PO BOX 378 CHESHIRE, OH 45620	225872	08/05/2019	Other - Royalty	$24.69
	229068	09/10/2019	Other - Royalty	$22.17
	230584	10/07/2019	Other - Royalty	$23.03
			SUBTOTAL	$69.89
JENNCHEM, LLC PO BOX 603800 CHARLOTTE, NC 28260-3800	225766	08/05/2019	Suppliers or vendors	$161,547.43
	225767	08/05/2019	Suppliers or vendors	$241,107.14
	225768	08/05/2019	Suppliers or vendors	$90,258.85
	225769	08/05/2019	Suppliers or vendors	$176,356.13
	225770	08/05/2019	Suppliers or vendors	$86,406.02
	225771	08/05/2019	Suppliers or vendors	$10,791.85
	226569	08/13/2019	Suppliers or vendors	$56,183.04
	226570	08/13/2019	Suppliers or vendors	$285,427.71

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JENNCHEM, LLC PO BOX 603800 CHARLOTTE, NC 28260-3800	226571	08/13/2019	Suppliers or vendors	$76,682.88
	226572	08/13/2019	Suppliers or vendors	$21,591.12
	226573	08/13/2019	Suppliers or vendors	$106,687.65
	227117	08/19/2019	Suppliers or vendors	$149,913.77
	227118	08/19/2019	Suppliers or vendors	$209,352.40
	227119	08/19/2019	Suppliers or vendors	$107,280.56
	227120	08/19/2019	Suppliers or vendors	$87,088.90
	227121	08/19/2019	Suppliers or vendors	$256,741.14
	227122	08/19/2019	Suppliers or vendors	$457.50
	228027	08/28/2019	Suppliers or vendors	$83,770.45
	228028	08/28/2019	Suppliers or vendors	$91,164.26
	228029	08/28/2019	Suppliers or vendors	$8,796.48
	228030	08/28/2019	Suppliers or vendors	$32,812.72
	228031	08/28/2019	Suppliers or vendors	$35,917.05
	ACH	09/06/2019	Suppliers or vendors	$1,054,758.01
	Wire	09/23/2019	Suppliers or vendors	$329,213.46
	Wire	10/01/2019	Suppliers or vendors	$1,578,003.76
	231456	10/11/2019	Suppliers or vendors	$141,498.33
	231457	10/11/2019	Suppliers or vendors	$647,082.73
	231458	10/11/2019	Suppliers or vendors	$6,963.31
	231459	10/11/2019	Suppliers or vendors	$24,710.75
	231460	10/11/2019	Suppliers or vendors	$38,310.55
	Wire	10/21/2019	Suppliers or vendors	$956,307.61
			SUBTOTAL	$7,153,183.56
JENNIFER SHEETS 32855 COTTRILL ROAD POMEROY, OH 45769	225895	08/05/2019	Other - Royalty	$2.87
	229090	09/10/2019	Other - Royalty	$3.46
	230606	10/07/2019	Other - Royalty	$3.03
			SUBTOTAL	$9.36
JENNMAR CORPORATION PO BOX 603800 CHARLOTTE, NC 28260-3800	225693	08/05/2019	Suppliers or vendors	$70,098.09
	225694	08/05/2019	Suppliers or vendors	$800,770.51
	225695	08/05/2019	Suppliers or vendors	$136,855.57
	225696	08/05/2019	Suppliers or vendors	$637,540.34
	225697	08/05/2019	Suppliers or vendors	$254,458.31
	225698	08/05/2019	Suppliers or vendors	$43,639.77
	225699	08/05/2019	Suppliers or vendors	$129,056.10
	226503	08/13/2019	Suppliers or vendors	$280,551.23
	226504	08/13/2019	Suppliers or vendors	$811,295.56

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JENNMAR CORPORATION PO BOX 603800 CHARLOTTE, NC 28260-3800	226505	08/13/2019	Suppliers or vendors	$235,157.25
	226506	08/13/2019	Suppliers or vendors	$406,702.09
	226507	08/13/2019	Suppliers or vendors	$269,342.88
	226508	08/13/2019	Suppliers or vendors	$298,618.04
	226509	08/13/2019	Suppliers or vendors	$170,199.04
	227018	08/19/2019	Suppliers or vendors	$256,664.71
	227019	08/19/2019	Suppliers or vendors	$194,868.04
	227020	08/19/2019	Suppliers or vendors	$6,249.25
	227021	08/19/2019	Suppliers or vendors	$68,089.56
	227022	08/19/2019	Suppliers or vendors	$106,030.51
	227023	08/19/2019	Suppliers or vendors	$47,415.64
	227024	08/19/2019	Suppliers or vendors	$91,431.29
	227943	08/28/2019	Suppliers or vendors	$30,776.64
	227944	08/28/2019	Suppliers or vendors	$241,985.03
	227945	08/28/2019	Suppliers or vendors	$46,191.88
	227946	08/28/2019	Suppliers or vendors	$34,592.54
	227947	08/28/2019	Suppliers or vendors	$66,532.94
	227948	08/28/2019	Suppliers or vendors	$37,364.53
	ACH	09/06/2019	Suppliers or vendors	$1,563,750.80
	Wire	09/18/2019	Suppliers or vendors	$2,000,170.50
	Wire	09/23/2019	Suppliers or vendors	$1,723,442.32
	Wire	10/01/2019	Suppliers or vendors	$826,566.89
	Wire	10/21/2019	Suppliers or vendors	$183,313.30
			SUBTOTAL	$12,069,721.15
JENNMAR MCSWEENEY LLC PO BOX 645517 PITTSBURGH, PA 15264-5253	225628	08/05/2019	Suppliers or vendors	$11,643.66
	225629	08/05/2019	Suppliers or vendors	$3,001.24
	225630	08/05/2019	Suppliers or vendors	$1,591.64
	225631	08/05/2019	Suppliers or vendors	$444.90
	225632	08/05/2019	Suppliers or vendors	$1,882.40
	226927	08/19/2019	Suppliers or vendors	$3,901.70
	226928	08/19/2019	Suppliers or vendors	$5,275.33
	226929	08/19/2019	Suppliers or vendors	$3,048.15
	226930	08/19/2019	Suppliers or vendors	$2,650.40
	226931	08/19/2019	Suppliers or vendors	$1,526.00
	227860	08/28/2019	Suppliers or vendors	$12,554.07
	227861	08/28/2019	Suppliers or vendors	$994.06
	227862	08/28/2019	Suppliers or vendors	$3,498.00
	227863	08/28/2019	Suppliers or vendors	$2,540.24

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JENNMAR MCSWEENEY LLC PO BOX 645517 PITTSBURGH, PA 15264-5253	227864	08/28/2019	Suppliers or vendors	$1,882.40
	ACH	09/06/2019	Suppliers or vendors	$80,463.65
	Wire	09/23/2019	Suppliers or vendors	$61,931.53
	Wire	10/21/2019	Suppliers or vendors	$10,125.99
			SUBTOTAL	$208,955.36
JENNMAR SANSHELL LLC PO BOX 645684 PITTSBURGH, PA 15264-5254	225827	08/05/2019	Suppliers or vendors	$10,863.86
	225828	08/05/2019	Suppliers or vendors	$50,446.64
	225829	08/05/2019	Suppliers or vendors	$7,328.60
	225830	08/05/2019	Suppliers or vendors	$57,679.52
	225831	08/05/2019	Suppliers or vendors	$5,628.00
	225832	08/05/2019	Suppliers or vendors	$60,322.04
	227189	08/19/2019	Suppliers or vendors	$17,451.26
	227190	08/19/2019	Suppliers or vendors	$2,148.00
	227191	08/19/2019	Suppliers or vendors	$21,650.88
	227192	08/19/2019	Suppliers or vendors	$26,838.00
	227193	08/19/2019	Suppliers or vendors	$9,841.94
	228122	08/28/2019	Suppliers or vendors	$2,301.00
	228123	08/28/2019	Suppliers or vendors	$3,580.00
	228124	08/28/2019	Suppliers or vendors	$6,700.00
	228125	08/28/2019	Suppliers or vendors	$10,884.88
	228126	08/28/2019	Suppliers or vendors	$30,408.36
	ACH	09/06/2019	Suppliers or vendors	$384,884.18
	Wire	09/23/2019	Suppliers or vendors	$288,649.12
	Wire	10/21/2019	Suppliers or vendors	$40,478.76
			SUBTOTAL	$1,038,085.04
JENNMAR SERVICES PO BOX 603800 CHARLOTTE, NC 28260-3800	225774	08/05/2019	Suppliers or vendors	$4,181.24
	225775	08/05/2019	Suppliers or vendors	$2,840.00
	225776	08/05/2019	Suppliers or vendors	$28,743.13
	225777	08/05/2019	Suppliers or vendors	$315,804.53
	225778	08/05/2019	Suppliers or vendors	$6,582.44
	225779	08/05/2019	Suppliers or vendors	$2,348.64
	225780	08/05/2019	Suppliers or vendors	$7,902.84
	225781	08/05/2019	Suppliers or vendors	$6,750.00
	225782	08/05/2019	Suppliers or vendors	$71,165.55
	225783	08/05/2019	Suppliers or vendors	$24,222.03
	225784	08/05/2019	Suppliers or vendors	$103,812.86
	226574	08/13/2019	Suppliers or vendors	$90,429.47

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JENNMAR SERVICES PO BOX 603800 CHARLOTTE, NC 28260-3800	226575	08/13/2019	Suppliers or vendors	$7,203.59
	226576	08/13/2019	Suppliers or vendors	$2,942.60
	226577	08/13/2019	Suppliers or vendors	$22,452.30
	226578	08/13/2019	Suppliers or vendors	$96,769.26
	226579	08/13/2019	Suppliers or vendors	$12,149.07
	227125	08/19/2019	Suppliers or vendors	$1,930.17
	227126	08/19/2019	Suppliers or vendors	$32,791.83
	227127	08/19/2019	Suppliers or vendors	$197,899.52
	227128	08/19/2019	Suppliers or vendors	$12,825.57
	227129	08/19/2019	Suppliers or vendors	$2,779.52
	227130	08/19/2019	Suppliers or vendors	$13,405.30
	227131	08/19/2019	Suppliers or vendors	$139,129.11
	227132	08/19/2019	Suppliers or vendors	$13,474.12
	228032	08/28/2019	Suppliers or vendors	$528.73
	228033	08/28/2019	Suppliers or vendors	$2,556.64
	228034	08/28/2019	Suppliers or vendors	$35,378.33
	228035	08/28/2019	Suppliers or vendors	$300.00
	228036	08/28/2019	Suppliers or vendors	$14,249.09
	228037	08/28/2019	Suppliers or vendors	$15,675.20
	228038	08/28/2019	Suppliers or vendors	$12,102.41
	228039	08/28/2019	Suppliers or vendors	$55,684.02
	ACH	09/06/2019	Suppliers or vendors	$1,394,328.45
	Wire	09/23/2019	Suppliers or vendors	$1,596,652.36
	Wire	10/21/2019	Suppliers or vendors	$489,568.26
			SUBTOTAL	$4,837,558.18
JENNMAR SERVICES WESTERN DIV PO BOX 603800 CHARLOTTE, NC 28260-3800	Wire	09/23/2019	Suppliers or vendors	$110.00
			SUBTOTAL	$110.00
JEREMIAH L KEMP NEW EDGE MAINTENANCE PO BOX 147 BELMONT, OH 43718	226132	08/13/2019	Suppliers or vendors	$1,900.00
	229507	09/20/2019	Suppliers or vendors	$1,900.00
	231111	10/11/2019	Suppliers or vendors	$1,900.00
			SUBTOTAL	$5,700.00

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JERRY M TAYLOR 60980 WARNER DRIVE BARNESVILLE, OH 43713	225998	08/13/2019	Suppliers or vendors	$4,479.85
	229311	09/20/2019	Suppliers or vendors	$4,747.49
	231876	10/25/2019	Suppliers or vendors	$5,538.71
			SUBTOTAL	$14,766.05
JET-CARE INTERNATIONAL 3 SADDLE ROAD CEDAR KNOLLS, NJ 07927	228522	09/06/2019	Suppliers or vendors	$124.40
			SUBTOTAL	$124.40
JEWELL G. MUSSATTO TRUST C/O TINA M JORDAN TRUSTEE 48836 N. 35TH AVE NEW RIVER, AZ 85087	227463	08/23/2019	Other - Royalty	$148.17
			SUBTOTAL	$148.17
JIM HENRIES HEAVY HAULING PO BOX 1773 PRICE, UT 84501	230825	10/10/2019	Services	$11,575.00
			SUBTOTAL	$11,575.00
J-LOK COMPANY PO BOX 603800 CHARLOTTE, NC 28260-3800	227088	08/19/2019	Suppliers or vendors	$24,360.80
	227089	08/19/2019	Suppliers or vendors	$50,738.00
	227090	08/19/2019	Suppliers or vendors	$7,965.00
	227091	08/19/2019	Suppliers or vendors	$9,660.00
	227092	08/19/2019	Suppliers or vendors	$21,042.00
	227093	08/19/2019	Suppliers or vendors	$21,698.80
	Wire	10/01/2019	Suppliers or vendors	$343,158.00
			SUBTOTAL	$478,622.60
JM CONVEYORS LLC PO BOX 603800 CHARLOTTE, NC 28260-3800	227220	08/19/2019	Suppliers or vendors	$24,782.40
	Wire	10/01/2019	Suppliers or vendors	$752,001.81
	Wire	10/21/2019	Suppliers or vendors	$820,185.72
			SUBTOTAL	$1,596,969.93
JMO MOBILE MODULAR LLC RT. 37 NORTH PO BOX 547 MARION, IL 62959	228507	09/06/2019	Suppliers or vendors	$250.00
	230725	10/07/2019	Suppliers or vendors	$250.00
			SUBTOTAL	$500.00
JOAN LOIS MARLING 4202 DRAGON HIGHWAY CAMERON, WV 26033	229581	09/20/2019	Other - Royalty	$391.14
			SUBTOTAL	$391.14

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JOE R PYLE COMPLETE AUCTION AND REA 5546 BENEDUM DR SHINNSTON, WV 26431	225285	07/31/2019	Suppliers or vendors	$10,000.00
	225286	07/31/2019	Suppliers or vendors	$10,000.00
	225287	07/31/2019	Suppliers or vendors	$5,000.00
	225288	07/31/2019	Suppliers or vendors	$5,000.00
	225289	07/31/2019	Suppliers or vendors	$5,000.00
	225290	07/31/2019	Suppliers or vendors	$5,000.00
	225291	07/31/2019	Suppliers or vendors	$5,000.00
	225292	07/31/2019	Suppliers or vendors	$5,000.00
	225294	07/31/2019	Suppliers or vendors	$5,000.00
	225295	07/31/2019	Suppliers or vendors	$5,000.00
	225296	07/31/2019	Suppliers or vendors	$5,000.00
	225297	07/31/2019	Suppliers or vendors	$1,000.00
	225298	07/31/2019	Suppliers or vendors	$1,000.00
	225299	07/31/2019	Suppliers or vendors	$1,000.00
	225300	07/31/2019	Suppliers or vendors	$1,000.00
	225301	07/31/2019	Suppliers or vendors	$1,000.00
	225302	07/31/2019	Suppliers or vendors	$1,000.00
	225303	07/31/2019	Suppliers or vendors	$1,000.00
	225304	07/31/2019	Suppliers or vendors	$1,000.00
	225305	07/31/2019	Suppliers or vendors	$100.00
			SUBTOTAL	$73,100.00
JOEL BRAIDO 40801 BETHESDA-BELMONT RD BETHESDA, OH 43719	227420	08/23/2019	Suppliers or vendors	$825.00
			SUBTOTAL	$825.00
JOHN DUDLEY JUDY 318 N. SYCAMORE STREET MT. STERLING, KY 40353	227464	08/23/2019	Other - Royalty	$297.84
	229978	09/26/2019	Other - Royalty	$364.29
			SUBTOTAL	$662.13
JOHN F. DAVIS III 41690 VALLEY VIEW CT. ELIZABETH, CO 80107	227466	08/23/2019	Other - Royalty	$114.46
			SUBTOTAL	$114.46

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JOHN FABICK TRACTOR COMPANY PO BOX 952121 ST. LOUIS, MO 63195-2121	226017	08/13/2019	Suppliers or vendors	$7,292.02
	227352	08/23/2019	Suppliers or vendors	$870.29
	229341	09/20/2019	Suppliers or vendors	$403.99
	230965	10/11/2019	Suppliers or vendors	$8,774.23
			SUBTOTAL	$17,340.53
JOHN FAHEY C/O BENESCH, FRIEDLANDR, COPLN, ARO 2300 BP TOWER, 200 PUBLIC SQUARE CLEVELAND, OH 44114	ACH	09/13/2019	Suppliers or vendors	$20,000.00
			SUBTOTAL	$20,000.00
JOHN HENRY FOSTER COMPANY PO BOX 419161 CREVE COEUR, MO 63141-9161	ACH	08/07/2019	Suppliers or vendors	$1,389.43
	ACH	08/19/2019	Suppliers or vendors	$2,525.32
			SUBTOTAL	$3,914.75
JOHN INGELS 39841 ROUTE 143 POMEROY, OH 45769	225867	08/05/2019	Other - Royalty	$0.50
			SUBTOTAL	$0.50
JOHN J. MORGAN 1034 FIFTHE AVE, SUITE 400 PITTSBURGH, PA 15219	226283	08/13/2019	Services	$2,421.81
	230766	10/07/2019	Services	$2,424.69
			SUBTOTAL	$4,846.50
JOHN ROGER CURD 7136 TUCKER RD. HOLLY, MI 48442	226276	08/13/2019	Other - Royalty	$62.27
			SUBTOTAL	$62.27
JOHN T JOHNSON 364 PATTERSON DR.#122 MORGANTOWN, WV 26505	227202	08/19/2019	Services	$735.00
	229650	09/20/2019	Services	$490.00
			SUBTOTAL	$1,225.00
JOHN W BACKER JR 2081 HARMONY COURT LEXINGTON, KY 40502	227601	08/23/2019	Other - Royalty	$123.49
			SUBTOTAL	$123.49

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JOHN W CLAY IRREV FAMILY GSTT TRUST EXEMPT SHARE PO BOX 363 MT. STERLING, KY 40353	227616	08/23/2019	Other - Royalty	$409.73
	230038	09/26/2019	Other - Royalty	$435.06
			SUBTOTAL	$844.79
JOHN W.CLAY TR UW PO BOX 363 MT.STERLING, KY 40353	227596	08/23/2019	Other - Royalty	$177.34
			SUBTOTAL	$177.34
JOHN'S TOWING SERVICE, INC. PO BOX 17 SHIPPINGPORT, PA 15077	225425	08/02/2019	Suppliers or vendors	$27,000.00
	226151	08/13/2019	Suppliers or vendors	$59,033.50
			SUBTOTAL	$86,033.50
JOHNSON CONTROLS SECURITY SOULTIONS TYCO INTEGRATED SECURITY LLC PO BOX 371967 PITTSBURGH, PA 15250-7967	231069	10/11/2019	Suppliers or vendors	$205.42
			SUBTOTAL	$205.42
JONATHAN A. GETZLAFF DBA J & W ROLL-OFF SERVICES LLC PO BOX 4 WARNOCK, OH 43967	226945	08/19/2019	Suppliers or vendors	$14,417.39
	228792	09/06/2019	Suppliers or vendors	$595.00
	228793	09/06/2019	Suppliers or vendors	$17,885.60
	229888	09/25/2019	Suppliers or vendors	$595.00
	229889	09/25/2019	Suppliers or vendors	$31,711.85
			SUBTOTAL	$65,204.84
JOSEPH G MCPHERSON BLACK DIAMOND PAVING 66304 MUELLER ROAD BELMONT, OH 43718	225580	08/02/2019	Services	$112,000.00
			SUBTOTAL	$112,000.00
JOSEPH G. PASTORIAL 5 LEGEND DRIVE BRIDGEPORT, WV 26330	228483	09/06/2019	Services	$400.00
	231204	10/11/2019	Services	$400.00
			SUBTOTAL	$800.00
JOSEPH W. MATOSZKIA 57619 VALLEY DRIVE SHADYSIDE, OH 43947	225996	08/13/2019	Suppliers or vendors	$2,790.00
	225997	08/13/2019	Suppliers or vendors	$2,058.00
	227340	08/23/2019	Suppliers or vendors	$1,750.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JOSEPH W. MATOSZKIA 57619 VALLEY DRIVE SHADYSIDE, OH 43947	228285	09/06/2019	Suppliers or vendors	$2,604.00
	228286	09/06/2019	Suppliers or vendors	$2,058.00
	229310	09/20/2019	Suppliers or vendors	$1,750.00
	230492	10/07/2019	Suppliers or vendors	$2,604.00
	230493	10/07/2019	Suppliers or vendors	$2,058.00
	230942	10/11/2019	Suppliers or vendors	$1,750.00
			SUBTOTAL	$19,422.00
JOY GLOBAL CONVEYORS, INC. PO BOX 74008951 CHICAGO, IL 60674-8951	225582	08/05/2019	Suppliers or vendors	$79,270.00
	226471	08/13/2019	Suppliers or vendors	$163,285.60
	226867	08/19/2019	Suppliers or vendors	$24,256.79
	226868	08/19/2019	Suppliers or vendors	$79,270.00
	226869	08/19/2019	Suppliers or vendors	$24,633.86
	226870	08/19/2019	Suppliers or vendors	$1,465.00
	227777	08/28/2019	Suppliers or vendors	$46,159.96
	227778	08/28/2019	Suppliers or vendors	$339,252.33
	227779	08/28/2019	Suppliers or vendors	$22,343.64
	227780	08/28/2019	Suppliers or vendors	$2,138.50
	227781	08/28/2019	Suppliers or vendors	$35,237.50
	228724	09/06/2019	Suppliers or vendors	$5,491.85
	228725	09/06/2019	Suppliers or vendors	$109,180.80
	228726	09/06/2019	Suppliers or vendors	$91,182.58
	231365	10/11/2019	Suppliers or vendors	$1,105.34
	231366	10/11/2019	Suppliers or vendors	$128,135.52
	231367	10/11/2019	Suppliers or vendors	$333.24
	231368	10/11/2019	Suppliers or vendors	$127,418.98
	231369	10/11/2019	Suppliers or vendors	$10,214.12
	231370	10/11/2019	Suppliers or vendors	$12,730.50
	231371	10/11/2019	Suppliers or vendors	$5,206.75
			SUBTOTAL	$1,308,312.86
JOY GLOBAL UNDERGROUND MINING LLC PO BOX 504794 ST. LOUIS, MO 63150-4794	225700	08/05/2019	Suppliers or vendors	$8,595.87
	225701	08/05/2019	Suppliers or vendors	$255,000.00
	225702	08/05/2019	Suppliers or vendors	$18,517.00
	ACH	08/06/2019	Suppliers or vendors	($131,832.99)
	226024	08/13/2019	Suppliers or vendors	$131,832.99
	226510	08/13/2019	Suppliers or vendors	$229,638.17
	226511	08/13/2019	Suppliers or vendors	$844,697.34

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JOY GLOBAL UNDERGROUND MINING LLC PO BOX 504794 ST. LOUIS, MO 63150-4794	226512	08/13/2019	Suppliers or vendors	$246,170.78
	226513	08/13/2019	Suppliers or vendors	$9,510.70
	226514	08/13/2019	Suppliers or vendors	$322,155.18
	226515	08/13/2019	Suppliers or vendors	$580.84
	226516	08/13/2019	Suppliers or vendors	$687.50
	226517	08/13/2019	Suppliers or vendors	$4,908.23
	226518	08/13/2019	Suppliers or vendors	$21,050.41
	226519	08/13/2019	Suppliers or vendors	$23,792.64
	227025	08/19/2019	Suppliers or vendors	$268.84
	227026	08/19/2019	Suppliers or vendors	$265,569.33
	227027	08/19/2019	Suppliers or vendors	$586,894.60
	227028	08/19/2019	Suppliers or vendors	$11,735.69
	227029	08/19/2019	Suppliers or vendors	$293,516.97
	227030	08/19/2019	Suppliers or vendors	$93,806.72
	227031	08/19/2019	Suppliers or vendors	$33,268.15
	227032	08/19/2019	Suppliers or vendors	$12,570.23
	227033	08/19/2019	Suppliers or vendors	$130,124.37
	227034	08/19/2019	Suppliers or vendors	$91,382.41
	227035	08/19/2019	Suppliers or vendors	$511,045.27
	227949	08/28/2019	Suppliers or vendors	$27,102.91
	227950	08/28/2019	Suppliers or vendors	$12,447.28
	227951	08/28/2019	Suppliers or vendors	$333,931.42
	227952	08/28/2019	Suppliers or vendors	$699,075.36
	227953	08/28/2019	Suppliers or vendors	$1,222.14
	227954	08/28/2019	Suppliers or vendors	$6,912.70
	227955	08/28/2019	Suppliers or vendors	$17,774.67
	227956	08/28/2019	Suppliers or vendors	$28,328.07
	227957	08/28/2019	Suppliers or vendors	$22,597.63
	227958	08/28/2019	Suppliers or vendors	$47,940.51
	228879	09/06/2019	Suppliers or vendors	$7,543.74
	228880	09/06/2019	Suppliers or vendors	$24,956.47
	228881	09/06/2019	Suppliers or vendors	$12,135.01
	228882	09/06/2019	Suppliers or vendors	$16,752.02
	228883	09/06/2019	Suppliers or vendors	$696,352.18
	228884	09/06/2019	Suppliers or vendors	$53,837.41
	228885	09/06/2019	Suppliers or vendors	$402.34
	228886	09/06/2019	Suppliers or vendors	$875.00
	228887	09/06/2019	Suppliers or vendors	$30,423.21
	228888	09/06/2019	Suppliers or vendors	$31,581.42

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
JOY GLOBAL UNDERGROUND MINING LLC PO BOX 504794 ST. LOUIS, MO 63150-4794	228889	09/06/2019	Suppliers or vendors	$22,854.63
	228890	09/06/2019	Suppliers or vendors	$238,683.03
	229908	09/26/2019	Suppliers or vendors	$5,555.60
	229909	09/26/2019	Suppliers or vendors	$34,607.05
	230059	10/01/2019	Suppliers or vendors	$2,846.24
	230071	10/02/2019	Suppliers or vendors	$22,915.98
	230375	10/04/2019	Suppliers or vendors	$800.69
	230376	10/04/2019	Suppliers or vendors	$10,837.88
	230377	10/04/2019	Suppliers or vendors	$3,013.34
	230378	10/04/2019	Suppliers or vendors	$809.55
	230379	10/04/2019	Suppliers or vendors	$4,134.20
	230380	10/04/2019	Suppliers or vendors	$2,955.03
	230381	10/04/2019	Suppliers or vendors	$22,340.39
	231408	10/11/2019	Suppliers or vendors	$4,619.10
	231409	10/11/2019	Suppliers or vendors	$348.16
	231410	10/11/2019	Suppliers or vendors	$12,022.22
	231411	10/11/2019	Suppliers or vendors	$26,908.48
	231412	10/11/2019	Suppliers or vendors	$456.92
	231413	10/11/2019	Suppliers or vendors	$10,311.40
	231414	10/11/2019	Suppliers or vendors	$94,929.96
	231487	10/14/2019	Suppliers or vendors	$57,823.13
	231549	10/17/2019	Suppliers or vendors	$9,505.82
			SUBTOTAL	$6,676,957.53
JUDITH ARNOLD 625 CHESTNUT STREET MIDDLEPORT, OH 45760	225856	08/05/2019	Other - Royalty	$6.23
	229053	09/10/2019	Other - Royalty	$6.05
	230569	10/07/2019	Other - Royalty	$5.14
			SUBTOTAL	$17.42
JUDITH E. ELKINS 32080 CAMERON ST PO BOX 168 WINONA, OH 44493	226277	08/13/2019	Other - Royalty	$62.26
			SUBTOTAL	$62.26
JULIE SEILER 1207 BORAH STREET OLNEY, IL 62450	226280	08/13/2019	Other - Royalty	$4,908.11
			SUBTOTAL	$4,908.11

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
K & J MACHINE 326 FAIRMONT AVENUE BARNESVILLE, OH 43713-9669	225703	08/05/2019	Suppliers or vendors	$55,316.41
	225704	08/05/2019	Suppliers or vendors	$2,852.00
	227036	08/19/2019	Suppliers or vendors	$7,035.29
			SUBTOTAL	$65,203.70
K & K PROFESSIONAL KLEANING PO BOX 285 ST. CLAIRSVILLE, OH 43950	225329	08/02/2019	Suppliers or vendors	$1,002.00
	225330	08/02/2019	Suppliers or vendors	$4,400.00
	225331	08/02/2019	Suppliers or vendors	$12,716.33
	225332	08/02/2019	Suppliers or vendors	$35,743.00
	225333	08/02/2019	Suppliers or vendors	$3,710.00
	225334	08/02/2019	Suppliers or vendors	$3,675.00
	225335	08/02/2019	Suppliers or vendors	$770.00
	225336	08/02/2019	Suppliers or vendors	$16,503.00
	225337	08/02/2019	Suppliers or vendors	$17,118.00
	225338	08/02/2019	Suppliers or vendors	$2,600.00
	228226	09/06/2019	Suppliers or vendors	$1,002.00
	228227	09/06/2019	Suppliers or vendors	$4,400.00
	228228	09/06/2019	Suppliers or vendors	$12,466.33
	228229	09/06/2019	Suppliers or vendors	$35,743.00
	228230	09/06/2019	Suppliers or vendors	$3,710.00
	228231	09/06/2019	Suppliers or vendors	$3,675.00
	228232	09/06/2019	Suppliers or vendors	$770.00
	228233	09/06/2019	Suppliers or vendors	$16,503.00
	228234	09/06/2019	Suppliers or vendors	$17,243.00
	228235	09/06/2019	Suppliers or vendors	$2,600.00
	230812	10/10/2019	Suppliers or vendors	$1,002.00
	230813	10/10/2019	Suppliers or vendors	$4,400.00
	230814	10/10/2019	Suppliers or vendors	$12,466.33
	230815	10/10/2019	Suppliers or vendors	$35,743.00
	230816	10/10/2019	Suppliers or vendors	$3,753.75
	230817	10/10/2019	Suppliers or vendors	$3,675.00
	230818	10/10/2019	Suppliers or vendors	$850.00
	230819	10/10/2019	Suppliers or vendors	$16,503.00
	230820	10/10/2019	Suppliers or vendors	$17,243.00
	230821	10/10/2019	Suppliers or vendors	$2,600.00
	231866	10/25/2019	Suppliers or vendors	$1,002.00
	231867	10/25/2019	Suppliers or vendors	$4,400.00
	231868	10/25/2019	Suppliers or vendors	$12,466.33
	231869	10/25/2019	Suppliers or vendors	$35,743.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
K & K PROFESSIONAL KLEANING PO BOX 285 ST. CLAIRSVILLE, OH 43950	231870	10/25/2019	Suppliers or vendors	$3,753.75
	231871	10/25/2019	Suppliers or vendors	$3,675.00
	231872	10/25/2019	Suppliers or vendors	$770.00
	231873	10/25/2019	Suppliers or vendors	$16,503.00
	231874	10/25/2019	Suppliers or vendors	$15,243.00
	231875	10/25/2019	Suppliers or vendors	$2,000.00
			SUBTOTAL	$390,141.82
K DOLAN CONVEYOR COMPANY LLC 110 CONEMAUGH STREET PO BOX 175 BLAIRSVILLE, PA 15717	227179	08/19/2019	Services	$16,576.00
	227180	08/19/2019	Services	$4,584.00
	228105	08/28/2019	Services	$31,696.00
	229021	09/06/2019	Services	$16,114.00
	229022	09/06/2019	Services	$4,754.00
	229023	09/06/2019	Services	$3,585.00
	230053	09/27/2019	Services	$14,208.00
	230054	09/27/2019	Services	$16,298.00
	230055	09/27/2019	Services	$8,450.00
	230834	10/10/2019	Services	$12,969.00
	231479	10/11/2019	Services	$27,954.00
	231480	10/11/2019	Services	$15,576.50
	231577	10/17/2019	Services	$16,088.00
			SUBTOTAL	$188,852.50
KANAWHA SCALES & SYSTEMS, INC. PO BOX 569 POCA, WV 25159	225939	08/13/2019	Suppliers or vendors	$2,200.00
	227291	08/23/2019	Suppliers or vendors	$16,238.54
	228236	09/06/2019	Suppliers or vendors	$4,041.30
	229218	09/20/2019	Suppliers or vendors	$2,200.00
	229219	09/20/2019	Suppliers or vendors	$186.12
	229220	09/20/2019	Suppliers or vendors	$1,695.00
			SUBTOTAL	$26,560.96
KATHERINE FISH EIGHER 6161 LOUISVILLE STREET NEW ORLEANS, LA 70124	227470	08/23/2019	Other - Royalty	$141.41
	229983	09/26/2019	Other - Royalty	$176.87
			SUBTOTAL	$318.28

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
KATHRYN BRIGGS CLAY PO BOX 22319 LEXINGTON, KY 40522	227447	08/23/2019	Other - Royalty	$177.36
			SUBTOTAL	$177.36
KATHY LYNN PIERCE 1121 GYPSY HILL ROAD LANCASTER, PA 17602	229583	09/20/2019	Other - Royalty	$358.65
			SUBTOTAL	$358.65
KEITH A BASSI 109 MOOD LANE FAYETTE CITY, PA 15438	228504	09/06/2019	Suppliers or vendors	$759.54
	230034	09/26/2019	Suppliers or vendors	$379.77
			SUBTOTAL	$1,139.31
KEITH MILLER DBA KM COMPUTERS 1057 HARRISON CITY EXPORT RD JEANNETTE, PA 15644	226793	08/19/2019	Suppliers or vendors	$3,600.82
	228446	09/06/2019	Suppliers or vendors	$1,877.26
	228447	09/06/2019	Suppliers or vendors	$1,948.28
	228448	09/06/2019	Suppliers or vendors	$2,340.00
	229569	09/20/2019	Suppliers or vendors	$4,959.74
	229570	09/20/2019	Suppliers or vendors	$6,837.00
	229571	09/20/2019	Suppliers or vendors	$232.14
	230688	10/07/2019	Suppliers or vendors	$4,682.80
	230689	10/07/2019	Suppliers or vendors	$3,319.44
	230690	10/07/2019	Suppliers or vendors	$195.00
	231168	10/11/2019	Suppliers or vendors	$852.24
	231169	10/11/2019	Suppliers or vendors	$656.14
			SUBTOTAL	$31,500.86
KEITHS INDUSTRIAL WELDING & FAB. IN 600 INDIANA AVE. BLAIRSVILLE, PA 15717	ACH	08/19/2019	Suppliers or vendors	$2,520.00
	231698	10/22/2019	Suppliers or vendors	$19,500.40
			SUBTOTAL	$22,020.40
KENNETH A. JOHNSON 35908 WOLF PEN ROAD POMEROY, OH 45769	225873	08/05/2019	Other - Royalty	$30.92
	229069	09/10/2019	Other - Royalty	$32.24
	230585	10/07/2019	Other - Royalty	$27.35
			SUBTOTAL	$90.51

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KENNETH W EBLIN 37492 SR 143 RUTLAND, OH 45775	225863	08/05/2019	Other - Royalty	$80.55
	229060	09/10/2019	Other - Royalty	$67.00
	230576	10/07/2019	Other - Royalty	$49.14
			SUBTOTAL	$196.69
KENTUCKY AMERICAN WATER COMPANY P.O. BOX 790247 ST.LOUIS, MO 63179-0247	225448	08/02/2019	Other - Utilities	$572.19
	228476	09/06/2019	Other - Utilities	$231.93
	230190	10/03/2019	Other - Utilities	$216.65
			SUBTOTAL	$1,020.77
KENTUCKY BASIC MANAGEMENT LLC BENNETT E. BAYER 106 WEST VINE STREET, SUITE 800 LEXINGTON, KY 40507	228167	08/30/2019	Other - Royalty	$71,776.50
	229436	09/20/2019	Other - Royalty	$84,460.77
			SUBTOTAL	$156,237.27
KENTUCKY COAL ASSOCIATION 880 CORPORATE DRIVE #101 LEXINGTON, KY 40503	226103	08/13/2019	Suppliers or vendors	$3,051.11
			SUBTOTAL	$3,051.11
KENTUCKY STATE TREASURER KENTUCKY REVENUE CABINET FRANKFORT, KY 40620	ACH	08/22/2019	Other - Regulatory/Tax	$2,400.68
	ACH	08/31/2019	Other - Regulatory/Tax	$2,232.60
	ACH	09/20/2019	Other - Regulatory/Tax	$2,562.50
	ACH	10/11/2019	Other - Regulatory/Tax	$7,024.39
	ACH	10/21/2019	Other - Regulatory/Tax	$650.04
			SUBTOTAL	$14,870.21
KENTUCKY UTILITIES COMPANY ATTN: REMITTANCE AND COLLECTION 820 WEST BROADWAY LOUISVILLE, KY 40202	226605	08/15/2019	Other - Utilities	$15,469.71
			SUBTOTAL	$15,469.71
KENTUCKY UTILITIES COMPANY KU/ODP PO BOX 9001954 LOUISVILLE, KY 40290	ACH	07/31/2019	Other - Utilities	$59,748.48
	ACH	08/09/2019	Other - Utilities	$73,468.98
	225978	08/13/2019	Other - Utilities	$343.84
	225979	08/13/2019	Other - Utilities	$309.07
	225980	08/13/2019	Other - Utilities	$2,300.56
	225981	08/13/2019	Other - Utilities	$2,890.52

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
KENTUCKY UTILITIES COMPANY KU/ODP PO BOX 9001954 LOUISVILLE, KY 40290	225982	08/13/2019	Other - Utilities	$947.90
	225983	08/13/2019	Other - Utilities	$4,404.67
	225984	08/13/2019	Other - Utilities	$9,226.25
	ACH	08/14/2019	Other - Utilities	$835.24
	ACH	08/31/2019	Other - Utilities	$59,384.84
	ACH	09/17/2019	Other - Utilities	$72,494.40
	229283	09/20/2019	Other - Utilities	$338.83
	229284	09/20/2019	Other - Utilities	$295.07
	229285	09/20/2019	Other - Utilities	$2,274.22
	229286	09/20/2019	Other - Utilities	$2,870.45
	229287	09/20/2019	Other - Utilities	$2,754.05
	229288	09/20/2019	Other - Utilities	$927.36
	229289	09/20/2019	Other - Utilities	$9,172.53
	ACH	09/30/2019	Other - Utilities	$52,392.69
	230111	10/03/2019	Other - Utilities	$303.44
	230906	10/11/2019	Other - Utilities	$9,556.57
	230907	10/11/2019	Other - Utilities	$345.89
	230908	10/11/2019	Other - Utilities	$2,261.81
	230909	10/11/2019	Other - Utilities	$2,833.74
	230910	10/11/2019	Other - Utilities	$2,609.48
	230911	10/11/2019	Other - Utilities	$964.16
	ACH	10/11/2019	Other - Utilities	$69,639.29
	Wire	10/28/2019	Other - Utilities	$121,201.51
			SUBTOTAL	$567,095.84
KETCHEM CONSTRUCTION COMPANY, INC. 105 KETCHEM LANE WAYNESBURG, PA 15370	ACH	08/19/2019	Suppliers or vendors	$7,137.64
	ACH	08/30/2019	Suppliers or vendors	$4,800.00
			SUBTOTAL	$11,937.64
KEVIN ROBERTS & SHAWNA ROBERTS 60425 KEMP RD BELMONT, OH 43718	228395	09/06/2019	Suppliers or vendors	$1,500.00
			SUBTOTAL	$1,500.00
KEVIN TAYLOR RYE 510 CARRIGAN DRIVE DANVILLE, KY 40422	227473	08/23/2019	Other - Royalty	$107.17
			SUBTOTAL	$107.17

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
KEWA US INC 238 BEDFORD WAY FRAANKLIN, TN 37064	ACH	10/04/2019	Suppliers or vendors	$317,500.00
			SUBTOTAL	$317,500.00
KIMBALL MIDWEST DIV. OF MIDWEST MOTOR SUPPLY CO., I DEPT. L-2780 COLUMBUS, OH 43260-2780	ACH	08/07/2019	Suppliers or vendors	$574.80
	ACH	08/19/2019	Suppliers or vendors	$2,548.00
	ACH	09/13/2019	Suppliers or vendors	$1,249.85
	230004	09/26/2019	Suppliers or vendors	$100.35
	230005	09/26/2019	Suppliers or vendors	$293.19
	230006	09/26/2019	Suppliers or vendors	$1,255.34
	230007	09/26/2019	Suppliers or vendors	$402.96
	230166	10/03/2019	Suppliers or vendors	$122.24
	231097	10/11/2019	Suppliers or vendors	$128.09
			SUBTOTAL	$6,674.82
KIMBERLY KETTLER 2629 DANDELION DRIVE HIGH POINT, NC 27265	229584	09/20/2019	Other - Royalty	$16.30
			SUBTOTAL	$16.30
KIMBERLY L BRASHEAR KCK WELDING LLC 8460 NEBO ROAD MADIONVILLE, KY 42431	231256	10/11/2019	Suppliers or vendors	$32,400.00
			SUBTOTAL	$32,400.00
KIMBERLY POWELL & DENNIS POWELL 302 STUART STREET WEST UNION, WV 26456	231223	10/11/2019	Suppliers or vendors	$1,000.00
			SUBTOTAL	$1,000.00
KING'S AUTO GLASS 1008 LAFAYETTE AVENUE MOUNDSVILLE, WV 26041	225940	08/13/2019	Suppliers or vendors	$200.00
	227292	08/23/2019	Suppliers or vendors	$334.00
	227293	08/23/2019	Suppliers or vendors	$250.00
	228237	09/06/2019	Suppliers or vendors	$2,278.00
	229221	09/20/2019	Suppliers or vendors	$600.00
			SUBTOTAL	$3,662.00
KIRKLAND & ELLIS LLP 601 LEXINGTON AVE. NEW YORK, NY 10022	ACH	09/26/2019	Services	$592,395.01
			SUBTOTAL	$592,395.01

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
KLEAR LLC KLEAR WATER MANAGEMENT 183 NORTH RIVER ROAD PO BOX 6358 WHEELING, WV 26003	229693	09/20/2019	Suppliers or vendors	$812.72
			SUBTOTAL	$812.72
KLEINSCHMIDT, INC. PO BOX 7158 DEERFIELD, IL 60015-7158	228436	09/06/2019	Services	$624.09
	229553	09/20/2019	Services	$776.24
	231151	10/11/2019	Services	$474.88
			SUBTOTAL	$1,875.21
KLONDIKE BLOCK & MASONARY 331 SHOAF RD SMITHFIELD, PA 15478	228073	08/28/2019	Suppliers or vendors	$24,967.44
	231463	10/11/2019	Suppliers or vendors	$16,660.08
			SUBTOTAL	$41,627.52
KNIGHT E/A INC 221 N LASALLE ST SUITE 300 CHICAGO, IL 60601-1211	225823	08/05/2019	Suppliers or vendors	$6,889.50
			SUBTOTAL	$6,889.50
KNIGHT MANUFACTURING CO. 399 EAST 40TH STREET PO BOX 98 SHADYSIDE, OH 43947	226871	08/19/2019	Suppliers or vendors	$14,548.50
	226872	08/19/2019	Suppliers or vendors	$26,062.00
	226873	08/19/2019	Suppliers or vendors	$2,150.00
	226874	08/19/2019	Suppliers or vendors	$43,165.00
	226875	08/19/2019	Suppliers or vendors	$9,922.31
	227782	08/28/2019	Suppliers or vendors	$9,558.22
	231372	10/11/2019	Suppliers or vendors	$14,660.00
	231495	10/16/2019	Suppliers or vendors	$17,600.00
	231496	10/16/2019	Suppliers or vendors	$12,772.00
	231587	10/18/2019	Suppliers or vendors	$3,525.00
	231588	10/18/2019	Suppliers or vendors	$2,260.00
	231636	10/18/2019	Suppliers or vendors	$1,440.00
	231669	10/22/2019	Suppliers or vendors	$517.00
			SUBTOTAL	$158,180.03
KNOTTS & COMPANY PO BOX 70 SPANISH FORK, UT 84660	227961	08/28/2019	Suppliers or vendors	$10,182.14
	231600	10/18/2019	Suppliers or vendors	$22,292.75
			SUBTOTAL	$32,474.89

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KOK LAND MANAGEMENT SERVICES LLC 8200 S QUEBEC STREET,#A3-798 CENTENNIAL, CO 80112	230703	10/07/2019	Services	$337.50
	230704	10/07/2019	Services	$11,062.71
	230705	10/07/2019	Services	$1,312.50
	230706	10/07/2019	Services	$787.50
			SUBTOTAL	$13,500.21
KONECRANES INC PO BOX 644994 PITTSBURGH, PA 15264-4994	ACH	08/30/2019	Suppliers or vendors	$4,619.00
			SUBTOTAL	$4,619.00
KRISTIE N LIGON REP ESTATE OF QUINEVERE NIELSON DEC 14970 N DOVE CANYON PASS MARANA, AZ 85658	228471	09/06/2019	Suppliers or vendors	$480.00
			SUBTOTAL	$480.00
KRONOS INC PO BOX 743208 ATLANTA, GA 30374-3208	230474	10/07/2019	Suppliers or vendors	$57,041.89
			SUBTOTAL	$57,041.89
KUCERA PLUMBING/HEATING/COOLING LLC 4150 CENTRAL AVENUE SHADYSIDE, OH 43947	230073	10/02/2019	Suppliers or vendors	$20,074.70
			SUBTOTAL	$20,074.70
KWIK LUBE & TIRE LLC 660 EAST MAIN PO BOX 804 WELLINGTON, UT 84542	ACH	08/30/2019	Suppliers or vendors	$64.81
	ACH	09/13/2019	Suppliers or vendors	$838.49
	230518	10/07/2019	Suppliers or vendors	$49.81
			SUBTOTAL	$953.11
LAKEN WELLING LAKEN WELLING CONTRACTING 50580 GREEN VALLEY ROAD ST.CLAIRSVILLE, OH 43950	226235	08/13/2019	Suppliers or vendors	$939.60
	226829	08/19/2019	Suppliers or vendors	$2,169.05
	227612	08/23/2019	Suppliers or vendors	$1,146.69
	228514	09/06/2019	Suppliers or vendors	$724.05
	229668	09/20/2019	Suppliers or vendors	$1,747.98
	230737	10/07/2019	Suppliers or vendors	$974.60
	231240	10/11/2019	Suppliers or vendors	$1,912.05
	231880	10/25/2019	Suppliers or vendors	$3,221.15
			SUBTOTAL	$12,835.17

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
LAMOINE & CHERYL WEBB 2900 SWIGART ROAD DAYTON, OH 45440	229993	09/26/2019	Other - Royalty	$212.12
			SUBTOTAL	$212.12
LANA B. MEANS SEW SPECIAL PO BOX 910173 ST. GEORGE, UT 84790	228362	09/06/2019	Suppliers or vendors	$432.03
			SUBTOTAL	$432.03
LARROL SUPPLY, INC. 66261 NORTH 26 ROAD BETHESDA, OH 43719-9748	225589	08/05/2019	Suppliers or vendors	$35,158.02
	225590	08/05/2019	Suppliers or vendors	$34,120.25
	225591	08/05/2019	Suppliers or vendors	$4,038.10
	225592	08/05/2019	Suppliers or vendors	$9,742.76
	225593	08/05/2019	Suppliers or vendors	$6,011.76
	225594	08/05/2019	Suppliers or vendors	$1,622.86
	225595	08/05/2019	Suppliers or vendors	$9,284.22
	225596	08/05/2019	Suppliers or vendors	$304.34
	225597	08/05/2019	Suppliers or vendors	$1,366.99
	225598	08/05/2019	Suppliers or vendors	$879.92
	225941	08/13/2019	Suppliers or vendors	$194.00
	225942	08/13/2019	Suppliers or vendors	$501.13
	225943	08/13/2019	Suppliers or vendors	$6,238.62
	225944	08/13/2019	Suppliers or vendors	$457.44
	226876	08/19/2019	Suppliers or vendors	$321.06
	226877	08/19/2019	Suppliers or vendors	$3,963.43
	226878	08/19/2019	Suppliers or vendors	$88,442.93
	226879	08/19/2019	Suppliers or vendors	$90,895.85
	226880	08/19/2019	Suppliers or vendors	$5,862.20
	226881	08/19/2019	Suppliers or vendors	$32,890.09
	226882	08/19/2019	Suppliers or vendors	$35,737.86
	226883	08/19/2019	Suppliers or vendors	$6,113.56
	226884	08/19/2019	Suppliers or vendors	$40,453.10
	226885	08/19/2019	Suppliers or vendors	$315.52
	226886	08/19/2019	Suppliers or vendors	$4,980.92
	226887	08/19/2019	Suppliers or vendors	$3,787.88
	227294	08/23/2019	Suppliers or vendors	$1,283.88
	227295	08/23/2019	Suppliers or vendors	$146.25
	227296	08/23/2019	Suppliers or vendors	$7,446.34
	227783	08/28/2019	Suppliers or vendors	$2,436.64
	227784	08/28/2019	Suppliers or vendors	$3,130.13

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
LARROL SUPPLY, INC. 66261 NORTH 26 ROAD BETHESDA, OH 43719-9748	227785	08/28/2019	Suppliers or vendors	$36,751.36
	227786	08/28/2019	Suppliers or vendors	$25,685.14
	227787	08/28/2019	Suppliers or vendors	$1,420.16
	227788	08/28/2019	Suppliers or vendors	$9,112.66
	227789	08/28/2019	Suppliers or vendors	$11,961.80
	227790	08/28/2019	Suppliers or vendors	$1,072.96
	227791	08/28/2019	Suppliers or vendors	$5,769.86
	227792	08/28/2019	Suppliers or vendors	$132.90
	227793	08/28/2019	Suppliers or vendors	$1,278.35
	227794	08/28/2019	Suppliers or vendors	$1,400.03
	228729	09/06/2019	Suppliers or vendors	$2,866.51
	228730	09/06/2019	Suppliers or vendors	$18,523.32
	228731	09/06/2019	Suppliers or vendors	$18,913.70
	228732	09/06/2019	Suppliers or vendors	$894.17
	228733	09/06/2019	Suppliers or vendors	$5,203.73
	228734	09/06/2019	Suppliers or vendors	$63.73
	228736	09/06/2019	Suppliers or vendors	$741.19
	228735	09/09/2019	Suppliers or vendors	$9,658.54
	229222	09/20/2019	Suppliers or vendors	$4,368.94
	229223	09/20/2019	Suppliers or vendors	$569.07
	229224	09/20/2019	Suppliers or vendors	$1,559.93
	229225	09/20/2019	Suppliers or vendors	$74.83
	230338	10/04/2019	Suppliers or vendors	$7,471.30
	230447	10/07/2019	Suppliers or vendors	$6,963.21
	230791	10/09/2019	Suppliers or vendors	$4,547.48
	231497	10/16/2019	Suppliers or vendors	$402.00
	231498	10/16/2019	Suppliers or vendors	$22,236.48
	231535	10/17/2019	Suppliers or vendors	$1,486.85
	231536	10/17/2019	Suppliers or vendors	$9,949.10
	231537	10/17/2019	Suppliers or vendors	$4,955.67
	231589	10/18/2019	Suppliers or vendors	$5,020.00
	231637	10/18/2019	Suppliers or vendors	$10,044.78
	231638	10/18/2019	Suppliers or vendors	$3,959.14
	231670	10/22/2019	Suppliers or vendors	$19,054.55
			SUBTOTAL	$692,241.49
LARRY CANTRELL 6460 HIGHWAY 589 WEST LIBERTY, KY 41472	225409	08/02/2019	Other - Royalty	$591.32
	229979	09/26/2019	Other - Royalty	$203.94
			SUBTOTAL	$795.26

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
LATHAM & WATKINS LLP PO BOX 2130 CAROL STREAM, IL 60132-2130	226083	08/13/2019	Services	$39,617.24
			SUBTOTAL	$39,617.24
LAUREL AGGREGATES OF DELAWARE LLC 103 CORPORATE DR., SUITE 202 MORGANTOWN, WV 26501	227155	08/19/2019	Suppliers or vendors	$3,700.22
	227156	08/19/2019	Suppliers or vendors	$10,893.42
	228990	09/06/2019	Suppliers or vendors	$21,290.88
	228991	09/06/2019	Suppliers or vendors	$1,909.41
	228992	09/06/2019	Suppliers or vendors	$16,597.36
	228993	09/06/2019	Suppliers or vendors	$9,420.32
	231620	10/18/2019	Suppliers or vendors	$6,076.00
			SUBTOTAL	$69,887.61
LAURITA INC 3748 DENTS RUN BLVD., STE A MORGANTOWN, WV 26501	229013	09/06/2019	Suppliers or vendors	$35,000.00
			SUBTOTAL	$35,000.00
LAWRENCE J TAYLOR 39425 TAYLORS DRIVE MIDDLEPORT, OH 45760	225888	08/05/2019	Other - Royalty	$10.60
	229083	09/10/2019	Other - Royalty	$10.45
	230600	10/07/2019	Other - Royalty	$10.49
			SUBTOTAL	$31.54
LAWSON PRODUCTS, INC. PO BOX 809401 CHICAGO, IL 60680	225705	08/05/2019	Suppliers or vendors	$104.48
			SUBTOTAL	$104.48
LEAF PO BOX 5066 HARTFORD, CT 06102-5066	225414	08/02/2019	Suppliers or vendors	$1,568.08
	225415	08/02/2019	Suppliers or vendors	$615.52
	225416	08/02/2019	Suppliers or vendors	$485.55
	225417	08/02/2019	Suppliers or vendors	$750.00
	225418	08/02/2019	Suppliers or vendors	$1,456.65
	226109	08/13/2019	Suppliers or vendors	$2,574.52
	226110	08/13/2019	Suppliers or vendors	$5,998.38
	226111	08/13/2019	Suppliers or vendors	$2,060.43
	226112	08/13/2019	Suppliers or vendors	$2,650.35
	226113	08/13/2019	Suppliers or vendors	$2,698.00
	226114	08/13/2019	Suppliers or vendors	$795.60
	226115	08/13/2019	Suppliers or vendors	$10,300.87

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
LEAF PO BOX 5066 HARTFORD, CT 06102-5066	226747	08/19/2019	Suppliers or vendors	$4,840.56
	226748	08/19/2019	Suppliers or vendors	$3,691.47
	226749	08/19/2019	Suppliers or vendors	$707.86
	228382	09/06/2019	Suppliers or vendors	$4,142.60
	228383	09/06/2019	Suppliers or vendors	$7,447.20
	228384	09/06/2019	Suppliers or vendors	$6,154.02
	228385	09/06/2019	Suppliers or vendors	$2,029.46
	228386	09/06/2019	Suppliers or vendors	$1,258.52
	228387	09/06/2019	Suppliers or vendors	$1,266.70
	228388	09/06/2019	Suppliers or vendors	$2,530.63
	229477	09/20/2019	Suppliers or vendors	$4,840.56
	229478	09/20/2019	Suppliers or vendors	$3,691.47
	229479	09/20/2019	Suppliers or vendors	$5,457.41
	229480	09/20/2019	Suppliers or vendors	$793.73
	229481	09/20/2019	Suppliers or vendors	$1,294.80
	229482	09/20/2019	Suppliers or vendors	$795.60
	229483	09/20/2019	Suppliers or vendors	$9,555.15
	230001	09/26/2019	Suppliers or vendors	$5,538.50
	230002	09/26/2019	Suppliers or vendors	$2,650.35
	230003	09/26/2019	Suppliers or vendors	$1,403.20
	230632	10/07/2019	Suppliers or vendors	$1,568.08
	230633	10/07/2019	Suppliers or vendors	$615.52
	230634	10/07/2019	Suppliers or vendors	$485.55
	230635	10/07/2019	Suppliers or vendors	$2,530.63
	231080	10/11/2019	Suppliers or vendors	$2,574.52
	231081	10/11/2019	Suppliers or vendors	$4,840.56
	231082	10/11/2019	Suppliers or vendors	$5,998.38
	231083	10/11/2019	Suppliers or vendors	$750.00
	231084	10/11/2019	Suppliers or vendors	$2,060.43
	231085	10/11/2019	Suppliers or vendors	$485.55
	231086	10/11/2019	Suppliers or vendors	$795.60
	231087	10/11/2019	Suppliers or vendors	$9,226.89
			SUBTOTAL	$133,975.45
LEAF PO BOX 5066 HARTFORD, CT 06115-5066	229710	09/20/2019	Suppliers or vendors	$15,691.25
			SUBTOTAL	$15,691.25

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LEE ANN LOCKWOOD 2501 FERGUSON STREET MT.VERNON, IL 62864	226076	08/13/2019	Other - Royalty	$7,695.74
			SUBTOTAL	$7,695.74
LEE JEFFERS 2994 CADENA WAY COULTERVILLE, CA 95311	225870	08/05/2019	Other - Royalty	$13.32
	229066	09/10/2019	Other - Royalty	$12.85
	230582	10/07/2019	Other - Royalty	$9.77
			SUBTOTAL	$35.94
LEE PENDLETON TAYLOR 2926 BECKNERVILLE ROAD WINCHESTER, KY 40391	227443	08/23/2019	Other - Royalty	$355.04
	229961	09/26/2019	Other - Royalty	$369.65
			SUBTOTAL	$724.69
LEE SUPPLY CO., INC. PO BOX 640335 PITTSBURGH, PA 15264-0335	226888	08/19/2019	Suppliers or vendors	$5,374.13
	226889	08/19/2019	Suppliers or vendors	$36,297.47
	226890	08/19/2019	Suppliers or vendors	$25,978.57
	226891	08/19/2019	Suppliers or vendors	$74,762.59
	226892	08/19/2019	Suppliers or vendors	$37,812.10
	226893	08/19/2019	Suppliers or vendors	$606.00
	227795	08/28/2019	Suppliers or vendors	$1,929.24
	227796	08/28/2019	Suppliers or vendors	$7,322.56
	227797	08/28/2019	Suppliers or vendors	$14,793.95
	227798	08/28/2019	Suppliers or vendors	$52,838.16
	227799	08/28/2019	Suppliers or vendors	$21,429.02
	227800	08/28/2019	Suppliers or vendors	$640.00
	228737	09/06/2019	Suppliers or vendors	$55,665.62
	228738	09/06/2019	Suppliers or vendors	$31,751.81
	228739	09/06/2019	Suppliers or vendors	$44,693.97
	228740	09/06/2019	Suppliers or vendors	$39,948.00
	228741	09/06/2019	Suppliers or vendors	$20,368.18
	228742	09/06/2019	Suppliers or vendors	$9,977.78
	228743	09/06/2019	Suppliers or vendors	$812.40
	231590	10/18/2019	Suppliers or vendors	$9,769.58
			SUBTOTAL	$492,771.13
LEGEND 1 CONSULTING LLC 15728 ALDAMA CIRCLE PORT CHARLOTTE, FL 33981	226844	08/19/2019	Services	$8,400.20
			SUBTOTAL	$8,400.20

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LEMAC MINE SERVICE 166 DISTRIBUTOR DRIVE MORGANTOWN, WV 26501	225795	08/05/2019	Suppliers or vendors	$23,119.71
	225796	08/05/2019	Suppliers or vendors	$6,892.98
	225797	08/05/2019	Suppliers or vendors	$55,870.50
			SUBTOTAL	$85,883.19
LENSCRAFTERS 14963 COLLECTIONS CENTER DRIVE CHICAGO, IL 60693	225339	08/02/2019	Suppliers or vendors	$1,045.00
	225340	08/02/2019	Suppliers or vendors	$149.99
	225945	08/13/2019	Suppliers or vendors	$630.00
	225946	08/13/2019	Suppliers or vendors	$295.00
	225947	08/13/2019	Suppliers or vendors	$310.00
	226618	08/19/2019	Suppliers or vendors	$610.00
	226619	08/19/2019	Suppliers or vendors	$375.00
	227297	08/23/2019	Suppliers or vendors	$60.00
	227298	08/23/2019	Suppliers or vendors	$220.00
	228238	09/06/2019	Suppliers or vendors	$20.00
	228239	09/06/2019	Suppliers or vendors	$130.00
	229226	09/20/2019	Suppliers or vendors	$345.00
	229227	09/20/2019	Suppliers or vendors	$190.00
	229228	09/20/2019	Suppliers or vendors	$410.00
	230448	10/07/2019	Suppliers or vendors	$240.00
	230449	10/07/2019	Suppliers or vendors	$150.00
	230450	10/07/2019	Suppliers or vendors	$190.00
	230851	10/11/2019	Suppliers or vendors	$4,695.00
	230852	10/11/2019	Suppliers or vendors	$140.00
	230853	10/11/2019	Suppliers or vendors	$120.00
			SUBTOTAL	$10,324.99
LEWIS PIERSON CRESCENT PRINT SHOP 513 SEVENTH STREET MOUNDSVILLE, WV 26041	226162	08/13/2019	Suppliers or vendors	$720.48
	227538	08/23/2019	Suppliers or vendors	$587.00
	230667	10/07/2019	Suppliers or vendors	$8,773.00
			SUBTOTAL	$10,080.48
LIBERTY KING 106 HOLLY LANE POMEROY, OH 45769	225875	08/05/2019	Other - Royalty	$3.49
	229071	09/10/2019	Other - Royalty	$3.27
	230587	10/07/2019	Other - Royalty	$3.70
			SUBTOTAL	$10.46

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LIBERTY MUTUAL INSURANCE 1 N FRANKLIN STREET, SUITE 2200 CHICAGO, IL 60606	ACH	08/05/2019	Services	$2,590.00
	ACH	08/26/2019	Services	$73,062.45
	ACH	09/05/2019	Services	$2,590.00
	ACH	09/25/2019	Services	$72,445.90
	ACH	10/03/2019	Services	$2,660.00
	ACH	10/23/2019	Services	$68,576.49
			SUBTOTAL	$221,924.84
LIBERTY UTILITIES MIDSTATES 75 REMITTANCE DRIVE, SUITE 1741 CHICAGO, IL 60675-1741	225361	08/02/2019	Other - Utilities	$144.51
	229304	09/20/2019	Other - Utilities	$128.15
	230112	10/03/2019	Other - Utilities	$125.45
			SUBTOTAL	$398.11
LICKING VALLEY RURAL ELECT COOP COR PO BOX 605 WEST LIBERTY, KY 41472-0605	225399	08/02/2019	Other - Utilities	$1,339.53
	229424	09/20/2019	Other - Utilities	$1,464.00
	230152	10/03/2019	Other - Utilities	$1,418.80
			SUBTOTAL	$4,222.33
LILLIAN UNDERWOOD C/O BENESCH, FRIEDLANDR, COPLN, ARO 2300 BP TOWER, 200 PUBLIC SQUARE CLEVELAND, OH 44114	ACH	09/13/2019	Suppliers or vendors	$20,000.00
			SUBTOTAL	$20,000.00
LINCOLN CONTRACTING & EQUIP CO INC PO BOX 951609 CLEVELAND, OH 44193	227041	08/19/2019	Suppliers or vendors	$11,783.41
	228898	09/06/2019	Suppliers or vendors	$15,597.66
			SUBTOTAL	$27,381.07
LINDA F. CLARK 7415 GEORGE GAINES ROAD NASHVILLE, TN 37221	229989	09/26/2019	Other - Royalty	$109.20
			SUBTOTAL	$109.20
LINDA R DZIERZANOWSKI 1021 COUNTY ROAD 4642 HONDO, TX 78861	227592	08/23/2019	Other - Royalty	$102.15
			SUBTOTAL	$102.15
LION INDUSTRIES, LLC 49068 RESERVOIR ROAD PO BOX 455 ST. CLAIRSVILLE, OH 43950	227867	08/28/2019	Suppliers or vendors	$7,364.75

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
LION INDUSTRIES, LLC 49068 RESERVOIR ROAD PO BOX 455 ST. CLAIRSVILLE, OH 43950	227868	08/28/2019	Suppliers or vendors	$18,553.85
	227869	08/28/2019	Suppliers or vendors	$580.53
	230340	10/04/2019	Suppliers or vendors	$2,577.50
	230341	10/04/2019	Suppliers or vendors	$37,405.22
	231594	10/18/2019	Suppliers or vendors	$56,250.78
			SUBTOTAL	$122,732.63
LITCHFIELD HOTEL VENTURES, LLC HAMPTON INN 11 THUNDERBIRD CIRCLE LITCHFIELD, IL 62056	226226	08/13/2019	Suppliers or vendors	$86.90
			SUBTOTAL	$86.90
LLOYD HOFF HOLDING CORPORATION PO BOX 250 MILLWOOD, WV 25262	226724	08/19/2019	Suppliers or vendors	$371.00
	229430	09/20/2019	Suppliers or vendors	$371.00
	231038	10/11/2019	Suppliers or vendors	$371.00
			SUBTOTAL	$1,113.00
LOGOTEK SIGNS 40670 BETHESDA-BELMONT ROAD PO BOX 252 BELMONT, OH 43718	226644	08/19/2019	Suppliers or vendors	$1,023.62
	227323	08/23/2019	Suppliers or vendors	$320.00
	227324	08/23/2019	Suppliers or vendors	$231.41
	230471	10/07/2019	Suppliers or vendors	$320.00
	230472	10/07/2019	Suppliers or vendors	$231.41
	230473	10/07/2019	Suppliers or vendors	$472.84
			SUBTOTAL	$2,599.28
LONE PINE CONSTRUCTION, INC. 83 LUSK ROAD BENTLEYVILLE, PA 15314	226894	08/19/2019	Suppliers or vendors	$37,168.86
	227801	08/28/2019	Suppliers or vendors	$15,840.00
	227802	08/28/2019	Suppliers or vendors	$47,100.00
	227803	08/28/2019	Suppliers or vendors	$1,250.00
	227804	08/28/2019	Suppliers or vendors	$17,635.00
	230835	10/11/2019	Suppliers or vendors	$298,921.40
	230836	10/11/2019	Suppliers or vendors	$40,050.00
	230837	10/11/2019	Suppliers or vendors	$101,682.50
	230838	10/11/2019	Suppliers or vendors	$15,970.00
	230839	10/11/2019	Suppliers or vendors	$36,658.00
	230840	10/11/2019	Suppliers or vendors	$9,120.00
			SUBTOTAL	$621,395.76

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
LONGWALL ASSOCIATES, INC. 212 KENDALL AVENUE PO BOX 1488 CHILHOWIE, VA 24319	228899	09/06/2019	Suppliers or vendors	$437,499.00
			SUBTOTAL	$437,499.00
LONGWALL MINING SERVICES (LMS) 9682 OLD KUMMER ROAD ALLISON PARK, PA 15101	ACH	09/13/2019	Suppliers or vendors	$59,589.00
			SUBTOTAL	$59,589.00
LONGWALL WEST, INC. 401 NORTH CARBONVILLE ROAD PO BOX 973 PRICE, UT 84501-0973	227042	08/19/2019	Suppliers or vendors	$39,730.11
	227963	08/28/2019	Suppliers or vendors	$232,702.60
	228900	09/06/2019	Suppliers or vendors	$48,719.67
	230056	09/30/2019	Suppliers or vendors	$13,293.75
	230060	10/01/2019	Suppliers or vendors	$30,820.23
	230772	10/08/2019	Suppliers or vendors	$6,447.47
	231550	10/17/2019	Suppliers or vendors	$2,645.45
			SUBTOTAL	$374,359.28
LOUISE HEAD DUNCAN TRST U/W PEYTON SAMUEL HEAD FAMILY TRUST P0 BOX 41779 AUSTIN, TX 78704	227606	08/23/2019	Other - Royalty	$553.43
	230032	09/26/2019	Other - Royalty	$505.25
			SUBTOTAL	$1,058.68
LOWES HOME CENTERS, INC. 1605 CURTIS BRIDGE ROAD WILKESBORO, NC 28697	228198	09/04/2019	Suppliers or vendors	$5,279.06
	229484	09/20/2019	Suppliers or vendors	$5,000.00
			SUBTOTAL	$10,279.06
LUCAS FAMILY TRUST, JEANNETTE C. LUCAS, TRUSTEE PO BOX 22635 LEXINGTON, KY 40522	227441	08/23/2019	Other - Royalty	$776.95
			SUBTOTAL	$776.95
LUCRE GROUP LLC GLASS DOCTOR OF EVANSVILLE PO BOX 6821 EVANSVILLE, IN 47719	229281	09/20/2019	Suppliers or vendors	$494.47
			SUBTOTAL	$494.47

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
LUCY BACKER COX 608 HUNTERS RUN CAMPBELLSVILLE, KY 42718	227602	08/23/2019	Other - Royalty	$123.49
			SUBTOTAL	$123.49
LUNDEBERG MD SEAMANSHIP SCHOOL MANPOWER MONITORING SYSTEM 5201 AUTH WAY CAMP SPRINGS, MD 20746	226170	08/13/2019	Other - Regulatory/Tax	$365.50
	229153	09/17/2019	Other - Regulatory/Tax	$358.00
	230677	10/07/2019	Other - Regulatory/Tax	$317.50
			SUBTOTAL	$1,041.00
LYNNE C. BROWN 7067 BIGGERT ROAD LONDON, OH 43140	225901	08/05/2019	Other - Royalty	$2.87
			SUBTOTAL	$2.87
M.A. HESTON, INC. 1131 PLEASANT VALLEY ROAD FAIRMONT, WV 26554	225748	08/05/2019	Suppliers or vendors	$25,746.00
	225749	08/05/2019	Suppliers or vendors	$17,569.50
	225750	08/05/2019	Suppliers or vendors	$11,835.68
	226561	08/13/2019	Suppliers or vendors	$13,553.56
	227098	08/19/2019	Suppliers or vendors	$6,182.00
	227099	08/19/2019	Suppliers or vendors	$2,500.00
	228947	09/06/2019	Suppliers or vendors	$37,350.00
	228948	09/06/2019	Suppliers or vendors	$6,180.00
			SUBTOTAL	$120,916.74
M.H. COURTNEY AGENT C/O E. THOMPSON COURTNEY PO BOX 431 BOCA GRANDE, FL 33921	227460	08/23/2019	Other - Royalty	$323.15
	229974	09/26/2019	Other - Royalty	$163.20
			SUBTOTAL	$486.35
MABLE L RIGGLE 1284 DRY RIDGE RD CAMERON, WV 26033	229128	09/13/2019	Suppliers or vendors	$250,000.00
			SUBTOTAL	$250,000.00
MACK L AND BARBARA A JOHNSON 1983 BURLEY HILL RD CAMERON, WV 26033	226850	08/19/2019	Suppliers or vendors	$125,000.00
			SUBTOTAL	$125,000.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MACK L BARBARA A JOHNSON 1983 BURLEY HILL ROAD CAMERON, WV 26033	229727	09/20/2019	Suppliers or vendors	$6,000.00
			SUBTOTAL	$6,000.00
MACKEY LANDSCAPES, LLC 13380 HOPKINSVILLE ROAD NORTONVILLE, KY 42442	ACH	08/07/2019	Suppliers or vendors	$551.25
	ACH	08/19/2019	Suppliers or vendors	$350.78
	230636	10/07/2019	Suppliers or vendors	$3,180.00
	231088	10/11/2019	Suppliers or vendors	$943.40
			SUBTOTAL	$5,025.43
MAC'S MINING REPAIR SERVICE, INC. 225 WEST 400 SOUTH PO BOX 480 HUNTINGTON, UT 84528	225641	08/05/2019	Suppliers or vendors	$235,764.00
	227878	08/28/2019	Suppliers or vendors	$52,433.90
	230494	10/07/2019	Suppliers or vendors	$18,758.03
			SUBTOTAL	$306,955.93
MAHAFFEY LABORATORY LTD 551 STATE STREET CURWENSVILLE, PA 16833	ACH	08/30/2019	Suppliers or vendors	$68.50
	230482	10/07/2019	Suppliers or vendors	$68.50
			SUBTOTAL	$137.00
MAIER'S TIDY BOWL, INC. 12515 US HIGHWAY 45 SOUTH PO BOX 9 STONEFORT, IL 62987	225999	08/13/2019	Suppliers or vendors	$115.50
	229312	09/20/2019	Suppliers or vendors	$115.50
	230495	10/07/2019	Suppliers or vendors	$121.00
			SUBTOTAL	$352.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MANNINGTON PSD PO BOX 205 MANNINGTON, WV 26582	226179	08/13/2019	Other - Utilities	$216.60
	226180	08/13/2019	Other - Utilities	$1,268.11
	226788	08/19/2019	Other - Utilities	$4,710.90
	226789	08/19/2019	Other - Utilities	$5,362.77
	227553	08/23/2019	Other - Utilities	$382.32
	229162	09/19/2019	Other - Utilities	$626.90
	229163	09/19/2019	Other - Utilities	$7,263.06
	229164	09/19/2019	Other - Utilities	$7,116.71
	231159	10/11/2019	Other - Utilities	$628.66
	231160	10/11/2019	Other - Utilities	$5,702.02
	231161	10/11/2019	Other - Utilities	$7,335.35
			SUBTOTAL	$40,613.40
MAPLE LEAF INDUSTRIES 450 SOUTH 50 EAST EPHRAIM, UT 84627	227406	08/23/2019	Suppliers or vendors	$2,419.09
			SUBTOTAL	$2,419.09
MARATHON FLEET SERVICES WEX BANK PO BOX 6293 CAROL STREAM, IL 60197-6293	ACH	08/05/2019	Suppliers or vendors	$459.83
	ACH	09/05/2019	Suppliers or vendors	$823.58
	ACH	10/04/2019	Suppliers or vendors	$682.75
			SUBTOTAL	$1,966.16
MARGARET ELIZABETH KAU 1915 NW COLUMBINE LN PORTLAND, OR 97229	227604	08/23/2019	Other - Royalty	$177.35
			SUBTOTAL	$177.35
MARGARET L SWYERS 3046 FM 1343 DEVINE, TX 78016	227593	08/23/2019	Other - Royalty	$102.15
			SUBTOTAL	$102.15
MARIAN E BRNA TOTAL SP LLC 22 CREST DRIVE MONONGALHELA, PA 15063-1081	226231	08/13/2019	Suppliers or vendors	$140.00
			SUBTOTAL	$140.00
MARILYN VIRGINIA WENDT 5704 DRAGON HIGHWAY CAMERON, WV 26033	227655	08/23/2019	Suppliers or vendors	$95,000.00
	227656	08/23/2019	Suppliers or vendors	$1,500.00
			SUBTOTAL	$96,500.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MARION COUNTY COLLECTOR PATTI J HAHN COUNTY COLLECTOR PO BOX 907 SALEM, IL 62881	229269	09/20/2019	Other - Regulatory/Tax	$28,425.56
	230894	10/11/2019	Other - Regulatory/Tax	$436.38
			SUBTOTAL	$28,861.94
MARJORIE ANN WARNER 35642 WOLFE PEN ROAD PO BOX 271 POMEROY, OH 45769	225900	08/05/2019	Other - Royalty	$3.12
	229096	09/10/2019	Other - Royalty	$3.15
	230611	10/07/2019	Other - Royalty	$6.58
			SUBTOTAL	$12.85
MARMIC FIRE & SAFETY CO., INC. PO BOX 1939 LOWELL, AR 72745	ACH	08/30/2019	Suppliers or vendors	$60,454.79
	230387	10/04/2019	Suppliers or vendors	$29,357.72
	230388	10/04/2019	Suppliers or vendors	$38,592.48
	230389	10/04/2019	Suppliers or vendors	$3,643.20
	230390	10/04/2019	Suppliers or vendors	$12,107.19
	230391	10/04/2019	Suppliers or vendors	$6,107.20
	230392	10/04/2019	Suppliers or vendors	$3,474.75
	230393	10/04/2019	Suppliers or vendors	$12,372.41
	230394	10/04/2019	Suppliers or vendors	$975.00
	230395	10/04/2019	Suppliers or vendors	$1,540.00
	230396	10/04/2019	Suppliers or vendors	$1,201.87
	230397	10/04/2019	Suppliers or vendors	$12,369.31
	230398	10/04/2019	Suppliers or vendors	$4,012.72
			SUBTOTAL	$186,208.64
MARSH TIRE SERVICES 215B EX LINCOLN AVE CHARLEROI, PA 15022	227541	08/23/2019	Services	$1,788.27
			SUBTOTAL	$1,788.27
MARSHALL COUNTY CLERK 600 7TH ST, #106 MOUNDSVILLE, WV 26041	ACH	08/05/2019	Other - Regulatory/Tax	$11.00
	226804	08/19/2019	Other - Regulatory/Tax	$41.50
	229600	09/20/2019	Other - Regulatory/Tax	$46.50
	230022	09/26/2019	Other - Regulatory/Tax	$156.00
			SUBTOTAL	$255.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MARSHALL COUNTY PSD NO 1 3537 FAIRMONT PK WHEELING, WV 26003	226796	08/19/2019	Other - Utilities	$3,514.90
	229575	09/20/2019	Other - Utilities	$4,801.01
	231174	10/11/2019	Other - Utilities	$4,745.90
			SUBTOTAL	$13,061.81
MARSHALL COUNTY PSD NO 3 5779 WAYNESBURG PIKE ROAD MOUNDSVILLE, WV 26041	225421	08/02/2019	Other - Utilities	$262,000.00
	226131	08/13/2019	Other - Utilities	$2,933.88
	229503	09/20/2019	Other - Utilities	$3,867.74
	231109	10/11/2019	Other - Utilities	$2,932.82
			SUBTOTAL	$271,734.44
MARSHALL COUNTY PSD#4 P.O. BOX 709 MOUNDSVILLE, WV 26041	226201	08/13/2019	Other - Utilities	$330.82
	226809	08/19/2019	Other - Utilities	$17,766.19
	227635	08/23/2019	Suppliers or vendors	$1,191.00
	229623	09/20/2019	Other - Utilities	$359.01
	229624	09/20/2019	Other - Utilities	$22,412.65
	229694	09/20/2019	Suppliers or vendors	$97.00
	230191	10/03/2019	Other - Utilities	$313.44
	231197	10/11/2019	Other - Utilities	$324.16
	231198	10/11/2019	Other - Utilities	$26,591.02
			SUBTOTAL	$69,385.29
MARSHALL MILLER & ASSOC., INC. 582 INDUSTRIAL PARK ROAD BLUEFIELD, VA 24605	225371	08/02/2019	Suppliers or vendors	$4,861.65
	225372	08/02/2019	Suppliers or vendors	$532.00
	225373	08/02/2019	Suppliers or vendors	$9,306.02
	225374	08/02/2019	Suppliers or vendors	$727.50
	225375	08/02/2019	Suppliers or vendors	$3,367.50
	229360	09/20/2019	Suppliers or vendors	$11,416.25
	229361	09/20/2019	Suppliers or vendors	$5,654.27
	229362	09/20/2019	Suppliers or vendors	$72.47
	229363	09/20/2019	Suppliers or vendors	$2,261.25
			SUBTOTAL	$38,198.91
MARTHA DAVIS ROYALTY 2018 HIGHLANDS DRIVE RICHMOND, KY 40475	227469	08/23/2019	Other - Royalty	$110.16
			SUBTOTAL	$110.16

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MARVEL EXCAVATING 4398 MARVEL ROAD THOMPSONVILLE, IL 62890	ACH	09/13/2019	Suppliers or vendors	$48,140.00
			SUBTOTAL	$48,140.00
MARY E MOWRER STONEHOUSE VETERINARY SERVICE 67610 AIRPORT ROAD ST.CLAIRSVILLE, OH 43950	226232	08/13/2019	Suppliers or vendors	$123.00
	229658	09/20/2019	Suppliers or vendors	$504.42
			SUBTOTAL	$627.42
MARY JORDAN 39255 LAUREL ROAD ALBANY, OH 45710	221616	09/06/2019	Other - Royalty	$10.40
	229070	09/10/2019	Other - Royalty	$12.85
	230586	10/07/2019	Other - Royalty	$9.77
			SUBTOTAL	$33.02
MARY KAY HARRISON 255 EAST FIFTH STREET CINCINNATI, OH 45202	ACH	10/18/2019	Services	$15,000.00
			SUBTOTAL	$15,000.00
MASTER MACHINE COMPANY 310 RIVER STREET SOUTH FORK, PA 15956	225759	08/05/2019	Suppliers or vendors	$30,990.00
	225760	08/05/2019	Suppliers or vendors	$8,030.00
	225761	08/05/2019	Suppliers or vendors	$2,333.34
	225762	08/05/2019	Suppliers or vendors	$29,250.00
	227109	08/19/2019	Suppliers or vendors	$9,318.00
	227110	08/19/2019	Suppliers or vendors	$17,882.14
	227111	08/19/2019	Suppliers or vendors	$16,924.95
	227112	08/19/2019	Suppliers or vendors	$1,500.00
	227113	08/19/2019	Suppliers or vendors	$17,809.54
	227114	08/19/2019	Suppliers or vendors	$6,250.00
	228022	08/28/2019	Suppliers or vendors	$36,712.48
	228023	08/28/2019	Suppliers or vendors	$10,593.00
	228024	08/28/2019	Suppliers or vendors	$6,333.33
	228025	08/28/2019	Suppliers or vendors	$2,333.34
	228026	08/28/2019	Suppliers or vendors	$28,500.00
			SUBTOTAL	$224,760.12
MATHESON TRI-GAS, INC. PO BOX 347297 PITTSBURGH, PA 15251-4297	ACH	08/07/2019	Suppliers or vendors	$510.43
	ACH	08/19/2019	Suppliers or vendors	$45,370.63
	ACH	09/13/2019	Suppliers or vendors	$493.96

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MATHESON TRI-GAS, INC. PO BOX 347297 PITTSBURGH, PA 15251-4297	230620	10/07/2019	Suppliers or vendors	$409.16
	230621	10/07/2019	Suppliers or vendors	$14.26
	230622	10/07/2019	Suppliers or vendors	$239.49
	230623	10/07/2019	Suppliers or vendors	$136.42
	231444	10/11/2019	Suppliers or vendors	$1,965.48
	231445	10/11/2019	Suppliers or vendors	$1,532.17
	231446	10/11/2019	Suppliers or vendors	$2,597.95
	231447	10/11/2019	Suppliers or vendors	$4,566.74
	231448	10/11/2019	Suppliers or vendors	$4,698.85
	231449	10/11/2019	Suppliers or vendors	$8,773.77
	231450	10/11/2019	Suppliers or vendors	$4,839.11
	231451	10/11/2019	Suppliers or vendors	$3,265.55
	231452	10/11/2019	Suppliers or vendors	$5,815.23
	231453	10/11/2019	Suppliers or vendors	$55.85
	231454	10/11/2019	Suppliers or vendors	$6,495.10
	231455	10/11/2019	Suppliers or vendors	$4,227.20
	231564	10/17/2019	Suppliers or vendors	$5,543.54
	231603	10/18/2019	Suppliers or vendors	$2,829.04
	231604	10/18/2019	Suppliers or vendors	$3,218.18
	231605	10/18/2019	Suppliers or vendors	$4,192.55
	231606	10/18/2019	Suppliers or vendors	$9,702.01
	231607	10/18/2019	Suppliers or vendors	$9,726.01
	231608	10/18/2019	Suppliers or vendors	$15,139.58
	231609	10/18/2019	Suppliers or vendors	$5,741.28
	231610	10/18/2019	Suppliers or vendors	$5,019.10
	231611	10/18/2019	Suppliers or vendors	$9,633.05
	231612	10/18/2019	Suppliers or vendors	$362.00
	231613	10/18/2019	Suppliers or vendors	$18,465.24
	231614	10/18/2019	Suppliers or vendors	$11,828.30
			SUBTOTAL	$197,407.23
MATTHEW HENIGIN MAX PSI 9870 RT. 119 SOUTH BLAIRSVILLE, PA 15717	227595	08/23/2019	Suppliers or vendors	$17,132.78
	231581	10/17/2019	Suppliers or vendors	$9,838.95
			SUBTOTAL	$26,971.73

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MATTHEW OFFUTT M.O. LANDSCAPE AND CONTRACTING 205 LOCUST AVE. #13 FAIRMONT, WV 26554	226256	08/13/2019	Suppliers or vendors	$24,500.00
	228536	09/06/2019	Suppliers or vendors	$10,000.00
			SUBTOTAL	$34,500.00
MAXINE DORRIS IRREVOCABLE LIVING TR MAXINE DORRIS TRUSTEE 6806 GLEN RIDGE DR. AUSTIN, TX 78731	226282	08/13/2019	Other - Royalty	$4,908.11
			SUBTOTAL	$4,908.11
MAYO MANUFACTURING COMPANY, INC. 54 OWENS ROAD, SUITE B CHAPMANVILLE, WV 25508	ACH	09/13/2019	Suppliers or vendors	$2,869.67
			SUBTOTAL	$2,869.67
MCCUTCHEON ENTERPRISES INC PO BOX 74807 CLEVELAND, OH 44194-4807	225800	08/05/2019	Suppliers or vendors	$24,066.60
			SUBTOTAL	$24,066.60
MCDONOUGH MARINE SERVICE AND MCDONOUGH PROJECT SERVICES PO BOX 919227 DALLAS, TX 75391-9227	228449	09/06/2019	Suppliers or vendors	$15,399.50
			SUBTOTAL	$15,399.50
MCF INCORPORATED 616 WASHINGTON STREET ST. ALBANS, WV 25177	226727	08/19/2019	Suppliers or vendors	$285.00
			SUBTOTAL	$285.00
MCGHEE & COMPANY PO BOX 6843 WHEELING, WV 26003	225948	08/13/2019	Suppliers or vendors	$1,669.42
	225949	08/13/2019	Suppliers or vendors	$2,305.89
	225950	08/13/2019	Suppliers or vendors	$3,663.48
	225951	08/13/2019	Suppliers or vendors	$2,186.07
	226620	08/19/2019	Suppliers or vendors	$685.05
	226621	08/19/2019	Suppliers or vendors	$1,297.03
	226622	08/19/2019	Suppliers or vendors	$1,415.75
	226623	08/19/2019	Suppliers or vendors	$3,255.41
	226624	08/19/2019	Suppliers or vendors	$737.57
	226625	08/19/2019	Suppliers or vendors	$30.01
	227299	08/23/2019	Suppliers or vendors	$681.80
	227300	08/23/2019	Suppliers or vendors	$341.91
	227301	08/23/2019	Suppliers or vendors	$48.78
	227302	08/23/2019	Suppliers or vendors	$3,290.43

Debtor Name: Murray Energy Corporation

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Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 3: Certain payments or transfers to creditors within 90 days before filing this case

Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MCGHEE & COMPANY PO BOX 6843 WHEELING, WV 26003	227303	08/23/2019	Suppliers or vendors	$124.94
	227304	08/23/2019	Suppliers or vendors	$930.55
	227305	08/23/2019	Suppliers or vendors	$305.04
	228240	09/06/2019	Suppliers or vendors	$692.23
	228241	09/06/2019	Suppliers or vendors	$810.38
	228242	09/06/2019	Suppliers or vendors	$934.00
	229229	09/20/2019	Suppliers or vendors	$3,219.79
	229230	09/20/2019	Suppliers or vendors	$2,845.17
	229231	09/20/2019	Suppliers or vendors	$4,645.24
	229232	09/20/2019	Suppliers or vendors	$229.36
	229233	09/20/2019	Suppliers or vendors	$1,508.15
	229234	09/20/2019	Suppliers or vendors	$33.22
	230452	10/07/2019	Suppliers or vendors	$361.59
	230453	10/07/2019	Suppliers or vendors	$1,634.50
	230454	10/07/2019	Suppliers or vendors	$826.08
	230455	10/07/2019	Suppliers or vendors	$384.87
	230456	10/07/2019	Suppliers or vendors	$230.96
	230457	10/07/2019	Suppliers or vendors	$1,466.91
	230855	10/11/2019	Suppliers or vendors	$152.99
	230856	10/11/2019	Suppliers or vendors	$943.59
	230857	10/11/2019	Suppliers or vendors	$1,521.00
	230858	10/11/2019	Suppliers or vendors	$3,320.41
	230859	10/11/2019	Suppliers or vendors	$242.49
	230860	10/11/2019	Suppliers or vendors	$313.23
			SUBTOTAL	$49,285.29
MCGUIREWOODS LLP ATTN: ACCOUNTS RECEIVABLE 800 E. CANAL STREET RICHMOND, VA 23219-4030	226035	08/13/2019	Services	$18,143.50
	229364	09/20/2019	Services	$19,910.00
	229365	09/20/2019	Services	$15,392.50
	229366	09/20/2019	Services	$387.30
			SUBTOTAL	$53,833.30
MCINTOSH & MCINTOSH PLLC 1136 ST. GREGORY, STE 100 CINCINNATI, OH 45202	229716	09/20/2019	Services	$2,916.19
			SUBTOTAL	$2,916.19

Debtor Name: Murray Energy Corporation

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MCKAY NAPA AUTO PARTS, INC. 414 NORTH OLD ROUTE 66 PO BOX 70 LITCHFIELD, IL 62056	225627	08/05/2019	Suppliers or vendors	$3,914.50
			SUBTOTAL	$3,914.50
MCKINLEY MORGAN 921 S MAIN STREET LONDON, KY 40741	229980	09/26/2019	Other - Royalty	$7.14
			SUBTOTAL	$7.14
MCLANAHAN CORPORATION 200 WALL STREET HOLLIDAYSBURG, PA 16648	227964	08/28/2019	Suppliers or vendors	$2,129.40
	227965	08/28/2019	Suppliers or vendors	$1,245.72
	227966	08/28/2019	Suppliers or vendors	$15,960.03
	227967	08/28/2019	Suppliers or vendors	$2,220.64
			SUBTOTAL	$21,555.79
MCNAY & WILLIAMS LP MICROTEL INN & SUITES BY WYNDAM W 300 COMFORT LANE WAYNESBURG, PA 15370	226224	08/13/2019	Services	$344.44
	231224	10/11/2019	Services	$1,291.65
			SUBTOTAL	$1,636.09
MCR ST LOUIS LLC DBA HILTON ST LOUIS 400 OLIVE STREET ST. LOUIS, MO 63102	229672	09/20/2019	Suppliers or vendors	$2,950.56
	230740	10/07/2019	Suppliers or vendors	$3,278.40
			SUBTOTAL	$6,228.96
MECHANICAL & CERAMIC SOLUTIONS, INC 730 SUPERIOR STREET PO BOX 536 CARNEGIE, PA 15106	227043	08/19/2019	Suppliers or vendors	$4,410.59
	227044	08/19/2019	Suppliers or vendors	$4,861.16
	227968	08/28/2019	Suppliers or vendors	$2,400.59
	227969	08/28/2019	Suppliers or vendors	$19,392.70
	228901	09/06/2019	Suppliers or vendors	$286.46
	228902	09/06/2019	Suppliers or vendors	$32,493.20
	Wire	10/28/2019	Suppliers or vendors	$5,950.00
			SUBTOTAL	$69,794.70

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MELANKO CONSTRUCTION COMPANY 451 EAST 39TH STREET SHADYSIDE, OH 43947	225635	08/05/2019	Suppliers or vendors	$65,500.00
	231381	10/11/2019	Suppliers or vendors	$119,250.00
			SUBTOTAL	$184,750.00
MEMMO CONTRACTING, INC. 600 CHERRY BLOSSOM WAY BRIDGEVILLE, PA 15017	225706	08/05/2019	Suppliers or vendors	$22,220.00
	225707	08/05/2019	Suppliers or vendors	$16,510.00
	225708	08/05/2019	Suppliers or vendors	$83,285.00
	225709	08/05/2019	Suppliers or vendors	$3,950.00
	225710	08/05/2019	Suppliers or vendors	$18,450.00
	225711	08/05/2019	Suppliers or vendors	$19,940.00
	227045	08/19/2019	Suppliers or vendors	$12,500.00
	227046	08/19/2019	Suppliers or vendors	$35,000.00
			SUBTOTAL	$211,855.00
MERCER HUMAN RESOURCE CONSULT INC PO BOX 730182 DALLAS, TX 75373-0182	Wire	10/28/2019	Suppliers or vendors	$99,527.00
			SUBTOTAL	$99,527.00
MERICO S LIGNELLI 631 WEST MAIN STREET, PO BOX 182 MONONGAHELA, PA 15063	226837	08/19/2019	Suppliers or vendors	$475.00
			SUBTOTAL	$475.00
MERITECH, INC., CLT499 4577 HINCKLEY INDUSTRIAL PARKWAY CLEVELAND, OH 44109-6009	230932	10/11/2019	Suppliers or vendors	$1,543.22
			SUBTOTAL	$1,543.22
METROPOLITAN TOWER LIFE INSURANCE C PO BOX 790196 ST.LOUIS, MO 63179-0196	226252	08/13/2019	Services	$96,472.03
	230789	10/09/2019	Services	$103,361.43
			SUBTOTAL	$199,833.46
MEYERS, ROMAN, FRIEDBERG & LEWIS 28601 CHAGRIN BLVD SUITE 500 CLEVELAND, OH 44122	226822	08/19/2019	Services	$1,080.00
	Wire	10/28/2019	Services	$2,433.39
			SUBTOTAL	$3,513.39
MICHAEL AND AMY STEWART 42727 WATER TOWER RD BELMONT, OH 43718	229725	09/20/2019	Suppliers or vendors	$65,000.00
			SUBTOTAL	$65,000.00

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Part 2, Question 3: Certain payments or transfers to creditors within 90 days before filing this case

Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MICHAEL G RUBLE 30138 N 133RD LN PEORIA, AZ 85383	ACH	08/09/2019	Services	$3,120.00
	ACH	08/22/2019	Services	$4,505.82
	ACH	09/11/2019	Services	$4,582.50
	ACH	10/04/2019	Services	$714.16
	ACH	10/11/2019	Services	$682.50
	ACH	10/21/2019	Services	$898.32
			SUBTOTAL	$14,503.30
MICHAEL L LEEK & CRYSTAL G LEEK 488 STOUT RUN RD SMITHFIELD, WV 26437	226222	08/13/2019	Suppliers or vendors	$1,000.00
			SUBTOTAL	$1,000.00
MICHAEL R. BALL 34719 BALL RUN ROAD POMEROY, OH 45769	225906	08/05/2019	Other - Royalty	$24.57
	229102	09/10/2019	Other - Royalty	$23.80
	230624	10/07/2019	Other - Royalty	$19.24
			SUBTOTAL	$67.61
MICON #25 ALLEGHENY SQUARE GLASSPORT, PA 15045	228213	09/05/2019	Suppliers or vendors	$14,626.68
			SUBTOTAL	$14,626.68
MIDAMERICAN ENERGY COMPANY PO BOX 8019 DAVENPORT, IA 52808-8019	227416	08/23/2019	Suppliers or vendors	$15,935.23
	229432	09/20/2019	Suppliers or vendors	$14,898.11
			SUBTOTAL	$30,833.34
MILAN YAGODICH 10014 FOUNDERS WAY DAMASCUS, MD 20872	226846	08/19/2019	Other - Royalty	$2,500.00
			SUBTOTAL	$2,500.00
MILDRED DYER 33325 JESSE CREEK ROAD BIDWELL, OH 45614	225862	08/05/2019	Other - Royalty	$0.75
	229059	09/10/2019	Other - Royalty	$2.02
	230575	10/07/2019	Other - Royalty	$0.62
			SUBTOTAL	$3.39
MILLER BUILDING SUPPLY 12292 KY 81 SOUTH SACRAMENTO, KY 42372	228783	09/06/2019	Suppliers or vendors	$465.23
			SUBTOTAL	$465.23

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MILLER TIRE CENTER & AUTO PART 675 MAIN STREET SACRAMENTO, KY 42372	228784	09/06/2019	Suppliers or vendors	$36.00
			SUBTOTAL	$36.00
MILTECH ANALYTICAL SERVICES 1214 HEMINGWAY DRIVE GREENSBURG, PA 15601	226155	08/13/2019	Services	$2,136.50
			SUBTOTAL	$2,136.50
MINE & PROCESS SERVICE, INC. PO BOX 484 KEWANEE, IL 61443	227047	08/19/2019	Suppliers or vendors	$2,977.38
			SUBTOTAL	$2,977.38
MINE EQUIPMENT TRANSFER, LLC PO BOX 6274 WHEELING, WV 26003	225376	08/02/2019	Services	$11,790.00
	226037	08/13/2019	Services	$46,430.00
	226682	08/19/2019	Services	$20,740.00
	227374	08/23/2019	Services	$16,230.00
	228307	09/06/2019	Services	$12,705.00
	229370	09/20/2019	Services	$15,270.00
	230521	10/07/2019	Services	$58,590.00
	230973	10/11/2019	Services	$15,305.00
			SUBTOTAL	$197,060.00
MINE SITE TECHNOLOGIES USA INC. 13301 WEST 43RD DRIVE, UNIT #15 GOLDEN, CO 80403	228006	08/28/2019	Suppliers or vendors	$19,637.97
	228007	08/28/2019	Suppliers or vendors	$25,157.50
	228943	09/06/2019	Suppliers or vendors	$7,650.00
			SUBTOTAL	$52,445.47
MINE WEST SALES AND SERVICE 1210 EAST MAIN STREET PO BOX 218 WELLINGTON, UT 84542-0218	225714	08/05/2019	Suppliers or vendors	$62,357.28
	227062	08/19/2019	Suppliers or vendors	$27,732.25
	227384	08/23/2019	Suppliers or vendors	$1,525.08
	227973	08/28/2019	Suppliers or vendors	$15,833.17
	230541	10/07/2019	Suppliers or vendors	$13,682.67
	231422	10/11/2019	Suppliers or vendors	$20,347.65
	231520	10/16/2019	Suppliers or vendors	$1,903.55
	231557	10/17/2019	Suppliers or vendors	$25,144.38
	231601	10/18/2019	Suppliers or vendors	$2,163.33
			SUBTOTAL	$170,689.36

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Part 2, Question 3: Certain payments or transfers to creditors within 90 days before filing this case

Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MINERAL LABS, INC. 480 PARKWAY DRIVE PO BOX 549 SALYERSVILLE, KY 41465	225976	08/13/2019	Suppliers or vendors	$355.00
			SUBTOTAL	$355.00
MINERD & SONS INC PO BOX 581 LAWRENCE, PA 15055-0581	ACH	08/30/2019	Suppliers or vendors	$9,601.04
	ACH	09/13/2019	Suppliers or vendors	$3,482.42
			SUBTOTAL	$13,083.46
MINGO JUNCTION STEEL WORKS LLC 500 SENECA STREET, SUITE 504 BUFFALO, NY 14201	230425	10/04/2019	Suppliers or vendors	$9,455.75
	231250	10/11/2019	Suppliers or vendors	$708.50
			SUBTOTAL	$10,164.25
MINING CLAMPS FASTENERS & MORE 117 LITTLE SHANNON RUN RD. MOUNT MORRIS, PA 15349	226939	08/19/2019	Suppliers or vendors	$509.81
	226940	08/19/2019	Suppliers or vendors	$2,596.32
	226941	08/19/2019	Suppliers or vendors	$7,475.00
	227873	08/28/2019	Suppliers or vendors	$765.05
	227874	08/28/2019	Suppliers or vendors	$816.10
	227875	08/28/2019	Suppliers or vendors	$1,089.83
			SUBTOTAL	$13,252.11
MISS UTILITY OF WEST VIRGINIA INC PO BOX 11890 CHARLESTON, WV 25339	229504	09/20/2019	Suppliers or vendors	$6.00
			SUBTOTAL	$6.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MISSCO PO BOX 206 TRIADELPHIA, WV 26059-0206	226895	08/19/2019	Suppliers or vendors	$13,344.20
	226896	08/19/2019	Suppliers or vendors	$7,112.40
	227805	08/28/2019	Suppliers or vendors	$2,346.00
	227806	08/28/2019	Suppliers or vendors	$5,580.94
	227807	08/28/2019	Suppliers or vendors	$4,995.55
	227808	08/28/2019	Suppliers or vendors	$20,497.78
	227809	08/28/2019	Suppliers or vendors	$8,339.00
	227810	08/28/2019	Suppliers or vendors	$199.50
	227811	08/28/2019	Suppliers or vendors	$4,089.50
	227812	08/28/2019	Suppliers or vendors	$119.21
	230792	10/09/2019	Suppliers or vendors	$2,211.75
	230793	10/09/2019	Suppliers or vendors	$3,332.00
	231373	10/11/2019	Suppliers or vendors	$392.50
	231499	10/16/2019	Suppliers or vendors	$4,575.00
			SUBTOTAL	$77,135.33
MISSISSIPPI LIME COMPANY PO BOX 840033 KANSAS CITY, MO 64184-0033	227149	08/19/2019	Suppliers or vendors	$26,000.28
	227150	08/19/2019	Suppliers or vendors	$4,691.20
			SUBTOTAL	$30,691.48
MITCHELL B BASSI PO BOX 15957 PITTSBURGH, PA 15244	228506	09/06/2019	Suppliers or vendors	$759.52
	230036	09/26/2019	Suppliers or vendors	$379.76
			SUBTOTAL	$1,139.28
MITCHELL INSTRUMENT CO 1570 CHEROKEE STREET SAN MARCOS, CA 92078	225633	08/05/2019	Suppliers or vendors	$1,466.45
			SUBTOTAL	$1,466.45
MJ ENGINEERING & CONSULTING, INC. 750 CROSS POINTE RD SUITE P GAHANNA, OH 43230	ACH	08/30/2019	Suppliers or vendors	$1,750.00
			SUBTOTAL	$1,750.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MODEL CLEANERS UNIFORMS&APPAREL LLC 100 3RD ST CHARLEROI, PA 15022	226156	08/13/2019	Suppliers or vendors	$7,064.21
	226765	08/19/2019	Suppliers or vendors	$3,323.45
	227533	08/23/2019	Suppliers or vendors	$3,382.67
	228425	09/06/2019	Suppliers or vendors	$5,789.56
	229533	09/20/2019	Suppliers or vendors	$6,632.20
	230660	10/07/2019	Suppliers or vendors	$6,729.67
	231130	10/11/2019	Suppliers or vendors	$5,909.34
			SUBTOTAL	$38,831.10
MOHLER TECHNOLOGY, INC. PO BOX 4 BOONVILLE, IN 47601-0004	ACH	08/19/2019	Suppliers or vendors	$87,080.00
	ACH	09/13/2019	Suppliers or vendors	$82,060.00
			SUBTOTAL	$169,140.00
MON POWER PO BOX 3615 AKRON, OH 44309-3615	225364	08/02/2019	Other - Utilities	$745,127.77
	226000	08/13/2019	Other - Utilities	$11,143.83
	226001	08/13/2019	Other - Utilities	$80.80
	226002	08/13/2019	Other - Utilities	$22.21
	226003	08/13/2019	Other - Utilities	$271.88
	226004	08/13/2019	Other - Utilities	$499.64
	226005	08/13/2019	Other - Utilities	$5.00
	226599	08/14/2019	Other - Utilities	$684,043.31
	226606	08/16/2019	Other - Utilities	$51,776.64
	226607	08/16/2019	Other - Utilities	$836,583.38
	227232	08/20/2019	Other - Utilities	$7.64
	227233	08/20/2019	Other - Utilities	$1,862.45
	227234	08/20/2019	Other - Utilities	$267,987.06
	228188	09/03/2019	Other - Utilities	$710,468.51
	229130	09/13/2019	Other - Utilities	$3,753.52
	229131	09/13/2019	Other - Utilities	$746,258.60
	229132	09/13/2019	Other - Utilities	$1,620.45
	229133	09/13/2019	Other - Utilities	$286,407.25
	229134	09/13/2019	Other - Utilities	$613.83
	229135	09/13/2019	Other - Utilities	$5.00
	229158	09/18/2019	Other - Utilities	$11,638.50
	229159	09/18/2019	Other - Utilities	$56,572.27
	229160	09/18/2019	Other - Utilities	$976,489.25
	229161	09/18/2019	Other - Utilities	$10.00
	230113	10/03/2019	Other - Utilities	$816,342.30

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MON POWER PO BOX 3615 AKRON, OH 44309-3615	230114	10/03/2019	Other - Utilities	$2,049.15
	230115	10/03/2019	Other - Utilities	$1,620.61
	230116	10/03/2019	Other - Utilities	$154.93
	230117	10/03/2019	Other - Utilities	$638.35
	230943	10/11/2019	Other - Utilities	$11,196.50
	230944	10/11/2019	Other - Utilities	$693,590.74
	230945	10/11/2019	Other - Utilities	$478,924.79
	230946	10/11/2019	Other - Utilities	$346,927.67
	231625	10/18/2019	Other - Utilities	$662,576.75
	231626	10/18/2019	Other - Utilities	$2,219.46
	231627	10/18/2019	Other - Utilities	$429,875.35
			SUBTOTAL	$8,839,365.39
MON VALLEY INTEGRATION LLC PO BOX 247 DELLSLOW, WV 26531	225810	08/05/2019	Suppliers or vendors	$30,000.00
	228086	08/28/2019	Suppliers or vendors	$28,000.00
	229003	09/06/2019	Suppliers or vendors	$1,200.00
	229004	09/06/2019	Suppliers or vendors	$1,120.00
			SUBTOTAL	$60,320.00
MOODY AND ASSOCIATES, INC. 11548 COTTON RD. MEADVILLE, PA 16335	225377	08/02/2019	Suppliers or vendors	$2,958.75
			SUBTOTAL	$2,958.75
MORGAN, LEWIS & BOCKIUS LLP P.O. BOX 8500 S-6050 PHILADELPHIA, PA 19178-6050	230694	10/07/2019	Services	$8,000.62
	ACH	10/25/2019	Services	$20,000.00
			SUBTOTAL	$28,000.62
MORGANTOWN MACHINE & HYDRAULICS WV PO BOX 536276 PITTSBURGH, PA 15253-5904	225719	08/05/2019	Suppliers or vendors	$2,699.52
	225720	08/05/2019	Suppliers or vendors	$618.96
	225721	08/05/2019	Suppliers or vendors	$2,130.00
	225722	08/05/2019	Suppliers or vendors	$26,084.97
	225723	08/05/2019	Suppliers or vendors	$13,071.24
	225724	08/05/2019	Suppliers or vendors	$68,886.64
	227063	08/19/2019	Suppliers or vendors	$5,000.00
	227064	08/19/2019	Suppliers or vendors	$11,640.49
	227065	08/19/2019	Suppliers or vendors	$5,000.00
	227066	08/19/2019	Suppliers or vendors	$8,975.00
	227067	08/19/2019	Suppliers or vendors	$5,000.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MORGANTOWN MACHINE & HYDRAULICS WV PO BOX 536276 PITTSBURGH, PA 15253-5904	227068	08/19/2019	Suppliers or vendors	$40,261.79
	227069	08/19/2019	Suppliers or vendors	$5,000.00
	227070	08/19/2019	Suppliers or vendors	$203,545.00
	227974	08/28/2019	Suppliers or vendors	$662.51
	227975	08/28/2019	Suppliers or vendors	$29,714.46
	227976	08/28/2019	Suppliers or vendors	$27,623.97
	227977	08/28/2019	Suppliers or vendors	$75,490.00
			SUBTOTAL	$531,404.55
MORGANTOWN TECHNICAL SERVICES, INC. PO BOX 536276 PITTSBURGH, PA 15253-5904	225743	08/05/2019	Suppliers or vendors	$17,865.00
	225744	08/05/2019	Suppliers or vendors	$50,024.00
	225745	08/05/2019	Suppliers or vendors	$39,709.00
	225746	08/05/2019	Suppliers or vendors	$187.07
	225747	08/05/2019	Suppliers or vendors	$3,360.00
			SUBTOTAL	$111,145.07
MORGANTOWN UTILITY BOARD PO BOX 852 MORGANTOWN, WV 26507	227510	08/23/2019	Services	$82.38
	229505	09/20/2019	Services	$32.14
			SUBTOTAL	$114.52
MOSEBACH ELECTRIC & SUPPLY CO. PO BOX 780758 PHILADELPHIA, PA 19178	225820	08/05/2019	Suppliers or vendors	$2,830.00
	225821	08/05/2019	Suppliers or vendors	$996.42
	225822	08/05/2019	Suppliers or vendors	$10,760.37
	227173	08/19/2019	Suppliers or vendors	$2,960.48
	227174	08/19/2019	Suppliers or vendors	$6,874.00
	227175	08/19/2019	Suppliers or vendors	$16,141.12
	227176	08/19/2019	Suppliers or vendors	$25,886.16
	229016	09/06/2019	Suppliers or vendors	$1,333.00
	229017	09/06/2019	Suppliers or vendors	$2,455.20
	229018	09/06/2019	Suppliers or vendors	$160.86
	229019	09/06/2019	Suppliers or vendors	$108.73
	229020	09/06/2019	Suppliers or vendors	$4,681.05
			SUBTOTAL	$75,187.39
MOTION INDUSTRIES, INC. PO BOX 404130 ATLANTA, GA 30384-4130	225826	08/05/2019	Suppliers or vendors	$208.30
			SUBTOTAL	$208.30

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MOTION INDUSTRIES, INC. PO BOX 504606 ST LOUIS, MO 63150	225735	08/05/2019	Suppliers or vendors	$4,271.05
			SUBTOTAL	$4,271.05
MOTION INDUSTRIES, INC. PO BOX 98412 CHICAGO, IL 60693-8412	225613	08/05/2019	Suppliers or vendors	$1,843.07
	225614	08/05/2019	Suppliers or vendors	$4,649.37
	225615	08/05/2019	Suppliers or vendors	$5,671.89
	225616	08/05/2019	Suppliers or vendors	$2,324.50
	225617	08/05/2019	Suppliers or vendors	$83.85
	225618	08/05/2019	Suppliers or vendors	$8,866.07
	225619	08/05/2019	Suppliers or vendors	$1,826.36
	231592	10/18/2019	Suppliers or vendors	$1,519.50
	Wire	10/28/2019	Suppliers or vendors	$1,304.82
			SUBTOTAL	$28,089.43
MOUNTAIN MEDIA LLC PO BOX 429 LEWISBURG, WV 24901	228539	09/06/2019	Services	$96.79
	230762	10/07/2019	Services	$510.46
			SUBTOTAL	$607.25
MOUNTAIN VALLEY SPRING WATER PO BOX 1531 MT. VERNON, IL 62864	225972	08/13/2019	Suppliers or vendors	$427.22
	226647	08/19/2019	Suppliers or vendors	$39.94
	228271	09/06/2019	Suppliers or vendors	$717.55
	229267	09/20/2019	Suppliers or vendors	$338.40
	230892	10/11/2019	Suppliers or vendors	$284.95
			SUBTOTAL	$1,808.06
MOUNTAINEER EXCAVATING CO INC PO BOX 498 MOUNDSVILLE, WV 26041	227151	08/19/2019	Suppliers or vendors	$18,017.98
	228985	09/06/2019	Suppliers or vendors	$32,499.29
	229834	09/20/2019	Suppliers or vendors	$14,719.49
	230831	10/10/2019	Suppliers or vendors	$16,308.05
	231486	10/11/2019	Suppliers or vendors	$15,000.00
	231530	10/16/2019	Suppliers or vendors	$8,360.00
	231695	10/22/2019	Suppliers or vendors	$18,500.00
			SUBTOTAL	$123,404.81
MOUNTAINEER GAS COMPANY PO BOX 580211 CHARLOTTE, NC 28258-0211	225353	08/02/2019	Other - Utilities	$28.58

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MOUNTAINEER GAS COMPANY PO BOX 580211 CHARLOTTE, NC 28258-0211	225975	08/13/2019	Other - Utilities	$31.75
	226648	08/19/2019	Other - Utilities	$10.10
	227328	08/23/2019	Other - Utilities	$18.48
	227329	08/23/2019	Other - Utilities	$33.44
	Credit Card	08/27/2019	Other - Utilities	$305.70
	229271	09/20/2019	Other - Utilities	$30.31
	229272	09/20/2019	Other - Utilities	$20.20
	229273	09/20/2019	Other - Utilities	$10.10
	229274	09/20/2019	Other - Utilities	$39.24
	229933	09/26/2019	Other - Utilities	$26.85
	229934	09/26/2019	Other - Utilities	$56.06
	230108	10/03/2019	Other - Utilities	$77.60
	230109	10/03/2019	Other - Utilities	$28.66
	230110	10/03/2019	Other - Utilities	$31.75
	230896	10/11/2019	Other - Utilities	$10.10
			SUBTOTAL	$758.92
MR FLUSH LLC DBA APPROVED TOILET RENTAL 438 DIVISION ST SEWICKLY, PA 15143	225463	08/02/2019	Suppliers or vendors	$438.70
	226834	08/19/2019	Suppliers or vendors	$438.70
	229683	09/20/2019	Suppliers or vendors	$219.35
	230748	10/07/2019	Suppliers or vendors	$438.70
	231244	10/11/2019	Suppliers or vendors	$219.35
			SUBTOTAL	$1,754.80
MSHA - ADMINISTRATION & MANAGEMENT US DEPT OF LABOR PAYMENT OFFICE PO BOX 790390 ST. LOUIS, MO 63179-0390	225389	08/02/2019	Other - Regulatory/Tax	$24,135.00
	225390	08/02/2019	Other - Regulatory/Tax	$15,881.00
	225391	08/02/2019	Other - Regulatory/Tax	$35,568.00
	225392	08/02/2019	Other - Regulatory/Tax	$6,147.00
	225393	08/02/2019	Other - Regulatory/Tax	$2,885.00
	225394	08/02/2019	Other - Regulatory/Tax	$3,991.00
	226064	08/13/2019	Other - Regulatory/Tax	$11,122.00
	226065	08/13/2019	Other - Regulatory/Tax	$10,640.00
	226066	08/13/2019	Other - Regulatory/Tax	$1,151.00
	226707	08/19/2019	Other - Regulatory/Tax	$33,859.00
	227394	08/23/2019	Other - Regulatory/Tax	$15,087.00
	227395	08/23/2019	Other - Regulatory/Tax	$24,441.00
	227396	08/23/2019	Other - Regulatory/Tax	$20,742.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MSHA - ADMINISTRATION & MANAGEMENT US DEPT OF LABOR PAYMENT OFFICE PO BOX 790390 ST. LOUIS, MO 63179-0390	227397	08/23/2019	Other - Regulatory/Tax	$26,779.00
	227398	08/23/2019	Other - Regulatory/Tax	$21,894.00
	227399	08/23/2019	Other - Regulatory/Tax	$810.00
	227400	08/23/2019	Other - Regulatory/Tax	$12,918.00
	227401	08/23/2019	Other - Regulatory/Tax	$121.00
	227402	08/23/2019	Other - Regulatory/Tax	$3,979.00
	228334	09/06/2019	Other - Regulatory/Tax	$605.00
	228335	09/06/2019	Other - Regulatory/Tax	$12,721.00
	228336	09/06/2019	Other - Regulatory/Tax	$6,458.00
	228337	09/06/2019	Other - Regulatory/Tax	$6,827.00
	228338	09/06/2019	Other - Regulatory/Tax	$10,994.00
	228339	09/06/2019	Other - Regulatory/Tax	$23,405.00
	228340	09/06/2019	Other - Regulatory/Tax	$21,984.00
	228341	09/06/2019	Other - Regulatory/Tax	$1,309.00
	229410	09/20/2019	Other - Regulatory/Tax	$10,140.00
	229411	09/20/2019	Other - Regulatory/Tax	$10,442.00
	229412	09/20/2019	Other - Regulatory/Tax	$19,039.00
	229413	09/20/2019	Other - Regulatory/Tax	$25,546.00
	229414	09/20/2019	Other - Regulatory/Tax	$3,722.00
	230131	10/03/2019	Other - Regulatory/Tax	$2,834.00
	230132	10/03/2019	Other - Regulatory/Tax	$121.00
	230133	10/03/2019	Other - Regulatory/Tax	$18,613.00
	230134	10/03/2019	Other - Regulatory/Tax	$15,600.00
	230135	10/03/2019	Other - Regulatory/Tax	$15,600.00
	230136	10/03/2019	Other - Regulatory/Tax	$9,300.00
	230137	10/03/2019	Other - Regulatory/Tax	$15,033.00
	230138	10/03/2019	Other - Regulatory/Tax	$31,908.00
	230139	10/03/2019	Other - Regulatory/Tax	$12,364.00
	230140	10/03/2019	Other - Regulatory/Tax	$3,094.00
	230141	10/03/2019	Other - Regulatory/Tax	$4,840.00
	230142	10/03/2019	Other - Regulatory/Tax	$24,410.00
	230143	10/03/2019	Other - Regulatory/Tax	$21,178.00
	230144	10/03/2019	Other - Regulatory/Tax	$2,936.00
	230145	10/03/2019	Other - Regulatory/Tax	$15,804.00
	230146	10/03/2019	Other - Regulatory/Tax	$363.00
	230147	10/03/2019	Other - Regulatory/Tax	$20,000.00
	230148	10/03/2019	Other - Regulatory/Tax	$3,800.00
	230149	10/03/2019	Other - Regulatory/Tax	$19,400.00
	230150	10/03/2019	Other - Regulatory/Tax	$3,170.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
MSHA - ADMINISTRATION & MANAGEMENT US DEPT OF LABOR PAYMENT OFFICE PO BOX 790390 ST. LOUIS, MO 63179-0390	231020	10/11/2019	Other - Regulatory/Tax	$121.00
	231021	10/11/2019	Other - Regulatory/Tax	$661.00
			SUBTOTAL	$666,492.00
MSHA FINANCE BRANCH OF FINANCE PO BOX 25367 D.F.C. DENVER, CO 80225-0367	226062	08/13/2019	Other - Regulatory/Tax	$7,472.00
	226702	08/19/2019	Other - Regulatory/Tax	$24,875.00
	228214	09/05/2019	Other - Regulatory/Tax	$2,057.00
	228215	09/05/2019	Other - Regulatory/Tax	$5,270.00
			SUBTOTAL	$39,674.00
MUHLENBERG COUNTY SHERIFF PO BOX 227 GREENVILLE, KY 42345-0000	229123	09/12/2019	Other - Regulatory/Tax	$2,932.50
			SUBTOTAL	$2,932.50
MUHLENBERG COUNTY WATER DIST. 3 PO BOX 67 BREMEN, KY 42325	225985	08/13/2019	Other - Utilities	$2,270.75
	228187	09/03/2019	Other - Utilities	$1,997.89
	230912	10/11/2019	Other - Utilities	$1,527.57
			SUBTOTAL	$5,796.21
MULTI SERVICE AVIATION PO BOX 410435 KANSAS CITY, MO 64141-0435	ACH	08/02/2019	Suppliers or vendors	$7,211.00
	ACH	08/09/2019	Suppliers or vendors	$5,778.61
	ACH	08/16/2019	Suppliers or vendors	$4,377.98
	ACH	08/22/2019	Suppliers or vendors	$6,121.27
	ACH	09/06/2019	Suppliers or vendors	$11,089.04
	ACH	09/17/2019	Suppliers or vendors	$22,272.04
	ACH	09/27/2019	Suppliers or vendors	$7,127.98
	ACH	10/07/2019	Suppliers or vendors	$9,790.14
	ACH	10/18/2019	Suppliers or vendors	$2,317.15
	Wire	10/28/2019	Suppliers or vendors	$5,764.94
			SUBTOTAL	$81,850.15
NALCO COMPANY PO BOX 70716 CHICAGO, IL 60673-0716	225732	08/05/2019	Suppliers or vendors	$12,335.16
			SUBTOTAL	$12,335.16

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
NANCY G PHILLIPS - LIFE PO BOX 2272 BUFORD, GA 30515	229656	09/20/2019	Other - Royalty	$32.60
			SUBTOTAL	$32.60
NATIONAL BELT SERVICE OF WV, INC. DIV OF VEYANCE INDUSTRIAL SERVICES, PO BOX 603134 CHARLOTTE, NC 28260-3134	231538	10/17/2019	Suppliers or vendors	$34,720.00
	231539	10/17/2019	Suppliers or vendors	$18,530.00
			SUBTOTAL	$53,250.00
NATIONAL MARITIME CENTER 100 FORBES DRIVE MARTINSBURG, WV 25404	ACH	08/19/2019	Other - Regulatory/Tax	$70.00
	ACH	08/30/2019	Other - Regulatory/Tax	$145.00
			SUBTOTAL	$215.00
NATIONAL MINING HALL OF FAME & MUSE PO BOX 981 LEADVILLE, CO 80461	228216	09/05/2019	Suppliers or vendors	$35,000.00
			SUBTOTAL	$35,000.00
NATIONAL OILWELL DHT LP WELLS FARGO BANK PO BOX 201224 DALLAS, TX 75320-1224	227172	08/19/2019	Suppliers or vendors	$17,639.60
			SUBTOTAL	$17,639.60
NATIONS FUND I LLC 501 MERRITT SEVEN NORWALK, CT 06851	ACH	08/06/2019	Suppliers or vendors	$64,718.55
	ACH	08/26/2019	Suppliers or vendors	$55,604.00
	ACH	09/06/2019	Suppliers or vendors	$64,718.55
	ACH	09/26/2019	Suppliers or vendors	$55,604.00
	ACH	10/07/2019	Suppliers or vendors	$64,718.55
			SUBTOTAL	$305,363.65
NATURAL RESOURCE PARTNERS LTD PARNE WPP LLC L2495 COLUMBUS, OH 43260	230040	09/26/2019	Suppliers or vendors	$33,500.00
			SUBTOTAL	$33,500.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
NATURAL RESOURCE PARTNERS C/O WPP LLC L-2495 PO BOX 2495 COLUMBUS, OH 43260	228265	09/06/2019	Other - Royalty	$8,034.18
			SUBTOTAL	$8,034.18
NATURAL RESOURCES PARTNERS LIMITED WPP LLC C/O NRP (OPERATING) LLC 1200 LOUISIANA STREET SUITE 3400 HOUSTON, TX 77002	229578	09/20/2019	Other - Royalty	$2,187.50
	230018	09/26/2019	Other - Royalty	$12,422.83
			SUBTOTAL	$14,610.33
NEDA MITCHELL PO BOX 5616 ATHENS, OH 45701	225894	08/05/2019	Other - Royalty	$0.96
	229089	09/10/2019	Other - Royalty	$1.15
	230605	10/07/2019	Other - Royalty	$1.01
			SUBTOTAL	$3.12
NEIL D BASSI 202 CONSTITUTION COURT WASHINGTON, PA 15301	228505	09/06/2019	Suppliers or vendors	$759.52
	230035	09/26/2019	Suppliers or vendors	$379.76
			SUBTOTAL	$1,139.28
NEIL M WATSON CINDY L WATSON 115 ALLMAN ROAD WIND RIDGE, PA 15380	225473	08/02/2019	Suppliers or vendors	$1,000.00
			SUBTOTAL	$1,000.00
NEMO'S AUTO BODY, INC. PO BOX 307 RAYLAND, OH 43943-0307	227970	08/28/2019	Suppliers or vendors	$10,807.50
	228903	09/06/2019	Suppliers or vendors	$5,300.00
			SUBTOTAL	$16,107.50
NEOFUNDS BY NEOPOST PO BOX 6813 CAROL STREAM, IL 60197-6813	226797	08/19/2019	Suppliers or vendors	$770.14
	229576	09/20/2019	Suppliers or vendors	$2,593.27
			SUBTOTAL	$3,363.41
NEW PIG CORPORATION ONE PORK AVE TIPTON, PA 16684	ACH	09/13/2019	Suppliers or vendors	$3,163.87
			SUBTOTAL	$3,163.87

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
NEWBRIDGE SERVICES INC. 340 SOUTH BROADWAY, SUITE 100 LEXINGTON, KY 40508	229262	09/20/2019	Suppliers or vendors	$68,296.00
			SUBTOTAL	$68,296.00
NEWMAN TRACTOR LLC 2841 VERONA RD VERONA, KY 41092	225839	08/05/2019	Suppliers or vendors	$139.47
			SUBTOTAL	$139.47
NEWMED DIAGNOSTICS 19662 NORTH PISQUE LANE PO BOX 851 MT. VERNON, IL 62864	226725	08/19/2019	Suppliers or vendors	$742.00
	231039	10/11/2019	Suppliers or vendors	$742.00
			SUBTOTAL	$1,484.00
NEWTE FERGUSON ESTATE C/O LOIS STINSON EXEC 155 NEW HAVEN DRIVE URBANA, OH 43078	229977	09/26/2019	Other - Royalty	$110.86
			SUBTOTAL	$110.86

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
NEXGEN INDUSTRIAL SERVICES, INC. 125 LONG STREET RICES LANDING, PA 15357	225755	08/05/2019	Suppliers or vendors	$3,769.00
	225756	08/05/2019	Suppliers or vendors	$26,106.82
	225757	08/05/2019	Suppliers or vendors	$41,597.50
	225758	08/05/2019	Suppliers or vendors	$22,837.76
	227102	08/19/2019	Suppliers or vendors	$28,744.12
	227103	08/19/2019	Suppliers or vendors	$44,780.24
	227104	08/19/2019	Suppliers or vendors	$4,967.63
	227105	08/19/2019	Suppliers or vendors	$3,209.41
	228017	08/28/2019	Suppliers or vendors	$11,372.00
	228018	08/28/2019	Suppliers or vendors	$61,305.55
	228019	08/28/2019	Suppliers or vendors	$3,399.98
	228020	08/28/2019	Suppliers or vendors	$39,371.52
	228951	09/06/2019	Suppliers or vendors	$16,275.85
	228952	09/06/2019	Suppliers or vendors	$26,420.50
	228953	09/06/2019	Suppliers or vendors	$28,220.00
	228954	09/06/2019	Suppliers or vendors	$26,012.00
	228955	09/06/2019	Suppliers or vendors	$17,476.00
	229151	09/17/2019	Suppliers or vendors	$16,975.00
	230401	10/04/2019	Suppliers or vendors	$14,521.70
	231440	10/11/2019	Suppliers or vendors	$5,459.00
	Wire	10/28/2019	Suppliers or vendors	$14,203.79
			SUBTOTAL	$457,025.37
NICOLE R. OHMS 31040 MEIERS ROAD MIDDLEPORT, OH 45760	225908	08/05/2019	Other - Royalty	$29.93
	229104	09/10/2019	Other - Royalty	$32.74
	230642	10/07/2019	Other - Royalty	$31.26
			SUBTOTAL	$93.93
NIELSEN ARC SERVICES, INC. DBA NASCO PO BOX 305 REDMOND, UT 84652	230382	10/04/2019	Suppliers or vendors	$22,050.00
			SUBTOTAL	$22,050.00
NORFOLK SOUTHERN CORPORATION MAIL CODE 5629 PO BOX 71209 CHARLOTTE, NC 28272-1209	227375	08/23/2019	Services	$2,376.54
			SUBTOTAL	$2,376.54
NORFOLK SOUTHERN RAILWAY CO. 1200 PEACHTREE STREET NE 12TH ATLANTA, GA 30309	226852	08/19/2019	Suppliers or vendors	$12,961.78
			SUBTOTAL	$12,961.78

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NORFOLK SOUTHERN RAILWAY CORP PNC BANK 1669 PHOENIX PKWY, SUITE 210 PO BOX 532797 ATLANTA, GA 30349	ACH	08/06/2019	Services	$323,568.00
	ACH	08/13/2019	Services	$269,265.50
	ACH	08/21/2019	Services	$269,640.00
	ACH	08/28/2019	Services	$161,784.00
	ACH	09/03/2019	Services	$134,820.00
	ACH	09/16/2019	Services	$458,388.00
	ACH	09/26/2019	Services	$296,604.00
	ACH	10/03/2019	Services	$296,604.00
	ACH	10/11/2019	Services	$323,568.00
	ACH	10/18/2019	Services	$350,532.00
			SUBTOTAL	$2,884,773.50
NORMA JEAN PERDUE 1741 OLD HIGHWAY 11 BEATTYVILLE, KY 41311	227461	08/23/2019	Other - Royalty	$222.98
	229975	09/26/2019	Other - Royalty	$182.77
			SUBTOTAL	$405.75
NORRIS SCREEN & MFG, LLC 24707 NETWORK PLACE CHICAGO, IL 60673-1247	227055	08/19/2019	Suppliers or vendors	$14,356.00
	227056	08/19/2019	Suppliers or vendors	$3,965.74
	227057	08/19/2019	Suppliers or vendors	$9,550.42
	227058	08/19/2019	Suppliers or vendors	$6,023.32
			SUBTOTAL	$33,895.48
NORRIS TRUCKING INC 5280 EAST DUBOIS ROAD WALTONVILLE, IL 62894	225451	08/02/2019	Services	$1,312.50
	229638	09/20/2019	Services	$1,390.00
			SUBTOTAL	$2,702.50
NORTH AMERICAN DRILLERS LLC 130 MEADOW RIDGE RD MT. MORRIS, PA 15349	226520	08/13/2019	Suppliers or vendors	$202,453.20
	227048	08/19/2019	Suppliers or vendors	$688,461.25
			SUBTOTAL	$890,914.45
NORTH FRANKLIN TOWNSHIP 620 FRANKLIN FARMS RD WASHINGTON, PA 15301	229534	09/20/2019	Suppliers or vendors	$9,161.91
			SUBTOTAL	$9,161.91

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
NORTH STRABANE TWP. TAX COLLECTOR PO BOX 202 STRABANE, PA 15363	226657	08/19/2019	Other - Regulatory/Tax	$38.82
	226658	08/19/2019	Other - Regulatory/Tax	$210.07
			SUBTOTAL	$248.89
NORTHCO CORPORATION PO BOX 2100 MORGANTOWN, WV 26502-2100	231517	10/16/2019	Suppliers or vendors	$5,750.00
			SUBTOTAL	$5,750.00
NORTHCOAST LANDING SYSTEMS, INC. 13005 YORK DELTA DRIVE, UNIT #2 NORTH ROYALTON, OH 44133	ACH	09/13/2019	Suppliers or vendors	$2,629.56
	230559	10/07/2019	Suppliers or vendors	$7,620.03
			SUBTOTAL	$10,249.59
NPN ENVIRONMENTAL 1631 HEADLAND DR. FENTON, MO 63026	229308	09/20/2019	Suppliers or vendors	$5,022.50
			SUBTOTAL	$5,022.50
NTT DATA ENTERPRISE SERVICES, INC ATTN: TREASURY DEPARTMENT PO BOX 4201 BOSTON, MA 02211	ACH	08/30/2019	Suppliers or vendors	$28,000.00
	230553	10/07/2019	Suppliers or vendors	$28,000.00
	ACH	10/28/2019	Suppliers or vendors	$28,000.00
			SUBTOTAL	$84,000.00
ODNR-DIV OF OIL AND GAS RESOURCES 2045 MORSE ROAD BLDG F-2 COLUMBUS, OH 43229-6693	231208	10/11/2019	Other - Regulatory/Tax	$948.95
	231209	10/11/2019	Other - Regulatory/Tax	$715.96
			SUBTOTAL	$1,664.91
OFFICE ETC 55 EAST MAIN STREET PO BOX 760 PRICE, UT 84501	226025	08/13/2019	Suppliers or vendors	$882.16
	227358	08/23/2019	Suppliers or vendors	$85.38
	228301	09/06/2019	Suppliers or vendors	$217.01
	229350	09/20/2019	Suppliers or vendors	$938.09
	230969	10/11/2019	Suppliers or vendors	$766.01
			SUBTOTAL	$2,888.65

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
OFFICE OF NATURAL RESOURCES REVENUE PO BOX 5810 DENVER, CO 80217-5810	ACH	08/02/2019	Other - Regulatory/Tax	$372,572.40
	ACH	08/30/2019	Other - Regulatory/Tax	$364,289.42
	ACH	09/30/2019	Other - Regulatory/Tax	$586,468.52
			SUBTOTAL	$1,323,330.34
OFFICE OF SURFACE MINING OSMRE DIV. OF COMPLIANCE MANAGEMENT PO BOX 979068 ST. LOUIS, MO 63197-9000	ACH	07/31/2019	Suppliers or vendors	$99,296.22
			SUBTOTAL	$99,296.22
OFF-SITE RECORDS MANAGEMENT PO BOX 5063 LEXINGTON, KY 40555-5063	227331	08/23/2019	Suppliers or vendors	$136.95
	230480	10/07/2019	Suppliers or vendors	$137.76
			SUBTOTAL	$274.71
OGLETREE DEAKINS NASH SMOAK & STEWA PO BOX 89 COLUMBIA, SC 29202	226026	08/13/2019	Services	$43.00
	226027	08/13/2019	Services	$720.90
	226028	08/13/2019	Services	$16,049.50
	226029	08/13/2019	Services	$60,290.00
	226030	08/13/2019	Services	$140,460.38
	226031	08/13/2019	Services	$5,248.50
	226032	08/13/2019	Services	$10,337.16
	226033	08/13/2019	Services	$1,610.00
	226034	08/13/2019	Services	$2,498.50
	227359	08/23/2019	Services	$5,996.70
	227360	08/23/2019	Services	$1,624.00
	227361	08/23/2019	Services	$13,421.23
	227362	08/23/2019	Services	$9,068.70
	227363	08/23/2019	Services	$15,395.90
	227364	08/23/2019	Services	$8,371.45
	227365	08/23/2019	Services	$33,830.07
	227366	08/23/2019	Services	$1,342.00
	227367	08/23/2019	Services	$29.65
	229351	09/20/2019	Services	$1,856.00
	229352	09/20/2019	Services	$145.20
	229353	09/20/2019	Services	$145.20
	229354	09/20/2019	Services	$76,136.72
	229355	09/20/2019	Services	$72,356.55

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
OGLETREE DEAKINS NASH SMOAK & STEWA PO BOX 89 COLUMBIA, SC 29202	229356	09/20/2019	Services	$10,507.60
	229357	09/20/2019	Services	$4,865.91
	229358	09/20/2019	Services	$1,736.43
	229359	09/20/2019	Services	$9,509.00
	ACH	10/25/2019	Services	$300,000.00
			SUBTOTAL	$803,596.25
OHIO & LEE WATER SEWER PO BOX 182 HANNIBAL, OH 43931	226123	08/13/2019	Other - Utilities	$275.98
	229496	09/20/2019	Other - Utilities	$277.78
	231100	10/11/2019	Other - Utilities	$265.96
			SUBTOTAL	$819.72
OHIO BUREAU OF WORKERS COMPENSATION BWC STATE INSURANCE FUND PO BOX 89492 CLEVELAND, OH 44101-6492	ACH	09/03/2019	Suppliers or vendors	$131,726.59
	231553	10/17/2019	Suppliers or vendors	$2,700.00
			SUBTOTAL	$134,426.59
OHIO CAT 4439 SOLUTIONS CENTER PO BOX 774439 CHICAGO, IL 60677-4004	225958	08/13/2019	Suppliers or vendors	$15,841.42
	226640	08/19/2019	Suppliers or vendors	$1,948.67
	228249	09/06/2019	Suppliers or vendors	$2,287.08
			SUBTOTAL	$20,077.17
OHIO CHAMBER OF COMMERCE 34 SOUTH THIRD STREET, SUITE 100 COLUMBUS, OH 43215	228349	09/06/2019	Suppliers or vendors	$2,150.00
			SUBTOTAL	$2,150.00
OHIO CHRISTIAN ALLIANCE EDUCATION FUND PO BOX 3076 AKRON, OH 44309	228217	09/05/2019	Suppliers or vendors	$10,000.00
			SUBTOTAL	$10,000.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
OHIO COUNTY PUBLIC SERVICE DISTRICT PO BOX 216 TRIADELPHIA, WV 26059	226655	08/19/2019	Other - Utilities	$670.15
	226656	08/19/2019	Other - Utilities	$31.61
	229298	09/20/2019	Other - Utilities	$635.92
	229299	09/20/2019	Other - Utilities	$34.46
	230920	10/11/2019	Other - Utilities	$1,987.56
	230921	10/11/2019	Other - Utilities	$42.36
			SUBTOTAL	$3,402.06
OHIO DEPARTMENT OF TAXATION OHIO TREASURER OF STATE PO BOX 16561 COLUMBUS, OH 43216-6561	ACH	10/22/2019	Other - Regulatory/Tax	$9,237.46
			SUBTOTAL	$9,237.46
OHIO SELF-INSURERS ASSOCIATION PO BOX 1073 COLUMBUS, OH 43216-1073	228279	09/06/2019	Services	$300.00
			SUBTOTAL	$300.00
OHIO TREASURER OF STATE OHIO DEPARTMENT OF TAXATION PO BOX 182101 COLUMBUS, OH 43218-2101	ACH	08/14/2019	Other - Regulatory/Tax	$432,372.00
			SUBTOTAL	$432,372.00
OIL PRICE INFORMATION SERVICE LLC P.O. BOX 9407 GAITHERSBURG, MD 20898-9407	228466	09/06/2019	Suppliers or vendors	$492.28
			SUBTOTAL	$492.28
OLIVER WYMAN ACTUARIAL CONSULTING PO BOX 5160 NEW YORK, NY 10087-5160	226208	08/13/2019	Services	$11,000.00
			SUBTOTAL	$11,000.00
OMEGA CEMENTING CO PO BOX 357 APPLE CREEK, OH 44606	227164	08/19/2019	Suppliers or vendors	$114,827.25
	228085	08/28/2019	Suppliers or vendors	$25,506.50
	229002	09/06/2019	Suppliers or vendors	$12,038.00
	230420	10/04/2019	Suppliers or vendors	$89,424.75
	230421	10/04/2019	Suppliers or vendors	$7,907.00
	230833	10/10/2019	Suppliers or vendors	$30,000.00
			SUBTOTAL	$279,703.50

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
OMNINET HOTEL LP HOLIDAY INN EVANSVILLE AIRPORT HOTE 7101 HWY 41 NORTH EVANSVILLE, IN 47725	230723	10/07/2019	Services	$109.48
			SUBTOTAL	$109.48
ON SITE GAS SYSTEMS 35 BUDNEY ROAD NEWINGTON, CT 06111	226138	08/13/2019	Suppliers or vendors	$2,549.25
	229510	09/20/2019	Suppliers or vendors	$3,999.12
	229511	09/20/2019	Suppliers or vendors	$5,186.41
	229512	09/20/2019	Suppliers or vendors	$15,431.42
			SUBTOTAL	$27,166.20
ORRISON MAINTENANCE SERVICE INC. 105 BETHESDA ST BARNESVILLE, OH 43713	228744	09/06/2019	Suppliers or vendors	$4,318.00
			SUBTOTAL	$4,318.00
OTIS ELEVATOR COMPANY P.O. BOX 73579 CHICAGO, IL 60673-7579	229513	09/20/2019	Suppliers or vendors	$5,468.16
			SUBTOTAL	$5,468.16
OWENSBORO HEALTH MEDICAL GROUP, INC DBA ONE HEALTH @ WORK MADISONVILLE 510 RUBY DRIVE MADISONVILLE, KY 42431	228364	09/06/2019	Suppliers or vendors	$95.00
			SUBTOTAL	$95.00
OWENSBORO HOTEL ASSOCIATES LLC HAMPTON BY HILTON OWENSBORO-SOUTH 615 SALEM DR OWENSBORO, KY 42303	227636	08/23/2019	Services	$2,245.80
	230754	10/07/2019	Services	$224.58
			SUBTOTAL	$2,470.38
PA DEPARTMENT OF REVENUE PAYMENT ENCLOSED PO BOX 280427 HARRISBURG, PA 17128-0427	ACH	08/20/2019	Other - Regulatory/Tax	$101.17
	ACH	09/20/2019	Other - Regulatory/Tax	$504.96
	ACH	10/21/2019	Other - Regulatory/Tax	$64.68
			SUBTOTAL	$670.81

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
PA DEPARTMENT OF REVENUE PO BOX 280437 HARRISBURG, PA 17128-0437	ACH	10/21/2019	Other - Regulatory/Tax	$121.51
			SUBTOTAL	$121.51
PA DEPT OF ENVIRONMENTAL PROTECTIO COMPTROLLER OPERATIONS-AR PO BOX 2833 HARRISBURG, PA 17105	226191	08/13/2019	Other - Regulatory/Tax	$5,850.00
	228463	09/06/2019	Other - Regulatory/Tax	$7,590.00
			SUBTOTAL	$13,440.00
PA DEPT OF ENVIRON. PROTECTION PO BOX 8454 HARRISBURG, PA 17105-8454	230922	10/11/2019	Suppliers or vendors	$2,850.00
			SUBTOTAL	$2,850.00
PA DEPT OF ENVIRONMENTAL PROTECTION DIVISION OF STORAGE TANKS PO BOX 8762 HARRISBURG, PA 17105-8762	228331	09/06/2019	Suppliers or vendors	$300.00
			SUBTOTAL	$300.00
PACIFIC WESTERN BANK C/O CAPITALSOURCE 4598 SOLUTIONS CENTER CHICAGO, IL 60677-4005	228493	09/06/2019	Services	$27,060.02
	229641	09/20/2019	Services	$19,391.48
			SUBTOTAL	$46,451.50
PARCO PROPANE 3756 SALTWELL RD BRIDGEPORT, WV 26330	226161	08/13/2019	Suppliers or vendors	$1,484.20
	230666	10/07/2019	Suppliers or vendors	$3,058.66
			SUBTOTAL	$4,542.86
PARK N STOR PO BOX 700 PRICE, UT 84501	225350	08/02/2019	Suppliers or vendors	$101.00
	228266	09/06/2019	Suppliers or vendors	$101.00
	230469	10/07/2019	Suppliers or vendors	$101.00
			SUBTOTAL	$303.00
PARTSMASTER/X-ERGON DIVISION OF NCH PO BOX 971342 DALLAS, TX 75397-1342	227037	08/19/2019	Suppliers or vendors	$233.57
	227038	08/19/2019	Suppliers or vendors	$2,549.01
	227039	08/19/2019	Suppliers or vendors	$135.13
	227959	08/28/2019	Suppliers or vendors	$984.35

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
PARTSMASTER/X-ERGON DIVISION OF NCH PO BOX 971342 DALLAS, TX 75397-1342	227960	08/28/2019	Suppliers or vendors	$490.82
	228303	09/06/2019	Suppliers or vendors	$1,244.09
	228891	09/06/2019	Suppliers or vendors	$1,060.94
	228892	09/06/2019	Suppliers or vendors	$44.00
	228893	09/06/2019	Suppliers or vendors	$44.40
			SUBTOTAL	$6,786.31
PATRICIA L. HIDEN 50 RANDOLPH ROAD BIRMINGHAM, AL 35213	227481	08/23/2019	Other - Royalty	$104.07
			SUBTOTAL	$104.07
PAUL DAVID HIERONIMUS AND SANDRA HIERONIMUS 65 PLEASANT DRIVE CAMERON, WV 26033	227646	08/23/2019	Suppliers or vendors	$28,919.15
			SUBTOTAL	$28,919.15
PAUL'S FAN COMPANY PO BOX 61 BIG ROCK, VA 24603	226521	08/13/2019	Suppliers or vendors	$285,000.00
			SUBTOTAL	$285,000.00
PEABODY INVESTMENTS CORPORATION AMERICAN LAND HOLDINGS OF KENTUCKY 701 MARKET STREET, SUITE 700 ST.LOUIS, MO 63101	ACH	08/31/2019	Other - Royalty	$140,000.00
			SUBTOTAL	$140,000.00
PECZUH PRINTING COMPANY PO BOX 1024 PRICE, UT 84501	228302	09/06/2019	Suppliers or vendors	$1,671.71
			SUBTOTAL	$1,671.71

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
PENN LINE SERVICE, INC. PO BOX 280 INDIANA, PA 15701-0280	226522	08/13/2019	Suppliers or vendors	$1,345.50
	226523	08/13/2019	Suppliers or vendors	$45,870.20
	226524	08/13/2019	Suppliers or vendors	$13,792.83
	226525	08/13/2019	Suppliers or vendors	$20,267.22
	226526	08/13/2019	Suppliers or vendors	$11,115.64
	226527	08/13/2019	Suppliers or vendors	$17,082.55
	227050	08/19/2019	Suppliers or vendors	$19,255.22
	227051	08/19/2019	Suppliers or vendors	$40,101.48
	227052	08/19/2019	Suppliers or vendors	$28,695.12
	227053	08/19/2019	Suppliers or vendors	$7,262.82
	227054	08/19/2019	Suppliers or vendors	$36,922.98
	228907	09/06/2019	Suppliers or vendors	$28,829.20
			SUBTOTAL	$270,540.76
PENN MAG, INC. 719 TARRTOWN ROAD ADRIAN, PA 16210	231531	10/16/2019	Suppliers or vendors	$9,600.00
			SUBTOTAL	$9,600.00
PENNSYLVANIA AMERICAN WATER PO BOX 371412 PITTSBURGH, PA 15250-7412	225359	08/02/2019	Other - Utilities	$2,047.23
	226652	08/19/2019	Other - Utilities	$33.83
	226653	08/19/2019	Other - Utilities	$258.83
	229290	09/20/2019	Other - Utilities	$466.88
	229291	09/20/2019	Other - Utilities	$34.98
	229292	09/20/2019	Other - Utilities	$180.94
	229293	09/20/2019	Other - Utilities	$2,182.63
	230914	10/11/2019	Other - Utilities	$168.12
	230915	10/11/2019	Other - Utilities	$30.76
	230916	10/11/2019	Other - Utilities	$2,270.09
			SUBTOTAL	$7,674.29
PENNSYLVANIA DEPT OF REVENUE P.O. BOX 280705 HARRISBURG, PA 17128-0705	ACH	10/15/2019	Other - Regulatory/Tax	$8,095.00
			SUBTOTAL	$8,095.00
PEOPLES GAS PO BOX 644760 PITTSBURGH, PA 15264-4760	225470	08/02/2019	Other - Utilities	$17.89
	229711	09/20/2019	Other - Utilities	$22.33
	230201	10/03/2019	Other - Utilities	$20.30
			SUBTOTAL	$60.52

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
PEROULIS BROS. LTD. PO BOX 355 CRAIG, CO 81626	228267	09/06/2019	Services	$18,000.00
	229263	09/20/2019	Services	$18,000.00
	230475	10/07/2019	Services	$18,000.00
			SUBTOTAL	$54,000.00
PERRY TOWNSHIP TAX COLLECTOR ATTN: CHRISTINE K. JARRELL 181 BIG SHANNON RUN ROAD MT MORRIS, PA 15349	228489	09/06/2019	Other - Regulatory/Tax	$431.74
			SUBTOTAL	$431.74
PEST MANAGEMENT SERVICES INC 167 MIDDLETOWN CIRLCE FAIRMONT, WV 26554	228406	09/06/2019	Suppliers or vendors	$159.00
			SUBTOTAL	$159.00
PETER A. POLVERINI III 125 TOWNSHIP ROAD 1283 BLOOMINGDALE, OH 43910	226041	08/13/2019	Suppliers or vendors	$700.00
	226687	08/19/2019	Suppliers or vendors	$4,000.00
	227377	08/23/2019	Suppliers or vendors	$6,000.00
	229375	09/20/2019	Suppliers or vendors	$14,000.00
	230977	10/11/2019	Suppliers or vendors	$11,000.00
	230978	10/11/2019	Suppliers or vendors	$16,000.00
			SUBTOTAL	$51,700.00
PETERS EQUIPMENT CO, LLC RT. 720 INDUSTRIAL PARK PO BOX 1050 BLUEFIELD, VA 24605	229855	09/24/2019	Suppliers or vendors	$43,782.80
	Wire	10/28/2019	Suppliers or vendors	$25,325.00
			SUBTOTAL	$69,107.80
PETROLEUM MAINTENANCE & EQUIPMENT 322 WEST RAILROAD AVENUE PO BOX 761 PRICE, UT 84501	228904	09/06/2019	Suppliers or vendors	$1,105.54
			SUBTOTAL	$1,105.54
PETTY CASH- THOMAS MIHALIK CITIZENS BANK 1731 GRAND BLVD MONESSEN, PA 15062	229611	09/20/2019	Services	$1,265.00
			SUBTOTAL	$1,265.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
PHIL NISLY DBA JONES-PORTA JONS 20424 CADIZ ROAD FREEPORT, OH 43973	228345	09/06/2019	Suppliers or vendors	$729.30
	228346	09/06/2019	Suppliers or vendors	$430.00
			SUBTOTAL	$1,159.30
PHILLIP M AND REBEKKAH G HERRLE 63 LENA LANE WASHINGTON, PA 15301	229722	09/20/2019	Suppliers or vendors	$1,000.00
			SUBTOTAL	$1,000.00
PHILLIPS MACHINE SERVICE, INC. 367 GEORGE STREET BECKLEY, WV 25801	228908	09/06/2019	Suppliers or vendors	$674.47
			SUBTOTAL	$674.47
PHIL'S TOWING CO INC 1125 GREINER ST MONACA, PA 15061	228420	09/06/2019	Suppliers or vendors	$1,650.00
	231120	10/11/2019	Suppliers or vendors	$1,650.00
			SUBTOTAL	$3,300.00
PHONETICS INC DBA SENSAPHONE 901 TRYENS ROAD ASTON, PA 19014	231635	10/18/2019	Suppliers or vendors	$1,260.00
			SUBTOTAL	$1,260.00
PHYLLIS V REED 4015 CARROLL EASTERN RD CARROLL, OH 43112	229114	09/10/2019	Other - Royalty	$7.26
			SUBTOTAL	$7.26
PIERCE OIL CO., INC. 322 WEST RAILROAD AVENUE PO BOX 792 PRICE, UT 84501	230798	10/09/2019	Suppliers or vendors	$74,674.39
			SUBTOTAL	$74,674.39
PILGRIM ENERGY, INC. 110 CAROLINE AVE. PO BOX 89 PIKEVILLE, KY 41502	230030	09/26/2019	Other - Royalty	$100.52
			SUBTOTAL	$100.52
PILLAR INNOVATIONS LLC 92 CORPORATE DRIVE GRANTSVILLE, MD 21536	225725	08/05/2019	Suppliers or vendors	$115.50
	231688	10/22/2019	Suppliers or vendors	$27,155.41
			SUBTOTAL	$27,270.91

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
PINNACLE GROUP LLC 15 NORMANDY DR WINTERSVILLE, OH 43953	226923	08/19/2019	Suppliers or vendors	$14,520.00
	228781	09/06/2019	Suppliers or vendors	$6,624.00
			SUBTOTAL	$21,144.00
PIONEER CONVEYOR LLC 224 MOYERS ROAD BRUCETON MILLS, WV 26525	229005	09/06/2019	Suppliers or vendors	$28,205.00
	229006	09/06/2019	Suppliers or vendors	$87,242.50
	229007	09/06/2019	Suppliers or vendors	$36,700.00
	230665	10/07/2019	Suppliers or vendors	$6,179.00
	231473	10/11/2019	Suppliers or vendors	$21,975.00
	231474	10/11/2019	Suppliers or vendors	$40,035.00
	231475	10/11/2019	Suppliers or vendors	$5,423.00
			SUBTOTAL	$225,759.50
PITNEY BOWES GLOBAL FINANCIAL SERV. PO BOX 371887 PITTSBURGH, PA 15250-7887	226708	08/19/2019	Suppliers or vendors	$49.99
	226709	08/19/2019	Suppliers or vendors	$44.15
	226710	08/19/2019	Suppliers or vendors	$54.17
	227403	08/23/2019	Suppliers or vendors	$829.39
	227404	08/23/2019	Suppliers or vendors	$344.62
	228342	09/06/2019	Suppliers or vendors	$265.32
	228343	09/06/2019	Suppliers or vendors	$157.68
	231023	10/11/2019	Suppliers or vendors	$32.00
	231024	10/11/2019	Suppliers or vendors	$550.00
			SUBTOTAL	$2,327.32
PITNEY BOWES, INC. PO BOX 371896 PITTSBURGH, PA 15250-7896	227417	08/23/2019	Services	$538.97
	228366	09/06/2019	Services	$240.68
	231042	10/11/2019	Services	$741.10
			SUBTOTAL	$1,520.75
PM SUPPLY, INC. PO BOX 566 EBENSBURG, PA 15931-0566	226934	08/19/2019	Suppliers or vendors	$13,726.95
	226935	08/19/2019	Suppliers or vendors	$17,480.80
	226936	08/19/2019	Suppliers or vendors	$8,743.21
	226937	08/19/2019	Suppliers or vendors	$6,159.62
			SUBTOTAL	$46,110.58

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
PNC BANK 199 WEST MAIN STREET ST. CLAIRSVILLE, OH 43950	226609	08/16/2019	Services	$1,541.19
			SUBTOTAL	$1,541.19
PNC EQUIPMENT FINANCE, LLC PO BOX 640306 PITTSBURGH, PA 15264-0306	226792	08/19/2019	Suppliers or vendors	$27,000.00
	229566	09/20/2019	Suppliers or vendors	$27,000.00
			SUBTOTAL	$54,000.00
POLARIS LABORATORIES, LLC P.O. BOX 6457- DEPT #278 INDIANAPOLIS, IN 46206	226688	08/19/2019	Suppliers or vendors	$1,837.44
			SUBTOTAL	$1,837.44
POLESET, INC. 5355 PROSPERITY PIKE PROSPERITY, PA 15329	227972	08/28/2019	Suppliers or vendors	$207,905.70
	229376	09/20/2019	Suppliers or vendors	$6,929.88
			SUBTOTAL	$214,835.58
POLSINELLI PC PO BOX 878681 KANSAS CITY, MO 64187-8681	231078	10/11/2019	Services	$16,248.00
	ACH	10/25/2019	Services	$10,000.00
			SUBTOTAL	$26,248.00
POLYDECK SCREEN CORPORATION PO BOX 602783 CHARLOTTE, NC 28260-2783	226529	08/13/2019	Suppliers or vendors	$6,378.26
	226530	08/13/2019	Suppliers or vendors	$7,173.42
	226531	08/13/2019	Suppliers or vendors	$9,702.21
	226532	08/13/2019	Suppliers or vendors	$5,408.82
	226533	08/13/2019	Suppliers or vendors	$1,457.87
	226534	08/13/2019	Suppliers or vendors	$3,057.50
	227978	08/28/2019	Suppliers or vendors	$23,100.90
	227979	08/28/2019	Suppliers or vendors	$10,875.70
	228922	09/06/2019	Suppliers or vendors	$14,720.44
	231426	10/11/2019	Suppliers or vendors	$24,263.24
	231427	10/11/2019	Suppliers or vendors	$7,747.92
	231428	10/11/2019	Suppliers or vendors	$6,274.96
	231429	10/11/2019	Suppliers or vendors	$24,862.44
			SUBTOTAL	$145,023.68
PONZANI LANDSCAPING COMPANY 66741 WARNOCK-ST. CLAIRSVILLE RD ST. CLAIRSVILLE, OH 43950	226104	08/13/2019	Suppliers or vendors	$4,121.09
	226105	08/13/2019	Suppliers or vendors	$552.28

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
PONZANI LANDSCAPING COMPANY 66741 WARNOCK-ST. CLAIRSVILLE RD ST. CLAIRSVILLE, OH 43950	226745	08/19/2019	Suppliers or vendors	$10,800.08
	227488	08/23/2019	Suppliers or vendors	$1,782.50
	227489	08/23/2019	Suppliers or vendors	$2,369.69
	227490	08/23/2019	Suppliers or vendors	$240.00
	229470	09/20/2019	Suppliers or vendors	$2,182.41
	229471	09/20/2019	Suppliers or vendors	$240.00
	229472	09/20/2019	Suppliers or vendors	$6,867.75
	230628	10/07/2019	Suppliers or vendors	$1,445.73
	230629	10/07/2019	Suppliers or vendors	$60.00
	231074	10/11/2019	Suppliers or vendors	$1,445.73
	231075	10/11/2019	Suppliers or vendors	$1,274.13
	231076	10/11/2019	Suppliers or vendors	$4,129.13
			SUBTOTAL	$37,510.52
PONZANI LENDON FLORIST & GARDEN CENTER LLC 46540 NATIONAL ROAD W ST. CLAIRSVILLE, OH 43950	228322	09/06/2019	Suppliers or vendors	$81.38
	228323	09/06/2019	Suppliers or vendors	$224.21
	229400	09/20/2019	Suppliers or vendors	$58.99
	230546	10/07/2019	Suppliers or vendors	$92.82
	231010	10/11/2019	Suppliers or vendors	$96.53
	231877	10/25/2019	Suppliers or vendors	$81.03
	231878	10/25/2019	Suppliers or vendors	$287.43
			SUBTOTAL	$922.39
PORTER WRIGHT MORRIS & ARTHUR 41 SOUTH HIGH ST, STES 2800-3200 COLUMBUS, OH 43215-6194	229387	09/20/2019	Services	$1,037.50
	229388	09/20/2019	Services	$1,660.00
	229389	09/20/2019	Services	$4,642.50
	230991	10/11/2019	Services	$944.61
	230992	10/11/2019	Services	$13,132.75
	230993	10/11/2019	Services	$12,325.92
	ACH	10/18/2019	Services	$100,000.00
			SUBTOTAL	$133,743.28
POWER TECHNOLOGIES LLC PO BOX 241 PETERSBURG, IN 47567	231541	10/17/2019	Suppliers or vendors	$18,385.00
			SUBTOTAL	$18,385.00

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POWERPLAN MURPHY TRACTOR & EQUIPMENT COMPANY PO BOX 4450 CAROL STREAM, IL 60197-4450	225772	08/05/2019	Suppliers or vendors	$1,103.03
			SUBTOTAL	$1,103.03
POWHATAN POINT CABLE CO 510 WARWOOD AVE WHEELING, WV 26003	227325	08/23/2019	Services	$700.00
	229932	09/26/2019	Services	$700.00
			SUBTOTAL	$1,400.00
PRAXAIR DISTRIBUTION INC. DEPT 0812 PO BOX 120812 DALLAS, TX 75312-0812	ACH	09/13/2019	Suppliers or vendors	$75.57
			SUBTOTAL	$75.57
PRAXAIR DISTRIBUTION INC. DEPT. CH 10660 PALATINE, IL 60055-0660	229117	09/11/2019	Suppliers or vendors	$14,973.03
	229118	09/11/2019	Suppliers or vendors	$82,015.41
			SUBTOTAL	$96,988.44
PREMIER PUMP INC PO BOX 76913 CLEVELAND, OH 44101-6500	226839	08/19/2019	Suppliers or vendors	$1,080.00
	227638	08/23/2019	Suppliers or vendors	$1,080.00
			SUBTOTAL	$2,160.00
PREMIERE GLOBAL SERVICES PO BOX 404351 ATLANTA, GA 30384-4351	229597	09/20/2019	Suppliers or vendors	$54.78
	230184	10/03/2019	Suppliers or vendors	$8,099.84
			SUBTOTAL	$8,154.62
PRO STAR AVIATION LLC 8 KELLY AVE LONDONDERRY, NH 03053	226285	08/13/2019	Services	$34,092.08
			SUBTOTAL	$34,092.08
PROCESS PUMP & SEAL, INC. PO BOX 630158 CINCINNATI, OH 45263-0258	225802	08/05/2019	Suppliers or vendors	$61,835.19
			SUBTOTAL	$61,835.19
PROFESSIONAL SERVICE IND INC PO BOX 74008418 CHICAGO, IL 60674-8418	225809	08/05/2019	Suppliers or vendors	$283.50
	231574	10/17/2019	Suppliers or vendors	$5,295.58
			SUBTOTAL	$5,579.08

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
PROSKAUER ROSE LLP ELEVEN TIMES SQUARE NEW YORK, NY 10036	226273	08/13/2019	Services	$2,528.75
	229718	09/20/2019	Services	$4,750.00
			SUBTOTAL	$7,278.75
PRUDENTIAL GROUP INSURANCE PO BOX 101241 ATLANTA, GA 30392-1241	ACH	08/21/2019	Services	$234,646.03
	ACH	09/20/2019	Services	$205,973.50
	ACH	10/15/2019	Services	$203,782.31
			SUBTOTAL	$644,401.84
PRUDENTIAL PRUCO LIFE INSURANCE COMPANY PO BOX 856138 LOUISVILLE, KY 40285	228324	09/06/2019	Services	$84,022.53
			SUBTOTAL	$84,022.53
PUBLIC SERVICE COMMISSION ATTN EXECUTIVE DIRECTOR 201 BROOKS ST PO BOX 812 CHARLESTON, WV 25323	Credit Card	08/27/2019	Suppliers or vendors	$1,782.24
	Credit Card	09/19/2019	Suppliers or vendors	$1,980.79
			SUBTOTAL	$3,763.03
PURCHASE POWER PO BOX 371874 PITTSBURGH, PA 15250-7874	226716	08/19/2019	Suppliers or vendors	$149.46
	230560	10/07/2019	Suppliers or vendors	$165.36
	231030	10/11/2019	Suppliers or vendors	$467.69
			SUBTOTAL	$782.51
PURVIS INDUSTRIES LLC MINE SUPPLY P.O. BOX 540757 DALLAS, TX 75354-0757	ACH	08/19/2019	Suppliers or vendors	$108.45
	ACH	09/13/2019	Suppliers or vendors	$496.35
			SUBTOTAL	$604.80
PVH DEVELOPMENT HAMPTON BY HILTON 2121 PLEASANT VALLEY RD FAIRMONT, WV 26554	226265	08/13/2019	Services	$158.28
			SUBTOTAL	$158.28
QUALITY ENVIRONMENTAL SERVICES 67440 FALLOURE RD BELMONT, OH 43718	225583	08/05/2019	Suppliers or vendors	$151.64
	225584	08/05/2019	Suppliers or vendors	$5,857.19
	225585	08/05/2019	Suppliers or vendors	$12,391.07
	225586	08/05/2019	Suppliers or vendors	$3,777.77

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
QUALITY ENVIRONMENTAL SERVICES 67440 FALLOURE RD BELMONT, OH 43718	225587	08/05/2019	Suppliers or vendors	$465.20
	225588	08/05/2019	Suppliers or vendors	$4,588.57
	227290	08/23/2019	Suppliers or vendors	$4,585.06
	228728	09/06/2019	Suppliers or vendors	$1,613.81
	230336	10/04/2019	Suppliers or vendors	$1,538.35
	230337	10/04/2019	Suppliers or vendors	$20,983.79
	230811	10/10/2019	Suppliers or vendors	$28,750.00
			SUBTOTAL	$84,702.45
QUALITY HYDRAULICS, INC. 857 MORROW CROSS ROAD FLEMINGTON, WV 26347	227004	08/19/2019	Suppliers or vendors	$1,994.89
	227005	08/19/2019	Suppliers or vendors	$2,403.42
	227006	08/19/2019	Suppliers or vendors	$30,511.87
	227007	08/19/2019	Suppliers or vendors	$3,873.61
	227008	08/19/2019	Suppliers or vendors	$1,260.00
	227009	08/19/2019	Suppliers or vendors	$8,487.59
			SUBTOTAL	$48,531.38
QUALITY MAGNETITE, LLC P.O. BOX 671413 DALLAS, TX 75267-1413	225736	08/05/2019	Suppliers or vendors	$21,833.70
	225737	08/05/2019	Suppliers or vendors	$105,079.77
	225738	08/05/2019	Suppliers or vendors	$7,078.23
	225739	08/05/2019	Suppliers or vendors	$28,381.08
	225740	08/05/2019	Suppliers or vendors	$21,990.54
	226545	08/13/2019	Suppliers or vendors	$21,653.86
	226546	08/13/2019	Suppliers or vendors	$64,981.89
	226547	08/13/2019	Suppliers or vendors	$21,899.02
	226548	08/13/2019	Suppliers or vendors	$14,547.06
	226549	08/13/2019	Suppliers or vendors	$21,218.88
	226550	08/13/2019	Suppliers or vendors	$44,149.82
	227078	08/19/2019	Suppliers or vendors	$21,552.70
	227079	08/19/2019	Suppliers or vendors	$71,892.72
	227080	08/19/2019	Suppliers or vendors	$22,142.12
	227081	08/19/2019	Suppliers or vendors	$14,376.84
	227082	08/19/2019	Suppliers or vendors	$22,153.56
	227996	08/28/2019	Suppliers or vendors	$29,128.46
	227997	08/28/2019	Suppliers or vendors	$64,462.95
	227998	08/28/2019	Suppliers or vendors	$7,401.68
	227999	08/28/2019	Suppliers or vendors	$7,273.53
	228000	08/28/2019	Suppliers or vendors	$29,483.74
	228940	09/06/2019	Suppliers or vendors	$79,007.22

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
QUALITY MAGNETITE, LLC P.O. BOX 671413 DALLAS, TX 75267-1413	228941	09/06/2019	Suppliers or vendors	$28,593.60
	228942	09/06/2019	Suppliers or vendors	$36,853.96
	229892	09/25/2019	Suppliers or vendors	$43,400.45
	229893	09/25/2019	Suppliers or vendors	$107,473.59
	229894	09/25/2019	Suppliers or vendors	$44,718.96
	229895	09/25/2019	Suppliers or vendors	$21,496.95
	229896	09/25/2019	Suppliers or vendors	$14,180.88
	229897	09/25/2019	Suppliers or vendors	$29,529.50
	ACH	10/09/2019	Suppliers or vendors	$7,038.00
	ACH	10/10/2019	Suppliers or vendors	$539,750.08
	ACH	10/15/2019	Suppliers or vendors	$266,454.46
	ACH	10/23/2019	Suppliers or vendors	$64,594.08
	Wire	10/28/2019	Suppliers or vendors	$50,233.95
			SUBTOTAL	$1,996,007.83
QUALITY ON TAP GALLIA RURAL WATER ASSOCIATION 308 BURNETT ROAD GALLIPOLIS, OH 45631	226651	08/19/2019	Other - Utilities	$105.93
	229277	09/20/2019	Other - Utilities	$141.38
			SUBTOTAL	$247.31
QUALITY WATER SERVICES, LLC 67440 FALLOURE ROAD BELMONT, OH 43718	228270	09/06/2019	Suppliers or vendors	$4,619.27
	229266	09/20/2019	Suppliers or vendors	$2,844.09
			SUBTOTAL	$7,463.36
QUILL CORPORATION PO BOX 37600 PHILADELPHIA, PA 19101-0600	226022	08/13/2019	Suppliers or vendors	$988.57
	226023	08/13/2019	Suppliers or vendors	$93.78
	226679	08/19/2019	Suppliers or vendors	$4,796.85
	226680	08/19/2019	Suppliers or vendors	$64.77
	227355	08/23/2019	Suppliers or vendors	$1,923.11
	227356	08/23/2019	Suppliers or vendors	$59.94
	228300	09/06/2019	Suppliers or vendors	$2,774.87
	229347	09/20/2019	Suppliers or vendors	$2,655.04
	229348	09/20/2019	Suppliers or vendors	$222.35
	230517	10/07/2019	Suppliers or vendors	$2,298.56
	230967	10/11/2019	Suppliers or vendors	$1,284.84
	230968	10/11/2019	Suppliers or vendors	$189.48
			SUBTOTAL	$17,352.16

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
R M MANUFACTURING SALES & SERVICES PO BOX 750 WAYNESBURG, PA 15370	229152	09/17/2019	Suppliers or vendors	$12,992.00
			SUBTOTAL	$12,992.00
R M WILSON CO PO BOX 6274 WHEELING, WV 26003	225605	08/05/2019	Suppliers or vendors	$13,179.13
	225606	08/05/2019	Suppliers or vendors	$29,801.93
	225607	08/05/2019	Suppliers or vendors	$434,891.26
	225608	08/05/2019	Suppliers or vendors	$7,838.27
	225609	08/05/2019	Suppliers or vendors	$10,807.29
	225610	08/05/2019	Suppliers or vendors	$8,682.25
	225611	08/05/2019	Suppliers or vendors	$56,593.62
	225612	08/05/2019	Suppliers or vendors	$33,025.97
	226897	08/19/2019	Suppliers or vendors	$10,548.11
	226898	08/19/2019	Suppliers or vendors	$57,519.72
	226899	08/19/2019	Suppliers or vendors	$87,144.12
	226900	08/19/2019	Suppliers or vendors	$778.25
	226901	08/19/2019	Suppliers or vendors	$5,552.75
	226902	08/19/2019	Suppliers or vendors	$18,835.47
	226903	08/19/2019	Suppliers or vendors	$1,174.06
	227821	08/28/2019	Suppliers or vendors	$466.38
	227822	08/28/2019	Suppliers or vendors	$16,227.66
	227823	08/28/2019	Suppliers or vendors	$57,521.21
	227824	08/28/2019	Suppliers or vendors	$3,777.01
	227825	08/28/2019	Suppliers or vendors	$14,053.80
	227826	08/28/2019	Suppliers or vendors	$2,208.48
	227827	08/28/2019	Suppliers or vendors	$16,906.76
	227828	08/28/2019	Suppliers or vendors	$4,774.41
	227829	08/28/2019	Suppliers or vendors	$78,174.00
	228753	09/06/2019	Suppliers or vendors	$17,183.95
	228754	09/06/2019	Suppliers or vendors	$3,301.50
	228755	09/06/2019	Suppliers or vendors	$391.30
	228756	09/06/2019	Suppliers or vendors	$1,779.00
	228757	09/06/2019	Suppliers or vendors	$16,906.76
	228758	09/06/2019	Suppliers or vendors	$62,003.90
	228759	09/06/2019	Suppliers or vendors	$95,313.26
			SUBTOTAL	$1,167,361.58
R.G. JOHNSON COMPANY, INC. 25 SOUTH COLLEGE STREET WASHINGTON, PA 15301	225751	08/05/2019	Suppliers or vendors	$23,784.40

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
R.G. JOHNSON COMPANY, INC. 25 SOUTH COLLEGE STREET WASHINGTON, PA 15301	225752	08/05/2019	Suppliers or vendors	$126,114.06
	225753	08/05/2019	Suppliers or vendors	$79,938.06
	225754	08/05/2019	Suppliers or vendors	$5,435.49
	227101	08/19/2019	Suppliers or vendors	$7,178.34
	227274	08/23/2019	Suppliers or vendors	$872,002.80
	227275	08/23/2019	Suppliers or vendors	$26,648.54
	227276	08/23/2019	Suppliers or vendors	$228,458.88
	227277	08/23/2019	Suppliers or vendors	$22,909.70
	228168	08/30/2019	Suppliers or vendors	$81,286.68
	228169	08/30/2019	Suppliers or vendors	$14,975.83
	228170	08/30/2019	Suppliers or vendors	$268,041.14
	228949	09/06/2019	Suppliers or vendors	$249,028.92
	229147	09/17/2019	Suppliers or vendors	$156,403.79
	229148	09/17/2019	Suppliers or vendors	$169,267.76
	229149	09/17/2019	Suppliers or vendors	$79,890.05
	229150	09/17/2019	Suppliers or vendors	$13,229.70
	230399	10/04/2019	Suppliers or vendors	$334,018.44
	230400	10/04/2019	Suppliers or vendors	$24,900.00
	230787	10/09/2019	Suppliers or vendors	$173,695.45
	230788	10/09/2019	Suppliers or vendors	$189,505.89
	231439	10/11/2019	Suppliers or vendors	$177,321.40
	231488	10/14/2019	Suppliers or vendors	$173,764.12
	231691	10/22/2019	Suppliers or vendors	$134,889.16
	231692	10/22/2019	Suppliers or vendors	$119,562.66
			SUBTOTAL	$3,752,251.26
RACHEL BROWN 2009 PEARL STREET OWENSBORO, KY 42303	226272	08/13/2019	Suppliers or vendors	$1,620.85
			SUBTOTAL	$1,620.85
RAIL SWITCHING SERVICES 27596 NETWORK PLACE CHICAGO, IL 60673-1275	228319	09/06/2019	Services	$38,896.01
	229394	09/20/2019	Services	$38,896.01
	230539	10/07/2019	Services	$38,896.01
			SUBTOTAL	$116,688.03
RAILCREW XPRESS 9867 WIDMER ROAD LENEXA, KS 66215	225453	08/02/2019	Services	$2,932.36
	226219	08/13/2019	Services	$2,696.47
	226818	08/19/2019	Services	$2,517.08
	227589	08/23/2019	Services	$3,159.46

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
RAILCREW XPRESS 9867 WIDMER ROAD LENEXA, KS 66215	228490	09/06/2019	Services	$4,652.32
	229640	09/20/2019	Services	$3,973.92
	230715	10/07/2019	Services	$2,207.46
	231215	10/11/2019	Services	$4,415.13
			SUBTOTAL	$26,554.20
RAILINC PO BOX 79860 BALTIMORE, MD 21279-0860	227388	08/23/2019	Services	$261.80
			SUBTOTAL	$261.80
RALEIGH MINE & INDUSTRIAL SUPPLY IN PO BOX 72 MT. HOPE, WV 25880	225636	08/05/2019	Suppliers or vendors	$16,998.25
	225637	08/05/2019	Suppliers or vendors	$7,350.00
	225638	08/05/2019	Suppliers or vendors	$2,345.24
	225639	08/05/2019	Suppliers or vendors	$6,273.20
			SUBTOTAL	$32,966.69
RALEIGH WATER DISTRICT PO BOX 187 RALEIGH, IL 62977	226661	08/19/2019	Other - Utilities	$475.00
			SUBTOTAL	$475.00
RALPH H COLFLESH JR ESQ PO BOX 28398 PHILADELPHIA, PA 19149	225461	08/02/2019	Services	$3,150.51
	225462	08/02/2019	Services	$1,082.66
	229680	09/20/2019	Services	$3,235.54
			SUBTOTAL	$7,468.71
RAS DATA SERVICES, INC. 1510 PLAINFIELD ROAD, STE 3 DARIEN, IL 60561	226825	08/19/2019	Services	$62,206.12
	229657	09/20/2019	Services	$6,567.15
			SUBTOTAL	$68,773.27
RAVEN ENERGY LLC 1011 WARRENVILLE ROAD SUITE 600 LISLE, IL 60532	ACH	10/11/2019	Suppliers or vendors	$168,373.98
	ACH	10/18/2019	Suppliers or vendors	$64,693.85
			SUBTOTAL	$233,067.83
RAYMOND E WHITAKER 8135 E FM 462 BIGFOOT, TX 78005	227590	08/23/2019	Other - Royalty	$101.56
			SUBTOTAL	$101.56

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
REBECCA COWGILL BYRNE 100 IDLE HOUR DRIVE #11 LEXINGTON, KY 40502-1171	227457	08/23/2019	Other - Royalty	$174.84
	229971	09/26/2019	Other - Royalty	$162.12
			SUBTOTAL	$336.96
REBUILDERS INC 225 HOLBERT RD FAIRMONT, WV 26554-5838	229011	09/06/2019	Suppliers or vendors	$367.00
	229012	09/06/2019	Suppliers or vendors	$4,015.00
			SUBTOTAL	$4,382.00
REDWING COMPANY INC 419 MAIN STREET MOUNT HOPE, WV 25880	228102	08/28/2019	Suppliers or vendors	$3,762.00
	228103	08/28/2019	Suppliers or vendors	$1,913.11
	231651	10/18/2019	Suppliers or vendors	$4,541.90
			SUBTOTAL	$10,217.01
REDWING LOGGING SUPPLY INC 419 MAIN STREET MT. HOPE, WV 25880	228096	08/28/2019	Suppliers or vendors	$1,067.36
			SUBTOTAL	$1,067.36
REED SMITH LLP PO BOX 360074M PITTSBURGH, PA 15251-6074	227518	08/23/2019	Services	$15,478.15
	230652	10/07/2019	Services	$311.50
	ACH	10/25/2019	Services	$9,464.65
			SUBTOTAL	$25,254.30
REFERENCE SERVICES INC 101 PLAZA EAST BLVD SUITE 300 EVANSVILLE, IN 47715	226238	08/13/2019	Services	$5,421.95
	229670	09/20/2019	Services	$6,101.00
	231241	10/11/2019	Services	$2,804.15
			SUBTOTAL	$14,327.10
RELX, INC. DBA LEXISNEXIS 28544 NETWORK PLACE CHICAGO, IL 60673-1285	227627	08/23/2019	Suppliers or vendors	$2,406.27
			SUBTOTAL	$2,406.27
REPUBLIC DIESEL, INC. PO BOX 35650 LOUISVILLE, KY 40232	226932	08/19/2019	Suppliers or vendors	$30,809.80
	227865	08/28/2019	Suppliers or vendors	$1,880.74
			SUBTOTAL	$32,690.54
REPUBLIC SERVICES #757 PO BOX 9001099 LOUISVILLE, KY 40290-1099	225358	08/02/2019	Suppliers or vendors	$6,083.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
REPUBLIC SERVICES #757 PO BOX 9001099 LOUISVILLE, KY 40290-1099	227332	08/23/2019	Suppliers or vendors	$7,976.30
	229282	09/20/2019	Suppliers or vendors	$2,372.13
	230905	10/11/2019	Suppliers or vendors	$3,898.08
			SUBTOTAL	$20,329.51
REPUBLIC SERVICES INC #384 PO BOX 9001099 LOUISVILLE, KY 40290-1099	226106	08/13/2019	Suppliers or vendors	$610.50
	226107	08/13/2019	Suppliers or vendors	$99.96
	226108	08/13/2019	Suppliers or vendors	$2,179.87
	226746	08/19/2019	Suppliers or vendors	$4,824.63
	227491	08/23/2019	Suppliers or vendors	$14,946.75
	229119	09/11/2019	Suppliers or vendors	$806.12
	229473	09/20/2019	Suppliers or vendors	$14,045.75
	229474	09/20/2019	Suppliers or vendors	$1,312.73
	229475	09/20/2019	Suppliers or vendors	$8,370.94
	229998	09/26/2019	Suppliers or vendors	$481.69
	230158	10/03/2019	Suppliers or vendors	$1,221.00
	230159	10/03/2019	Suppliers or vendors	$199.92
	230773	10/08/2019	Suppliers or vendors	$380.06
	230830	10/10/2019	Suppliers or vendors	$403.06
	231077	10/11/2019	Suppliers or vendors	$1,439.71
			SUBTOTAL	$51,322.69
REPUBLIC SERVICES INC #732 DBA CWI OF ILLINOIS PO BOX 9001099 LOUISVILLE, KY 40290-1099	225419	08/02/2019	Other - Utilities	$151.68
	230160	10/03/2019	Other - Utilities	$152.90
			SUBTOTAL	$304.58
REPUBLIC SERVICES INC P.O. BOX 9001099 LOUISVILLE, KY 40290-1099	226166	08/13/2019	Suppliers or vendors	$114.60
	226779	08/19/2019	Suppliers or vendors	$3,910.85
	226780	08/19/2019	Suppliers or vendors	$32,206.91
	226781	08/19/2019	Suppliers or vendors	$28,469.82
	227539	08/23/2019	Suppliers or vendors	$10,076.64
	229137	09/16/2019	Suppliers or vendors	$129.68
	229138	09/16/2019	Suppliers or vendors	$1,092.16
	229139	09/16/2019	Suppliers or vendors	$158.58
	229140	09/16/2019	Suppliers or vendors	$35,427.56
	229141	09/16/2019	Suppliers or vendors	$17,949.52
	229142	09/16/2019	Suppliers or vendors	$7,414.24

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REPUBLIC SERVICES INC P.O. BOX 9001099 LOUISVILLE, KY 40290-1099	229143	09/16/2019	Suppliers or vendors	$2,433.17
	230011	09/26/2019	Suppliers or vendors	$232.61
	230167	10/03/2019	Suppliers or vendors	$4,839.53
	231142	10/11/2019	Suppliers or vendors	$37,645.10
	231143	10/11/2019	Suppliers or vendors	$27,250.79
	231144	10/11/2019	Suppliers or vendors	$12,573.52
	231145	10/11/2019	Suppliers or vendors	$127.24
			SUBTOTAL	$222,052.52
RESCHINI AGENCY, INC. 922 PHILADELPHIA STREET PO BOX 449 INDIANA, PA 15701	ACH	08/06/2019	Services	$683,237.63
	ACH	08/08/2019	Services	$349,873.00
	ACH	08/12/2019	Services	$1,249,046.51
	225927	08/13/2019	Services	$38.00
	225928	08/13/2019	Services	$516.00
	225929	08/13/2019	Services	$6,002.00
	227279	08/23/2019	Services	$94.00
	227280	08/23/2019	Services	$332.00
	227281	08/23/2019	Services	$938.00
	227282	08/23/2019	Services	$771.00
	227283	08/23/2019	Services	$190.00
	227284	08/23/2019	Services	$1,527.00
	227285	08/23/2019	Services	$468.00
	227286	08/23/2019	Services	$15,581.00
	227287	08/23/2019	Services	$34,275.00
	ACH	09/05/2019	Services	$476,642.63
	ACH	09/10/2019	Services	$1,249,046.51
	229166	09/20/2019	Services	$15,144.00
	229167	09/20/2019	Services	$6,515.00
	229168	09/20/2019	Services	$8,147.00
	229169	09/20/2019	Services	$520,107.00
	229170	09/20/2019	Services	$32,071.00
	229171	09/20/2019	Services	$55,751.00
	229172	09/20/2019	Services	$166,590.00
	229173	09/20/2019	Services	$33,480.00
	229174	09/20/2019	Services	$48,787.00
	229175	09/20/2019	Services	$1,424.00
	229176	09/20/2019	Services	$359,345.00
	229177	09/20/2019	Services	$81,714.87
	229178	09/20/2019	Services	$1,596.00

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RESCHINI AGENCY, INC. 922 PHILADELPHIA STREET PO BOX 449 INDIANA, PA 15701	229179	09/20/2019	Services	$1,739.00
	229180	09/20/2019	Services	$15,681.00
	229181	09/20/2019	Services	$20,264.00
	229182	09/20/2019	Services	$11,055.00
	229183	09/20/2019	Services	$13,905.00
	229184	09/20/2019	Services	$12,749.00
	229185	09/20/2019	Services	$148,624.00
	229186	09/20/2019	Services	$10,015.00
	229187	09/20/2019	Services	$21,246.00
	229188	09/20/2019	Services	$5,663.00
	229189	09/20/2019	Services	$58,826.18
	230430	10/07/2019	Services	$15,615.00
	230431	10/07/2019	Services	$8,147.00
	230432	10/07/2019	Services	$65,554.00
	230433	10/07/2019	Services	$55,229.00
	230434	10/07/2019	Services	$78,567.00
	230435	10/07/2019	Services	$33,537.00
	230436	10/07/2019	Services	$48,635.00
	230437	10/07/2019	Services	$1,424.00
	230438	10/07/2019	Services	$356,219.00
	230439	10/07/2019	Services	$328.00
	230440	10/07/2019	Services	$1,596.00
	230441	10/07/2019	Services	$15,681.00
	230442	10/07/2019	Services	$548.00
	230443	10/07/2019	Services	$1,422.00
	230444	10/07/2019	Services	$7,090.00
	230445	10/07/2019	Services	$36,237.60
	ACH	10/07/2019	Services	$476,642.63
	ACH	10/10/2019	Services	$1,249,046.51
			SUBTOTAL	$8,170,536.07
RESERVE ACCOUNT PO BOX 223648 PITTSBURGH, PA 15250-2648	228171	08/30/2019	Other - Regulatory/Tax	$5,000.00
			SUBTOTAL	$5,000.00
RGGS LAND & MINERALS, LTD., L.P. 100 WAUGH DRIVE, SUITE 400 HOUSTON, TX 77007	ACH	10/07/2019	Services	$12,185.15
			SUBTOTAL	$12,185.15

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
RICE ELECTRIC PO BOX 429 EIGHTY FOUR, PA 15330	227987	08/28/2019	Suppliers or vendors	$15,677.48
	227988	08/28/2019	Suppliers or vendors	$14,316.50
	227989	08/28/2019	Suppliers or vendors	$9,438.73
	227990	08/28/2019	Suppliers or vendors	$12,941.00
			SUBTOTAL	$52,373.71
RICES LANDING BOROUGH TAX COLLECTOR 108 MONONGAHELA AVE. RICES LANDING, PA 15357	231219	10/11/2019	Other - Regulatory/Tax	$19.35
	231220	10/11/2019	Other - Regulatory/Tax	$112.23
			SUBTOTAL	$131.58
RICHARD A WARNER 26 EPCOT DR, APT. C ELKVIEW, WV 25071	225890	08/05/2019	Other - Royalty	$3.12
	229085	09/10/2019	Other - Royalty	$3.15
			SUBTOTAL	$6.27
RICHARD B WHITE PE PLLC 13441 SOUTH LONE PEAK LANE DRAPER, UT 84020	230752	10/07/2019	Suppliers or vendors	$140.00
	230753	10/07/2019	Suppliers or vendors	$1,120.00
			SUBTOTAL	$1,260.00
RICHARD C CLINE 2033 SLOAN AVENUE LATROBE, PA 15650	228453	09/06/2019	Services	$2,982.32
	230691	10/07/2019	Services	$2,541.41
			SUBTOTAL	$5,523.73
RICHARD D MARCAVITCH 735 SARA DRIVE WASHINGTON, PA 15301	226783	08/19/2019	Suppliers or vendors	$997.00
	227543	08/23/2019	Suppliers or vendors	$437.00
	229552	09/20/2019	Suppliers or vendors	$454.80
	230676	10/07/2019	Suppliers or vendors	$629.60
	231150	10/11/2019	Suppliers or vendors	$507.40
			SUBTOTAL	$3,025.80
RICHARD D WENDT 6086 DRAGON HIGHWAY CAMERON, WV 26033	227653	08/23/2019	Suppliers or vendors	$1,000.00
	227654	08/23/2019	Suppliers or vendors	$4,500.00
			SUBTOTAL	$5,500.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
RICHARD G. TROTTER 4000 N CHARLES ST. STE. 1401 BALTIMORE, MD 21218	229717	09/20/2019	Services	$6,103.88
			SUBTOTAL	$6,103.88
RICHARD M CROLLEY 109 MOUNT VIEW DRIVE WHEELING, WV 26003	227657	08/23/2019	Suppliers or vendors	$45,000.00
			SUBTOTAL	$45,000.00
RICHARD WILBUR III ADVANTAGE TECHNOLOGY 950 KANAWHA BLVD E CHARLESTON, WV 25301	225471	08/02/2019	Suppliers or vendors	$4,920.79
	226268	08/13/2019	Suppliers or vendors	$524.17
			SUBTOTAL	$5,444.96
RICHHILL TOWNSHIP TAX COLLECTOR ATTN: JOYCE HELPHENSTINE 449 W. ROY FURMAN HWY WIND RIDGE, PA 15380	229637	09/20/2019	Other - Regulatory/Tax	$10,164.75
			SUBTOTAL	$10,164.75
RICHWOOD INDUSTRIES, INC. PO BOX 1298 HUNTINGTON, WV 25714-1298	225599	08/05/2019	Suppliers or vendors	$7,404.98
	225600	08/05/2019	Suppliers or vendors	$12,824.53
	225601	08/05/2019	Suppliers or vendors	$6,309.50
	225602	08/05/2019	Suppliers or vendors	$5,017.00
	225603	08/05/2019	Suppliers or vendors	$29,567.88
	225604	08/05/2019	Suppliers or vendors	$9,100.78
	228745	09/06/2019	Suppliers or vendors	$21,832.16
	228746	09/06/2019	Suppliers or vendors	$4,673.79
	228747	09/06/2019	Suppliers or vendors	$10,207.93
	228748	09/06/2019	Suppliers or vendors	$25,457.44
	228749	09/06/2019	Suppliers or vendors	$20,365.11
	228750	09/06/2019	Suppliers or vendors	$5,469.00
	228751	09/06/2019	Suppliers or vendors	$9,318.42
	231654	10/19/2019	Suppliers or vendors	$17,924.50
	231655	10/19/2019	Suppliers or vendors	$11,433.98
	231656	10/19/2019	Suppliers or vendors	$3,165.45
	231657	10/19/2019	Suppliers or vendors	$2,508.50
			SUBTOTAL	$202,580.95

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
RICK'S ACE HARDWARE & GARDEN 904 W. BROADWAY CENTRALIA, IL 62801	225971	08/13/2019	Suppliers or vendors	$66.31
	230479	10/07/2019	Suppliers or vendors	$58.15
			SUBTOTAL	$124.46
RICOTTILLI LUMBER COMPANY 227 SOUTH HADDIX RD MONTROSE, WV 26283	231653	10/18/2019	Suppliers or vendors	$9,590.40
			SUBTOTAL	$9,590.40
RITA LEE AULICINO 748 CR 18 RAYLAND, OH 43943	226729	08/19/2019	Suppliers or vendors	$46.54
	229951	09/26/2019	Suppliers or vendors	$82.54
			SUBTOTAL	$129.08
RIVER FRONT HONDA 436 STATE ROUTE 7 GALLIPOLIS, OH 45631	228377	09/06/2019	Suppliers or vendors	$626.38
	231061	10/11/2019	Suppliers or vendors	$85.69
			SUBTOTAL	$712.07
RIVER SALVAGE COMPANY, INC. 4900 GRAND AVENUE PITTSBURGH, PA 15225	226100	08/13/2019	Suppliers or vendors	$2,000.00
	229468	09/20/2019	Suppliers or vendors	$2,000.00
	231071	10/11/2019	Suppliers or vendors	$274,600.00
			SUBTOTAL	$278,600.00
ROBERT A POOLE AUTO ELECTRIC REPAIR PO BOX 750 MADISONVILLE, KY 42431	228274	09/06/2019	Suppliers or vendors	$503.50
			SUBTOTAL	$503.50
ROBERT B STADELMAN 1255 CROSS KEYS COURT LEXINGTON, KY 40504	227583	08/23/2019	Other - Royalty	$218.91
	230026	09/26/2019	Other - Royalty	$196.96
			SUBTOTAL	$415.87
ROBERT B. ELLIOTT & KATHY A. ELLIOT 1081 W ALEXANDER RD VALLEY GROVE, WV 26060	229129	09/13/2019	Suppliers or vendors	$250,000.00
			SUBTOTAL	$250,000.00
ROBERT CAUDILL 63621 ROWLAND ROAD HAMDEN, OH 45634	225859	08/05/2019	Other - Royalty	$94.45
	229056	09/10/2019	Other - Royalty	$97.16
	230572	10/07/2019	Other - Royalty	$94.88
			SUBTOTAL	$286.49

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ROBERT E. RILEY, JR. 309 BARNES MILL ROAD RICHMOND, KY 40475	227453	08/23/2019	Other - Royalty	$1,038.53
	229967	09/26/2019	Other - Royalty	$1,176.18
			SUBTOTAL	$2,214.71
ROBERT H KLATT 507 TOWNHOUSE RD WHEELING, WV 26003	228500	09/06/2019	Services	$27,840.00
			SUBTOTAL	$27,840.00
ROBERT H RUCKER TERESA L RUCKER 16891 W HEFNER RD EL RENO, OK 73036-9034	229589	09/20/2019	Other - Royalty	$108.33
			SUBTOTAL	$108.33
ROBERT J. REYNOLDS TRUST CO-TRUSTEE PO BOX 373 MT. STERLING, KY 40353	227452	08/23/2019	Other - Royalty	$117.66
			SUBTOTAL	$117.66
ROBERT L STAMPER OILPATCH DEPOT LLC PO BOX 286 BEATTYVILLE, KY 41311	226247	08/13/2019	Suppliers or vendors	$2,458.67
	227625	08/23/2019	Suppliers or vendors	$3,970.76
	228523	09/06/2019	Suppliers or vendors	$1,101.23
	229681	09/20/2019	Suppliers or vendors	$1,640.88
	231243	10/11/2019	Suppliers or vendors	$6,754.16
			SUBTOTAL	$15,925.70
ROBERT N CLAY IRREV FAMILY GSTT TRU EXEMPT SHARE 2705 TATES CREEK ROAD LEXINGTON, KY 40502	227615	08/23/2019	Other - Royalty	$409.73
	230037	09/26/2019	Other - Royalty	$435.06
			SUBTOTAL	$844.79
ROBERT N. CLAY 2705 TATES CREEK ROAD LEXINGTON, KY 40502	227446	08/23/2019	Other - Royalty	$177.35
			SUBTOTAL	$177.35
ROBERT P. TAYLOR, JR. 253 BLUE ISLAND AVE FAIRHOPE, AL 36532	227483	08/23/2019	Other - Royalty	$104.03
			SUBTOTAL	$104.03

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ROBERT SLAUGHTER 39 SAPPS HOLLOW ROAD SHINNSTON, WV 26431	226196	08/13/2019	Services	$640.00
	228469	09/06/2019	Services	$480.00
	231192	10/11/2019	Services	$2,080.00
			SUBTOTAL	$3,200.00
ROBERT SWISHER MILDRED SWISHER, TRUST PO BOX 115 LAKE CITY, TN 37769	225854	08/05/2019	Other - Royalty	$34.41
	229051	09/10/2019	Other - Royalty	$8.56
			SUBTOTAL	$42.97
ROCKWOOD CASUALTY INSURANCE COMPANY ACCOUNTING DEPARTMENT 654 MAIN STREET ROCKWOOD, PA 15557	225341	08/02/2019	Services	$217,814.32
	225342	08/02/2019	Services	$230,994.93
	225343	08/02/2019	Services	$46,816.02
	225344	08/02/2019	Services	$82,772.85
	ACH	08/15/2019	Services	$508,461.00
	ACH	08/27/2019	Services	$1,933.00
	228245	09/06/2019	Services	$186,206.58
	228246	09/06/2019	Services	$99,706.70
	228247	09/06/2019	Services	$14,641.52
	228248	09/06/2019	Services	$129,561.18
	ACH	09/17/2019	Services	$623,341.00
	ACH	09/25/2019	Services	$59,266.00
	230463	10/07/2019	Services	$346,755.02
	230464	10/07/2019	Services	$69,858.00
	230465	10/07/2019	Services	$74,022.10
	230466	10/07/2019	Services	$106,867.86
	230467	10/07/2019	Services	$25.63
	ACH	10/15/2019	Services	$428,734.00
			SUBTOTAL	$3,227,777.71
ROCKY MOUNTAIN POWER 1033 NE 6TH AVENUE PO BOX 26000 PORTLAND, OR 97256-0001	226042	08/13/2019	Other - Utilities	$3,690.75
	226043	08/13/2019	Other - Utilities	$3,765.57
	226044	08/13/2019	Other - Utilities	$4,560.72
	227378	08/23/2019	Other - Utilities	$199,030.02
	229377	09/20/2019	Other - Utilities	$3,435.18
	229378	09/20/2019	Other - Utilities	$2,428.88

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ROCKY MOUNTAIN POWER 1033 NE 6TH AVENUE PO BOX 26000 PORTLAND, OR 97256-0001	229379	09/20/2019	Other - Utilities	$4,193.08
	229904	09/25/2019	Other - Utilities	$237,648.89
	230980	10/11/2019	Other - Utilities	$2,456.23
	230981	10/11/2019	Other - Utilities	$4,032.59
	231859	10/24/2019	Other - Utilities	$239,541.63
	231860	10/24/2019	Other - Utilities	$4,382.92
			SUBTOTAL	$709,166.46
RODERIC L. MURRAY III 634 TIMBER LANE NASHVILLE, TN 37215	227451	08/23/2019	Other - Royalty	$119.67
	229965	09/26/2019	Other - Royalty	$148.98
			SUBTOTAL	$268.65
ROD'S WELDING & REBUILD SHOP 34225 HOLLAND ROAD BARNESVILLE, OH 43713	227059	08/19/2019	Suppliers or vendors	$935.31
	227060	08/19/2019	Suppliers or vendors	$1,452.77
			SUBTOTAL	$2,388.08
ROHRIG HEAVY EQUIPMENT MAINTENANCE PO BOX 4032 WHEELING, WV 26003	225817	08/05/2019	Suppliers or vendors	$826.27
	225818	08/05/2019	Suppliers or vendors	$4,679.10
	225819	08/05/2019	Suppliers or vendors	$39,864.28
			SUBTOTAL	$45,369.65
ROLAND L SMITH 9 GREENTREE DRIVE MORGANTOWN, WV 26508	225472	08/02/2019	Services	$6,545.06
			SUBTOTAL	$6,545.06
RONALD A & TINA M NOWAKOWSKI D & S MARKET 397 GALLITIN ROAD ROSTRAVER TWP, PA 15012	225426	08/02/2019	Suppliers or vendors	$3,952.26
	225427	08/02/2019	Suppliers or vendors	$3,794.54
	226153	08/13/2019	Suppliers or vendors	$3,434.54
	226154	08/13/2019	Suppliers or vendors	$3,728.68
	226763	08/19/2019	Suppliers or vendors	$3,602.75
	226764	08/19/2019	Suppliers or vendors	$4,306.06
	227529	08/23/2019	Suppliers or vendors	$3,482.11
	227530	08/23/2019	Suppliers or vendors	$3,628.13
	228422	09/06/2019	Suppliers or vendors	$6,755.39
	228423	09/06/2019	Suppliers or vendors	$9,101.60
	229530	09/20/2019	Suppliers or vendors	$6,859.91

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
RONALD A & TINA M NOWAKOWSKI D & S MARKET 397 GALLITIN ROAD ROSTRAVER TWP, PA 15012	229531	09/20/2019	Suppliers or vendors	$13,331.37
	230658	10/07/2019	Suppliers or vendors	$10,090.70
	230659	10/07/2019	Suppliers or vendors	$7,502.56
	231128	10/11/2019	Suppliers or vendors	$2,679.88
	231129	10/11/2019	Suppliers or vendors	$2,626.08
			SUBTOTAL	$88,876.56
RONALD D HIGGINS PO BOX 194 RACHEL, WV 26587	230043	09/26/2019	Suppliers or vendors	$2,000.00
			SUBTOTAL	$2,000.00
RONNIE SMITH ONSITE PLUMBING & EXCA 775 HUMPHREY ROAD CENTRAL CITY, KY 42330	228931	09/06/2019	Suppliers or vendors	$19,800.00
			SUBTOTAL	$19,800.00
ROSS HATFIELD CONSTRUCTION, INC 4655 HUSKY HIGHWAY MANNINGTON, WV 26582	225824	08/05/2019	Services	$27,450.00
			SUBTOTAL	$27,450.00
ROSS TIRES, INC. 145 OLD HIGHWAY 11 NORTH BEATTYVILLE, KY 41311	227438	08/23/2019	Suppliers or vendors	$21.20
	228376	09/06/2019	Suppliers or vendors	$557.03
	229457	09/20/2019	Suppliers or vendors	$968.31
			SUBTOTAL	$1,546.54
ROTESCO INC 150 MILNER AVE UNIT 25 SCARBOROUGH, ON M1S 3R3 CANADA	231619	10/18/2019	Suppliers or vendors	$10,069.22
			SUBTOTAL	$10,069.22
ROTORK PITTSBURGH LLC 3000 COMMERCE LOOP, BUILDING 3,STE NORTH HUNTINGDON, PA 15642	229042	09/06/2019	Suppliers or vendors	$5,390.60
			SUBTOTAL	$5,390.60
ROY MILLER 2514 HARRINGTON MILL RD SHELBYVILLE, KY 40065	229987	09/26/2019	Other - Royalty	$128.87
			SUBTOTAL	$128.87

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ROY R. GILKEY 31853 DEAD MAN'S CURVE RD. POMEROY, OH 45769	225865	08/05/2019	Other - Royalty	$23.44
	229062	09/10/2019	Other - Royalty	$25.44
	230578	10/07/2019	Other - Royalty	$22.41
			SUBTOTAL	$71.29
ROYAL HYDRAULIC SERVICE & MFG. PO BOX 122 COKEBURG, PA 15324	231501	10/16/2019	Suppliers or vendors	$1,394.20
	231639	10/18/2019	Suppliers or vendors	$12,247.98
	231640	10/18/2019	Suppliers or vendors	$2,086.44
	231641	10/18/2019	Suppliers or vendors	$590.00
	231672	10/22/2019	Suppliers or vendors	$2,980.30
			SUBTOTAL	$19,298.92
RUMPKE CONSOLIDATED COMPANIES PO BOX 538710 CINCINNATI, OH 45253-8710	226728	08/19/2019	Suppliers or vendors	$181.35
	229433	09/20/2019	Suppliers or vendors	$180.83
	231041	10/11/2019	Suppliers or vendors	$181.87
			SUBTOTAL	$544.05
RUMPKE OF KENTUCKY INC PO BOX 538710 CINCINNATI, OH 45253	226199	08/13/2019	Suppliers or vendors	$418.68
	229618	09/20/2019	Suppliers or vendors	$849.59
	231196	10/11/2019	Suppliers or vendors	$455.49
			SUBTOTAL	$1,723.76
RUTH E RIGGLE 875 DRAGON HIGHWAY CAMERON, WV 26033	228545	09/06/2019	Suppliers or vendors	$27,929.25
	228546	09/06/2019	Suppliers or vendors	$65,168.25
			SUBTOTAL	$93,097.50
RYAN GUNTO 2567 OLD NC HWY MOUNT HOLLY, NC 28120	230770	10/07/2019	Suppliers or vendors	$150,000.00
			SUBTOTAL	$150,000.00
S & M GLASS, INC. 204 MORGANTOWN AVE FAIRMONT, WV 26554	226133	08/13/2019	Suppliers or vendors	$750.00
	227511	08/23/2019	Suppliers or vendors	$790.00
			SUBTOTAL	$1,540.00
SABIA INC 10919 TECHNOLOGY PLACE SUITE A SAN DIEGO, CA 92127	229120	09/11/2019	Suppliers or vendors	$8,500.00
			SUBTOTAL	$8,500.00

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SAFETEK PO BOX 488 READER, WV 26167	ACH	08/30/2019	Suppliers or vendors	$950.00
	230662	10/07/2019	Suppliers or vendors	$1,900.00
	231131	10/11/2019	Suppliers or vendors	$1,425.00
			SUBTOTAL	$4,275.00
SAFETY KLEEN, INC. PO BOX 382066 PITTSBURGH, PA 15250-2066	225620	08/05/2019	Suppliers or vendors	$732.16
	226472	08/13/2019	Suppliers or vendors	$2,366.30
	227843	08/28/2019	Suppliers or vendors	$683.28
	227844	08/28/2019	Suppliers or vendors	$829.60
	227845	08/28/2019	Suppliers or vendors	$292.41
	227846	08/28/2019	Suppliers or vendors	$1,372.05
			SUBTOTAL	$6,275.80
SALINE VALLEY CONSERVANCY DISTRICT 900 DEWEY STREET PO BOX 369 ELDORADO, IL 62930	229316	09/20/2019	Other - Utilities	$1,279.66
	229939	09/26/2019	Other - Utilities	$1,318.30
			SUBTOTAL	$2,597.96
SAMINCO, INC. 10030 AMBERWOOD ROAD FORT MYERS, FL 33913	ACH	08/19/2019	Suppliers or vendors	$79,202.75
	ACH	09/13/2019	Suppliers or vendors	$33,187.09
	231551	10/17/2019	Suppliers or vendors	$3,302.85
			SUBTOTAL	$115,692.69
SAMUEL FRONTIER STEEL DBA SAMUEL, SON & CO., INC. PO BOX 77920 DETROIT, MI 48277	227230	08/19/2019	Suppliers or vendors	$5,012.00
			SUBTOTAL	$5,012.00
SAMUEL SPENCER STONE 44 HIGH STREET MORGANTOWN, WV 26505	226211	08/13/2019	Suppliers or vendors	$900.00
	227582	08/23/2019	Suppliers or vendors	$3,300.00
			SUBTOTAL	$4,200.00
SANDRA MILLIRON 610 4TH AVENUE GALLIPOLIS, OH 45631	225879	08/05/2019	Other - Royalty	$3.24
	229075	09/10/2019	Other - Royalty	$4.28
	230591	10/07/2019	Other - Royalty	$2.68
			SUBTOTAL	$10.20

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SANDVIK MINING & CONST. USA, LLC DEPT CH-10576 PALATINE, IL 60055-0576	225726	08/05/2019	Suppliers or vendors	$20,423.91
	225727	08/05/2019	Suppliers or vendors	$40,826.16
	225728	08/05/2019	Suppliers or vendors	$51.14
	225729	08/05/2019	Suppliers or vendors	$6,623.44
	225730	08/05/2019	Suppliers or vendors	$114,559.43
	225731	08/05/2019	Suppliers or vendors	$24,845.53
	226538	08/13/2019	Suppliers or vendors	$18,057.76
	226539	08/13/2019	Suppliers or vendors	$10,751.51
	226540	08/13/2019	Suppliers or vendors	$1,593.06
	226541	08/13/2019	Suppliers or vendors	$1,041.74
	226542	08/13/2019	Suppliers or vendors	$180,463.79
	226543	08/13/2019	Suppliers or vendors	$300.75
	227071	08/19/2019	Suppliers or vendors	$89,054.08
	227072	08/19/2019	Suppliers or vendors	$58,193.20
	227073	08/19/2019	Suppliers or vendors	$8,693.05
	227074	08/19/2019	Suppliers or vendors	$18,309.16
	227075	08/19/2019	Suppliers or vendors	$20,965.51
	227076	08/19/2019	Suppliers or vendors	$3,058.48
			SUBTOTAL	$617,811.70
SATCOM DIRECT INC PO BOX 101617 ATLANTA, GA 30392-1617	226815	08/19/2019	Suppliers or vendors	$250.00
	230025	09/26/2019	Suppliers or vendors	$250.00
			SUBTOTAL	$500.00
SATURN BRONZE, INC. 13 12TH STREET PO BOX 128 MCMECHEN, WV 26040-0128	227165	08/19/2019	Suppliers or vendors	$9,319.00
	227166	08/19/2019	Suppliers or vendors	$122,638.00
	227167	08/19/2019	Suppliers or vendors	$1,520.00
	228087	08/28/2019	Suppliers or vendors	$14,314.00
	228088	08/28/2019	Suppliers or vendors	$15,284.00
	228089	08/28/2019	Suppliers or vendors	$998.00
	229009	09/06/2019	Suppliers or vendors	$3,315.00
	229010	09/06/2019	Suppliers or vendors	$1,857.00
			SUBTOTAL	$169,245.00
SAVAGE SERVICES CORPORATION PO BOX 413070 SALT LAKE CITY, UT 84141-3070	226045	08/13/2019	Services	$1,503,597.45
	226689	08/19/2019	Services	$78,285.16
	228309	09/06/2019	Services	$955,412.64

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
SAVAGE SERVICES CORPORATION PO BOX 413070 SALT LAKE CITY, UT 84141-3070	229380	09/20/2019	Services	$541,766.52
	230524	10/07/2019	Services	$1,982,436.81
	230982	10/11/2019	Services	$260,039.22
			SUBTOTAL	$5,321,537.80
SCHINDLER ELEVATOR CORPORATION PO BOX 93050 CHICAGO, IL 60673-3050	226046	08/13/2019	Suppliers or vendors	$7,747.00
	226690	08/19/2019	Suppliers or vendors	$8,761.83
	226691	08/19/2019	Suppliers or vendors	$6,962.80
	226692	08/19/2019	Suppliers or vendors	$62,110.81
	226693	08/19/2019	Suppliers or vendors	$20,775.82
	226694	08/19/2019	Suppliers or vendors	$9,117.33
	228310	09/06/2019	Suppliers or vendors	$2,747.24
	228311	09/06/2019	Suppliers or vendors	$6,922.99
	229381	09/20/2019	Suppliers or vendors	$8,761.83
	229382	09/20/2019	Suppliers or vendors	$6,052.47
	229383	09/20/2019	Suppliers or vendors	$27,007.56
	229384	09/20/2019	Suppliers or vendors	$8,502.82
	230525	10/07/2019	Suppliers or vendors	$644.74
	230526	10/07/2019	Suppliers or vendors	$9,934.54
	230527	10/07/2019	Suppliers or vendors	$1,568.33
	230983	10/11/2019	Suppliers or vendors	$8,761.83
	230984	10/11/2019	Suppliers or vendors	$6,052.47
	230985	10/11/2019	Suppliers or vendors	$23,405.39
			SUBTOTAL	$225,837.80
SCHULTE ROTH & ZABEL LLP 919 THIRD AVENUE NEW YORK, NY 10022	226075	08/13/2019	Services	$395,059.45
	229420	09/20/2019	Services	$168,341.86
	ACH	10/25/2019	Services	$36,064.15
			SUBTOTAL	$599,465.46
SEAFARERS INTERNATIONAL UNION OF N ATTN:SEAFARERS UNION CONTROLLER 5201 AUTH WAY CAMP SPRINGS, MD 20746	226185	08/13/2019	Other - Regulatory/Tax	$700.00
	227556	08/23/2019	Other - Regulatory/Tax	$1,666.40
	228445	09/06/2019	Other - Regulatory/Tax	$250.00
	229567	09/20/2019	Other - Regulatory/Tax	$950.00
	230175	10/03/2019	Other - Regulatory/Tax	$1,624.74
			SUBTOTAL	$5,191.14

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
SEAFARERS MONEY PURCH PENSION PLAN MANPOWER MONITORING SYSTEM 5201 AUTH WAY CAMP SPRINGS, MD 20746	226171	08/13/2019	Other - Regulatory/Tax	$731.00
	229154	09/17/2019	Other - Regulatory/Tax	$716.00
	230678	10/07/2019	Other - Regulatory/Tax	$635.00
			SUBTOTAL	$2,082.00
SEARLES SAVON PROPANE PO BOX 1003 PRICE, UT 84501-1003	226665	08/19/2019	Suppliers or vendors	$48.04
			SUBTOTAL	$48.04
SECRETARY OF STATE DEPT OF BUSINESS SERVICES 501 S 2ND STREET SPRINGFIELD, IL 62756-5510	227185	08/19/2019	Other - Regulatory/Tax	$202.00
	227576	08/23/2019	Other - Regulatory/Tax	$303.00
	228478	09/06/2019	Other - Regulatory/Tax	$121.00
			SUBTOTAL	$626.00
SECURITY ALARM CORP. 1511 EAST MAIN PO BOX 665 SALEM, IL 62881	228312	09/06/2019	Suppliers or vendors	$97.50
			SUBTOTAL	$97.50
SEETECH, LLC 1963 EDENS FORK ROAD CHARLESTON, WV 25312	228920	09/06/2019	Suppliers or vendors	$1,298.36
	228921	09/06/2019	Suppliers or vendors	$1,155.20
	231423	10/11/2019	Suppliers or vendors	$327.36
	231424	10/11/2019	Suppliers or vendors	$2,999.30
	231425	10/11/2019	Suppliers or vendors	$2,152.73
			SUBTOTAL	$7,932.95
SERVICE PUMP & SUPPLY, INC. PO BOX 2097 HUNTINGTON, WV 25721-2097	230540	10/07/2019	Suppliers or vendors	$2,802.56
	230801	10/09/2019	Suppliers or vendors	$3,334.00
			SUBTOTAL	$6,136.56
SGS NORTH AMERICA INC MINERALS SERVICES DIVISION PO BOX 2502 CAROL STREAM, IL 60132-2502	226703	08/19/2019	Suppliers or vendors	$31,165.64
	226704	08/19/2019	Suppliers or vendors	$4,450.33
	226705	08/19/2019	Suppliers or vendors	$400.82
	228332	09/06/2019	Suppliers or vendors	$33,288.87
	229405	09/20/2019	Suppliers or vendors	$79,760.64
	229406	09/20/2019	Suppliers or vendors	$1,325.75

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
SGS NORTH AMERICA INC MINERALS SERVICES DIVISION PO BOX 2502 CAROL STREAM, IL 60132-2502	229407	09/20/2019	Suppliers or vendors	$634.44
	229408	09/20/2019	Suppliers or vendors	$5,052.86
	229409	09/20/2019	Suppliers or vendors	$5,787.47
	231016	10/11/2019	Suppliers or vendors	$57,756.10
	231017	10/11/2019	Suppliers or vendors	$1,884.77
	231018	10/11/2019	Suppliers or vendors	$1,535.97
			SUBTOTAL	$223,043.66
SHADYSIDE CARTAGE CO. PO BOX 121 POWHATAN POINT, OH 43942	225952	08/13/2019	Suppliers or vendors	$375.00
	229237	09/20/2019	Suppliers or vendors	$375.00
	230091	10/03/2019	Suppliers or vendors	$375.00
			SUBTOTAL	$1,125.00
SHAFFER'S FABRICATING, INC. 15 LIBERTY STREET SMITHFIELD, PA 15478	225773	08/05/2019	Suppliers or vendors	$2,100.00
	227123	08/19/2019	Suppliers or vendors	$6,000.00
	227124	08/19/2019	Suppliers or vendors	$3,800.00
			SUBTOTAL	$11,900.00
SHARON L HODOROWSKI 67133 CLARK RD ST CLAIRSVILLE, OH 43950	229582	09/20/2019	Other - Royalty	$32.60
			SUBTOTAL	$32.60
SHAW-ALMEX FUSION LLC 2933 MILLER ROAD DECATUR, GA 30035	226593	08/13/2019	Suppliers or vendors	$115,053.17
	228056	08/28/2019	Suppliers or vendors	$61,697.23
	230807	10/09/2019	Suppliers or vendors	$25,040.86
	231461	10/11/2019	Suppliers or vendors	$88,197.13
			SUBTOTAL	$289,988.39
SHAW-ALMEX INDUSTRIES, LTD. PO BOX 430 PARRY SOUND, ON P2A 2X4 CANADA	229910	09/26/2019	Suppliers or vendors	$34,068.40
	231415	10/11/2019	Suppliers or vendors	$37,968.00
			SUBTOTAL	$72,036.40

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
SHERIDAN BARGE LLC 212 COAL BLUFF ROAD FINLEYVILLE, PA 15332-3009	226135	08/13/2019	Suppliers or vendors	$6,820.00
	229509	09/20/2019	Suppliers or vendors	$6,820.00
	231112	10/11/2019	Suppliers or vendors	$6,600.00
			SUBTOTAL	$20,240.00
SHERIFF OF BROOKE COUNTY BROOKE COUNTY COURTHOUSE 202 COURTHOUSE SQUARE WELLSBURG, WV 26070	226683	08/19/2019	Other - Regulatory/Tax	$82.58
			SUBTOTAL	$82.58
SHERIFF OF DODDRIDGE COUNTY 108 COURT STREET, SUITE 2 WEST UNION, WV 26456	227570	08/23/2019	Other - Regulatory/Tax	$1,003.86
	229612	09/20/2019	Other - Regulatory/Tax	$443.84
			SUBTOTAL	$1,447.70
SHERIFF OF MARION COUNTY PO BOX 1348 FAIRMONT, WV 26555-1348	229613	09/20/2019	Other - Regulatory/Tax	$319,655.25
			SUBTOTAL	$319,655.25
SHERIFF OF MARSHALL COUNTY PO BOX 648 MOUNDSVILLE, WV 26041	228472	09/06/2019	Other - Regulatory/Tax	$84.29
	229614	09/20/2019	Other - Regulatory/Tax	$46.17
			SUBTOTAL	$130.46
SHERWIN-WILLIAMS #1018 67739 BANFIELD ROAD ST. CLAIRSVILLE, OH 43950	226752	08/19/2019	Suppliers or vendors	$41.23
	226753	08/19/2019	Suppliers or vendors	$112.90
	228396	09/06/2019	Suppliers or vendors	$1,826.05
	229493	09/20/2019	Suppliers or vendors	$206.50
			SUBTOTAL	$2,186.68
SHERWIN-WILLIAMS CO 901 DONNER AVE MONESSEN, PA 15062	226134	08/13/2019	Suppliers or vendors	$280.96
	226758	08/19/2019	Suppliers or vendors	$613.36
	229508	09/20/2019	Suppliers or vendors	$968.64
			SUBTOTAL	$1,862.96
SHIMA LIMOUSINE SERVICE, INC. 7555 TYLER BOULEVARD #12 MENTOR, OH 44060	225420	08/02/2019	Services	$100.25
	226125	08/13/2019	Services	$101.00
	226756	08/19/2019	Services	$85.43
	227504	08/23/2019	Services	$188.71
	228399	09/06/2019	Services	$88.20

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SHIMA LIMOUSINE SERVICE, INC. 7555 TYLER BOULEVARD #12 MENTOR, OH 44060	230643	10/07/2019	Services	$100.25
	231102	10/11/2019	Services	$276.75
			SUBTOTAL	$940.59
SHINNSTON PLUMBING CO 37 CHARLES STREET SHINNSTON, WV 26431	230668	10/07/2019	Suppliers or vendors	$800.00
	230669	10/07/2019	Suppliers or vendors	$2,769.74
			SUBTOTAL	$3,569.74
SHIRLEY JEAN REDD 13241 WAYNESBURG PIKE RD CAMERON, WV 26033-1914	229585	09/20/2019	Other - Royalty	$391.14
			SUBTOTAL	$391.14
SHIRLEY M. ZIPPAY 262 ZIPPAY RD CHARLEROI, PA 15022-9426	226684	08/19/2019	Other - Royalty	$2,500.00
			SUBTOTAL	$2,500.00
SHORT LINE P.S.D. PO BOX 188 WALLACE, WV 26448	226099	08/13/2019	Other - Utilities	$32.91
	229465	09/20/2019	Other - Utilities	$39.73
	231068	10/11/2019	Other - Utilities	$32.51
			SUBTOTAL	$105.15
SHRED IT US JV LLC 28883 NETWORK PLACE CHICAGO, IL 60673-1288	228464	09/06/2019	Suppliers or vendors	$589.50
			SUBTOTAL	$589.50
SIBERT AUTO REPAIR LLC 679 CAMDEN AVE MONONGAH, WV 26554	226164	08/13/2019	Suppliers or vendors	$890.40
	226772	08/19/2019	Suppliers or vendors	$80.00
	226773	08/19/2019	Suppliers or vendors	$1,102.40
	228429	09/06/2019	Suppliers or vendors	$1,270.00
	228430	09/06/2019	Suppliers or vendors	$1,399.20
	229541	09/20/2019	Suppliers or vendors	$1,490.00
	229542	09/20/2019	Suppliers or vendors	$1,105.00
	229543	09/20/2019	Suppliers or vendors	$1,817.90
	230670	10/07/2019	Suppliers or vendors	$795.00
	230671	10/07/2019	Suppliers or vendors	$810.90
			SUBTOTAL	$10,760.80

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SIEMAG TECBERG, INC. 2969 SOUTH CHASE AVENUE MILWAUKEE, WI 53207	228021	08/28/2019	Suppliers or vendors	$123,125.00
			SUBTOTAL	$123,125.00
SIERRA BRAVO CONTRACTORS LLC 7038 HIGHWAY 154 PO BOX 130 SESSER, IL 62884	229121	09/11/2019	Services	$39,900.00
			SUBTOTAL	$39,900.00
SIGN EDGE PO BOX 570 PRICE, UT 84501	228308	09/06/2019	Suppliers or vendors	$3,917.73
	229371	09/20/2019	Suppliers or vendors	$2,096.57
			SUBTOTAL	$6,014.30
SKYMIRA 167 CHERRY ST.,SUITE 430 MILFORD, CT 06460	ACH	08/19/2019	Suppliers or vendors	$1,350.00
	231103	10/11/2019	Suppliers or vendors	$1,350.00
			SUBTOTAL	$2,700.00
SMC ELECTRICAL PRODUCTS, INC. PO BOX 1688 ABINGDON, VA 24212	227049	08/19/2019	Suppliers or vendors	$40,000.00
	227971	08/28/2019	Suppliers or vendors	$848.53
			SUBTOTAL	$40,848.53
SNELL & WILMER LLP CLT ID 37952 DD 400 E VAN BUREN ST STE 1900 PHOENIX, AZ 85004-9955	ACH	08/30/2019	Services	$21,532.05
	230997	10/11/2019	Services	$14,498.39
	230998	10/11/2019	Services	$2,036.06
	230999	10/11/2019	Services	$749.70
	231000	10/11/2019	Services	$6,530.85
	231001	10/11/2019	Services	$2,159.10
	231002	10/11/2019	Services	$4,276.94
	231003	10/11/2019	Services	$5,029.20
	231004	10/11/2019	Services	$2,721.60
	231005	10/11/2019	Services	$650.60
	231006	10/11/2019	Services	$267.75
	231007	10/11/2019	Services	$107.10
			SUBTOTAL	$60,559.34
SNF MINING INC PO BOX 405655 ATLANTA, GA 30384-5655	225803	08/05/2019	Suppliers or vendors	$10,780.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
SNF MINING INC PO BOX 405655 ATLANTA, GA 30384-5655	225804	08/05/2019	Suppliers or vendors	$23,403.80
	225805	08/05/2019	Suppliers or vendors	$13,111.80
	225806	08/05/2019	Suppliers or vendors	$6,066.20
	225807	08/05/2019	Suppliers or vendors	$26,440.60
	229898	09/25/2019	Suppliers or vendors	$76,476.40
	229899	09/25/2019	Suppliers or vendors	$133,274.20
	229900	09/25/2019	Suppliers or vendors	$19,646.76
	229901	09/25/2019	Suppliers or vendors	$20,261.20
	229902	09/25/2019	Suppliers or vendors	$69,871.60
	229903	09/25/2019	Suppliers or vendors	$67,720.40
			SUBTOTAL	$467,052.96
SNOGA LLC 800 DAVIS SCHOOL RD WASHINGTON, PA 15301	231257	10/11/2019	Suppliers or vendors	$3,000.00
			SUBTOTAL	$3,000.00
SOHAM GROUP LLC HOLIDAY INN EXPRESS 5001 ACADEMY LANE BESSEMER, AL 35022	226274	08/13/2019	Suppliers or vendors	$2,165.48
	229720	09/20/2019	Suppliers or vendors	$765.18
			SUBTOTAL	$2,930.66
SOLES ELECTRIC CO., INC. 1552 TULIP LANE FAIRMONT, WV 26554	228809	09/06/2019	Suppliers or vendors	$10,625.55
	228810	09/06/2019	Suppliers or vendors	$2,070.00
	228811	09/06/2019	Suppliers or vendors	$5,613.36
	228812	09/06/2019	Suppliers or vendors	$10,099.62
	228813	09/06/2019	Suppliers or vendors	$13,496.56
			SUBTOTAL	$41,905.09
SOMERSET TOWNSHIP BOARD OF SUPERVIS 615 VANCEVILLE RD EIGHTY FOUR, PA 15330	228492	09/06/2019	Other - Regulatory/Tax	$134.50
			SUBTOTAL	$134.50
SOMERSET TWP. TAX COLLECTOR 685 LINCOLN AVENUE BENTLEYVILLE, PA 15314	227336	08/23/2019	Other - Regulatory/Tax	$173.71
			SUBTOTAL	$173.71
SOUHEGAN WOOD PRODUCTS INC 10 SOUHEGAN STREET WILTON, NH 03086	225853	08/05/2019	Suppliers or vendors	$1,125.91
			SUBTOTAL	$1,125.91

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
SOUTH ALLEGHENY SCHOOL DIST. TAX COLLECTOR 45 ABE'S WAY ELIZABETH, PA 15037	228189	09/03/2019	Other - Regulatory/Tax	$4,471.74
			SUBTOTAL	$4,471.74
SOUTH ATLANTIC CONTROLS INC PO BOX 280 WILLIAMSPORT, MD 21795	ACH	08/07/2019	Suppliers or vendors	$191,200.00
			SUBTOTAL	$191,200.00
SOUTH CENTRAL POWER CO. PO BOX 182058 COLUMBUS, OH 43218-2058	225397	08/02/2019	Other - Utilities	$2,418.00
	225398	08/02/2019	Other - Utilities	$716,250.00
	226079	08/13/2019	Other - Utilities	$1,129.28
	226718	08/19/2019	Other - Utilities	$2,620.00
	226719	08/19/2019	Other - Utilities	$17,782.00
	226720	08/19/2019	Other - Utilities	$42.00
	226721	08/19/2019	Other - Utilities	$5,818.00
	228191	09/03/2019	Other - Utilities	$5,052.90
	228192	09/03/2019	Other - Utilities	$786,209.00
	229945	09/26/2019	Other - Utilities	$2,125.00
	229946	09/26/2019	Other - Utilities	$2,541.60
	229947	09/26/2019	Other - Utilities	$1,106.84
	229948	09/26/2019	Other - Utilities	$44.00
	229949	09/26/2019	Other - Utilities	$6,195.00
	230151	10/03/2019	Other - Utilities	$688,086.00
	231034	10/11/2019	Other - Utilities	$46.20
			SUBTOTAL	$2,237,465.82
SOUTH CENTRAL PROPERTY MANAGEMENT 1550 WESTERN STREET BOWLING GREEN, KY 42103	ACH	08/09/2019	Services	$15,685.00
	ACH	09/24/2019	Services	$20,439.90
			SUBTOTAL	$36,124.90
SOUTH FRANKLIN TOWNSHIP TAX COLLECT 65 VERNER LANE WASHINGTON, PA 15301	228509	09/06/2019	Other - Regulatory/Tax	$3,259.34
			SUBTOTAL	$3,259.34

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SOUTHEASTERN EQUIPMENT COMPANY, INC PO BOX 536 CAMBRIDGE, OH 43725	228013	08/28/2019	Suppliers or vendors	$1,666.53
	228014	08/28/2019	Suppliers or vendors	$3,689.40
	228361	09/06/2019	Suppliers or vendors	$656.25
			SUBTOTAL	$6,012.18
SOUTHEASTERN ILLINOIS ELEC COOP INC 100 COOPERATIVE WAY PO BOX 961 CARRIER MILLS, IL 62917	ACH	08/22/2019	Other - Utilities	$19,626.80
	ACH	09/19/2019	Other - Utilities	$18,543.45
	ACH	10/17/2019	Other - Utilities	$17,538.77
			SUBTOTAL	$55,709.02
SOUTHEASTERN UTAH DIST HEALTH DEPT PO BOX 800 PRICE, UT 84501	226052	08/13/2019	Other - Regulatory/Tax	$15.00
	229395	09/20/2019	Other - Regulatory/Tax	$15.00
			SUBTOTAL	$30.00
SOUTHERN CAST PRODUCTS, INC. 1010 WILE ROAD PO BOX 3644 MERIDIAN, MS 39303-3644	227083	08/19/2019	Suppliers or vendors	$39,019.20
			SUBTOTAL	$39,019.20
SOUTHERN OIL FIELD SUPPLY COMPANY 306 SOUTH 3RD STREET PO BOX 732 RACINE, OH 45771	226084	08/13/2019	Suppliers or vendors	$1,755.53
	226726	08/19/2019	Suppliers or vendors	$1,940.90
	229431	09/20/2019	Suppliers or vendors	$2,586.59
			SUBTOTAL	$6,283.02
SPARKY'S SEPTIC SERVICE 36244 EDWINA ROAD. WOODSFIELD, OH 43793	226047	08/13/2019	Suppliers or vendors	$268.13
	229385	09/20/2019	Suppliers or vendors	$268.13
	230125	10/03/2019	Suppliers or vendors	$268.13
			SUBTOTAL	$804.39
SPECPRINT, INC 7R AYLESBURY ROAD TIMONIUM, MD 21093	226769	08/19/2019	Suppliers or vendors	$2,700.00
			SUBTOTAL	$2,700.00

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SPILMAN THOMAS & BATTLE PLLC PO BOX 273 CHARLESTON, WV 25321-0273	ACH	10/25/2019	Services	$8,508.50
			SUBTOTAL	$8,508.50
SPRINGFIELD ELECTRIC SUPPLY COMPANY 700 NORTH 9TH STREET PO BOX 4106 SPRINGFIELD, IL 62708-4106	ACH	08/30/2019	Suppliers or vendors	$211.49
			SUBTOTAL	$211.49
SQUIRE PATTON BOGGS (US) LLP PO BOX 643051 CINCINNATI, OH 45264	227498	08/23/2019	Services	$3,753.75
	227499	08/23/2019	Services	$202.50
	227500	08/23/2019	Services	$1,660.31
	227501	08/23/2019	Services	$324.00
	230639	10/07/2019	Services	$29,889.00
	231094	10/11/2019	Services	$2,598.75
	231095	10/11/2019	Services	$2,499.38
	231096	10/11/2019	Services	$14,350.50
			SUBTOTAL	$55,278.19
SSAB INC PO BOX 347354 PITTSBURGH, PA 15251-7354	229034	09/06/2019	Suppliers or vendors	$29,403.65
			SUBTOTAL	$29,403.65
ST. LOUIS TESTING LABS 2810 CLARK AVE. ST. LOUIS, MO 63103	ACH	09/13/2019	Suppliers or vendors	$500.00
			SUBTOTAL	$500.00
ST.CLAIRSVILLE MUNICIPAL UTILITIES 100 N MARKET STRRET PO BOX 537 ST.CLAIRSVILLE, OH 43950	226824	08/19/2019	Other - Utilities	$177.26
	229655	09/20/2019	Other - Utilities	$146.47
	231232	10/11/2019	Other - Utilities	$133.97
			SUBTOTAL	$457.70
STABLEINS WHOLESALE PO BOX 565 DUNLEVY, PA 15432	225801	08/05/2019	Suppliers or vendors	$1,846.80
			SUBTOTAL	$1,846.80

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
STAHURA CONVEYOR PRODUCTS INC PO BOX 250 LEWISVILLE, NC 27023	227819	08/28/2019	Suppliers or vendors	$20,577.00
	227820	08/28/2019	Suppliers or vendors	$6,507.00
			SUBTOTAL	$27,084.00
STAKER & PARSON COMPANIES NIELSON CONSTRUCTION & MATERIALS 2350 S 1900 W SUITE 100 OGDEN, UT 84401-3481	226528	08/13/2019	Suppliers or vendors	$5,268.85
	228909	09/06/2019	Suppliers or vendors	$31,966.90
	231416	10/11/2019	Suppliers or vendors	$196,472.51
			SUBTOTAL	$233,708.26
STANDARD LABORATORIES, INC. 147 11TH AVENUE, SUITE 100 SOUTH CHARLESTON, WV 25303	225407	08/02/2019	Suppliers or vendors	$24.85
	225408	08/02/2019	Suppliers or vendors	$45,076.64
	226092	08/13/2019	Suppliers or vendors	$3,533.40
	226093	08/13/2019	Suppliers or vendors	$222.80
	226733	08/19/2019	Suppliers or vendors	$14,467.73
	226734	08/19/2019	Suppliers or vendors	$7,706.11
	226735	08/19/2019	Suppliers or vendors	$4,942.93
	226736	08/19/2019	Suppliers or vendors	$10,226.95
	227430	08/23/2019	Suppliers or vendors	$3,560.85
	227431	08/23/2019	Suppliers or vendors	$16,463.21
	227432	08/23/2019	Suppliers or vendors	$3,406.23
	227433	08/23/2019	Suppliers or vendors	$2,037.04
	227434	08/23/2019	Suppliers or vendors	$5,300.64
	227435	08/23/2019	Suppliers or vendors	$975.07
	228371	09/06/2019	Suppliers or vendors	$15,860.25
	228372	09/06/2019	Suppliers or vendors	$21,722.50
	228373	09/06/2019	Suppliers or vendors	$20,490.00
	228374	09/06/2019	Suppliers or vendors	$48,496.02
	228956	09/06/2019	Suppliers or vendors	$1,860.40
	229443	09/20/2019	Suppliers or vendors	$24.85
	229444	09/20/2019	Suppliers or vendors	$4,048.15
	229445	09/20/2019	Suppliers or vendors	$6,736.45
	229446	09/20/2019	Suppliers or vendors	$7,613.80
	229447	09/20/2019	Suppliers or vendors	$21,773.93
	229448	09/20/2019	Suppliers or vendors	$7,929.88
	229449	09/20/2019	Suppliers or vendors	$14,822.75
	229450	09/20/2019	Suppliers or vendors	$3,959.50
	229451	09/20/2019	Suppliers or vendors	$340.15

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STANDARD LABORATORIES, INC. 147 11TH AVENUE, SUITE 100 SOUTH CHARLESTON, WV 25303	229452	09/20/2019	Suppliers or vendors	$11,860.15
	229453	09/20/2019	Suppliers or vendors	$185.10
	229454	09/20/2019	Suppliers or vendors	$3,832.15
	230402	10/04/2019	Suppliers or vendors	$10,810.00
	230403	10/04/2019	Suppliers or vendors	$13,877.75
	230404	10/04/2019	Suppliers or vendors	$1,758.00
	230405	10/04/2019	Suppliers or vendors	$4,950.00
	231048	10/11/2019	Suppliers or vendors	$52,949.50
	231049	10/11/2019	Suppliers or vendors	$13,117.75
	231050	10/11/2019	Suppliers or vendors	$11,652.14
	231051	10/11/2019	Suppliers or vendors	$18,054.25
	231052	10/11/2019	Suppliers or vendors	$12,898.70
	231053	10/11/2019	Suppliers or vendors	$979.17
	231054	10/11/2019	Suppliers or vendors	$61,698.61
	231055	10/11/2019	Suppliers or vendors	$149.10
			SUBTOTAL	$512,395.45
STANDARD PARKING CORPORATION 8037 COLLECTION CENTER DRIVE CHICAGO, IL 60693	225413	08/02/2019	Suppliers or vendors	$190.00
	228381	09/06/2019	Suppliers or vendors	$190.00
	231079	10/11/2019	Suppliers or vendors	$190.00
			SUBTOTAL	$570.00
STAR CITY LODGING CANDLEWOOD SUITES 7200 WILLIE G AVE SUITE 100 WESTOVER, WV 26501	229679	09/20/2019	Services	$12,463.36
			SUBTOTAL	$12,463.36
STATE ELECTRIC SUPPLY COMPANY PO BOX 890889 CHARLOTTE, NC 28289-0889	ACH	08/30/2019	Suppliers or vendors	$50,549.51
	231552	10/17/2019	Suppliers or vendors	$518.56
			SUBTOTAL	$51,068.07
STATE FIRE DC SPECIALITIES INTERSTATE FIRE SALES & SERVICE PO BOX 65248 SALT LAKE CITY, UT 84165	229029	09/06/2019	Suppliers or vendors	$10,712.39
			SUBTOTAL	$10,712.39
STATE OF UTAH DEPT. OF ENV. QUALITY DIVISION OF WATER QUALITY 195 NORTH 1950 WEST PO BOX 144870 SALT LAKE CITY, UT 84114-4870	229338	09/20/2019	Other - Regulatory/Tax	$436.00

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STATE OF UTAH DEPT. OF ENV. QUALITY DIVISION OF WATER QUALITY 195 NORTH 1950 WEST PO BOX 144870 SALT LAKE CITY, UT 84114-4870	229339	09/20/2019	Other - Regulatory/Tax	$436.00
	230124	10/03/2019	Other - Regulatory/Tax	$871.00
	230963	10/11/2019	Other - Regulatory/Tax	$436.00
	230964	10/11/2019	Other - Regulatory/Tax	$871.00
			SUBTOTAL	$3,050.00
STATE OF UTAH SCHOOL AND INSTI TRUST LANDS ADMINISTRATION 675 EAST 500 SOUTH #500 SALT LAKE CITY, UT 84102-2818	229386	09/20/2019	Other - Royalty	$3,840.00
	230126	10/03/2019	Other - Royalty	$3,240.00
			SUBTOTAL	$7,080.00
STATE OF UTAH DEPT. OF NATURAL RESOURCES PO BOX 145801 SALT LAKE CITY, UT 84114-5801	229723	09/20/2019	Other - Regulatory/Tax	$396.00
			SUBTOTAL	$396.00
STEFAN FIGURA 69709 CRESTVIEW LANE ST. CLAIRSVILLE, OH 43950	226091	08/13/2019	Suppliers or vendors	$7,900.70
	227429	08/23/2019	Suppliers or vendors	$2,347.32
	229442	09/20/2019	Suppliers or vendors	$6,927.57
	231047	10/11/2019	Suppliers or vendors	$4,729.52
			SUBTOTAL	$21,905.11
STEINER AVIATION INTERNATIONAL, INC 5430 LAUBY ROAD, HANGAR 17 NORTH CANTON, OH 44720-1576	ACH	08/19/2019	Suppliers or vendors	$976.00
	ACH	09/13/2019	Suppliers or vendors	$2,591.05
	230523	10/07/2019	Suppliers or vendors	$13,094.95
	230979	10/11/2019	Suppliers or vendors	$35,282.96
			SUBTOTAL	$51,944.96
STEPHEN & ELIZABETH SCOTT PO BOX 33 MUNFORDVILLE, KY 42765	229981	09/26/2019	Other - Royalty	$22.31
			SUBTOTAL	$22.31
STEPHEN AND PATRICIA BORUSHKO 146 HIXON RD EIGHTY FOUR, PA 15330	229654	09/20/2019	Suppliers or vendors	$580.40
			SUBTOTAL	$580.40

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STEPHEN P NEW LC 114 MAIN ST. BECKLEY, WV 25801	229853	09/23/2019	Services	$35,170.21
			SUBTOTAL	$35,170.21
STEPHEN SAYRE 35352 CARSON ROAD MIDDLEPORT, OH 45760	225902	08/05/2019	Other - Royalty	$8.48
	229098	09/10/2019	Other - Royalty	$9.32
	230616	10/07/2019	Other - Royalty	$6.99
			SUBTOTAL	$24.79
STEPTOE & JOHNSON PLLC PO BOX 247 BRIDGEPORT, WV 26330-0247	ACH	08/07/2019	Services	$13,688.87
	ACH	08/19/2019	Services	$296,737.56
	230528	10/07/2019	Services	$353.00
	230529	10/07/2019	Services	$7,355.46
	230986	10/11/2019	Services	$13,835.13
	230987	10/11/2019	Services	$58,908.28
	230988	10/11/2019	Services	$1,814.20
	230989	10/11/2019	Services	$4,659.28
	ACH	10/25/2019	Services	$150,000.00
			SUBTOTAL	$547,351.78
STEVE PECKHAM 36340 PAULINS HILL ROAD MIDDLEPORT, OH 45760	225882	08/05/2019	Other - Royalty	$1.62
	229077	09/10/2019	Other - Royalty	$2.02
			SUBTOTAL	$3.64
STONEBRAKER'S GARAGE LTD 67085 PANCOAST ROAD S BELMONT, OH 43718	225953	08/13/2019	Suppliers or vendors	$233.04
	225954	08/13/2019	Suppliers or vendors	$1,627.65
	225955	08/13/2019	Suppliers or vendors	$5,804.43
	225956	08/13/2019	Suppliers or vendors	$443.21
	225957	08/13/2019	Suppliers or vendors	$2,014.00
	226635	08/19/2019	Suppliers or vendors	$878.70
	226636	08/19/2019	Suppliers or vendors	$8,895.22
	226637	08/19/2019	Suppliers or vendors	$165.00
	226638	08/19/2019	Suppliers or vendors	$138.62
	226639	08/19/2019	Suppliers or vendors	$467.62
	227306	08/23/2019	Suppliers or vendors	$317.95
	227307	08/23/2019	Suppliers or vendors	$250.00
	228243	09/06/2019	Suppliers or vendors	$60.26

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STONEBRAKER'S GARAGE LTD 67085 PANCOAST ROAD S BELMONT, OH 43718	228244	09/06/2019	Suppliers or vendors	$1,769.23
	229238	09/20/2019	Suppliers or vendors	$1,610.41
	229239	09/20/2019	Suppliers or vendors	$5,388.37
	229240	09/20/2019	Suppliers or vendors	$3,683.28
	229241	09/20/2019	Suppliers or vendors	$450.00
	229242	09/20/2019	Suppliers or vendors	$7,272.30
	229243	09/20/2019	Suppliers or vendors	$1,920.00
	229244	09/20/2019	Suppliers or vendors	$5,625.27
	229245	09/20/2019	Suppliers or vendors	$4,132.78
	230458	10/07/2019	Suppliers or vendors	$4,476.06
	230459	10/07/2019	Suppliers or vendors	$1,575.00
	230460	10/07/2019	Suppliers or vendors	$3,517.04
	230461	10/07/2019	Suppliers or vendors	$3,099.31
	230462	10/07/2019	Suppliers or vendors	$754.15
	230872	10/11/2019	Suppliers or vendors	$853.32
	230873	10/11/2019	Suppliers or vendors	$1,578.14
	230874	10/11/2019	Suppliers or vendors	$2,760.92
	230875	10/11/2019	Suppliers or vendors	$2,884.12
	230876	10/11/2019	Suppliers or vendors	$3,126.20
	230877	10/11/2019	Suppliers or vendors	$348.20
	231500	10/16/2019	Suppliers or vendors	$5,654.46
			SUBTOTAL	$83,774.26
STONEBRAKER'S TRANSIT LLC 46261 BELMONT CENTERVILLE RD. BELMONT, OH 43718	226038	08/13/2019	Services	$5,275.00
	226685	08/19/2019	Services	$16,925.00
	227376	08/23/2019	Services	$8,525.00
	229372	09/20/2019	Services	$14,725.00
	230522	10/07/2019	Services	$24,525.00
	230974	10/11/2019	Services	$4,225.20
	230975	10/11/2019	Services	$16,675.00
			SUBTOTAL	$90,875.20
STOWERS FIRE & SAFETY EQUIPMENT 500 VICTORY LANE WILLIAMSON, WV 25661	231697	10/22/2019	Suppliers or vendors	$5,000.73
	Wire	10/28/2019	Suppliers or vendors	$10,000.00
			SUBTOTAL	$15,000.73
STRATA EQUIPMENT LLC PO BOX 930228 ATLANTA, GA 31193-0228	229041	09/06/2019	Suppliers or vendors	$9,817.92
			SUBTOTAL	$9,817.92

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
STRATA MINE SERVICES, LLC PO BOX 930228 ATLANTA, GA 31193-0228	228925	09/06/2019	Suppliers or vendors	$97,533.80
	228926	09/06/2019	Suppliers or vendors	$317,311.00
	231493	10/15/2019	Suppliers or vendors	$21,652.56
			SUBTOTAL	$436,497.36
STRATA PRODUCTS (USA) LLC PO BOX 930228 ATLANTA, GA 31193-0228	230826	10/10/2019	Suppliers or vendors	$16,122.60
	231632	10/18/2019	Suppliers or vendors	$20,250.53
			SUBTOTAL	$36,373.13
STRAUB CHRYSLER DODGE JEEP RAM 1502 WHEELING AVE. GLEN DALE, WV 26038	228486	09/06/2019	Suppliers or vendors	$3,438.80
			SUBTOTAL	$3,438.80
STREYLE COURIER SERVICE LLC 77 MILL FALL ROAD FAIRMONT, WV 26554	226159	08/13/2019	Suppliers or vendors	$3,750.00
	226768	08/19/2019	Suppliers or vendors	$2,000.00
	227535	08/23/2019	Suppliers or vendors	$2,000.00
	227536	08/23/2019	Suppliers or vendors	$3,750.00
	229536	09/20/2019	Suppliers or vendors	$2,000.00
	229537	09/20/2019	Suppliers or vendors	$3,750.00
	230663	10/07/2019	Suppliers or vendors	$4,000.00
	230664	10/07/2019	Suppliers or vendors	$7,500.00
			SUBTOTAL	$28,750.00
STURM ENVIRONMENTAL SERVICES PO BOX 650 BRIDGEPORT, WV 26330	ACH	08/19/2019	Suppliers or vendors	$563.00
	ACH	09/13/2019	Suppliers or vendors	$413.00
			SUBTOTAL	$976.00
SUDDENLINK COMMUNICATIONS PO BOX 660365 DALLAS, TX 75266-0365	Credit Card	08/27/2019	Suppliers or vendors	$1,395.45
	Credit Card	09/19/2019	Suppliers or vendors	$1,313.00
	Credit Card	10/18/2019	Suppliers or vendors	$1,395.45
			SUBTOTAL	$4,103.90
SUN VALLEY COMMUNICATIONS 12505 N 146TH WAY SCOTTSDALE, AZ 85259	226157	08/13/2019	Services	$137.00
	228426	09/06/2019	Services	$212.21
			SUBTOTAL	$349.21

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SUNDA P GERARD 3188 RIVER RD MORGANTOWN, WV 26501	226229	08/13/2019	Services	$900.00
	227605	08/23/2019	Services	$900.00
	228502	09/06/2019	Services	$1,500.00
	230724	10/07/2019	Services	$1,800.00
	231229	10/11/2019	Services	$6,600.00
			SUBTOTAL	$11,700.00
SUNOCO PO BOX 78013 PHOENIX, AZ 85062-8013	228304	09/06/2019	Suppliers or vendors	$1,100.96
	230970	10/11/2019	Suppliers or vendors	$1,092.18
			SUBTOTAL	$2,193.14
SUNRISE HOSPITALITY LLC HOLIDAY INN HOTEL & SUITES 114 DRY HILL ROAD BECKLEY, WV 25801	228508	09/06/2019	Services	$8,777.44
	231233	10/11/2019	Services	$2,699.20
			SUBTOTAL	$11,476.64
SUNSET HEIGHTS FIRE DEPARTMENT 69604 SUNSET HEIGHTS BRIDGEPORT, OH 43912	229476	09/20/2019	Other - Regulatory/Tax	$800.00
			SUBTOTAL	$800.00
SUPER 8 CENTRAL CITY 635 SOUTH SECOND STREET CENTRAL CITY, KY 42330	229373	09/20/2019	Services	$3,864.00
			SUBTOTAL	$3,864.00
SUPERIOR CUSTOM CLEANING SERVICE 383 EAST GRAFTON ROAD FAIRMONT, WV 26554	226262	08/13/2019	Services	$3,000.00
	226263	08/13/2019	Services	$8,700.00
	226841	08/19/2019	Services	$1,000.00
	226842	08/19/2019	Services	$2,900.00
	227228	08/19/2019	Services	$2,000.00
	227229	08/19/2019	Services	$5,800.00
	227642	08/23/2019	Services	$15,000.00
	229705	09/20/2019	Services	$3,000.00
	229706	09/20/2019	Services	$8,700.00
	231258	10/11/2019	Services	$3,000.00
	231259	10/11/2019	Services	$8,700.00
			SUBTOTAL	$61,800.00
SUSAN JOHNSON 62288 HILLCREST RD. BARNESVILLE, OH 43713	226253	08/13/2019	Suppliers or vendors	$3,020.80

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
SUSAN JOHNSON 62288 HILLCREST RD. BARNESVILLE, OH 43713	228528	09/06/2019	Suppliers or vendors	$2,555.68
	229699	09/20/2019	Suppliers or vendors	$2,474.24
	230757	10/07/2019	Suppliers or vendors	$2,405.68
	231251	10/11/2019	Suppliers or vendors	$2,537.12
	231882	10/25/2019	Suppliers or vendors	$3,192.80
			SUBTOTAL	$16,186.32
SWCA ENVIRONMENTAL CONSULTANTS SWCA INC PO BOX 92170 ELK GROVE, IL 60009	229544	09/20/2019	Suppliers or vendors	$3,759.20
			SUBTOTAL	$3,759.20
SWIRE COCA COLA, USA PO BOX 413121 SALT LAKE CITY, UT 84141-3121	230976	10/11/2019	Suppliers or vendors	$1,429.56
			SUBTOTAL	$1,429.56
SWITZER WATER ASSOCIATION C/O BELMONT SAVINGS BANK 298 HIGHWAY 7 NORTH POWHATAN POINT, OH 43942	226059	08/13/2019	Other - Utilities	$2,655.96
	229403	09/20/2019	Other - Utilities	$2,674.87
	231013	10/11/2019	Other - Utilities	$2,380.78
			SUBTOTAL	$7,711.61
SWITZERLAND OF OHIO LOCAL SCHOOL DI 304 MILL STREET WOODSFIELD, OH 43793	226236	08/13/2019	Other - Regulatory/Tax	$492.53
			SUBTOTAL	$492.53
SWITZERLAND OF OHIO WATER DISTRICT 51746 MAIN STREET PO BOX 26 JERUSALEM, OH 43747	225382	08/02/2019	Other - Utilities	$384.00
	229396	09/20/2019	Other - Utilities	$4,106.60
	230127	10/03/2019	Other - Utilities	$8,499.26
			SUBTOTAL	$12,989.86
SWORMSCO INC PO BOX 99 LISTIE, PA 15549	228989	09/06/2019	Suppliers or vendors	$6,722.00
			SUBTOTAL	$6,722.00

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SYNTERRA CORPORATION 148 RIVER STREET, SUITE 220 GREENVILLE, SC 29601	229856	09/24/2019	Suppliers or vendors	$3,376.41
	229857	09/24/2019	Suppliers or vendors	$8,699.98
	229858	09/24/2019	Suppliers or vendors	$1,828.16
	229859	09/24/2019	Suppliers or vendors	$4,127.66
			SUBTOTAL	$18,032.21
SYSTEM CONTROLS, INC. 7015 HAISTEN DRIVE TRUSSVILLE, AL 35173	ACH	08/07/2019	Suppliers or vendors	$84,735.95
	ACH	08/30/2019	Suppliers or vendors	$108,380.00
			SUBTOTAL	$193,115.95
T & C WELDING, INC. P.O. BOX 576 REPUBLIC, PA 15475-0576	228999	09/06/2019	Suppliers or vendors	$25,810.20
	229000	09/06/2019	Suppliers or vendors	$28,000.00
			SUBTOTAL	$53,810.20
T & R ELECTRIC SUPPLY CO., INC. 308 SW 3RD STREET PO BOX 180 COLMAN, SD 57017	ACH	09/13/2019	Suppliers or vendors	$11,475.00
			SUBTOTAL	$11,475.00
T & T PUMP CO., INC. ONE PAGE DRIVE FAIRMONT, WV 26554	225712	08/05/2019	Suppliers or vendors	$923.58
	228905	09/06/2019	Suppliers or vendors	$5,460.32
	228906	09/06/2019	Suppliers or vendors	$196.02
			SUBTOTAL	$6,579.92
TABOR MACHINE COMPANY 24704 NETWORK PLACE CHICAGO, IL 60673-1247	227077	08/19/2019	Suppliers or vendors	$173.20
	228927	09/06/2019	Suppliers or vendors	$43,415.00
	228928	09/06/2019	Suppliers or vendors	$725.96
			SUBTOTAL	$44,314.16
TASSCO, LLC 25 WEST PARK CIRCLE BIRMINGHAM, AL 35211	ACH	09/13/2019	Suppliers or vendors	$27,970.92
			SUBTOTAL	$27,970.92
TEAMVIEWER GMBH PO BOX 743135 ATLANTA, GA 30374-3135	Credit Card	09/19/2019	Suppliers or vendors	$1,740.00
			SUBTOTAL	$1,740.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
TERRY JANE RYE GILBERT 1004 HWY 33 SOUTH HARRODSBURG, KY 40330	227471	08/23/2019	Other - Royalty	$107.17
			SUBTOTAL	$107.17
TERRY SEARLS 104 VAN ZANT ROAD BIDWELL, OH 45614	225899	08/05/2019	Other - Royalty	$4.00
	229094	09/10/2019	Other - Royalty	$4.04
	230610	10/07/2019	Other - Royalty	$3.70
			SUBTOTAL	$11.74
TETRA TECH, INC. PO BOX 911624 DENVER, CO 80291-1624	226039	08/13/2019	Suppliers or vendors	$6,562.00
			SUBTOTAL	$6,562.00
TETRICK GROUP II REVOCABLE TRUST GUY CORP. 92 16TH STREET WHEELING, WV 26003	226799	08/19/2019	Other - Royalty	$1,817.68
	229591	09/20/2019	Other - Royalty	$1,817.68
			SUBTOTAL	$3,635.36
THE BRENNAN GROUP 12221 BIG BEND ROAD ST. LOUIS, MO 63122	226088	08/13/2019	Services	$3,172.50
	227422	08/23/2019	Services	$1,576.43
	227423	08/23/2019	Services	$95.10
	227424	08/23/2019	Services	$162.44
	227425	08/23/2019	Services	$162.29
	229438	09/20/2019	Services	$236.93
			SUBTOTAL	$5,405.69
THE COURIER APG MEDIA OF OHIO PO BOX 468 MCAUTHUR, OH 45651	Credit Card	10/18/2019	Suppliers or vendors	$301.20
			SUBTOTAL	$301.20
THE EXPONENT TELEGRAM P.O. BOX 2000 CLARKSBURG, WV 26302-2000	226800	08/19/2019	Suppliers or vendors	$116.48
			SUBTOTAL	$116.48
THE JOHN B. LONG COMPANY, LLC JBLCO 1040 DUTCH VALLEY DRIVE KNOXVILLE, TN 37918	228165	08/28/2019	Suppliers or vendors	$1,658.82
	228166	08/28/2019	Suppliers or vendors	$2,080.39
			SUBTOTAL	$3,739.21

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
THE KERRY COMPANY, INC. 3003 WILDWOOD SAMPLE ROAD PO BOX 51 ALLISON PARK, PA 15101-0051	227818	08/28/2019	Suppliers or vendors	$4,993.00
			SUBTOTAL	$4,993.00
THE MEADOR BOYS EXPRESS, INC. PO BOX 128 SALEM, IL 62881	225404	08/02/2019	Services	$41,600.00
	226730	08/19/2019	Services	$49,800.00
	227421	08/23/2019	Services	$24,050.00
	228369	09/06/2019	Services	$71,650.00
	229437	09/20/2019	Services	$69,850.00
	230612	10/07/2019	Services	$131,200.00
			SUBTOTAL	$388,150.00
THE NEW ENGLAND FINANCIAL POLICY 28061411 PO BOX 371499 PITTSBURGH, PA 15250-7499	229303	09/20/2019	Services	$78,822.19
			SUBTOTAL	$78,822.19
THE OHIO DRILLING COMPANY INC 2400 BOSTIC BLVD SW MASSILLON, OH 44647	229001	09/06/2019	Suppliers or vendors	$6,200.00
			SUBTOTAL	$6,200.00
THE PORT AUTHORITY OF NY & NJ TETERBORO AIRPORT PO BOX 95000 PHILADELPHIA, PA 19195-1523	226686	08/19/2019	Other - Regulatory/Tax	$560.64
	229374	09/20/2019	Other - Regulatory/Tax	$179.58
			SUBTOTAL	$740.22
THE RIVER SCHOOL, INC. 44 N. SECOND STREET, SUITE 602 MEMPHIS, TN 38103	231056	10/11/2019	Suppliers or vendors	$10,800.00
			SUBTOTAL	$10,800.00
THE SWITCH PO BOX 12018 LEWISTON, ME 04243-9494	229666	09/20/2019	Suppliers or vendors	$1,651.26
			SUBTOTAL	$1,651.26

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
THE THRASHER GROUP, INC PO BOX 940 BRIDGEPORT, WV 26330	225811	08/05/2019	Services	$9,386.21
	225812	08/05/2019	Services	$12,322.50
	225813	08/05/2019	Services	$12,675.00
	225814	08/05/2019	Services	$2,450.00
	228090	08/28/2019	Services	$1,390.00
	228091	08/28/2019	Services	$960.00
			SUBTOTAL	$39,183.71
THE TIMES LEADER PO BOX 7005 WHEELING, WV 26003	226040	08/13/2019	Suppliers or vendors	$320.46
			SUBTOTAL	$320.46
THE WATERWAYS JOURNAL INC 319 N 4TH ST ST LOUIS, MO 63102-1994	ACH	08/30/2019	Suppliers or vendors	$924.00
	230189	10/03/2019	Suppliers or vendors	$924.00
	231194	10/11/2019	Suppliers or vendors	$924.00
			SUBTOTAL	$2,772.00
THE WFC GROUP INC 621 SUNNYSLOPE AVENUE PETALUMA, CA 94952	231267	10/11/2019	Suppliers or vendors	$3,675.00
			SUBTOTAL	$3,675.00
THOMAS GARAGE, INC 67791 MALL ROAD ST.CLAIRSVILLE, OH 43950	230719	10/07/2019	Suppliers or vendors	$1,146.30
	230720	10/07/2019	Suppliers or vendors	$4,679.01
			SUBTOTAL	$5,825.31
THOMAS W DUFFY MILLENNIUM SAFETY TRAINING 42 SHERWOOD AVE WHEELING, WV 26003	226194	08/13/2019	Suppliers or vendors	$1,350.00
	228465	09/06/2019	Suppliers or vendors	$5,400.00
	229601	09/20/2019	Suppliers or vendors	$450.00
	231187	10/11/2019	Suppliers or vendors	$900.00
			SUBTOTAL	$8,100.00
THREE RIVERS DIVING 14 GIFFIN DRIVE CANONSBURG, PA 15317	227512	08/23/2019	Suppliers or vendors	$2,000.00
			SUBTOTAL	$2,000.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
THURSTON C. TAYLOR 200 TABERNACLE RD. BLACK MOUNTAIN, NC 28711	227454	08/23/2019	Other - Royalty	$236.65
	229968	09/26/2019	Other - Royalty	$246.45
			SUBTOTAL	$483.10
TIEFENBACH NORTH AMERICA, LLC 112 CORPORATE DRIVE MORGANTOWN, WV 26501	ACH	09/13/2019	Suppliers or vendors	$104,279.19
	230530	10/07/2019	Suppliers or vendors	$3,365.23
	230531	10/07/2019	Suppliers or vendors	$10,770.73
	230532	10/07/2019	Suppliers or vendors	$2,980.15
	230533	10/07/2019	Suppliers or vendors	$1,861.38
	230799	10/09/2019	Suppliers or vendors	$2,716.80
	230827	10/10/2019	Suppliers or vendors	$6,289.21
	230828	10/10/2019	Suppliers or vendors	$2,976.00
	231417	10/11/2019	Suppliers or vendors	$3,138.00
	231518	10/16/2019	Suppliers or vendors	$504.68
	231519	10/16/2019	Suppliers or vendors	$916.70
	231554	10/17/2019	Suppliers or vendors	$1,000.04
	231555	10/17/2019	Suppliers or vendors	$3,646.56
			SUBTOTAL	$144,444.67
TIMES WEST VIRGINIAN PO BOX 2530 FAIRMONT, WV 26555-2530	Check	08/28/2019	Suppliers or vendors	$505.05
	230181	10/03/2019	Suppliers or vendors	$914.64
			SUBTOTAL	$1,419.69
TIMOTHY J LAROS FILTRATION TECHNOLOGIES LLC 3764 SUNRIDGE DR PARK CITY, UT 84098	231270	10/11/2019	Suppliers or vendors	$1,250.00
			SUBTOTAL	$1,250.00
TITAN ENERGY-APPALACHIA LLC 1050 MARKET STREET #1665 PO BOX 1665 PARKERSBURG, WV 26101	226826	08/19/2019	Services	$6,795.90
	227608	08/23/2019	Services	$6,143.38
	227609	08/23/2019	Services	$10,814.08
	228510	09/06/2019	Services	$12,969.04
	229659	09/20/2019	Services	$1,800.00
	229660	09/20/2019	Services	$6,447.80
	230727	10/07/2019	Services	$5,806.88
	231235	10/11/2019	Services	$6,522.00
			SUBTOTAL	$57,299.08

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
TJV TAX CONSULTING LLC 2040 MAJESTIC DRIVE CANONSBURG, PA 15317	ACH	08/19/2019	Services	$4,351.75
	230697	10/07/2019	Services	$3,646.40
	231195	10/11/2019	Services	$3,826.75
			SUBTOTAL	$11,824.90
TNT INDUSTRIAL SUPPLY, LLC 3535 FAIRMONT AVE FAIRMONT, WV 26554	ACH	08/30/2019	Suppliers or vendors	$2,219.38
			SUBTOTAL	$2,219.38
TOTAL EQUIPMENT CO. 400 FIFTH AVENUE CORAOPOLIS, PA 15108	228807	09/06/2019	Suppliers or vendors	$6,281.00
	228808	09/06/2019	Suppliers or vendors	$20,954.12
			SUBTOTAL	$27,235.12
TOWING VESSEL INSPECTION BUREAU 15201 EAST FREEWAY, SUITE 213 CHANNELVIEW, TX 77530	231185	10/11/2019	Suppliers or vendors	$3,000.00
			SUBTOTAL	$3,000.00
TOWN OF FAIRVIEW P.O. BOX 119 FAIRVIEW, WV 26570	227564	08/23/2019	Other - Utilities	$2,104.77
	229603	09/20/2019	Other - Utilities	$2,104.77
	230185	10/03/2019	Other - Utilities	$2,315.25
	231189	10/11/2019	Other - Utilities	$2,315.25
			SUBTOTAL	$8,840.04
TOWN OF MONONGAH 430 BRIDGE STREET MONONGAH, WV 26554	226190	08/13/2019	Other - Utilities	$1,596.59
	226802	08/19/2019	Other - Utilities	$27.38
	229594	09/20/2019	Other - Utilities	$2,120.54
			SUBTOTAL	$3,744.51
TR ELECTRIC & SUPPLY 80 SOUTH 100 WEST PO BOX 776 PRICE, UT 84501	228910	09/06/2019	Suppliers or vendors	$4,552.17
			SUBTOTAL	$4,552.17
TRACY OSTOJICH 71745 FAIRPOINT NEW ATHENS RD ST.CLAIRSVILLE, OH 43950	226838	08/19/2019	Suppliers or vendors	$1,372.50
	229698	09/20/2019	Suppliers or vendors	$2,767.50
	231881	10/25/2019	Suppliers or vendors	$427.50
			SUBTOTAL	$4,567.50

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TRADET, INC. 8 INDUSTRIAL PARK DRIVE WHEELING, WV 26003	226056	08/13/2019	Suppliers or vendors	$281.00
			SUBTOTAL	$281.00
TRAFFIC CLUB OF PITTSBURGH ATTN SEC/TREAS OFFICE 3361 STAFFORD STREET PITTSBURGH, PA 15204-1444	226198	08/13/2019	Suppliers or vendors	$250.00
			SUBTOTAL	$250.00
TRAM ELECTRIC INC 1566 EAST AIRPORT ROAD PO BOX 1104 PRICE, UT 84501	229890	09/25/2019	Suppliers or vendors	$4,580.83
			SUBTOTAL	$4,580.83
TRANSPORTATION FUNDING GROUP, INC. PO BOX 580054 MINNEAPOLIS, MN 55458-0054	226070	08/13/2019	Suppliers or vendors	$2,800.00
	226712	08/19/2019	Suppliers or vendors	$1,200.00
	227407	08/23/2019	Suppliers or vendors	$3,600.00
	228347	09/06/2019	Suppliers or vendors	$2,000.00
	230554	10/07/2019	Suppliers or vendors	$1,350.00
	231026	10/11/2019	Suppliers or vendors	$1,350.00
			SUBTOTAL	$12,300.00
TRE ENVIRONMENTAL STRATEGIES LLC 100 RACQUETTE DRIVE UNIT A FORT COLLINS, CO 80524-2757	230711	10/07/2019	Suppliers or vendors	$2,100.00
			SUBTOTAL	$2,100.00
TREASURER CITY OF PITTSBURGH DEPT OF FINANCE REAL ESTATE DIVISION 414 GRANT STREET PITTSBURGH, PA 15219	226202	08/13/2019	Other - Regulatory/Tax	$1,800.00
	229626	09/20/2019	Other - Regulatory/Tax	$1,800.00
	231200	10/11/2019	Other - Regulatory/Tax	$1,800.00
			SUBTOTAL	$5,400.00
TREASURER OF STATE OF OHIO PO BOX 27 COLUMBUS, OH 43266-0027	ACH	08/23/2019	Other - Regulatory/Tax	$49.36
	ACH	08/27/2019	Other - Regulatory/Tax	$11,700.32
	ACH	09/25/2019	Other - Regulatory/Tax	$15,465.34
	ACH	10/25/2019	Other - Regulatory/Tax	$14,203.00
			SUBTOTAL	$41,418.02

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
TREASURER STATE OF OHIO DIV. OF IND. COMPLIANCE 6606 TUSSING RD PO BOX 4009 REYNOLDSBURG, OH 43068-9009	227389	08/23/2019	Other - Regulatory/Tax	$370.25
	227390	08/23/2019	Other - Regulatory/Tax	$370.25
			SUBTOTAL	$740.50
TREASURER STATE OF OHIO OHIO DEPT OF TAXATION FITA P.O. BOX 1799 COLUMBUS, OH 43216-1799	ACH	08/02/2019	Other - Regulatory/Tax	$446.13
			SUBTOTAL	$446.13
TREASURER STATE OF OHIO, OHIO EPA PO BOX 77005 CLEVELAND, OH 44194-7005	228264	09/06/2019	Other - Regulatory/Tax	$300.00
			SUBTOTAL	$300.00
TREASURER STATE OF OHIO-EXCISE TAX EXCISE & MOTOR FUEL DIVISION EXCISE TAX UNIT PO BOX 530 COLUMBUS, OH 43216-0530	ACH	08/19/2019	Other - Regulatory/Tax	$329,894.18
	ACH	08/22/2019	Other - Regulatory/Tax	$24,445.00
	ACH	09/24/2019	Other - Regulatory/Tax	$30,103.00
	ACH	10/23/2019	Other - Regulatory/Tax	$20,266.00
	ACH	10/28/2019	Other - Regulatory/Tax	$2,370.00
			SUBTOTAL	$407,078.18
TRICON WEAR SOLUTIONS LLC PO BOX 677222 DALLAS, TX 75267-7222	228127	08/28/2019	Suppliers or vendors	$13,661.46
	228128	08/28/2019	Suppliers or vendors	$6,796.30
	229644	09/20/2019	Suppliers or vendors	$5,510.59
			SUBTOTAL	$25,968.35
TRI-COUNTY JOINT MUNICIPAL AUTHORIT P.O. BOX 758 FREDERICKTOWN, PA 15333-0758	226801	08/19/2019	Other - Utilities	$1,159.75
	229593	09/20/2019	Other - Utilities	$1,050.10
	231182	10/11/2019	Other - Utilities	$1,091.75
			SUBTOTAL	$3,301.60
TRINITY CONSULTANTS, INC. PO BOX 972047 DALLAS, TX 75397-2047	226097	08/13/2019	Suppliers or vendors	$5,197.50
	231067	10/11/2019	Suppliers or vendors	$1,196.50
			SUBTOTAL	$6,394.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
TRI-STATE BEARING COMPANY,INC. PO BOX 4737 EVANSVILLE, IN 47724-0737	228923	09/06/2019	Suppliers or vendors	$1,046.90
			SUBTOTAL	$1,046.90
TRI-STATE SUPPLY COMPANY, INC. PO BOX 785951 PHILADEPHIA, PA 19178-5951	226918	08/19/2019	Suppliers or vendors	$14,073.34
	226919	08/19/2019	Suppliers or vendors	$13,091.52
	226920	08/19/2019	Suppliers or vendors	$1,326.86
	228773	09/06/2019	Suppliers or vendors	$1,686.98
	228774	09/06/2019	Suppliers or vendors	$45,271.51
	228775	09/06/2019	Suppliers or vendors	$2,420.55
	228776	09/06/2019	Suppliers or vendors	$2,167.35
	230468	10/07/2019	Suppliers or vendors	$2,820.99
			SUBTOTAL	$82,859.10
TRIUMPH BUSINESS CAPITAL C/O STILES MARINE & MAINTENANCE IN PO BOX 610028 DALLAS, TX 75261-0028	ACH	08/19/2019	Suppliers or vendors	$7,470.46
			SUBTOTAL	$7,470.46
TRM SUPPORT 1296 STONE ROAD CHILLICOTHE, OH 45601	230640	10/07/2019	Suppliers or vendors	$12,740.82
			SUBTOTAL	$12,740.82
TRUSTEES OF THE UMWA 75 REMITTANCE DR. SUITE 1279 CHICAGO, IL 60675-1279	ACH	08/09/2019	Suppliers or vendors	$665,625.34
	ACH	08/12/2019	Suppliers or vendors	$292.71
	ACH	08/21/2019	Suppliers or vendors	$116,078.75
	ACH	09/06/2019	Suppliers or vendors	$947,094.88
	ACH	09/20/2019	Suppliers or vendors	$135,051.77
	ACH	10/07/2019	Suppliers or vendors	$117,435.76
	ACH	10/09/2019	Suppliers or vendors	$496,464.18
	ACH	10/17/2019	Suppliers or vendors	$118,059.38
			SUBTOTAL	$2,596,102.77

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
TRUSTEES OF UMWA PENS/BENEFIT TRUST 75 REMITTANCE DR STE# 1203 CHICAGO, IL 60675-1203	ACH	08/10/2019	Suppliers or vendors	$1,071,899.63
	ACH	08/16/2019	Suppliers or vendors	$154,883.41
	227321	08/23/2019	Suppliers or vendors	$315.68
	ACH	09/10/2019	Suppliers or vendors	$1,026,069.93
	ACH	09/13/2019	Suppliers or vendors	$288,467.07
	ACH	10/10/2019	Suppliers or vendors	$1,058,534.58
			SUBTOTAL	$3,600,170.30
TRUSTMARK VOLUNTARY BENEFIT SOLUTIO 75 REMITTANCE DRIVE, SUITE 1791 CHICAGO, IL 60675-1791	226057	08/13/2019	Suppliers or vendors	$131.68
	226058	08/13/2019	Suppliers or vendors	$113.91
	227386	08/23/2019	Suppliers or vendors	$131.68
	227387	08/23/2019	Suppliers or vendors	$89.67
	228325	09/06/2019	Suppliers or vendors	$97.74
	228326	09/06/2019	Suppliers or vendors	$113.91
	229401	09/20/2019	Suppliers or vendors	$131.68
	229402	09/20/2019	Suppliers or vendors	$113.91
	230129	10/03/2019	Suppliers or vendors	$131.68
	230130	10/03/2019	Suppliers or vendors	$113.91
	231011	10/11/2019	Suppliers or vendors	$64.32
	231012	10/11/2019	Suppliers or vendors	$113.91
			SUBTOTAL	$1,348.00
U. S. NUCLEAR REGULATORY COMM. OFFICE OF THE CFO PO BOX 979051 ST.LOUIS, MO 63197	Credit Card	08/27/2019	Other - Regulatory/Tax	$707.58
			SUBTOTAL	$707.58
U.S. COAST GUARD NAT'L. VESSEL DOC. CENTER PO BOX 1119 FALLING WATERS, WV 25419-1119	226808	08/19/2019	Other - Regulatory/Tax	$156.00
	ACH	09/06/2019	Other - Regulatory/Tax	$26.00
	ACH	09/10/2019	Other - Regulatory/Tax	$26.00
	229155	09/17/2019	Other - Regulatory/Tax	$234.00
	229156	09/17/2019	Other - Regulatory/Tax	$338.00
	229620	09/20/2019	Other - Regulatory/Tax	$26.00
			SUBTOTAL	$806.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
ULINE, INC. PO BOX 88741 CHICAGO, IL 60680-1741	227980	08/28/2019	Suppliers or vendors	$377.88
	227981	08/28/2019	Suppliers or vendors	$2,137.82
	227982	08/28/2019	Suppliers or vendors	$462.71
			SUBTOTAL	$2,978.41
UMWA 1992 BENEFIT PLAN 75 REMITTANCE DR STE #1203 CHICAGO, IL 60675-1203	230128	10/03/2019	Suppliers or vendors	$2,196.75
			SUBTOTAL	$2,196.75
UMWA 1993 BENEFIT TRUST UMWA HEALTH & RETIREMENT 2121 K STREET NW WASHINGTON, DC 20037	ACH	08/02/2019	Suppliers or vendors	$513,725.16
	ACH	08/09/2019	Suppliers or vendors	$1,135,360.66
	ACH	08/16/2019	Suppliers or vendors	$876,508.13
	ACH	08/23/2019	Suppliers or vendors	$4,589,595.20
	ACH	09/06/2019	Suppliers or vendors	$9,928,087.16
	ACH	09/16/2019	Suppliers or vendors	$5,428,146.72
	ACH	09/24/2019	Suppliers or vendors	$3,014,672.43
	ACH	10/03/2019	Suppliers or vendors	$5,962,612.96
	ACH	10/09/2019	Suppliers or vendors	$5,587,529.83
	ACH	10/21/2019	Suppliers or vendors	$1,040,830.85
	ACH	10/25/2019	Suppliers or vendors	$4,250,363.51
			SUBTOTAL	$42,327,432.61
UMWA GENERAL FUND MEMBERSHIP DUES P.O. BOX 172050 KANSAS CITY, KS 66117	225345	08/02/2019	Suppliers or vendors	$50.00
	225346	08/02/2019	Suppliers or vendors	$440.20
	225961	08/13/2019	Suppliers or vendors	$1,050.00
	225962	08/13/2019	Suppliers or vendors	$700.00
	225963	08/13/2019	Suppliers or vendors	$4,540.00
	225964	08/13/2019	Suppliers or vendors	$900.00
	225965	08/13/2019	Suppliers or vendors	$200.00
	226642	08/19/2019	Suppliers or vendors	$372.16
	227308	08/23/2019	Suppliers or vendors	$440.20
	227309	08/23/2019	Suppliers or vendors	$29,765.16
	227310	08/23/2019	Suppliers or vendors	$51,963.20
	227311	08/23/2019	Suppliers or vendors	$4,560.00
	227312	08/23/2019	Suppliers or vendors	$27,111.72
	227313	08/23/2019	Suppliers or vendors	$35,251.88
	227314	08/23/2019	Suppliers or vendors	$22,424.12
	228251	09/06/2019	Suppliers or vendors	$50.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
UMWA GENERAL FUND MEMBERSHIP DUES P.O. BOX 172050 KANSAS CITY, KS 66117	228252	09/06/2019	Suppliers or vendors	$250.00
	228253	09/06/2019	Suppliers or vendors	$1,000.00
	228254	09/06/2019	Suppliers or vendors	$4,400.00
	228255	09/06/2019	Suppliers or vendors	$1,016.28
	228256	09/06/2019	Suppliers or vendors	$250.00
	229250	09/20/2019	Suppliers or vendors	$322.16
	229251	09/20/2019	Suppliers or vendors	$600.00
	229252	09/20/2019	Suppliers or vendors	$4,350.00
	229253	09/20/2019	Suppliers or vendors	$176.08
	229254	09/20/2019	Suppliers or vendors	$250.00
	230093	10/03/2019	Suppliers or vendors	$447.70
	230094	10/03/2019	Suppliers or vendors	$26,593.38
	230095	10/03/2019	Suppliers or vendors	$49,865.62
	230096	10/03/2019	Suppliers or vendors	$4,320.00
	230097	10/03/2019	Suppliers or vendors	$26,166.60
	230098	10/03/2019	Suppliers or vendors	$34,830.02
	230099	10/03/2019	Suppliers or vendors	$27,772.38
	230881	10/11/2019	Suppliers or vendors	$250.00
			SUBTOTAL	$362,678.86
UMWA STRIKE FUND SECRETARY-TREASURER 18354 QUANTICO GATEWAY DR. ST. 200 TRIANGLE, VA 22172	225347	08/02/2019	Suppliers or vendors	$118.39
	225348	08/02/2019	Suppliers or vendors	$122.00
	225349	08/02/2019	Suppliers or vendors	$80.05
	225966	08/13/2019	Suppliers or vendors	$10,109.07
	225967	08/13/2019	Suppliers or vendors	$17,080.10
	225968	08/13/2019	Suppliers or vendors	$4,920.30
	225969	08/13/2019	Suppliers or vendors	$12,407.60
	225970	08/13/2019	Suppliers or vendors	$9,789.64
	226643	08/19/2019	Suppliers or vendors	$123.66
	227315	08/23/2019	Suppliers or vendors	$122.40
	227316	08/23/2019	Suppliers or vendors	$9,082.07
	227317	08/23/2019	Suppliers or vendors	$17,313.52
	227318	08/23/2019	Suppliers or vendors	$9,785.41
	227319	08/23/2019	Suppliers or vendors	$11,400.44
	227320	08/23/2019	Suppliers or vendors	$3,746.40
	228257	09/06/2019	Suppliers or vendors	$104.88
	228258	09/06/2019	Suppliers or vendors	$81.43
	228259	09/06/2019	Suppliers or vendors	$9,615.89

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
UMWA STRIKE FUND SECRETARY-TREASURER 18354 QUANTICO GATEWAY DR. ST. 200 TRIANGLE, VA 22172	228260	09/06/2019	Suppliers or vendors	$17,288.63
	228261	09/06/2019	Suppliers or vendors	$10,839.78
	228262	09/06/2019	Suppliers or vendors	$11,590.22
	228263	09/06/2019	Suppliers or vendors	$9,991.76
	229255	09/20/2019	Suppliers or vendors	$138.75
	229256	09/20/2019	Suppliers or vendors	$123.93
	229257	09/20/2019	Suppliers or vendors	$8,918.02
	229258	09/20/2019	Suppliers or vendors	$17,786.67
	229259	09/20/2019	Suppliers or vendors	$9,763.46
	229260	09/20/2019	Suppliers or vendors	$11,830.32
	229261	09/20/2019	Suppliers or vendors	$9,953.04
	230100	10/03/2019	Suppliers or vendors	$119.81
	230101	10/03/2019	Suppliers or vendors	$124.13
	230102	10/03/2019	Suppliers or vendors	$8,104.50
	230103	10/03/2019	Suppliers or vendors	$15,755.77
	230104	10/03/2019	Suppliers or vendors	$8,013.70
	230105	10/03/2019	Suppliers or vendors	$8,479.32
	230106	10/03/2019	Suppliers or vendors	$8,849.61
	230884	10/11/2019	Suppliers or vendors	$9,512.93
	230885	10/11/2019	Suppliers or vendors	$8,911.25
	230886	10/11/2019	Suppliers or vendors	$603.30
	230887	10/11/2019	Suppliers or vendors	$9,581.52
			SUBTOTAL	$302,283.67
UMWA-BCOA ROD TRUST P O BOX 940 EDGEWATER, MD 21037-0940	ACH	08/10/2019	Suppliers or vendors	$5,730.72
	ACH	08/20/2019	Suppliers or vendors	$808.53
	ACH	08/21/2019	Suppliers or vendors	$15.82
	ACH	09/10/2019	Suppliers or vendors	$16.74
	ACH	09/11/2019	Suppliers or vendors	$5,373.16
	ACH	09/13/2019	Suppliers or vendors	$1,521.71
	ACH	10/10/2019	Suppliers or vendors	$5,721.33
			SUBTOTAL	$19,188.01
UNDERGROUND RESPONSE, LLC PO BOX 188 FAYETTE CITY, PA 15438	231647	10/18/2019	Suppliers or vendors	$11,339.20
			SUBTOTAL	$11,339.20

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
UNI-SELECT USA DBA AUTO PLUS 660 EAST MAIN STRRET POMEROY, OH 45769	227577	08/23/2019	Suppliers or vendors	$1,788.97
	228481	09/06/2019	Suppliers or vendors	$275.54
	231202	10/11/2019	Suppliers or vendors	$1,205.07
			SUBTOTAL	$3,269.58
UNITED AMERICAN ENERGY, LLC 540 PITTS ROAD RAVENNA, KY 40472	227484	08/23/2019	Other - Royalty	$167.22
	229996	09/26/2019	Other - Royalty	$206.35
			SUBTOTAL	$373.57
UNITED CENTRAL IND. SUPPLY CO. LLC PO BOX 743849 ATLANTA, GA 30374-3849	226904	08/19/2019	Suppliers or vendors	$8,821.42
	226905	08/19/2019	Suppliers or vendors	$4,767.91
	226906	08/19/2019	Suppliers or vendors	$13,850.02
	226907	08/19/2019	Suppliers or vendors	$9,242.50
	226908	08/19/2019	Suppliers or vendors	$57,838.11
	226909	08/19/2019	Suppliers or vendors	$14,353.12
	226910	08/19/2019	Suppliers or vendors	$2,314.24
	226911	08/19/2019	Suppliers or vendors	$916.65
	226912	08/19/2019	Suppliers or vendors	$21,675.94
	226913	08/19/2019	Suppliers or vendors	$17,980.86
	226914	08/19/2019	Suppliers or vendors	$1,013.50
	226915	08/19/2019	Suppliers or vendors	$344.88
	226916	08/19/2019	Suppliers or vendors	$249.91
	226917	08/19/2019	Suppliers or vendors	$21.35
	227830	08/28/2019	Suppliers or vendors	$13,308.63
	227831	08/28/2019	Suppliers or vendors	$14,792.72
	227832	08/28/2019	Suppliers or vendors	$34,977.33
	227833	08/28/2019	Suppliers or vendors	$28,322.91
	227834	08/28/2019	Suppliers or vendors	$16,311.33
	227835	08/28/2019	Suppliers or vendors	$8,649.16
	227836	08/28/2019	Suppliers or vendors	$235.50
	227837	08/28/2019	Suppliers or vendors	$1,697.76
	227838	08/28/2019	Suppliers or vendors	$15,286.44
	227839	08/28/2019	Suppliers or vendors	$6,467.68
	227840	08/28/2019	Suppliers or vendors	$5,260.73
	227841	08/28/2019	Suppliers or vendors	$2,713.76
	227842	08/28/2019	Suppliers or vendors	$10,780.65
	228760	09/06/2019	Suppliers or vendors	$7,464.20
	228761	09/06/2019	Suppliers or vendors	$7,903.80
	228762	09/06/2019	Suppliers or vendors	$30,952.10

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
UNITED CENTRAL IND. SUPPLY CO. LLC PO BOX 743849 ATLANTA, GA 30374-3849	228763	09/06/2019	Suppliers or vendors	$8,389.09
	228764	09/06/2019	Suppliers or vendors	$134,990.10
	228765	09/06/2019	Suppliers or vendors	$23,655.26
	228766	09/06/2019	Suppliers or vendors	$7,387.46
	228767	09/06/2019	Suppliers or vendors	$380.32
	228768	09/06/2019	Suppliers or vendors	$46,824.09
	228769	09/06/2019	Suppliers or vendors	$10,318.04
	228770	09/06/2019	Suppliers or vendors	$1,867.51
	228771	09/06/2019	Suppliers or vendors	$4,857.12
	228772	09/06/2019	Suppliers or vendors	$5,122.40
	229874	09/25/2019	Suppliers or vendors	$54,578.17
	229875	09/25/2019	Suppliers or vendors	$55,501.30
	229876	09/25/2019	Suppliers or vendors	$113,952.28
	229877	09/25/2019	Suppliers or vendors	$55,689.78
	229878	09/25/2019	Suppliers or vendors	$97,218.21
	229879	09/25/2019	Suppliers or vendors	$138,782.88
	229880	09/25/2019	Suppliers or vendors	$31,872.29
	229881	09/25/2019	Suppliers or vendors	$5,434.73
	229882	09/25/2019	Suppliers or vendors	$333,245.63
	229883	09/25/2019	Suppliers or vendors	$83,127.62
	229884	09/25/2019	Suppliers or vendors	$1,367.83
	229885	09/25/2019	Suppliers or vendors	$6,477.86
	229886	09/25/2019	Suppliers or vendors	$56,204.41
	229887	09/25/2019	Suppliers or vendors	$275,431.06
	231540	10/17/2019	Suppliers or vendors	$294.00
			SUBTOTAL	$1,911,484.55
UNITED MINE WORKERS OF AMERICA ATTN: COMPAC TREASURER 18354 QUANTICO GATEWAY DRIVE SUITE TRIANGLE, VA 22172-1779	226077	08/13/2019	Suppliers or vendors	$40.00
	226078	08/13/2019	Suppliers or vendors	$30.00
	227411	08/23/2019	Suppliers or vendors	$20.00
	227412	08/23/2019	Suppliers or vendors	$70.00
	228353	09/06/2019	Suppliers or vendors	$20.00
	228354	09/06/2019	Suppliers or vendors	$90.00
	228355	09/06/2019	Suppliers or vendors	$20.00
	228356	09/06/2019	Suppliers or vendors	$50.00
	229421	09/20/2019	Suppliers or vendors	$10.00
	229422	09/20/2019	Suppliers or vendors	$10.00
			SUBTOTAL	$360.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
UNITED MINING EQUIPMENT, INC. 885 PITTSBURGH ROAD BUTLER, PA 16002	227983	08/28/2019	Suppliers or vendors	$2,811.00
	227984	08/28/2019	Suppliers or vendors	$7,848.00
	227985	08/28/2019	Suppliers or vendors	$180.00
	227986	08/28/2019	Suppliers or vendors	$12,000.00
	230330	10/03/2019	Suppliers or vendors	$3,340.00
	230384	10/04/2019	Suppliers or vendors	$1,548.00
	230385	10/04/2019	Suppliers or vendors	$1,825.00
	231430	10/11/2019	Suppliers or vendors	$10,236.00
	231431	10/11/2019	Suppliers or vendors	$7,744.00
	231432	10/11/2019	Suppliers or vendors	$3,705.00
	231433	10/11/2019	Suppliers or vendors	$1,165.00
	231559	10/17/2019	Suppliers or vendors	$3,575.00
			SUBTOTAL	$55,977.00
UNITED PARCEL SERVICE PO BOX 7247-0244 PHILADELPHIA, PA 19170-0001	226068	08/13/2019	Services	$1,218.85
	226711	08/19/2019	Services	$2,691.74
	227405	08/23/2019	Services	$1,061.63
	228344	09/06/2019	Services	$945.52
	229416	09/20/2019	Services	$3,351.72
	230552	10/07/2019	Services	$1,960.19
	231025	10/11/2019	Services	$2,641.03
			SUBTOTAL	$13,870.68
UNITED RENTALS, INC. PO BOX 100711 ATLANTA, GA 30384-0711	226535	08/13/2019	Suppliers or vendors	$61,178.80
	226536	08/13/2019	Suppliers or vendors	$16,152.41
	226537	08/13/2019	Suppliers or vendors	$11,361.75
	228924	09/06/2019	Suppliers or vendors	$838.59
	231434	10/11/2019	Suppliers or vendors	$95,756.76
			SUBTOTAL	$185,288.31
UNITED STATES TREASURY INTERNAL REVENUE SERVICE CINCINNATI, OH 45999-0039	ACH	09/03/2019	Other - Regulatory/Tax	$10,584.00
			SUBTOTAL	$10,584.00
UNIVERSAL COAL FILTER AND SUPPLY PO BOX 1659 BECKLEY, WV 25802	225733	08/05/2019	Suppliers or vendors	$12,850.00
	225734	08/05/2019	Suppliers or vendors	$16,238.50
	227991	08/28/2019	Suppliers or vendors	$8,525.00
	227992	08/28/2019	Suppliers or vendors	$18,617.50

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
UNIVERSAL COAL FILTER AND SUPPLY PO BOX 1659 BECKLEY, WV 25802	228929	09/06/2019	Suppliers or vendors	$3,250.00
	228930	09/06/2019	Suppliers or vendors	$9,080.50
	231436	10/11/2019	Suppliers or vendors	$4,420.00
	231437	10/11/2019	Suppliers or vendors	$9,037.00
	231562	10/17/2019	Suppliers or vendors	$1,560.00
			SUBTOTAL	$83,578.50
UNIVERSITY OF UTAH SEISMOGRAPH STAT ATTN: KEITH D. KOPER 115 SOUTH 1460 EAST, RM 211 FASB SALT LAKE CITY, UT 84112-0102	229344	09/20/2019	Suppliers or vendors	$1,200.00
	229345	09/20/2019	Suppliers or vendors	$1,200.00
			SUBTOTAL	$2,400.00
UPS FREIGHT 28013 NETWORK PLACE CHICAGO, IL 60673	226706	08/19/2019	Services	$628.16
	227391	08/23/2019	Services	$65.19
			SUBTOTAL	$693.35
US BANK CM-9690 PO BOX 70870 ST. PAUL, MN 55170-9690	226722	08/19/2019	Services	$12,000.00
	227414	08/23/2019	Services	$6,545.00
	230561	10/07/2019	Services	$1,990.00
			SUBTOTAL	$20,535.00
US DEPT OF LABOR 200 CONSTITUTION AVE NW ROOM C-4319 LONGSHORE WASHINGTON, DC 20210	226807	08/19/2019	Other - Regulatory/Tax	$89,748.00
			SUBTOTAL	$89,748.00
US SYNTHETIC MINING AND CONSTRUCTIO 1320 SOUTH 1600 WEST OREM, UT 84058	226964	08/19/2019	Suppliers or vendors	$2,649.29
	226965	08/19/2019	Suppliers or vendors	$14,393.20
	228829	09/06/2019	Suppliers or vendors	$1,610.06
	228830	09/06/2019	Suppliers or vendors	$14,894.63
	228831	09/06/2019	Suppliers or vendors	$59,801.02
	230044	09/27/2019	Suppliers or vendors	$28,320.60
	230797	10/09/2019	Suppliers or vendors	$19,485.60
	231545	10/17/2019	Suppliers or vendors	$19,485.60
			SUBTOTAL	$160,640.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
UTAH DEPT OF ENVIRONMENTAL QUALITY DIVISION OF AIR QUALITY 150 NORTH 1950 WEST PO BOX 144820 SALT LAKE CITY, UT 84114-4820	Credit Card	10/18/2019	Other - Regulatory/Tax	$917.70
			SUBTOTAL	$917.70
UTAH MINING ASSOCIATION 4286 S MAIN STREET SALT LAKE CITY, UT 84107	225384	08/02/2019	Suppliers or vendors	$1,600.00
			SUBTOTAL	$1,600.00
UTAH STATE TAX COMM. - MOTOR VEH 8800 MOTOR VEHICLE DIVISION SALT LAKE CITY, UT 84134-8800	226067	08/13/2019	Other - Regulatory/Tax	$120.50
	229415	09/20/2019	Other - Regulatory/Tax	$120.50
	231022	10/11/2019	Other - Regulatory/Tax	$60.25
			SUBTOTAL	$301.25
VANCE'S PARTS & SERVICE PO BOX 700 PURSGLOVE, WV 26546	226143	08/13/2019	Suppliers or vendors	$1,749.24
	226144	08/13/2019	Suppliers or vendors	$2,337.22
	226145	08/13/2019	Suppliers or vendors	$2,993.39
	226760	08/19/2019	Suppliers or vendors	$630.28
	226761	08/19/2019	Suppliers or vendors	$630.00
	226762	08/19/2019	Suppliers or vendors	$2,549.88
	227519	08/23/2019	Suppliers or vendors	$25.00
	227520	08/23/2019	Suppliers or vendors	$216.59
	228414	09/06/2019	Suppliers or vendors	$358.88
	229520	09/20/2019	Suppliers or vendors	$909.00
	229521	09/20/2019	Suppliers or vendors	$1,074.02
	229522	09/20/2019	Suppliers or vendors	$1,765.50
	229523	09/20/2019	Suppliers or vendors	$1,272.00
			SUBTOTAL	$16,511.00
VEOLIA WATER NA OPERATING SERVICES PO BOX 23654 CHICAGO, IL 60673-3654	226167	08/13/2019	Suppliers or vendors	$275,878.00
	227540	08/23/2019	Suppliers or vendors	$180,388.33
	228432	09/06/2019	Suppliers or vendors	$93,792.67
	229545	09/20/2019	Suppliers or vendors	$275,878.00
	230672	10/07/2019	Suppliers or vendors	$121,301.05
	231146	10/11/2019	Suppliers or vendors	$275,878.00
			SUBTOTAL	$1,223,116.05

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
VERIZON BUSINESS PO BOX 15043 ALBANY, NY 12212-5043	Credit Card	08/27/2019	Other - Utilities	$775.32
	Credit Card	09/19/2019	Other - Utilities	$787.79
	Credit Card	10/18/2019	Other - Utilities	$181.42
			SUBTOTAL	$1,744.53
VERIZON WIRELESS PO BOX 25505 LEHIGH VALLEY, PA 18002-5505	Credit Card	08/27/2019	Other - Utilities	$68,336.51
	Credit Card	09/19/2019	Other - Utilities	$35,918.98
	Credit Card	10/18/2019	Other - Utilities	$35,867.13
			SUBTOTAL	$140,122.62
VERIZON PO BOX 15124 ALBANY, NY 12212-5124	225443	08/02/2019	Other - Utilities	$246.72
	229598	09/20/2019	Other - Utilities	$245.14
	231186	10/11/2019	Other - Utilities	$245.14
			SUBTOTAL	$737.00
VERNON C AND ANNA MOORE 22 TULLEY COURT WIMBERLEY, TX 78676	229728	09/20/2019	Suppliers or vendors	$25,000.00
			SUBTOTAL	$25,000.00
VESTA MINE SERVICES 369 ROUTE 519 EIGHTY FOUR, PA 15333	227226	08/19/2019	Suppliers or vendors	$5,472.75
	227227	08/19/2019	Suppliers or vendors	$3,067.75
			SUBTOTAL	$8,540.50
VESTA MINE SUPPLY 369 RT 519 EIGHTY FOUR, PA 15330	227199	08/19/2019	Suppliers or vendors	$4,687.38
	227200	08/19/2019	Suppliers or vendors	$3,150.00
	228131	08/28/2019	Suppliers or vendors	$9,208.70
	228132	08/28/2019	Suppliers or vendors	$6,450.00
			SUBTOTAL	$23,496.08
VIASAT INC EXEDE/ WILDBLUE PO BOX 4427 ENGLEWOOD, CO 80155	Credit Card	08/27/2019	Other - Utilities	$170.69
	Credit Card	09/19/2019	Other - Utilities	$170.69
	Credit Card	10/18/2019	Other - Utilities	$357.94
			SUBTOTAL	$699.32

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
VICTORIA L DORNON 55776 WASHINGTON STREET BARNESVILLE, OH 43713	231273	10/11/2019	Suppliers or vendors	$7,500.00
			SUBTOTAL	$7,500.00
VILLAGE OF GALATIA PO BOX 9 GALATIA, IL 62935	226060	08/13/2019	Other - Regulatory/Tax	$30.82
	229404	09/20/2019	Other - Regulatory/Tax	$15.41
	231014	10/11/2019	Other - Regulatory/Tax	$14.01
			SUBTOTAL	$60.24
VILLAGE OF POWHATAN POINT BOARD OF PUBLIC AFFAIRS 104 MELLOTT STREET POWHATAN POINT, OH 43942	225959	08/13/2019	Other - Utilities	$448.34
	229246	09/20/2019	Other - Utilities	$481.31
	230878	10/11/2019	Other - Utilities	$461.62
			SUBTOTAL	$1,391.27
VINTON COUNTY TREASURER 100 EAST MAIN STREET MCARTHUR, OH 45654	229315	09/20/2019	Other - Regulatory/Tax	$7,481.93
			SUBTOTAL	$7,481.93
VIOLA B SHOEMAKER 11835 SE 72 TERRACE RD BELLEVIEW, FL 34420	225887	08/05/2019	Other - Royalty	$16.21
	229082	09/10/2019	Other - Royalty	$17.63
	230599	10/07/2019	Other - Royalty	$12.75
			SUBTOTAL	$46.59
VIRGINIA A. TETRICK TRUST GUY CORP. 92 16TH STREET WHEELING, WV 26003	226798	08/19/2019	Other - Royalty	$3,138.14
	229590	09/20/2019	Other - Royalty	$3,138.14
			SUBTOTAL	$6,276.28

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
VOTO MANUFACTURERS SALES CO. PO BOX 1299 STEUBENVILLE, OH 43952	227813	08/28/2019	Suppliers or vendors	$445.50
	227814	08/28/2019	Suppliers or vendors	$21,434.24
	227815	08/28/2019	Suppliers or vendors	$3,044.97
	227816	08/28/2019	Suppliers or vendors	$15,433.34
	227817	08/28/2019	Suppliers or vendors	$453.19
	230794	10/09/2019	Suppliers or vendors	$7,135.50
	230795	10/09/2019	Suppliers or vendors	$3,650.00
	231671	10/22/2019	Suppliers or vendors	$4,910.00
			SUBTOTAL	$56,506.74
W W PATTERSON COMPANY 870 RIVERSEA ROAD PITTSBURGH, PA 15233	227157	08/19/2019	Suppliers or vendors	$708.56
	228077	08/28/2019	Suppliers or vendors	$3,856.44
			SUBTOTAL	$4,565.00
W2005/FARGO HOTELS(POOL C) REALTY L FAIRFIELD INN & SUITES 67731 MALL RD. ST.CLAIRSVILLE, OH 43950	226216	08/13/2019	Services	$1,665.67
	227587	08/23/2019	Services	$312.57
	230714	10/07/2019	Services	$848.52
			SUBTOTAL	$2,826.76
WAGNER TRUCKING 231 9TH STREET SALTSBURG, PA 15681	225378	08/02/2019	Suppliers or vendors	$500.00
	230534	10/07/2019	Suppliers or vendors	$250.00
	230994	10/11/2019	Suppliers or vendors	$2,245.00
			SUBTOTAL	$2,995.00
WALDEN INDUSTRIES, INC. PO BOX 68 TILTONSVILLE, OH 43963	228911	09/06/2019	Suppliers or vendors	$1,996.00
	228912	09/06/2019	Suppliers or vendors	$29,343.20
	228913	09/06/2019	Suppliers or vendors	$1,994.08
	228914	09/06/2019	Suppliers or vendors	$23,289.60
	230800	10/09/2019	Suppliers or vendors	$1,994.08
	231418	10/11/2019	Suppliers or vendors	$6,369.60
	231419	10/11/2019	Suppliers or vendors	$29,724.80
	231420	10/11/2019	Suppliers or vendors	$11,964.48
	231421	10/11/2019	Suppliers or vendors	$23,289.60
	231556	10/17/2019	Suppliers or vendors	$2,123.20
			SUBTOTAL	$132,088.64

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
WALLACE ELECTRICAL SYSTEMS LLC 2853 KEN GRAY BLVD, SUITE 4 WEST FRANKFORT, IL 62896	225713	08/05/2019	Suppliers or vendors	$243,647.96
	228915	09/06/2019	Suppliers or vendors	$8,137.85
	228916	09/06/2019	Suppliers or vendors	$8,268.17
	228917	09/06/2019	Suppliers or vendors	$1,330.74
	228918	09/06/2019	Suppliers or vendors	$62.55
	228919	09/06/2019	Suppliers or vendors	$144,071.92
			SUBTOTAL	$405,519.19
WALLACE INDUSTRIAL LLC 2853 KEN GRAY BLVD, STE 4 WEST FRANKFORT, IL 62896	228932	09/06/2019	Suppliers or vendors	$1,135.32
	228933	09/06/2019	Suppliers or vendors	$50,300.68
	228934	09/06/2019	Suppliers or vendors	$28,742.32
	228935	09/06/2019	Suppliers or vendors	$5,090.34
	228936	09/06/2019	Suppliers or vendors	$47,755.51
	228937	09/06/2019	Suppliers or vendors	$9,208.47
	228938	09/06/2019	Suppliers or vendors	$7,918.56
	228939	09/06/2019	Suppliers or vendors	$6,640.34
			SUBTOTAL	$156,791.54
WALTER LEWIS & SON, INC. P O BOX 270 WORTHINGTON, WV 26591	228986	09/06/2019	Suppliers or vendors	$2,330.00
	228987	09/06/2019	Suppliers or vendors	$6,847.04
	228988	09/06/2019	Suppliers or vendors	$208.82
			SUBTOTAL	$9,385.86
WARCO SALES, INC. PO BOX 4008 WHEELING, WV 26003	ACH	08/19/2019	Suppliers or vendors	$14,359.00
	ACH	09/13/2019	Suppliers or vendors	$2,417.00
			SUBTOTAL	$16,776.00
WARE SURVEYING LLC 1344 NORTH 1000 WEST PRICE, UT 84501	226006	08/13/2019	Suppliers or vendors	$3,262.50
	230496	10/07/2019	Suppliers or vendors	$3,802.50
			SUBTOTAL	$7,065.00
WARREN NEIL CHISLER CHISSYS RECYCLING AND SOLID WASTE PO BOX 252 BLACKSVILLE, WV 26521	229500	09/20/2019	Suppliers or vendors	$28,794.50
			SUBTOTAL	$28,794.50
WARREN SHEETS, TRUST 19 LOCUST STREET, BOX 325 GALLIPOLIS, OH 45631	225893	08/05/2019	Other - Royalty	$32.92

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
WARREN SHEETS, TRUST 19 LOCUST STREET, BOX 325 GALLIPOLIS, OH 45631	229088	09/10/2019	Other - Royalty	$49.87
	230604	10/07/2019	Other - Royalty	$39.48
			SUBTOTAL	$122.27
WARWOOD ARMATURE REPAIR CO. PO BOX 4008 WHEELING, WV 26003	ACH	08/19/2019	Suppliers or vendors	$67,778.00
	Wire	10/28/2019	Suppliers or vendors	$16,414.00
			SUBTOTAL	$84,192.00
WASHINGTON COUNTY RECORDER 100 W BEAU ST #204 WASHINGTON, PA 15301	226220	08/13/2019	Other - Regulatory/Tax	$80.25
	226819	08/19/2019	Other - Regulatory/Tax	$1,900.00
	226820	08/19/2019	Other - Regulatory/Tax	$1,900.00
	231216	10/11/2019	Other - Regulatory/Tax	$4,400.00
	231217	10/11/2019	Other - Regulatory/Tax	$4,400.00
	231218	10/11/2019	Other - Regulatory/Tax	$80.25
			SUBTOTAL	$12,760.50
WASHINGTON TOWNSHIP TAX COLLECTOR 109 COZY LANE BELLE VERNON, PA 15012	229647	09/20/2019	Other - Regulatory/Tax	$1,966.17
			SUBTOTAL	$1,966.17
WASTE & WATER LOGISTICS, LLC PO BOX 220 HELPER, UT 84526	225379	08/02/2019	Suppliers or vendors	$3,477.79
	226048	08/13/2019	Suppliers or vendors	$6,074.30
	226695	08/19/2019	Suppliers or vendors	$9,165.90
	226696	08/19/2019	Suppliers or vendors	$250.00
	227379	08/23/2019	Suppliers or vendors	$5,312.30
	227380	08/23/2019	Suppliers or vendors	$402.20
	228313	09/06/2019	Suppliers or vendors	$2,415.00
	228314	09/06/2019	Suppliers or vendors	$265.75
	229390	09/20/2019	Suppliers or vendors	$6,831.10
	229391	09/20/2019	Suppliers or vendors	$908.50
	230535	10/07/2019	Suppliers or vendors	$9,502.00
	230536	10/07/2019	Suppliers or vendors	$748.70
	230537	10/07/2019	Suppliers or vendors	$1,450.00
	230538	10/07/2019	Suppliers or vendors	$250.00
			SUBTOTAL	$47,053.54

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
WASTE MANAGEMENT PO BOX 13648 PHILADELPHIA, PA 19101-3648	226049	08/13/2019	Suppliers or vendors	$781.63
	230995	10/11/2019	Suppliers or vendors	$5.58
			SUBTOTAL	$787.21
WAYNE DOUGLAS WHITAKER 1406 GENTILZ CASTROVILLE, TX 78009	227591	08/23/2019	Other - Royalty	$102.15
			SUBTOTAL	$102.15
WAYNE TOWNSHIP TAX COLLECTOR 106 FREEDOM STREET PO BOX 741 BRAVE, PA 15316	226195	08/13/2019	Other - Regulatory/Tax	$11,960.30
			SUBTOTAL	$11,960.30
WC HYDRAULICS, LLC 172 PHILPOT LANE BEAVER, WV 25813	225395	08/02/2019	Suppliers or vendors	$3,950.00
	227993	08/28/2019	Suppliers or vendors	$4,651.54
	227994	08/28/2019	Suppliers or vendors	$2,715.63
	227995	08/28/2019	Suppliers or vendors	$3,211.11
	231690	10/22/2019	Suppliers or vendors	$13,669.39
			SUBTOTAL	$28,197.67
WEAVERTOWN TRANSPORT LEASING INC DBA WEAVERTOWN ENVIRONMENT GROUP 2 DORRINGTON ROAD CARNEGIE, PA 15106	ACH	08/07/2019	Suppliers or vendors	$41,600.00
	230548	10/07/2019	Suppliers or vendors	$20,000.00
	231015	10/11/2019	Suppliers or vendors	$20,000.00
			SUBTOTAL	$81,600.00
WEB.COM GROUP INC NETWORK SOLUTIONS 12808 GRAN BAY PARKWAY WEST JACKSONVILLE, FL 32258	Credit Card	10/18/2019	Suppliers or vendors	$143.94
			SUBTOTAL	$143.94
WEIR SLURRY GROUP, INC. 21976 NETWORK PLACE CHICAGO, IL 60673-1219	225306	08/01/2019	Suppliers or vendors	$46,587.66
	227061	08/19/2019	Suppliers or vendors	$24,991.50
			SUBTOTAL	$71,579.16
WEISS WORLD LP 411 E. MAIN STREET CARNEGIE, PA 15106	226613	08/16/2019	Suppliers or vendors	$3,127.00
	229673	09/20/2019	Suppliers or vendors	$5,000.00
			SUBTOTAL	$8,127.00

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
WELLINGTON ALLOYS PO BOX 250298 FRANKLIN, MI 48025	228957	09/06/2019	Suppliers or vendors	$393.77
			SUBTOTAL	$393.77
WELLS FARGO EQUIPMENT FINANCE INC PO BOX 856937 MINNEAPOLIS, MN 55485-6937	225456	08/02/2019	Suppliers or vendors	$260.00
	228499	09/06/2019	Suppliers or vendors	$26,173.53
	229648	09/20/2019	Suppliers or vendors	$25,913.53
			SUBTOTAL	$52,347.06
WELLS FARGO EQUIPMENT FINANCE MANUFACTURER SERVICE GROUP PO BOX 7777 SAN FRANCISCO, CA 94120-7777	226248	08/13/2019	Services	$5,094.00
	229682	09/20/2019	Services	$5,094.00
			SUBTOTAL	$10,188.00
WELLS FARGO FINANCIAL LEASING P.O. BOX 10306 DES MOINES, IA 50306-0306	228315	09/06/2019	Suppliers or vendors	$2,136.73
	229943	09/26/2019	Suppliers or vendors	$2,136.73
			SUBTOTAL	$4,273.46
WEST FINLEY TOWNSHIP TAX COLLECTOR 244 MCDONALD RD WEST ALEXANDER, PA 15376	228515	09/06/2019	Other - Regulatory/Tax	$3,932.27
			SUBTOTAL	$3,932.27
WEST PENN POWER PO BOX 3687 AKRON, OH 44309-3687	225405	08/02/2019	Other - Utilities	$247.16
	225406	08/02/2019	Other - Utilities	$19,718.00
	226089	08/13/2019	Other - Utilities	$1,492.87
	226090	08/13/2019	Other - Utilities	$4,699.13
	226731	08/19/2019	Other - Utilities	$12,143.23
	226732	08/19/2019	Other - Utilities	$45.05
	227426	08/23/2019	Other - Utilities	$4,804.64
	227427	08/23/2019	Other - Utilities	$17.70
	227428	08/23/2019	Other - Utilities	$20,237.08
	229439	09/20/2019	Other - Utilities	$10,825.75
	229440	09/20/2019	Other - Utilities	$1,464.10
	229441	09/20/2019	Other - Utilities	$1,171.16
	229952	09/26/2019	Other - Utilities	$5,976.54
	229953	09/26/2019	Other - Utilities	$3,707.71

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
WEST PENN POWER PO BOX 3687 AKRON, OH 44309-3687	230156	10/03/2019	Other - Utilities	$20,422.26
	231044	10/11/2019	Other - Utilities	$12,542.63
	231045	10/11/2019	Other - Utilities	$4,051.83
	231046	10/11/2019	Other - Utilities	$4,854.05
	231628	10/18/2019	Other - Utilities	$99.53
	231629	10/18/2019	Other - Utilities	$7,041.33
	231630	10/18/2019	Other - Utilities	$45.55
			SUBTOTAL	$135,607.30
WEST RIVER CONVEYORS & MACHINERY CO 8936 DISMAL RIVER ROAD OAKWOOD, VA 24631	228752	09/06/2019	Suppliers or vendors	$3,179.68
	231374	10/11/2019	Suppliers or vendors	$6,398.22
	231375	10/11/2019	Suppliers or vendors	$17,337.93
	231376	10/11/2019	Suppliers or vendors	$26,906.69
			SUBTOTAL	$53,822.52
WEST SIDE TELECOMMUNICATIONS 1449 FAIRMONT ROAD MORGANTOWN, WV 26501	Credit Card	08/28/2019	Suppliers or vendors	$898.04
	Credit Card	09/19/2019	Suppliers or vendors	$899.09
	Credit Card	10/18/2019	Suppliers or vendors	$900.17
			SUBTOTAL	$2,697.30
WEST STAR AVIATION INC 2 AIRLINE COURT EAST ALTON, IL 62024	228474	09/06/2019	Services	$4,422.00
			SUBTOTAL	$4,422.00
WEST VIRGINIA COAL ASSOCIATION INC P.O. BOX 3923 CHARLESTON, WV 25339	226189	08/13/2019	Suppliers or vendors	$300.00
	227557	08/23/2019	Suppliers or vendors	$16,666.67
	229592	09/20/2019	Suppliers or vendors	$16,666.66
	231181	10/11/2019	Suppliers or vendors	$16,666.67
			SUBTOTAL	$50,300.00
WEST VIRGINIA NEWSPAPER PUBLISHING THE DOMINION POST 1251 EARL L CORE ROAD MORGANTOWN, WV 26505	ACH	08/19/2019	Suppliers or vendors	$615.16
	ACH	09/13/2019	Suppliers or vendors	$1,874.21
	230183	10/03/2019	Suppliers or vendors	$582.88
	231184	10/11/2019	Suppliers or vendors	$1,155.96
			SUBTOTAL	$4,228.21

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
WEST VIRGINIA STATE TAX DEPARTMENT INTERNAL AUDITING DIVISION PO BOX 1826 CHARLESTON, WV 25327-1826	ACH	08/20/2019	Suppliers or vendors	$7,410.99
	ACH	09/20/2019	Suppliers or vendors	$14,472.64
	ACH	10/20/2019	Suppliers or vendors	$7,004.75
			SUBTOTAL	$28,888.38
WEST VIRGINIA STATE TAX DEPARTMENT TAX ACCOUNT ADMN DIVISION PO BOX 425 CHARLESTON, WV 25322-0425	ACH	08/05/2019	Other - Regulatory/Tax	$5,986,781.82
	ACH	08/19/2019	Other - Regulatory/Tax	$3,780.27
	227551	08/20/2019	Other - Regulatory/Tax	$211.32
	ACH	08/22/2019	Other - Regulatory/Tax	$125,476.43
	ACH	09/05/2019	Other - Regulatory/Tax	$4,405,478.15
	ACH	09/20/2019	Other - Regulatory/Tax	$137.97
	ACH	09/24/2019	Other - Regulatory/Tax	$80,601.13
	ACH	09/30/2019	Other - Regulatory/Tax	$8,333.19
	ACH	10/03/2019	Other - Regulatory/Tax	$4,997,128.44
	ACH	10/22/2019	Other - Regulatory/Tax	$4,390.98
	ACH	10/23/2019	Other - Regulatory/Tax	$59,546.12
			SUBTOTAL	$15,671,865.82
WEST VIRGINIA STATE TAX DEPT TAX ACCOUNT ADMINISTRATION DIV P.O. BOX 1682 CHARLESTON, WV 25326-1682	ACH	10/11/2019	Other - Regulatory/Tax	$12,219.89
			SUBTOTAL	$12,219.89
WESTERN MINE TOOLS, INC. 1384 WEST 1955 NORTH HELPER, UT 84526	ACH	08/30/2019	Suppliers or vendors	$58,131.40
	230829	10/10/2019	Suppliers or vendors	$4,355.46
	231558	10/17/2019	Suppliers or vendors	$5,755.51
			SUBTOTAL	$68,242.37
WESTERN OILFIELDS SUPPLY COMPANY DBA RAIN FOR RENT 5101 OFFICE PARK DRIVE BAKERSFIELD, CA 93309	230074	10/02/2019	Suppliers or vendors	$18,343.24
			SUBTOTAL	$18,343.24
WETZEL CHRONICLE PO BOX 289 NEW MARTINSVILLE, WV 26155	228459	09/06/2019	Suppliers or vendors	$1,547.91
			SUBTOTAL	$1,547.91

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
WEX BANK PO BOX 6293 CAROL STREAM, IL 60197	ACH	08/16/2019	Services	$4,734.70
	ACH	09/06/2019	Services	$5,309.46
	ACH	10/11/2019	Services	$5,013.55
			SUBTOTAL	$15,057.71
WHEELER MACHINERY COMPANY PO BOX 413071 SALT LAKE CITY, UT 84141-3071	229833	09/20/2019	Suppliers or vendors	$5,361.34
	229891	09/25/2019	Suppliers or vendors	$138,533.24
	230057	09/30/2019	Suppliers or vendors	$19,153.68
	230331	10/03/2019	Suppliers or vendors	$62,206.24
	230386	10/04/2019	Suppliers or vendors	$43,364.55
	230547	10/07/2019	Suppliers or vendors	$63,298.68
	230802	10/09/2019	Suppliers or vendors	$505.16
	231435	10/11/2019	Suppliers or vendors	$19,115.82
	231521	10/16/2019	Suppliers or vendors	$3,640.98
	231633	10/18/2019	Suppliers or vendors	$2,266.07
	ACH	10/24/2019	Suppliers or vendors	$37,118.07
			SUBTOTAL	$394,563.83
WHEELING HAMPTON INN 795 NATIONAL ROAD WHEELING, WV 26003	226085	08/13/2019	Services	$678.72
			SUBTOTAL	$678.72
WHEELING SPRING SERVICE CO. PO BOX 6733 WHEELING, WV 26003	225718	08/05/2019	Suppliers or vendors	$773.16
			SUBTOTAL	$773.16
WHEELING UNIVERSITY 316 WASHINGTON AVE. WHEELING, WV 26003	227235	08/20/2019	Suppliers or vendors	$5,577.25
	231271	10/11/2019	Suppliers or vendors	$2,731.75
			SUBTOTAL	$8,309.00
WHEELING-OHIO COUNTY AIRPORT 115 SKYWAY LANE WHEELING, WV 26003	226700	08/19/2019	Other - Regulatory/Tax	$38,690.02
	229399	09/20/2019	Other - Regulatory/Tax	$46,904.36
	231009	10/11/2019	Other - Regulatory/Tax	$24,680.91
			SUBTOTAL	$110,275.29
WHITELEY TOWNSHIP TAX COLLECTOR 881 MT MORRIS ROAD WAYNESBURG, PA 15370	226817	08/19/2019	Other - Regulatory/Tax	$28.53
			SUBTOTAL	$28.53

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Part 2, Question 3: Certain payments or transfers to creditors within 90 days before filing this case

Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
WHITESIDE CHEVROLET-OLDS-BUICK-PONT 50714 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	225960	08/13/2019	Suppliers or vendors	$486.73
	228250	09/06/2019	Suppliers or vendors	$3,543.43
	229247	09/20/2019	Suppliers or vendors	$482.85
			SUBTOTAL	$4,513.01
WILBER W HESLEP 491 MARKET STREET PO BOX 27 CLARINGTON, OH 43915	229661	09/20/2019	Suppliers or vendors	$2,640.00
			SUBTOTAL	$2,640.00
WILLIAM H BAUER 1950 LITTLE FALLS RUN ROAD GRAFTON, WV 26354-4523	226234	08/13/2019	Services	$960.00
	228513	09/06/2019	Services	$2,340.00
	229667	09/20/2019	Services	$1,620.00
	230736	10/07/2019	Services	$1,440.00
	231239	10/11/2019	Services	$1,380.00
			SUBTOTAL	$7,740.00
WILLIAM H GABEL PO BOX 98 DARRAGH, PA 15625	226275	08/13/2019	Suppliers or vendors	$3,500.00
			SUBTOTAL	$3,500.00
WILLIAM H. PIPER 7601 TIMBERLY COURT MCLEAN, VA 22102	227472	08/23/2019	Other - Royalty	$146.86
			SUBTOTAL	$146.86
WILLIAM J. SIPLIVY PE INC. 4667 TURNBERRY TRAIL STOW, OH 44224	225380	08/02/2019	Suppliers or vendors	$3,000.00
	228316	09/06/2019	Suppliers or vendors	$200.00
	230996	10/11/2019	Suppliers or vendors	$1,950.80
			SUBTOTAL	$5,150.80
WILLIAM R. TAYLOR, II 224 TAYLOR THURSTON ROAD COLUMBUS, MS 39701	227482	08/23/2019	Other - Royalty	$104.03
			SUBTOTAL	$104.03
WILLIAM REX BIGGS 38970 ST. RT. 124 POMEROY, OH 45769	225919	08/05/2019	Other - Royalty	$23.57
	229115	09/10/2019	Other - Royalty	$22.79
			SUBTOTAL	$46.36
WILLIAM W HAWK 36372 WOLFE PEN ROAD POMEROY, OH 45769	225866	08/05/2019	Other - Royalty	$55.61

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Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
WILLIAM W HAWK 36372 WOLFE PEN ROAD POMEROY, OH 45769	229063	09/10/2019	Other - Royalty	$43.32
	230579	10/07/2019	Other - Royalty	$36.81
			SUBTOTAL	$135.74
WILLIAM W. TAYLOR 5531 ANN ARBOR DR. BOKEELIA, FL 33922	227493	08/23/2019	Other - Royalty	$177.47
	230000	09/26/2019	Other - Royalty	$184.82
			SUBTOTAL	$362.29
WILLIAMS SCOTSMAN PO BOX 91975 CHICAGO, IL 60693-1975	226050	08/13/2019	Suppliers or vendors	$1,327.94
	227381	08/23/2019	Suppliers or vendors	$699.64
	228317	09/06/2019	Suppliers or vendors	$604.39
	229392	09/20/2019	Suppliers or vendors	$1,423.19
			SUBTOTAL	$4,055.16
WILMA J DAVIDSON 37605 STATE ROUTE 143 RUTLAND, OH 45775	225913	08/05/2019	Other - Royalty	$6.08
	229109	09/10/2019	Other - Royalty	$7.26
	230726	10/07/2019	Other - Royalty	$6.42
			SUBTOTAL	$19.76
WILMERHALE PO BOX 7247-8760 PHILADELPHIA, PA 19170-8760	ACH	10/07/2019	Services	$5,338.00
			SUBTOTAL	$5,338.00
WILSON AUTO GLASS 2240 MAIN STREET WHEELING, WV 26003	226051	08/13/2019	Suppliers or vendors	$283.35
	227382	08/23/2019	Suppliers or vendors	$290.59
	227383	08/23/2019	Suppliers or vendors	$175.00
	228318	09/06/2019	Suppliers or vendors	$287.98
	229393	09/20/2019	Suppliers or vendors	$175.00
			SUBTOTAL	$1,211.92
WILSON WORKS, INC. 202 DISTRIBUTOR DRIVE MORGANTOWN, WV 26501-7176	ACH	08/07/2019	Suppliers or vendors	$53,281.04
	ACH	08/30/2019	Suppliers or vendors	$55,137.18
			SUBTOTAL	$108,418.22
WINDSTREAM PO BOX 9001908 LOUISVILLE, KY 40290-1908	226641	08/19/2019	Other - Utilities	$1,395.50
	Credit Card	08/27/2019	Other - Utilities	$858.07

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Part 2, Question 3: Certain payments or transfers to creditors within 90 days before filing this case

Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
WINDSTREAM PO BOX 9001908 LOUISVILLE, KY 40290-1908	229248	09/20/2019	Other - Utilities	$1,271.41
	229249	09/20/2019	Other - Utilities	$2,387.96
	229930	09/26/2019	Other - Utilities	$215.23
	230092	10/03/2019	Other - Utilities	$2,388.51
	230879	10/11/2019	Other - Utilities	$1,305.44
			SUBTOTAL	$9,822.12
WININSKY LAW OFFICES PINEBRIDGE COMMONS PITTSBURGH, PA 15241	229852	09/23/2019	Services	$75,000.00
			SUBTOTAL	$75,000.00
WINTECH INTERNATIONAL LLC 5020 HAZEL JONS ROAD BOSSIER CITY, LA 71111	227231	08/19/2019	Suppliers or vendors	$26,587.26
			SUBTOTAL	$26,587.26
WLLIAM B BRADFORD 207 WEST SOUTH COLLEGE STREET YELLOW SPRINGS, OH 45387	225897	08/05/2019	Other - Royalty	$0.96
	229092	09/10/2019	Other - Royalty	$1.15
	230608	10/07/2019	Other - Royalty	$1.01
			SUBTOTAL	$3.12
WOODCHUCKS GENERAL CONTRACTORS INC 102 MARYLAND AVE FAIRMONT, WV 26554	ACH	08/30/2019	Suppliers or vendors	$23,947.11
	ACH	09/13/2019	Suppliers or vendors	$23,614.40
			SUBTOTAL	$47,561.51
WOODROW ENGLE 38415 SHADY COVE ROAD MIDDLEPORT, OH 45760	225864	08/05/2019	Other - Royalty	$41.40
	229061	09/10/2019	Other - Royalty	$41.56
			SUBTOTAL	$82.96
WV DEPT OF ENVIRONMENTAL PROTECTION DIVISION OF MINING AND RECLAMATION 601 57TH STREET SE CHARLESTON, WV 25304	Credit Card	08/27/2019	Other - Regulatory/Tax	$2,000.00
	Credit Card	08/28/2019	Other - Regulatory/Tax	$6,761.29
	Credit Card	09/19/2019	Other - Regulatory/Tax	$6,609.00
	Credit Card	10/18/2019	Other - Regulatory/Tax	$41,040.00
			SUBTOTAL	$56,410.29

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Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 3: Certain payments or transfers to creditors within 90 days before filing this case

Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
WV DIV OF NATURAL RESOURCES OFFICE OF LAND & STREAMS 324 FOURTH AVENUE ROOM 200 SOUTH CHARLESTON, WV 25303	Credit Card	09/19/2019	Other - Regulatory/Tax	$300.00
	Credit Card	10/18/2019	Other - Regulatory/Tax	$1,800.00
			SUBTOTAL	$2,100.00
WV DIVISION OF LABOR 1900 KANAWHA BLVD EAST CHARELSTON, WV 25305	Credit Card	10/18/2019	Other - Regulatory/Tax	$92.03
			SUBTOTAL	$92.03
WV OFFICE OF MHS&T #7 PLAYERS CLUB DRIVE-SUITE 2 CHARLESTON, WV 25311	228473	09/06/2019	Other - Regulatory/Tax	$648.00
			SUBTOTAL	$648.00
WV OFFICE OF MINERS HEALTH SAFETY & TRAINING 830 VIRGINIA AVE. WELCH, WV 24801	225429	08/02/2019	Other - Regulatory/Tax	$1,644.00
	225430	08/02/2019	Other - Regulatory/Tax	$402.00
	225431	08/02/2019	Other - Regulatory/Tax	$1,344.00
	225432	08/02/2019	Other - Regulatory/Tax	$1,536.00
	225433	08/02/2019	Other - Regulatory/Tax	$516.00
	225434	08/02/2019	Other - Regulatory/Tax	$1,344.00
	225435	08/02/2019	Other - Regulatory/Tax	$288.00
	225436	08/02/2019	Other - Regulatory/Tax	$768.00
	225437	08/02/2019	Other - Regulatory/Tax	$1,536.00
	225438	08/02/2019	Other - Regulatory/Tax	$384.00
	227542	08/23/2019	Other - Regulatory/Tax	$402.00
	228433	09/06/2019	Other - Regulatory/Tax	$714.00
	229547	09/20/2019	Other - Regulatory/Tax	$6,288.00
	229548	09/20/2019	Other - Regulatory/Tax	$1,542.00
	229549	09/20/2019	Other - Regulatory/Tax	$96.00
	230168	10/03/2019	Other - Regulatory/Tax	$442.00
	231147	10/11/2019	Other - Regulatory/Tax	$246.00
			SUBTOTAL	$19,492.00
WV PAGING ONE PAGE DR FAIRMONT, WV 26554	227537	08/23/2019	Suppliers or vendors	$219.00
	229540	09/20/2019	Suppliers or vendors	$219.00
	231136	10/11/2019	Suppliers or vendors	$219.00
			SUBTOTAL	$657.00

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Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 3: Certain payments or transfers to creditors within 90 days before filing this case

Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
WVDEP - DIVISION OF AIR QUALITY PO BOX 40420 CHARLESTON, WV 25364	231058	10/11/2019	Other - Regulatory/Tax	$500.00
			SUBTOTAL	$500.00
WVU MINING & INDUSTRIAL EXTENSION WVU EXT. & OUTREACH PO BOX 6070 MINERAL RESOURCE BUILDI MORGANTOWN, WV 26506	225383	08/02/2019	Suppliers or vendors	$750.00
	226055	08/13/2019	Suppliers or vendors	$750.00
	226699	08/19/2019	Suppliers or vendors	$9,400.70
	229397	09/20/2019	Suppliers or vendors	$12,000.00
	229398	09/20/2019	Suppliers or vendors	$750.00
			SUBTOTAL	$23,650.70
XCEL MANAGEMENT SOLUTIONS 1301 AIRPORT RD BEAVER, WV 25813	226259	08/13/2019	Services	$713.00
			SUBTOTAL	$713.00
XEROX CORPORATION PO BOX 802555 CHICAGO, IL 60680-2555	226063	08/13/2019	Suppliers or vendors	$647.01
	227392	08/23/2019	Suppliers or vendors	$1,939.78
	227393	08/23/2019	Suppliers or vendors	$566.20
	228333	09/06/2019	Suppliers or vendors	$646.25
	229944	09/26/2019	Suppliers or vendors	$1,495.72
	231019	10/11/2019	Suppliers or vendors	$1,176.72
			SUBTOTAL	$6,471.68
XEROX FINANCIAL SERVICES PO BOX 202882 DALLAS, TX 75320-2882	225422	08/02/2019	Services	$1,566.56
	225423	08/02/2019	Services	$1,029.76
	226139	08/13/2019	Services	$2,678.67
	226140	08/13/2019	Services	$950.00
	226141	08/13/2019	Services	$2,336.45
	226759	08/19/2019	Services	$583.00
	227514	08/23/2019	Services	$4,117.64
	227515	08/23/2019	Services	$702.14
	228410	09/06/2019	Services	$2,518.22
	228411	09/06/2019	Services	$584.38
	228412	09/06/2019	Services	$1,029.76
	229514	09/20/2019	Services	$588.50
	229515	09/20/2019	Services	$4,846.79
	229516	09/20/2019	Services	$950.00

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Part 2, Question 3: Certain payments or transfers to creditors within 90 days before filing this case

Creditor Name & Address	Check or Wire Number	Payment Date	Reason For Payment	Amount Paid
XEROX FINANCIAL SERVICES PO BOX 202882 DALLAS, TX 75320-2882	229517	09/20/2019	Services	$2,336.45
	230009	09/26/2019	Services	$2,538.75
	230010	09/26/2019	Services	$702.14
	230649	10/07/2019	Services	$945.00
	230650	10/07/2019	Services	$1,132.74
	231113	10/11/2019	Services	$1,871.47
	231114	10/11/2019	Services	$3,674.21
			SUBTOTAL	$37,682.63
XYLEM DEWATERING SOLUTIONS, INC. DBA GODWIN PUMPS OF AMERICA, INC. 26717 NETWORK PLACE CHICAGO, IL 60673-1267	225691	08/05/2019	Suppliers or vendors	$10,250.00
	225692	08/05/2019	Suppliers or vendors	$26,389.90
	227937	08/28/2019	Suppliers or vendors	$4,104.00
			SUBTOTAL	$40,743.90
YOST DRILLING LLC PO BOX 598 MT MORRIS, PA 15349	226594	08/13/2019	Services	$404,132.72
			SUBTOTAL	$404,132.72
ZELLER ELECTRIC ZELLER TECHNOLOGIES, INC. 4250 HOFFMEISTER AVE. ST. LOUIS, MO 63125	227890	08/28/2019	Suppliers or vendors	$7,696.24
			SUBTOTAL	$7,696.24
ZHENGZHOU COAL MINING MACHINERY CO NO.167, 9TH AVENUE ZHENGZHOU CITY 450016 CHINA	ACH	08/02/2019	Suppliers or vendors	$482,404.00
	ACH	08/20/2019	Suppliers or vendors	$517,688.00
	ACH	09/03/2019	Suppliers or vendors	$482,404.00
	ACH	09/20/2019	Suppliers or vendors	$517,688.00
	ACH	10/02/2019	Suppliers or vendors	$482,404.00
			SUBTOTAL	$2,482,588.00
ZMJ AMERICA INC 885 PITTSBURGH ROAD BUTLER, PA 16002	228160	08/28/2019	Suppliers or vendors	$17,089.73
	228161	08/28/2019	Suppliers or vendors	$66.92
			SUBTOTAL	$17,156.65
			GRAND TOTAL	$353,689,036.60

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Part 2, Question 4: Payments or other transfers of property made within 1 year before filing this case that benefited any insider

Insider's name and address	Relationship to debtor	Total amount or value	Dates	Reasons for payment or transfer
AMERICAN CENTURY MINERALS LLC 211 NORTH BROADWAY SUITE 2600 ST. LOUIS, MO 63102	Affiliate	$2,153,125.90	12/21/2018 - 10/18/2019	Intercompany Cash Payment on behalf of American Energy Corporation
AMERICAN CENTURY TRANSPORT LLC 211 N BROADWAY, SUITE 2600 ST. LOUIS, MO 63102	Affiliate	$7,913,333.19	12/21/2018 - 10/18/2019	Intercompany Cash Payment on behalf of American Energy Corporation
COAL RESOURCES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$190,800.00	6/6/2019	Intercompany Cash Payment on behalf of Murray Kentucky Energy, Inc.
COALFIELD CONSTRUCTION COMPANY LLC ONE METROPOLITAN SQUARE SUITE 2600 ST LOUIS, MO 63102	Affiliate	$49,822.86	3/1/2019 - 9/20/2019	Intercompany Cash Payment on behalf of Murray Energy Corporation
COALFIELD CONSTRUCTION COMPANY LLC ONE METROPOLITAN SQUARE SUITE 2600 ST LOUIS, MO 63102	Affiliate	$5,738.40	9/20/2019	Intercompany Cash Payment on behalf of UtahAmerican Energy, Inc.
FORESIGHT COAL SALES LLC ONE METROPOLITAN SQUARE SUITE 2600 ST LOUIS, MO 63102	Affiliate	$16,702,250.86	3/22/2019 - 10/18/2019	Intercompany Cash Payment on behalf of American Energy Corporation
FORESIGHT COAL SALES LLC ONE METROPOLITAN SQUARE SUITE 2600 ST LOUIS, MO 63102	Affiliate	$29,592.76	3/22/2019 - 6/20/2019	Intercompany Cash Payment on behalf of KenAmerican Resources, Inc.
FORESIGHT COAL SALES LLC ONE METROPOLITAN SQUARE SUITE 2600 ST LOUIS, MO 63102	Affiliate	$4,622,106.00	3/29/2019	Intercompany Cash Payment on behalf of Murray American Coal, Inc.
FORESIGHT COAL SALES LLC ONE METROPOLITAN SQUARE SUITE 2600 ST LOUIS, MO 63102	Affiliate	$50,443,594.06	11/30/2018 - 10/28/2019	Intercompany Cash Payment on behalf of The American Coal Company
FORESIGHT ENERGY LP WILLIAMSON ENERGY LLC 211 N BROADWAY,SUITE 2600 SAINT LOUIS, MI 63102	Affiliate	$3,769,690.40	9/30/2019	Intercompany Cash Payment on behalf of Murray American Coal, Inc.
FORESIGHT ENERGY LP WILLIAMSON ENERGY LLC 211 N BROADWAY,SUITE 2600 SAINT LOUIS, MI 63102	Affiliate	$66,949.25	3/1/2019 - 10/18/2019	Intercompany Cash Payment on behalf of UtahAmerican Energy, Inc.
FORESIGHT ENERGY SERVICES LLC 211 N BROADWAY STE 2600 ST LOUIS, MO 63101	Affiliate	$3,174,964.28	3/1/2019 - 10/18/2019	Intercompany Cash Payment on behalf of Murray American Coal, Inc.

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Part 2, Question 4: Payments or other transfers of property made within 1 year before filing this case that benefited any insider

Insider's name and address	Relationship to debtor	Total amount or value	Dates	Reasons for payment or transfer
JAVELIN GLOBAL COMMODITIES(UK)LTD MANNING HOUSE 7 HOWICK PLACE LONDON LD SW1P 1BB UNITED KINGDOM	Affiliate	$265,380.24	12/28/2018 - 7/19/2019	Intercompany Cash Payment on behalf of American Energy Corporation
JAVELIN GLOBAL COMMODITIES(UK)LTD MANNING HOUSE 7 HOWICK PLACE LONDON LD SW1P 1BB UNITED KINGDOM	Affiliate	$36,422.05	11/21/2018 - 9/6/2019	Intercompany Cash Payment on behalf of KenAmerican Resources, Inc.
JAVELIN GLOBAL COMMODITIES(UK)LTD MANNING HOUSE 7 HOWICK PLACE LONDON LD SW1P 1BB UNITED KINGDOM	Affiliate	$4,226,544.01	11/15/2018 - 10/18/2019	Intercompany Cash Payment on behalf of Murray American Energy, Inc.
JAVELIN GLOBAL COMMODITIES(UK)LTD MANNING HOUSE 7 HOWICK PLACE LONDON LD SW1P 1BB UNITED KINGDOM	Affiliate	$244,857.80	11/16/2018 - 3/8/2019	Intercompany Cash Payment on behalf of The American Coal Company
JAVELIN GLOBAL COMMODITIES(UK)LTD MANNING HOUSE 7 HOWICK PLACE LONDON LD SW1P 1BB UNITED KINGDOM	Affiliate	$1,900.00	8/16/2019	Intercompany Cash Payment on behalf of The Marion County Coal Company
JAVELIN GLOBAL COMMODITIES(UK)LTD MANNING HOUSE 7 HOWICK PLACE LONDON LD SW1P 1BB UNITED KINGDOM	Affiliate	$28,632.38	8/16/2019 - 10/11/2019	Intercompany Cash Payment on behalf of The Monongalia County Coal Company
JAVELIN GLOBAL COMMODITIES(UK)LTD MANNING HOUSE 7 HOWICK PLACE LONDON LD SW1P 1BB UNITED KINGDOM	Affiliate	$388,430.75	11/5/2018 - 9/6/2019	Intercompany Cash Payment on behalf of UtahAmerican Energy, Inc.
KENAMERICAN RESOURCES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$470.79	8/15/2019	Intercompany Cash Payment on behalf of Western Kentucky Rail Loadout, LLC
MURRAY KENTUCKY ENERGY, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$245,800.00	6/6/2019	Intercompany Cash Payment on behalf of Murray Kentucky Energy Services, Inc.
MURRAY METALLURGICAL COAL PROPERTIES, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$1,000,000.00	10/16/2019	Intercompany Cash Payment on behalf of Murray Energy Corporation

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Part 2, Question 4: Payments or other transfers of property made within 1 year before filing this case that benefited any insider

Insider's name and address	Relationship to debtor	Total amount or value	Dates	Reasons for payment or transfer
OHIO VALLEY RESOURCES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$55,000.00	6/6/2019	Intercompany Cash Payment on behalf of Murray Kentucky Energy, Inc.
THE AMERICAN COAL COMPANY 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$1,054,555.45	11/30/2018	Intercompany Cash Payment on behalf of American Energy Corporation
THE AMERICAN COAL COMPANY 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$3,718,295.50	11/30/2018	Intercompany Cash Payment on behalf of Murray American Coal, Inc.
THE AMERICAN COAL COMPANY 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$1,395,563.07	11/30/2018 - 12/3/2018	Intercompany Cash Payment on behalf of Murray Energy Corporation
THE MUHLENBERG COUNTY COAL COMPANY, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$2,905.21	4/30/2019 - 9/20/2019	Intercompany Cash Payment on behalf of KenAmerican Resources, Inc.
THE MUHLENBERG COUNTY COAL COMPANY, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$132,557.12	1/25/2019 - 9/20/2019	Intercompany Cash Payment on behalf of Murray American Energy, Inc.
THE MUHLENBERG COUNTY COAL COMPANY, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$3,176.12	7/1/2019 - 7/25/2019	Intercompany Cash Payment on behalf of Murray Energy Corporation
THE MUHLENBERG COUNTY COAL COMPANY, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$266.55	6/6/2019	Intercompany Cash Payment on behalf of Murray Equipment & Machine, Inc.
THE WESTERN KENTUCKY COAL COMPANY, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$14,971.92	1/25/2019 - 7/12/2019	Intercompany Cash Payment on behalf of KenAmerican Resources, Inc.
THE WESTERN KENTUCKY COAL COMPANY, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$235,791.55	1/25/2019 - 9/20/2019	Intercompany Cash Payment on behalf of Murray American Energy, Inc.
THE WESTERN KENTUCKY COAL COMPANY, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$270.74	9/20/2019	Intercompany Cash Payment on behalf of Murray Equipment & Machine, Inc.
THOROUGHBRED RESOURCES LP 3033 E 1ST AVE STE 837 DENVER, CO 80206	Affiliate	$1,650,000.00	12/31/2018 - 9/30/2019	Intercompany Cash Payment on behalf of KenAmerican Resources, Inc.
WESTERN KENTUCKY CONSOLIDATED RESOURCES, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$6,280,704.83	4/30/2019 - 9/20/2019	Intercompany Cash Payment on behalf of KenAmerican Resources, Inc.

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Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 4: Payments or other transfers of property made within 1 year before filing this case that benefited any insider

Insider's name and address	Relationship to debtor	Total amount or value	Dates	Reasons for payment or transfer
WESTERN KENTUCKY CONSOLIDATED RESOURCES, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$649.45	6/6/2019 - 9/6/2019	Intercompany Cash Payment on behalf of Murray American Coal, Inc.
WESTERN KENTUCKY CONSOLIDATED RESOURCES, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$264,730.20	6/28/2019	Intercompany Cash Payment on behalf of Murray Energy Corporation
WESTERN KENTUCKY RESOURCES, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$9,940.00	1/25/2019	Intercompany Cash Payment on behalf of Coal Resources, Inc.
WESTERN KENTUCKY RESOURCES, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$280,128.73	1/25/2019 - 9/20/2019	Intercompany Cash Payment on behalf of KenAmerican Resources, Inc.
WESTERN KENTUCKY RESOURCES, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$2,692.93	6/6/2019	Intercompany Cash Payment on behalf of Murray Equipment & Machine, Inc.
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$18,893.78	11/2018	Corporate Plane/Helicopter Administrative Expenses
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$28,054.76	11/2018	Corporate Plane/Helicopter Overhead Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$63,457.50	11/2018	Corporate Plane/Helicopter Payroll Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$135,083.47	11/2018	Corporate Plane/Helicopter Supply Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$25,766.43	12/2018	Corporate Plane/Helicopter Administrative Expenses
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$22,761.71	12/2018	Corporate Plane/Helicopter Overhead Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$108,185.26	12/2018	Corporate Plane/Helicopter Payroll Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$97,329.28	12/2018	Corporate Plane/Helicopter Supply Costs

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 4: Payments or other transfers of property made within 1 year before filing this case that benefited any insider

Insider's name and address	Relationship to debtor	Total amount or value	Dates	Reasons for payment or transfer
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$13,787.59	01/2019	Corporate Plane/Helicopter Administrative Expenses
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$34,608.84	01/2019	Corporate Plane/Helicopter Overhead Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$33,958.85	01/2019	Corporate Plane/Helicopter Payroll Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$149,948.25	01/2019	Corporate Plane/Helicopter Supply Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$35,236.84	02/2019	Corporate Plane/Helicopter Administrative Expenses
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$54,993.50	02/2019	Corporate Plane/Helicopter Overhead Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$76,395.96	02/2019	Corporate Plane/Helicopter Payroll Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$218,797.01	02/2019	Corporate Plane/Helicopter Supply Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$28,754.22	03/2019	Corporate Plane/Helicopter Administrative Expenses
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$21,976.82	03/2019	Corporate Plane/Helicopter Overhead Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$64,857.50	03/2019	Corporate Plane/Helicopter Payroll Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$203,477.01	03/2019	Corporate Plane/Helicopter Supply Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$15,111.28	04/2019	Corporate Plane/Helicopter Administrative Expenses

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 4: Payments or other transfers of property made within 1 year before filing this case that benefited any insider

Insider's name and address	Relationship to debtor	Total amount or value	Dates	Reasons for payment or transfer
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$8,346.39	04/2019	Corporate Plane/Helicopter Overhead Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$64,857.50	04/2019	Corporate Plane/Helicopter Payroll Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$158,964.25	04/2019	Corporate Plane/Helicopter Supply Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$28,485.64	05/2019	Corporate Plane/Helicopter Administrative Expenses
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$20,817.62	05/2019	Corporate Plane/Helicopter Overhead Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$64,857.50	05/2019	Corporate Plane/Helicopter Payroll Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$292,382.06	05/2019	Corporate Plane/Helicopter Supply Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$27,698.86	06/2019	Corporate Plane/Helicopter Administrative Expenses
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$29,776.25	06/2019	Corporate Plane/Helicopter Overhead Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$75,839.56	06/2019	Corporate Plane/Helicopter Payroll Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$159,441.92	06/2019	Corporate Plane/Helicopter Supply Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$28,356.18	07/2019	Corporate Plane/Helicopter Administrative Expenses
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$35,929.79	07/2019	Corporate Plane/Helicopter Overhead Costs

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 4: Payments or other transfers of property made within 1 year before filing this case that benefited any insider

Insider's name and address	Relationship to debtor	Total amount or value	Dates	Reasons for payment or transfer
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$68,516.66	07/2019	Corporate Plane/Helicopter Payroll Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$79,691.36	07/2019	Corporate Plane/Helicopter Supply Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$41,196.27	08/2019	Corporate Plane/Helicopter Administrative Expenses
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$20,672.94	08/2019	Corporate Plane/Helicopter Overhead Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$68,516.66	08/2019	Corporate Plane/Helicopter Payroll Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$150,572.19	08/2019	Corporate Plane/Helicopter Supply Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$45,305.16	09/2019	Corporate Plane/Helicopter Administrative Expenses
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$20,176.92	09/2019	Corporate Plane/Helicopter Overhead Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$70,183.33	09/2019	Corporate Plane/Helicopter Payroll Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$187,652.27	09/2019	Corporate Plane/Helicopter Supply Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$21,675.96	10/2019	Corporate Plane/Helicopter Administrative Expenses
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$20,142.09	10/2019	Corporate Plane/Helicopter Overhead Costs
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$59,350.00	10/2019	Corporate Plane/Helicopter Payroll Costs

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 4: Payments or other transfers of property made within 1 year before filing this case that benefited any insider

Insider's name and address	Relationship to debtor	Total amount or value	Dates	Reasons for payment or transfer
CORPORATE AVIATION SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Affiliate	$116,208.29	10/2019	Corporate Plane/Helicopter Supply Costs
COX, MARK 680 LEGENDS CREST DRIVE FRANKLIN, TN 37069	Director	$50,000.00	10/28/2019	Director Fees
FAYNE, HENRY (ADDRESS ON FILE)	Director	$260,000.00	11/20/2018 - 10/28/2019	Director Fees
HARRISON, JEREMY J. (ADDRESS ON FILE)	Chief Accounting Officer	$337.50	10/31/2018 - 10/25/2019	Group Term Life
HARRISON, JEREMY J. (ADDRESS ON FILE)	Chief Accounting Officer	$370,416.88	10/31/2018 - 10/25/2019	Regular Wages
HARRISON, JEREMY J. (ADDRESS ON FILE)	Chief Accounting Officer	$840.12	11/15/2018 - 10/15/2019	Cell Phone Stipend
HARRISON, JEREMY J. (ADDRESS ON FILE)	Chief Accounting Officer	$14,400.00	11/15/2018 - 10/15/2019	Vehicle Allowance
HARRISON, JEREMY J. (ADDRESS ON FILE)	Chief Accounting Officer	$87,500.00	11/16/2018 - 10/16/2019	Mine Performance Program
HARRISON, JEREMY J. (ADDRESS ON FILE)	Chief Accounting Officer	$7,903.99	11/26/2018 - 10/28/2019	Travel Expenses
HARRISON, JEREMY J. (ADDRESS ON FILE)	Chief Accounting Officer	$3,030.35	12/21/2018 - 10/22/2019	Travel / Expense Reimbursement
HARRISON, JEREMY J. (ADDRESS ON FILE)	Chief Accounting Officer	$24,108.30	01/15/2019	Deferred Comp 2017
HARRISON, JEREMY J. (ADDRESS ON FILE)	Chief Accounting Officer	$37,349.77	01/15/2019	Deferred Comp 2018
HARRISON, JEREMY J. (ADDRESS ON FILE)	Chief Accounting Officer	$32,666.67	01/15/2019	Second Salary Bonus
HARRISON, JEREMY J. (ADDRESS ON FILE)	Chief Accounting Officer	$5,894.29	01/15/2019 - 03/15/2019	401k ER Match
HARRISON, JEREMY J. (ADDRESS ON FILE)	Chief Accounting Officer	$14,134.62	01/31/2019	Vacation Balance Payout
LAWSON, GENERAL RICHARD L. (ADDRESS ON FILE)	Director	$198,000.00	11/20/2018 - 10/28/2019	Director Fees
MCKOWN, MICHAEL O. (ADDRESS ON FILE)	Secretary, SVP Law & Administration	$1,713.66	10/29/2018 - 10/28/2019	Cell Phone Use
MCKOWN, MICHAEL O. (ADDRESS ON FILE)	Secretary, SVP Law & Administration	$14,400.00	11/02/2018 - 10/04/2019	Vehicle Allowance
MCKOWN, MICHAEL O. (ADDRESS ON FILE)	Secretary, SVP Law & Administration	$19,669.18	11/02/2018 - 10/11/2019	Travel / Expense Reimbursement
MCKOWN, MICHAEL O. (ADDRESS ON FILE)	Secretary, SVP Law & Administration	$25,604.65	11/02/2018 - 10/25/2019	401k ER Match
MCKOWN, MICHAEL O. (ADDRESS ON FILE)	Secretary, SVP Law & Administration	$4,747.95	11/02/2018 - 10/25/2019	Group Term Life
MCKOWN, MICHAEL O. (ADDRESS ON FILE)	Secretary, SVP Law & Administration	$548,640.60	11/02/2018 - 10/25/2019	Regular Wages
MCKOWN, MICHAEL O. (ADDRESS ON FILE)	Secretary, SVP Law & Administration	$76,699.40	11/07/2018 - 10/28/2019	Travel Expenses

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 4: Payments or other transfers of property made within 1 year before filing this case that benefited any insider

Insider's name and address	Relationship to debtor	Total amount or value	Dates	Reasons for payment or transfer
MCKOWN, MICHAEL O. (ADDRESS ON FILE)	Secretary, SVP Law & Administration	$96,250.00	11/16/2018 - 10/16/2019	Mine Performance Program
MCKOWN, MICHAEL O. (ADDRESS ON FILE)	Secretary, SVP Law & Administration	$64,253.99	01/15/2019	Deferred Comp 2017
MCKOWN, MICHAEL O. (ADDRESS ON FILE)	Secretary, SVP Law & Administration	$66,979.48	01/15/2019	Deferred Comp 2018
MCKOWN, MICHAEL O. (ADDRESS ON FILE)	Secretary, SVP Law & Administration	$51,500.00	01/15/2019	Second Salary Bonus
MCKOWN, MICHAEL O. (ADDRESS ON FILE)	Secretary, SVP Law & Administration	$29,711.54	01/25/2019	Vacation Balance Payout
MOORE, ROBERT D. (ADDRESS ON FILE)	President, CEO, and CFO	$1,980.83	10/29/2018 - 10/28/2019	Cell Phone Use
MOORE, ROBERT D. (ADDRESS ON FILE)	President, CEO, and CFO	$562.50	10/31/2018 - 10/25/2019	Group Term Life
MOORE, ROBERT D. (ADDRESS ON FILE)	President, CEO, and CFO	$9,791,670.50	10/31/2018 - 10/25/2019	Regular Wages
MOORE, ROBERT D. (ADDRESS ON FILE)	President, CEO, and CFO	$14,400.00	11/15/2018 - 10/15/2019	Vehicle Allowance
MOORE, ROBERT D. (ADDRESS ON FILE)	President, CEO, and CFO	$96,250.00	11/16/2018 - 10/16/2019	Mine Performance Program
MOORE, ROBERT D. (ADDRESS ON FILE)	President, CEO, and CFO	$7,797.80	01/11/2019 - 10/25/2019	Travel / Expense Reimbursement
MOORE, ROBERT D. (ADDRESS ON FILE)	President, CEO, and CFO	$405,789.89	01/15/2019	Deferred Comp 2017
MOORE, ROBERT D. (ADDRESS ON FILE)	President, CEO, and CFO	$666,960.23	01/15/2019	Deferred Comp 2018
MOORE, ROBERT D. (ADDRESS ON FILE)	President, CEO, and CFO	$4,200,000.00	12/28/2018	Retention Bonus
MOORE, ROBERT D. (ADDRESS ON FILE)	President, CEO, and CFO	$13,300.00	01/15/2019	401k ER Match
MURRAY, BRENDA L. (ADDRESS ON FILE)	Assistant to President & Chairman	$52,083.50	10/31/2018 - 10/28/2019	Regular Wages
MURRAY, BRENDA L. (ADDRESS ON FILE)	Assistant to President & Chairman	$6,000.00	09/06/2019	Land Lease
MURRAY, JONATHAN R. (ADDRESS ON FILE)	Asst to the President-MATI	$756.72	10/29/2018 - 10/28/2019	Cell Phone Use
MURRAY, JONATHAN R. (ADDRESS ON FILE)	Asst to the President-MATI	$6,163.75	10/31/2018 - 10/25/2019	401k ER Match
MURRAY, JONATHAN R. (ADDRESS ON FILE)	Asst to the President-MATI	$525.00	10/31/2018 - 10/25/2019	Group Term Life
MURRAY, JONATHAN R. (ADDRESS ON FILE)	Asst to the President-MATI	$205,458.38	10/31/2018 - 10/25/2019	Regular Wages
MURRAY, KELLY (ADDRESS ON FILE)	Spouse of Robert Edward Murray	$714.34	10/29/2018 - 10/28/2019	Cell Phone Use
MURRAY, ROBERT EDWARD (ADDRESS ON FILE)	EVP-Marketing and Sales	$1,567.52	10/29/2018 - 10/28/2019	Cell Phone Use
MURRAY, ROBERT EDWARD (ADDRESS ON FILE)	EVP-Marketing and Sales	$562.50	10/31/2018 - 10/25/2019	Group Term Life
MURRAY, ROBERT EDWARD (ADDRESS ON FILE)	EVP-Marketing and Sales	$505,833.49	10/31/2018 - 10/25/2019	Regular Wages

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 4: Payments or other transfers of property made within 1 year before filing this case that benefited any insider

Insider's name and address	Relationship to debtor	Total amount or value	Dates	Reasons for payment or transfer
MURRAY, ROBERT EDWARD (ADDRESS ON FILE)	EVP-Marketing and Sales	$11,602.89	11/02/2018 - 10/24/2019	Travel Expenses
MURRAY, ROBERT EDWARD (ADDRESS ON FILE)	EVP-Marketing and Sales	$14,400.00	11/15/2018 - 10/15/2019	Vehicle Allowance
MURRAY, ROBERT EDWARD (ADDRESS ON FILE)	EVP-Marketing and Sales	$80,820.88	11/15/2018 - 10/22/2019	Travel / Expense Reimbursement
MURRAY, ROBERT EDWARD (ADDRESS ON FILE)	EVP-Marketing and Sales	$79,442.00	11/16/2018 - 10/16/2019	Mine Performance Program
MURRAY, ROBERT EDWARD (ADDRESS ON FILE)	EVP-Marketing and Sales	$50,049.58	01/15/2019	Deferred Comp 2017
MURRAY, ROBERT EDWARD (ADDRESS ON FILE)	EVP-Marketing and Sales	$53,356.82	01/15/2019	Deferred Comp 2018
MURRAY, ROBERT EDWARD (ADDRESS ON FILE)	EVP-Marketing and Sales	$48,000.00	01/15/2019	Second Salary Bonus
MURRAY, ROBERT EDWARD (ADDRESS ON FILE)	EVP-Marketing and Sales	$7,252.11	01/15/2019 - 02/20/2019	401k ER Match
MURRAY, ROBERT EDWARD (ADDRESS ON FILE)	EVP-Marketing and Sales	$9,230.77	01/31/2019	Vacation Balance Payout
MURRAY, ROBERT EDWARD (ADDRESS ON FILE)	EVP-Marketing and Sales	$4,000.00	02/01/2019	Sold ATV to company
MURRAY, ROBERT EUGENE (ADDRESS ON FILE)	Chairman of the Board-Murray Energy Corporation	$9,716.52	10/29/2018 - 10/28/2019	Country Club Membership
MURRAY, ROBERT EUGENE (ADDRESS ON FILE)	Chairman of the Board-Murray Energy Corporation	$3,954.27	10/29/2018 - 10/28/2019	Frontier Internet/Television
MURRAY, ROBERT EUGENE (ADDRESS ON FILE)	Chairman of the Board-Murray Energy Corporation	$301.59	10/29/2018 - 10/28/2019	Home Office Expenses
MURRAY, ROBERT EUGENE (ADDRESS ON FILE)	Chairman of the Board-Murray Energy Corporation	$2,702.73	10/29/2018 - 10/28/2019	Cell Phone Use
MURRAY, ROBERT EUGENE (ADDRESS ON FILE)	Chairman of the Board-Murray Energy Corporation	$83,289.97	10/31/2018 - 10/25/2019	Travel / Expense Reimbursement
MURRAY, ROBERT EUGENE (ADDRESS ON FILE)	Chairman of the Board-Murray Energy Corporation	$26,452.50	10/31/2018 - 10/28/2019	Wildlife Investigation related to private residence
MURRAY, ROBERT EUGENE (ADDRESS ON FILE)	Chairman of the Board-Murray Energy Corporation	$14,062,500.00	10/31/2018 - 10/28/2019	Regular Wages
MURRAY, ROBERT EUGENE (ADDRESS ON FILE)	Chairman of the Board-Murray Energy Corporation	$15,000.00	10/31/2018 - 10/28/2019	Vehicle Allowance
MURRAY, ROBERT EUGENE (ADDRESS ON FILE)	Chairman of the Board-Murray Energy Corporation	$12,371.73	11/01/2018 - 10/01/2019	Comcast Internet/Television
MURRAY, ROBERT EUGENE (ADDRESS ON FILE)	Chairman of the Board-Murray Energy Corporation	$3,631.47	11/02/2018 - 10/11/2019	Car Service
MURRAY, ROBERT EUGENE (ADDRESS ON FILE)	Chairman of the Board-Murray Energy Corporation	$2,091.38	11/08/2018	Cemetery Landscaping
MURRAY, ROBERT EUGENE (ADDRESS ON FILE)	Chairman of the Board-Murray Energy Corporation	$1,137,500.00	12/31/2018 - 03/29/2019	Interest on note
MURRAY, ROBERT EUGENE (ADDRESS ON FILE)	Chairman of the Board-Murray Energy Corporation	$700.00	01/14/2019	Cottage Expenses
MURRAY, RYAN M. (ADDRESS ON FILE)	Vice President-Operations	$1,148.82	10/29/2018 - 10/28/2019	Cell Phone Use
MURRAY, RYAN M. (ADDRESS ON FILE)	Vice President-Operations	$375.00	10/31/2018 - 10/25/2019	Group Term Life

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 4: Payments or other transfers of property made within 1 year before filing this case that benefited any insider

Insider's name and address	Relationship to debtor	Total amount or value	Dates	Reasons for payment or transfer
MURRAY, RYAN M. (ADDRESS ON FILE)	Vice President-Operations	$629,229.50	10/31/2018 - 10/25/2019	Regular Wages
MURRAY, RYAN M. (ADDRESS ON FILE)	Vice President-Operations	$85,978.24	11/08/2018 - 09/06/2019	Travel / Expense Reimbursement
MURRAY, RYAN M. (ADDRESS ON FILE)	Vice President-Operations	$14,400.00	11/15/2018 - 10/15/2019	Vehicle Allowance
MURRAY, RYAN M. (ADDRESS ON FILE)	Vice President-Operations	$96,250.00	11/16/2018 - 10/16/2019	Mine Performance Program
MURRAY, RYAN M. (ADDRESS ON FILE)	Vice President-Operations	$62,563.09	01/15/2019	Deferred Comp 2017
MURRAY, RYAN M. (ADDRESS ON FILE)	Vice President-Operations	$65,262.06	01/15/2019	Deferred Comp 2018
MURRAY, RYAN M. (ADDRESS ON FILE)	Vice President-Operations	$59,650.00	01/15/2019	Second Salary Bonus
MURRAY, RYAN M. (ADDRESS ON FILE)	Vice President-Operations	$9,500.02	01/15/2019 - 03/15/2019	401k ER Match
PICCOLINI, PAUL B. (ADDRESS ON FILE)	V.P. Human Resources and Employee Relations	$2,430.51	10/29/2018 - 10/28/2019	Cell Phone Use
PICCOLINI, PAUL B. (ADDRESS ON FILE)	V.P. Human Resources and Employee Relations	$433,562.62	10/31/2018 - 10/25/2019	Regular Wages
PICCOLINI, PAUL B. (ADDRESS ON FILE)	V.P. Human Resources and Employee Relations	$2,543.53	11/09/2018 - 10/25/2019	Travel / Expense Reimbursement
PICCOLINI, PAUL B. (ADDRESS ON FILE)	V.P. Human Resources and Employee Relations	$14,400.00	11/15/2018 - 10/15/2019	Vehicle Allowance
PICCOLINI, PAUL B. (ADDRESS ON FILE)	V.P. Human Resources and Employee Relations	$87,626.00	11/16/2018 - 10/16/2019	Mine Performance Program
PICCOLINI, PAUL B. (ADDRESS ON FILE)	V.P. Human Resources and Employee Relations	$7,640.03	12/19/2018 - 10/05/2019	Travel Expenses
PICCOLINI, PAUL B. (ADDRESS ON FILE)	V.P. Human Resources and Employee Relations	$47,345.24	01/15/2019	Deferred Comp 2017
PICCOLINI, PAUL B. (ADDRESS ON FILE)	V.P. Human Resources and Employee Relations	$48,093.84	01/15/2019	Deferred Comp 2018
PICCOLINI, PAUL B. (ADDRESS ON FILE)	V.P. Human Resources and Employee Relations	$36,050.00	01/15/2019	Second Salary Bonus
PICCOLINI, PAUL B. (ADDRESS ON FILE)	V.P. Human Resources and Employee Relations	$2,475.00	01/15/2019	Group Term Life
PICCOLINI, PAUL B. (ADDRESS ON FILE)	V.P. Human Resources and Employee Relations	$7,013.40	01/15/2019 - 03/15/2019	401k ER Match
PICCOLINI, PAUL B. (ADDRESS ON FILE)	V.P. Human Resources and Employee Relations	$11,785.58	01/31/2019	Vacation Balance Payout
TURNER JR., JAMES R. (ADDRESS ON FILE)	Senior Vice President	$3,392.86	10/29/2018 - 10/28/2019	Cell Phone Use
TURNER JR., JAMES R. (ADDRESS ON FILE)	Senior Vice President	$375.00	10/31/2018 - 10/25/2019	Group Term Life
TURNER JR., JAMES R. (ADDRESS ON FILE)	Senior Vice President	$577,542.00	10/31/2018 - 10/25/2019	Regular Wages
TURNER JR., JAMES R. (ADDRESS ON FILE)	Senior Vice President	$14,400.00	11/15/2018 - 10/15/2019	Vehicle Allowance
TURNER JR., JAMES R. (ADDRESS ON FILE)	Senior Vice President	$9,941.50	11/15/2018 - 10/22/2019	Travel / Expense Reimbursement

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 2, Question 4: Payments or other transfers of property made within 1 year before filing this case that benefited any insider

Insider's name and address	Relationship to debtor	Total amount or value	Dates	Reasons for payment or transfer
TURNER JR., JAMES R. (ADDRESS ON FILE)	Senior Vice President	$96,250.00	11/16/2018 - 10/16/2019	Mine Performance Program
TURNER JR., JAMES R. (ADDRESS ON FILE)	Senior Vice President	$24,172.33	12/03/2018 - 10/02/2019	Travel Expenses
TURNER JR., JAMES R. (ADDRESS ON FILE)	Senior Vice President	$55,054.72	01/15/2019	Deferred Comp 2017
TURNER JR., JAMES R. (ADDRESS ON FILE)	Senior Vice President	$60,193.16	01/15/2019	Deferred Comp 2018
TURNER JR., JAMES R. (ADDRESS ON FILE)	Senior Vice President	$54,100.00	01/15/2019	Second Salary Bonus
TURNER JR., JAMES R. (ADDRESS ON FILE)	Senior Vice President	$5,792.69	01/15/2019	401k ER Match
TURNER JR., JAMES R. (ADDRESS ON FILE)	Senior Vice President	$8,323.08	01/31/2019	Vacation Balance Payout

MURRAY ENERGY HOLDINGS CO., et al.
Case No. 19-56885 (JEH)

Part 2, Question 4: Payments or other transfer of property made within 1 year before filing this case that benefited any insider

Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
Amcoal Holdings, Inc.	Murray Energy Corporation	$5,225	$5,225	$0
Amcoal Holdings, Inc.	The American Coal Company	43,572,318	44,809,818	1,237,500
Amcoal Holdings, Inc.	The American Coal Sales Company	(43,572,318)	(44,697,318)	(1,125,000)
American Compliance Coal, Inc.	Murray Energy Corporation	607,558	607,558	0
American Energy Corporation	American Equipment & Machine, Inc.	(3,741,151)	(5,628,592)	(1,887,441)
American Energy Corporation	American Mine Services, Inc.	(5,294,070)	(12,574,047)	(7,279,978)
American Energy Corporation	American Natural Gas, Inc.	(44,359)	(73,869)	(29,510)
American Energy Corporation	Anchor Longwall & Rebuild, Inc.	(982,228)	(1,402,134)	(419,906)
American Energy Corporation	Canterbury Coal Company	(2,100)	(2,100)	0
American Energy Corporation	Chagrin Executive Office, L.L.C.	(1,042)	(1,042)	0
American Energy Corporation	Coal Resources, Inc.	33,663,571	63,124,907	29,461,336
American Energy Corporation	Corporate Aviation Services, Inc.	(720,534)	(885,185)	(164,652)
American Energy Corporation	Foresight Energy, LP and subsidiaries	0	(65,277,311)	(65,277,311)
American Energy Corporation	Javelin Global Commodities	6,771,328	20,354	(6,750,974)
American Energy Corporation	Kanawha Transportation Center, Inc.	72,378	108,323	35,945
American Energy Corporation	KenAmerican Resources, Inc.	866,517	787,915	(78,602)
American Energy Corporation	Maple Creek Mining, Inc.	(107,085)	(107,085)	0
American Energy Corporation	MonValley Transportation Center, Inc.	(985,977)	3,015,585	4,001,562
American Energy Corporation	Murray American Coal Inc.	(2,057,355)	(2,406,596)	(349,241)
American Energy Corporation	Murray American Energy, Inc.	(2,753,392)	(2,023,283)	730,110
American Energy Corporation	Murray American River Towing, Inc.	(201,280)	(248,326)	(47,046)
American Energy Corporation	Murray American Transportation, Inc.	0	1,947	1,947
American Energy Corporation	Murray Energy Corporation	1,254,985,498	1,948,315,234	693,329,735
American Energy Corporation	Murray Equipment & Machine, Inc.	(157,202)	(1,971,196)	(1,813,994)
American Energy Corporation	Murray Keystone Processing, Inc.	(127,258)	(127,258)	0
American Energy Corporation	Murray Maple Eagle Coal, LLC.	0	1,466,852	1,466,852
American Energy Corporation	Murray Oak Grove Coal, LLC.	0	791	791
American Energy Corporation	Murray South America, Inc.	592,028	592,028	0
American Energy Corporation	Ohio Valley Resources, Inc.	(2,922,098)	(5,333,776)	(2,411,678)
American Energy Corporation	OhioAmerican Energy, Inc.	3,021,552	3,329,400	307,847
American Energy Corporation	TDK Coal Sales, Inc.	(17,411)	(17,411)	0
American Energy Corporation	The American Coal Company	(18,506,415)	(20,457,810)	(1,951,395)
American Energy Corporation	The American Coal Sales Company	(33,245,237)	(49,844,055)	(16,598,818)
American Energy Corporation	The Harrison County Coal Company	(9,430)	(1,500,058)	(1,490,628)
American Energy Corporation	The Marion County Coal Company	(2,045,645)	(80,030,656)	(77,985,011)
American Energy Corporation	The Marshall County Coal Company	(396,315,942)	(684,755,600)	(288,439,658)
American Energy Corporation	The Monongalia County Coal Company	37,791	(73,652,178)	(73,689,968)
American Energy Corporation	The Ohio County Coal Company	(157,408,421)	(390,001,084)	(232,592,663)
American Energy Corporation	The Ohio Valley Coal Company	(10,684,134)	(25,668,997)	(14,984,863)
American Energy Corporation	The Ohio Valley Transloading Co.	(79,994)	(224,754)	(144,760)
American Energy Corporation	The Washington County Coal Company	252	252	0
American Energy Corporation	Umco Energy, Inc.	(117,607)	(117,607)	0
American Energy Corporation	UtahAmerican Energy, Inc.	6,481	25,293	18,812
American Energy Corporation	West Virginia Resources, Inc.	(156,192)	(156,192)	0
American Equipment & Machine, Inc.	American Energy Corporation	3,741,151	5,628,592	1,887,441
American Equipment & Machine, Inc.	American Mine Services, Inc.	2,388,307	2,717,628	329,321
American Equipment & Machine, Inc.	Anchor Longwall & Rebuild, Inc.	(3,589)	(3,589)	0
American Equipment & Machine, Inc.	Coal Resources, Inc.	(43,549)	262,987	306,536
American Equipment & Machine, Inc.	Foresight Energy, LP and subsidiaries	121,111	58,620	(62,491)
American Equipment & Machine, Inc.	Kanawha Transportation Center, Inc.	0	0	0
American Equipment & Machine, Inc.	KenAmerican Resources, Inc.	503,923	523,437	19,515
American Equipment & Machine, Inc.	MonValley Transportation Center, Inc.	0	73	73
American Equipment & Machine, Inc.	Murray American Coal Inc.	454	1,230	776
American Equipment & Machine, Inc.	Murray American Energy, Inc.	(140,099)	(203,760)	(63,661)
American Equipment & Machine, Inc.	Murray Energy Corporation	(95,581,097)	(118,983,025)	(23,401,927)
American Equipment & Machine, Inc.	Murray Equipment & Machine, Inc.	960,595	1,016,299	55,705
American Equipment & Machine, Inc.	Murray Oak Grove Coal, LLC.	0	838,735	838,735
American Equipment & Machine, Inc.	The American Coal Company	853,030	853,846	816
American Equipment & Machine, Inc.	The American Coal Sales Company	0	(154)	(154)
American Equipment & Machine, Inc.	The Franklin County Coal Company	7,571	7,571	0
American Equipment & Machine, Inc.	The Harrison County Coal Company	1,325,677	2,987,235	1,661,557
American Equipment & Machine, Inc.	The Marion County Coal Company	6,473,473	8,019,036	1,545,563

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Part 2, Question 4: Payments or other transfer of property made within 1 year before filing this case that benefited any insider

Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
American Equipment & Machine, Inc.	The Marshall County Coal Company	6,170,503	7,823,790	1,653,287
American Equipment & Machine, Inc.	The Monongalia County Coal Company	3,160,497	4,479,850	1,319,352
American Equipment & Machine, Inc.	The Ohio County Coal Company	4,417,479	13,362,893	8,945,414
American Equipment & Machine, Inc.	The Ohio Valley Coal Company	224	224	0
American Equipment & Machine, Inc.	UtahAmerican Energy, Inc.	3,054,187	8,429,387	5,375,200
American Mine Services, Inc.	American Energy Corporation	5,294,070	12,574,047	7,279,978
American Mine Services, Inc.	American Equipment & Machine, Inc.	(2,388,307)	(2,717,628)	(329,321)
American Mine Services, Inc.	American Natural Gas, Inc.	(1,033)	(3,825)	(2,792)
American Mine Services, Inc.	Anchor Longwall & Rebuild, Inc.	(217,644)	(337,287)	(119,642)
American Mine Services, Inc.	Coal Resources, Inc.	967,310	2,436,351	1,469,041
American Mine Services, Inc.	Foresight Energy, LP and subsidiaries	18,141	0	(18,141)
American Mine Services, Inc.	KenAmerican Resources, Inc.	40	40	0
American Mine Services, Inc.	MonValley Transportation Center, Inc.	(990,640)	(1,838,928)	(848,288)
American Mine Services, Inc.	Murray American Energy, Inc.	(38,902)	(39,622)	(720)
American Mine Services, Inc.	Murray Energy Corporation	(13,959,507)	(25,341,613)	(11,382,105)
American Mine Services, Inc.	Murray Oak Grove Coal, LLC.	0	560,573	560,573
American Mine Services, Inc.	Ohio Energy Transportation, Inc.	(15,183)	(15,183)	0
American Mine Services, Inc.	Pleasant Farms, Inc.	(1,915)	(5,689)	(3,774)
American Mine Services, Inc.	The American Coal Company	421,308	421,308	0
American Mine Services, Inc.	The Harrison County Coal Company	523,461	898,873	375,413
American Mine Services, Inc.	The Marion County Coal Company	1,591,346	6,704,617	5,113,271
American Mine Services, Inc.	The Marshall County Coal Company	3,500,302	4,632,800	1,132,497
American Mine Services, Inc.	The Monongalia County Coal Company	1,265,345	2,023,513	758,169
American Mine Services, Inc.	The Ohio County Coal Company	948,052	1,590,926	642,874
American Mine Services, Inc.	The Ohio Valley Coal Company	(43,891)	(106,371)	(62,480)
American Mine Services, Inc.	UtahAmerican Energy, Inc.	74,570	273,854	199,284
American Natural Gas, Inc.	American Energy Corporation	44,359	73,869	29,510
American Natural Gas, Inc.	American Mine Services, Inc.	1,033	3,825	2,792
American Natural Gas, Inc.	Anchor Longwall & Rebuild, Inc.	191	512	321
American Natural Gas, Inc.	Coal Resources, Inc.	(275,929)	(530,435)	(254,505)
American Natural Gas, Inc.	Kanawha Transportation Center, Inc.	(34)	(34)	0
American Natural Gas, Inc.	Murray American Energy, Inc.	(16,404)	(16,617)	(214)
American Natural Gas, Inc.	Murray Energy Corporation	(22,617,924)	(23,358,273)	(740,348)
American Natural Gas, Inc.	Pleasant Farms, Inc.	12,270	12,435	165
American Natural Gas, Inc.	The American Coal Sales Company	(339)	(339)	0
American Natural Gas, Inc.	The Ohio Valley Coal Company	(822)	(2,265)	(1,443)
American Natural Gas, Inc.	The Washington County Coal Company	(45)	(45)	0
AmericanHocking Energy, Inc.	Murray Energy Corporation	(3,372,323)	(3,390,301)	(17,978)
AmericanMountaineer Energy, Inc.	AmericanMountaineer Properties, Inc.	2,000,000	2,000,000	0
AmericanMountaineer Energy, Inc.	Coal Resources, Inc.	(115,630)	(136,046)	(20,416)
AmericanMountaineer Energy, Inc.	Energy Resources, Inc.	0	168	168
AmericanMountaineer Energy, Inc.	Murray American Energy, Inc.	(8,886)	(10,086)	(1,200)
AmericanMountaineer Energy, Inc.	Murray American River Towing, Inc.	0	39,472	39,472
AmericanMountaineer Energy, Inc.	Murray Energy Corporation	(34,673,467)	(35,508,391)	(834,925)
AmericanMountaineer Energy, Inc.	OhioAmerican Energy, Inc.	0	1,800	1,800
AmericanMountaineer Energy, Inc.	The American Coal Company	301,958	297,662	(4,296)
AmericanMountaineer Energy, Inc.	The American Coal Sales Company	0	1,007	1,007
AmericanMountaineer Energy, Inc.	The Marshall County Coal Company	(819)	(819)	0
AmericanMountaineer Energy, Inc.	The Ohio Valley Coal Company	0	397	397
AmericanMountaineer Properties, Inc.	AmericanMountaineer Energy, Inc.	(2,000,000)	(2,000,000)	0
AmericanMountaineer Properties, Inc.	Murray American Energy, Inc.	0	(7,671,000)	(7,671,000)
AmericanMountaineer Properties, Inc.	Murray Energy Corporation	(41,642,710)	(41,642,710)	0
Anchor Longwall & Rebuild, Inc.	American Energy Corporation	982,228	1,402,134	419,906
Anchor Longwall & Rebuild, Inc.	American Equipment & Machine, Inc.	3,589	3,589	0
Anchor Longwall & Rebuild, Inc.	American Mine Services, Inc.	217,644	337,287	119,642
Anchor Longwall & Rebuild, Inc.	American Natural Gas, Inc.	(191)	(512)	(321)
Anchor Longwall & Rebuild, Inc.	Canterbury Coal Company	18,219	31,128	12,909
Anchor Longwall & Rebuild, Inc.	Coal Resources, Inc.	(65,760,045)	(72,362,121)	(6,602,076)
Anchor Longwall & Rebuild, Inc.	Corporate Aviation Services, Inc.	(250)	(34,522)	(34,272)
Anchor Longwall & Rebuild, Inc.	Foresight Energy, LP and subsidiaries	0	6,190	6,190
Anchor Longwall & Rebuild, Inc.	Kanawha Transportation Center, Inc.	(1,960,567)	(1,960,376)	191
Anchor Longwall & Rebuild, Inc.	KenAmerican Resources, Inc.	1,594,508	1,630,648	36,140

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Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
Anchor Longwall & Rebuild, Inc.	Maple Creek Mining, Inc.	84,873	91,661	6,788
Anchor Longwall & Rebuild, Inc.	MonValley Transportation Center, Inc.	19,654,526	33,258,635	13,604,108
Anchor Longwall & Rebuild, Inc.	Murray American Energy, Inc.	(37,235)	350,020	387,255
Anchor Longwall & Rebuild, Inc.	Murray Energy Corporation	(28,474,456)	(57,426,257)	(28,951,801)
Anchor Longwall & Rebuild, Inc.	Murray Equipment & Machine, Inc.	8,674	8,674	0
Anchor Longwall & Rebuild, Inc.	Murray Keystone Processing, Inc.	2,066	2,054	(12)
Anchor Longwall & Rebuild, Inc.	Murray Maple Eagle Coal, LLC.	0	695,614	695,614
Anchor Longwall & Rebuild, Inc.	Murray Oak Grove Coal, LLC.	0	228,146	228,146
Anchor Longwall & Rebuild, Inc.	Ohio Energy Transportation, Inc.	(647,431)	(1,025,906)	(378,475)
Anchor Longwall & Rebuild, Inc.	OhioAmerican Energy, Inc.	518,191	710,969	192,778
Anchor Longwall & Rebuild, Inc.	Pleasant Farms, Inc.	32,248	35,001	2,753
Anchor Longwall & Rebuild, Inc.	The American Coal Company	26,547	24,367	(2,181)
Anchor Longwall & Rebuild, Inc.	The Franklin County Coal Company	132,568	194,733	62,165
Anchor Longwall & Rebuild, Inc.	The Harrison County Coal Company	3,724,506	5,885,445	2,160,939
Anchor Longwall & Rebuild, Inc.	The Marion County Coal Company	5,168,485	6,927,912	1,759,426
Anchor Longwall & Rebuild, Inc.	The Marshall County Coal Company	16,199,358	26,987,738	10,788,380
Anchor Longwall & Rebuild, Inc.	The Monongalia County Coal Company	6,369,491	10,096,363	3,726,872
Anchor Longwall & Rebuild, Inc.	The Ohio County Coal Company	8,397,041	13,155,809	4,758,768
Anchor Longwall & Rebuild, Inc.	The Ohio Valley Coal Company	468,453	411,094	(57,360)
Anchor Longwall & Rebuild, Inc.	The Ohio Valley Transloading Co.	177,388	199,804	22,416
Anchor Longwall & Rebuild, Inc.	The Washington County Coal Company	376,109	838,607	462,498
Anchor Longwall & Rebuild, Inc.	UtahAmerican Energy, Inc.	6,614	7,915	1,301
Anchor Longwall & Rebuild, Inc.	West Virginia Resources, Inc.	(105,764)	(163,453)	(57,689)
Andalex Resources, Inc.	Coal Resources, Inc.	(236)	(236)	0
Andalex Resources, Inc.	Genwal Resources, Inc.	2,637,473	2,637,473	0
Andalex Resources, Inc.	McLean County Coal Company	79,941	89,941	10,000
Andalex Resources, Inc.	Murray American Energy, Inc.	(30)	(30)	0
Andalex Resources, Inc.	Murray Energy Corporation	(7,005,163)	(5,963,856)	1,041,307
Andalex Resources, Inc.	The American Coal Company	2,605,632	2,592,111	(13,521)
Andalex Resources, Inc.	UtahAmerican Energy, Inc.	5,827,231	4,165,981	(1,661,250)
Andalex Resources, Inc.	West Ridge Resources, Inc.	(1,986)	(1,986)	0
Avonmore Rail Loading, Inc.	Coal Resources, Inc.	(1,650,300)	(1,650,300)	0
Avonmore Rail Loading, Inc.	Murray Energy Corporation	230,000	230,000	0
Belmont Coal, Inc.	Murray Energy Corporation	(580,974)	(584,318)	(3,343)
Belmont County Broadcast Studio, Inc.	Murray Energy Corporation	7,768	7,537	(231)
Canterbury Coal Company	American Energy Corporation	2,100	2,100	0
Canterbury Coal Company	Anchor Longwall & Rebuild, Inc.	(18,219)	(31,128)	(12,909)
Canterbury Coal Company	Coal Resources, Inc.	(40,056,048)	(40,268,932)	(212,884)
Canterbury Coal Company	Foresight Energy, LP and subsidiaries	0	10,388	10,388
Canterbury Coal Company	Maple Creek Mining, Inc.	936	936	0
Canterbury Coal Company	MonValley Transportation Center, Inc.	(130)	(130)	0
Canterbury Coal Company	Murray Energy Corporation	(4,437,857)	(5,192,309)	(754,452)
Canterbury Coal Company	Murray Keystone Processing, Inc.	7,780	7,780	0
Canterbury Coal Company	The Washington County Coal Company	1,330	1,330	0
Canterbury Coal Company	West Virginia Resources, Inc.	(260)	(260)	0
Coal Resources, Inc.	American Energy Corporation	(33,663,571)	(63,124,907)	(29,461,336)
Coal Resources, Inc.	American Equipment & Machine, Inc.	43,549	(262,987)	(306,536)
Coal Resources, Inc.	American Mine Services, Inc.	(967,310)	(2,436,351)	(1,469,041)
Coal Resources, Inc.	American Natural Gas, Inc.	275,929	530,435	254,505
Coal Resources, Inc.	AmericanMountaineer Energy, Inc.	115,630	136,046	20,416
Coal Resources, Inc.	Anchor Longwall & Rebuild, Inc.	65,760,045	72,362,121	6,602,076
Coal Resources, Inc.	Andalex Resources, Inc.	236	236	0
Coal Resources, Inc.	Avonmore Rail Loading, Inc.	1,650,300	1,650,300	0
Coal Resources, Inc.	Canterbury Coal Company	40,056,048	40,268,932	212,884
Coal Resources, Inc.	Chagrin Executive Office, L.L.C.	11,934	18,275	6,341
Coal Resources, Inc.	Corporate Aviation Services, Inc.	10,844,853	11,963,980	1,119,127
Coal Resources, Inc.	Empire Dock, Inc.	112	112	0
Coal Resources, Inc.	Energy Resources, Inc.	(4,887,137)	(4,864,952)	22,185
Coal Resources, Inc.	Genwal Resources, Inc.	165	165	0
Coal Resources, Inc.	Kanawha Transportation Center, Inc.	123,385	207,636	84,251
Coal Resources, Inc.	KenAmerican Resources, Inc.	17,400,589	26,657,254	9,256,665
Coal Resources, Inc.	Maple Creek Mining, Inc.	342,975	516,019	173,044

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Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
Coal Resources, Inc.	McLean County Coal Company	20,000	20,000	0
Coal Resources, Inc.	Mill Creek Mining Company	17,394,776	17,394,776	0
Coal Resources, Inc.	MonValley Transportation Center, Inc.	452,688	825,151	372,463
Coal Resources, Inc.	Murray American Coal Inc.	10,442,451	17,570,488	7,128,037
Coal Resources, Inc.	Murray American Energy, Inc.	(2,858,487)	(5,058,557)	(2,200,070)
Coal Resources, Inc.	Murray American River Towing, Inc.	480,220	776,883	296,663
Coal Resources, Inc.	Murray American Transportation, Inc.	375,830	613,068	237,238
Coal Resources, Inc.	Murray Columbian Resources, Inc.	667	667	0
Coal Resources, Inc.	Murray Energy Corporation	(242,303,227)	(272,247,222)	(29,943,994)
Coal Resources, Inc.	Murray Equipment & Machine, Inc.	454,221	585,994	131,773
Coal Resources, Inc.	Murray Kentucky Energy Services, Inc.	22,309	742,054	719,745
Coal Resources, Inc.	Murray Keystone Processing, Inc.	132,875	195,133	62,258
Coal Resources, Inc.	Murray Maple Eagle Coal, LLC.	0	25,186	25,186
Coal Resources, Inc.	Murray Metallurgical Coal Holdings, LLC.	0	(30,735)	(30,735)
Coal Resources, Inc.	Murray Oak Grove Coal, LLC.	0	49,406	49,406
Coal Resources, Inc.	Murray South America, Inc.	3,960,501	5,793,333	1,832,832
Coal Resources, Inc.	Ohio Energy Transportation, Inc.	89,200	145,441	56,241
Coal Resources, Inc.	Ohio Valley Resources, Inc.	0	470	470
Coal Resources, Inc.	OhioAmerican Energy, Inc.	523,346	820,332	296,986
Coal Resources, Inc.	PennAmerica Coal, Inc.	(760,800)	(760,800)	0
Coal Resources, Inc.	PennAmerican Coal, L.P.	27,577,054	27,577,134	80
Coal Resources, Inc.	Pleasant Farms, Inc.	1,961,594	1,921,685	(39,908)
Coal Resources, Inc.	Spring Church Coal Company	(410,634)	(410,609)	26
Coal Resources, Inc.	TDK Coal Sales, Inc.	(17,335)	(17,335)	0
Coal Resources, Inc.	The American Coal Company	2,186,017	2,175,698	(10,319)
Coal Resources, Inc.	The American Coal Sales Company	34,849,384	39,236,417	4,387,033
Coal Resources, Inc.	The Franklin County Coal Company	67,074	122,583	55,509
Coal Resources, Inc.	The Harrison County Coal Company	4,295,756	7,482,057	3,186,301
Coal Resources, Inc.	The Marion County Coal Company	14,853,204	21,654,794	6,801,590
Coal Resources, Inc.	The Marshall County Coal Company	11,950,735	20,541,250	8,590,515
Coal Resources, Inc.	The Meigs County Coal Company	968	968	0
Coal Resources, Inc.	The Monongalia County Coal Company	11,528,769	16,174,642	4,645,873
Coal Resources, Inc.	The Muhlenberg County Coal Company, LLC	5,046	4,357	(688)
Coal Resources, Inc.	The Ohio County Coal Company	8,382,754	14,421,751	6,038,996
Coal Resources, Inc.	The Ohio Valley Coal Company	(61,515,601)	(65,591,676)	(4,076,075)
Coal Resources, Inc.	The Ohio Valley Transloading Co.	1,070,384	1,642,675	572,290
Coal Resources, Inc.	The Oklahoma Coal Company	525,627	493,732	(31,895)
Coal Resources, Inc.	The Washington County Coal Company	80,977	89,187	8,209
Coal Resources, Inc.	The Western Kentucky Coal Company, LLC	6,212	7,974	1,762
Coal Resources, Inc.	Umco Energy, Inc.	42	42	0
Coal Resources, Inc.	UtahAmerican Energy, Inc.	3,104,873	5,268,489	2,163,616
Coal Resources, Inc.	West Ridge Resources, Inc.	48,216	82,716	34,500
Coal Resources, Inc.	West Virginia Resources, Inc.	21,047,483	21,056,425	8,943
Coal Resources, Inc.	Western Kentucky Resources, LLC.	36,244	0	(36,244)
Consolidated Land Company	Murray Energy Corporation	(10,067,031)	(10,196,352)	(129,321)
Consolidated Land Company	The American Coal Sales Company	0	35,042	35,042
Corporate Aviation Services, Inc.	American Energy Corporation	720,534	885,185	164,652
Corporate Aviation Services, Inc.	Anchor Longwall & Rebuild, Inc.	250	34,522	34,272
Corporate Aviation Services, Inc.	Coal Resources, Inc.	(10,844,853)	(11,963,980)	(1,119,127)
Corporate Aviation Services, Inc.	KenAmerican Resources, Inc.	74,527	191,437	116,910
Corporate Aviation Services, Inc.	Maple Creek Mining, Inc.	62,534	62,534	0
Corporate Aviation Services, Inc.	Murray American Coal Inc.	6,954,675	8,050,672	1,095,997
Corporate Aviation Services, Inc.	Murray American Energy, Inc.	(4,129)	(3,986)	143
Corporate Aviation Services, Inc.	Murray Energy Corporation	(8,227,909)	(8,835,238)	(607,329)
Corporate Aviation Services, Inc.	Murray Kentucky Energy Services, Inc.	201,695	557,742	356,047
Corporate Aviation Services, Inc.	Murray South America, Inc.	1,235	1,235	0
Corporate Aviation Services, Inc.	The American Coal Company	11,499	11,499	0
Corporate Aviation Services, Inc.	The American Coal Sales Company	(6,245)	(6,550)	(306)
Corporate Aviation Services, Inc.	The Harrison County Coal Company	908,350	1,179,721	271,372
Corporate Aviation Services, Inc.	The Marion County Coal Company	493,690	743,928	250,238
Corporate Aviation Services, Inc.	The Marshall County Coal Company	1,183,837	1,633,924	450,087
Corporate Aviation Services, Inc.	The Monongalia County Coal Company	374,902	608,849	233,947

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Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
Corporate Aviation Services, Inc.	The Ohio County Coal Company	702,320	974,548	272,228
Corporate Aviation Services, Inc.	The Ohio Valley Coal Company	1,600	264	(1,336)
Corporate Aviation Services, Inc.	UtahAmerican Energy, Inc.	650,536	650,536	0
Empire Dock, Inc.	Coal Resources, Inc.	(112)	(112)	0
Empire Dock, Inc.	Murray American Energy, Inc.	(24)	(67)	(42)
Empire Dock, Inc.	Murray Energy Corporation	(6,639,447)	(7,131,223)	(491,776)
Empire Dock, Inc.	Ohio Energy Transportation, Inc.	(362,792)	(362,792)	0
Empire Dock, Inc.	The American Coal Company	(2,585)	(2,585)	0
Empire Dock, Inc.	The Franklin County Coal Company	0	0	0
Empire Dock, Inc.	The Ohio Valley Coal Company	(2)	(2)	0
Energy Resources, Inc.	AmericanMountaineer Energy, Inc.	0	(168)	(168)
Energy Resources, Inc.	Coal Resources, Inc.	4,887,137	4,864,952	(22,185)
Energy Resources, Inc.	Mill Creek Mining Company	(5,696,225)	(5,696,225)	0
Energy Resources, Inc.	Murray Energy Corporation	880,908	1,248,397	367,489
Energy Resources, Inc.	The American Coal Company	187,385	184,769	(2,615)
Energy Transportation, Inc.	Murray Energy Corporation	20,385	20,197	(187)
Genwal Resources, Inc.	Andalex Resources, Inc.	(2,637,473)	(2,637,473)	0
Genwal Resources, Inc.	Coal Resources, Inc.	(165)	(165)	0
Genwal Resources, Inc.	Murray American Energy, Inc.	(18)	(18)	0
Genwal Resources, Inc.	Murray Energy Corporation	(11,918,968)	(12,547,911)	(628,942)
Genwal Resources, Inc.	The American Coal Company	930,452	917,410	(13,043)
Genwal Resources, Inc.	UtahAmerican Energy, Inc.	(191,615)	(274,061)	(82,447)
Kanawha Transportation Center, Inc.	American Energy Corporation	(72,378)	(108,323)	(35,945)
Kanawha Transportation Center, Inc.	American Equipment & Machine, Inc.	0	0	0
Kanawha Transportation Center, Inc.	American Natural Gas, Inc.	34	34	0
Kanawha Transportation Center, Inc.	Anchor Longwall & Rebuild, Inc.	1,960,567	1,960,376	(191)
Kanawha Transportation Center, Inc.	Coal Resources, Inc.	(123,385)	(207,636)	(84,251)
Kanawha Transportation Center, Inc.	Maple Creek Mining, Inc.	0	(131)	(131)
Kanawha Transportation Center, Inc.	Murray Energy Corporation	(3,446,169)	(5,388,073)	(1,941,904)
Kanawha Transportation Center, Inc.	The American Coal Company	0	(105)	(105)
Kanawha Transportation Center, Inc.	The Ohio Valley Coal Company	1,637,899	3,611,200	1,973,301
Kanawha Transportation Center, Inc.	The Washington County Coal Company	0	(1,277)	(1,277)
KenAmerican Resources, Inc.	American Energy Corporation	(866,517)	(787,915)	78,602
KenAmerican Resources, Inc.	American Equipment & Machine, Inc.	(503,923)	(523,437)	(19,515)
KenAmerican Resources, Inc.	American Mine Services, Inc.	(40)	(40)	0
KenAmerican Resources, Inc.	Anchor Longwall & Rebuild, Inc.	(1,594,508)	(1,630,648)	(36,140)
KenAmerican Resources, Inc.	Coal Resources, Inc.	(17,400,589)	(26,657,254)	(9,256,665)
KenAmerican Resources, Inc.	Corporate Aviation Services, Inc.	(74,527)	(191,437)	(116,910)
KenAmerican Resources, Inc.	Foresight Energy, LP and subsidiaries	640,517	0	(640,517)
KenAmerican Resources, Inc.	Javelin Global Commodities	(18,166)	(15,277)	2,889
KenAmerican Resources, Inc.	KenAmerican Resources, Inc.	0	0	0
KenAmerican Resources, Inc.	McLean County Coal Company	36,825	36,825	0
KenAmerican Resources, Inc.	MonValley Transportation Center, Inc.	(484,656)	(1,289,374)	(804,718)
KenAmerican Resources, Inc.	Murray American Coal Inc.	(81,494)	(81,494)	0
KenAmerican Resources, Inc.	Murray American Energy, Inc.	(1,067,820)	(2,121,094)	(1,053,274)
KenAmerican Resources, Inc.	Murray Energy Corporation	(4,514,326)	(11,422,290)	(6,907,964)
KenAmerican Resources, Inc.	Murray Equipment & Machine, Inc.	(3,470,485)	(4,104,069)	(633,584)
KenAmerican Resources, Inc.	Murray Oak Grove Coal, LLC.	0	680,825	680,825
KenAmerican Resources, Inc.	Ohio Energy Transportation, Inc.	(359,152)	(424,452)	(65,300)
KenAmerican Resources, Inc.	Ohio Valley Resources, Inc.	(1,115,000)	(1,335,000)	(220,000)
KenAmerican Resources, Inc.	OhioAmerican Energy, Inc.	0	0	0
KenAmerican Resources, Inc.	The American Coal Company	7,720,367	7,885,434	165,067
KenAmerican Resources, Inc.	The American Coal Sales Company	(70,310)	(185,262)	(114,952)
KenAmerican Resources, Inc.	The Franklin County Coal Company	41,371	41,371	0
KenAmerican Resources, Inc.	The Marion County Coal Company	(1,091)	(1,091)	0
KenAmerican Resources, Inc.	The Marshall County Coal Company	(38,128)	(38,530)	(402)
KenAmerican Resources, Inc.	The Monongalia County Coal Company	(64,938)	(71,560)	(6,622)
KenAmerican Resources, Inc.	The Muhlenberg County Coal Company, LLC	441	5,455	5,014
KenAmerican Resources, Inc.	The Ohio County Coal Company	(6,030)	356,005	362,036
KenAmerican Resources, Inc.	The Ohio Valley Coal Company	(11,198)	(31,446)	(20,247)
KenAmerican Resources, Inc.	The Washington County Coal Company	(1,675)	(1,675)	0
KenAmerican Resources, Inc.	The Western Kentucky Coal Company, LLC	(148)	(638)	(490)

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Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
KenAmerican Resources, Inc.	UtahAmerican Energy, Inc.	46,711	46,711	0
KenAmerican Resources, Inc.	Western Kentucky Consolidated Resources, LLC.	83,094	(4,124,882)	(4,207,976)
KenAmerican Resources, Inc.	Western Kentucky Resources, LLC.	(1,493)	(435)	1,057
Maple Creek Mining, Inc.	American Energy Corporation	107,085	107,085	0
Maple Creek Mining, Inc.	Anchor Longwall & Rebuild, Inc.	(84,873)	(91,661)	(6,788)
Maple Creek Mining, Inc.	Canterbury Coal Company	(936)	(936)	0
Maple Creek Mining, Inc.	Coal Resources, Inc.	(342,975)	(516,019)	(173,044)
Maple Creek Mining, Inc.	Corporate Aviation Services, Inc.	(62,534)	(62,534)	0
Maple Creek Mining, Inc.	Foresight Energy, LP and subsidiaries	0	3,500	3,500
Maple Creek Mining, Inc.	Kanawha Transportation Center, Inc.	0	131	131
Maple Creek Mining, Inc.	Maple Creek Processing, Inc.	0	0	0
Maple Creek Mining, Inc.	MonValley Transportation Center, Inc.	0	0	0
Maple Creek Mining, Inc.	Murray American Energy, Inc.	(3,312,744)	(4,672,837)	(1,360,092)
Maple Creek Mining, Inc.	Murray Energy Corporation	(185,468,244)	(185,618,053)	(149,808)
Maple Creek Mining, Inc.	Murray Equipment & Machine, Inc.	0	(21,965)	(21,965)
Maple Creek Mining, Inc.	Ohio Valley Resources, Inc.	(4,672,478)	(6,069,615)	(1,397,138)
Maple Creek Mining, Inc.	PennAmerica Coal, Inc.	(8,805,880)	(8,805,880)	0
Maple Creek Mining, Inc.	The Monongalia County Coal Company	(4,200)	(4,200)	0
Maple Creek Mining, Inc.	The Ohio County Coal Company	0	0	0
Maple Creek Mining, Inc.	The Ohio Valley Coal Company	(12,723,657)	(13,311,562)	(587,906)
Maple Creek Mining, Inc.	The Washington County Coal Company	13,795	12,910	(886)
Maple Creek Processing, Inc.	Maple Creek Mining, Inc.	0	0	0
Maple Creek Processing, Inc.	Murray Energy Corporation	(241)	(241)	0
McLean County Coal Company	Andalex Resources, Inc.	(79,941)	(89,941)	(10,000)
McLean County Coal Company	Coal Resources, Inc.	(20,000)	(20,000)	0
McLean County Coal Company	KenAmerican Resources, Inc.	(36,825)	(36,825)	0
McLean County Coal Company	Murray Energy Corporation	24,272	27,171	2,899
Mill Creek Mining Company	Coal Resources, Inc.	(17,394,776)	(17,394,776)	0
Mill Creek Mining Company	Energy Resources, Inc.	5,696,225	5,696,225	0
Mill Creek Mining Company	Murray Energy Corporation	(11,219,416)	(11,219,416)	0
Mill Creek Mining Company	TDK Coal Sales, Inc.	1,630,249	1,630,249	0
MonValley Transportation Center, Inc.	American Energy Corporation	993,612	(3,015,585)	(4,009,197)
MonValley Transportation Center, Inc.	American Equipment & Machine, Inc.	0	(73)	(73)
MonValley Transportation Center, Inc.	American Mine Services, Inc.	990,640	1,838,928	848,288
MonValley Transportation Center, Inc.	Anchor Longwall & Rebuild, Inc.	(19,654,526)	(33,258,635)	(13,604,108)
MonValley Transportation Center, Inc.	Canterbury Coal Company	130	130	0
MonValley Transportation Center, Inc.	Coal Resources, Inc.	(452,688)	(825,151)	(372,463)
MonValley Transportation Center, Inc.	Foresight Energy, LP and subsidiaries	347,495	160,513	(186,983)
MonValley Transportation Center, Inc.	KenAmerican Resources, Inc.	484,656	1,289,374	804,718
MonValley Transportation Center, Inc.	Maple Creek Mining, Inc.	0	0	0
MonValley Transportation Center, Inc.	Murray American Coal Inc.	14,191	15,467	1,276
MonValley Transportation Center, Inc.	Murray American Energy, Inc.	(3,677)	(3,677)	0
MonValley Transportation Center, Inc.	Murray Energy Corporation	(5,551,551)	(6,162,522)	(610,971)
MonValley Transportation Center, Inc.	Murray Equipment & Machine, Inc.	120	(31,636)	(31,756)
MonValley Transportation Center, Inc.	Murray Maple Eagle Coal, LLC.	0	177,472	177,472
MonValley Transportation Center, Inc.	Murray Oak Grove Coal, LLC.	0	1,266,087	1,266,087
MonValley Transportation Center, Inc.	Ohio Valley Resources, Inc.	(10,392,727)	(11,883,979)	(1,491,252)
MonValley Transportation Center, Inc.	The American Coal Company	(398,373)	(394,431)	3,942
MonValley Transportation Center, Inc.	The American Coal Sales Company	(6,529)	(7,082)	(553)
MonValley Transportation Center, Inc.	The Harrison County Coal Company	3,722,599	5,919,588	2,196,989
MonValley Transportation Center, Inc.	The Marion County Coal Company	4,468,310	7,014,793	2,546,482
MonValley Transportation Center, Inc.	The Marshall County Coal Company	5,701,296	8,346,870	2,645,574
MonValley Transportation Center, Inc.	The Monongalia County Coal Company	3,574,634	5,538,307	1,963,672
MonValley Transportation Center, Inc.	The Muhlenberg County Coal Company, LLC	0	9,530	9,530
MonValley Transportation Center, Inc.	The Ohio County Coal Company	2,067,079	3,277,759	1,210,681
MonValley Transportation Center, Inc.	The Ohio Valley Coal Company	445	936,445	936,000
MonValley Transportation Center, Inc.	The Ohio Valley Transloading Co.	422,261	557,243	134,982
MonValley Transportation Center, Inc.	The Washington County Coal Company	1,673	(71,916)	(73,588)
MonValley Transportation Center, Inc.	The Western Kentucky Coal Company, LLC	0	25,914	25,914
MonValley Transportation Center, Inc.	UtahAmerican Energy, Inc.	27,711	168,359	140,647
Murray American Coal Inc.	American Energy Corporation	2,057,355	2,406,596	349,241
Murray American Coal Inc.	American Equipment & Machine, Inc.	(454)	(1,230)	(776)

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Part 2, Question 4: Payments or other transfer of property made within 1 year before filing this case that benefited any insider

Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
Murray American Coal Inc.	Coal Resources, Inc.	(10,442,451)	(17,570,488)	(7,128,037)
Murray American Coal Inc.	Corporate Aviation Services, Inc.	(6,954,675)	(8,050,672)	(1,095,997)
Murray American Coal Inc.	Foresight Energy, LP and subsidiaries	(3,776,925)	1,507,237	5,284,162
Murray American Coal Inc.	Javelin Global Commodities	24,370	9,244	(15,127)
Murray American Coal Inc.	KenAmerican Resources, Inc.	81,494	81,494	0
Murray American Coal Inc.	MonValley Transportation Center, Inc.	(14,191)	(15,467)	(1,276)
Murray American Coal Inc.	Murray American Energy, Inc.	(16,690)	(18,988)	(2,299)
Murray American Coal Inc.	Murray Energy Corporation	43,161,065	67,932,563	24,771,497
Murray American Coal Inc.	Murray Equipment & Machine, Inc.	(10,907)	(12,060)	(1,153)
Murray American Coal Inc.	Murray Maple Eagle Coal, LLC.	0	60,276	60,276
Murray American Coal Inc.	Ohio Valley Resources, Inc.	(3,550,000)	(3,840,000)	(290,000)
Murray American Coal Inc.	The American Coal Company	(9,075,474)	(12,799,100)	(3,723,626)
Murray American Coal Inc.	The American Coal Sales Company	(303)	(13,169)	(12,866)
Murray American Coal Inc.	The Harrison County Coal Company	(700)	(1,681)	(982)
Murray American Coal Inc.	The Marion County Coal Company	(6,638)	(6,638)	0
Murray American Coal Inc.	The Marshall County Coal Company	98,882	98,882	0
Murray American Coal Inc.	The Monongalia County Coal Company	(265)	(265)	0
Murray American Coal Inc.	The Ohio County Coal Company	(3,008)	(3,008)	0
Murray American Coal Inc.	UtahAmerican Energy, Inc.	626,884	626,884	0
Murray American Energy, Inc.	American Energy Corporation	2,753,392	2,023,283	(730,110)
Murray American Energy, Inc.	American Equipment & Machine, Inc.	140,099	203,760	63,661
Murray American Energy, Inc.	American Mine Services, Inc.	38,902	39,622	720
Murray American Energy, Inc.	American Natural Gas, Inc.	16,404	16,617	214
Murray American Energy, Inc.	AmericanMountaineer Energy, Inc.	8,886	10,086	1,200
Murray American Energy, Inc.	AmericanMountaineer Properties, Inc.	0	7,671,000	7,671,000
Murray American Energy, Inc.	Anchor Longwall & Rebuild, Inc.	81,679	(350,020)	(431,699)
Murray American Energy, Inc.	Andalex Resources, Inc.	30	30	0
Murray American Energy, Inc.	Coal Resources, Inc.	2,858,487	5,058,557	2,200,070
Murray American Energy, Inc.	Corporate Aviation Services, Inc.	4,129	3,986	(143)
Murray American Energy, Inc.	Empire Dock, Inc.	24	67	42
Murray American Energy, Inc.	Genwal Resources, Inc.	18	18	0
Murray American Energy, Inc.	Javelin Global Commodities	(1,878,480)	(225,905)	1,652,575
Murray American Energy, Inc.	KenAmerican Resources, Inc.	1,067,820	2,121,094	1,053,274
Murray American Energy, Inc.	Maple Creek Mining, Inc.	3,312,744	4,672,837	1,360,092
Murray American Energy, Inc.	MonValley Transportation Center, Inc.	3,677	3,677	0
Murray American Energy, Inc.	Murray American Coal Inc.	16,690	18,988	2,299
Murray American Energy, Inc.	Murray American River Towing, Inc.	2,334,698	3,177,616	842,918
Murray American Energy, Inc.	Murray American Transportation, Inc.	1,658,418	1,791,531	133,113
Murray American Energy, Inc.	Murray Energy Corporation	1,298,408,910	1,203,392,482	(95,016,428)
Murray American Energy, Inc.	Murray Equipment & Machine, Inc.	3,006	1,841	(1,165)
Murray American Energy, Inc.	Murray Kentucky Energy Services, Inc.	457	2,156	1,700
Murray American Energy, Inc.	Murray Keystone Processing, Inc.	459,373	547,919	88,546
Murray American Energy, Inc.	Murray Maple Eagle Coal, LLC.	0	39,295	39,295
Murray American Energy, Inc.	Murray Oak Grove Coal, LLC.	0	309,187	309,187
Murray American Energy, Inc.	Murray South America, Inc.	1,752,397	1,752,397	0
Murray American Energy, Inc.	Ohio Energy Transportation, Inc.	406	483	77
Murray American Energy, Inc.	Ohio Valley Resources, Inc.	(299,412,721)	(335,138,341)	(35,725,620)
Murray American Energy, Inc.	OhioAmerican Energy, Inc.	1,043	1,157	114
Murray American Energy, Inc.	Oneida Coal Company, Inc.	107,484	109,464	1,980
Murray American Energy, Inc.	The American Coal Company	1,187,794	1,558,182	370,388
Murray American Energy, Inc.	The American Coal Sales Company	(67,449)	(78,449)	(10,999)
Murray American Energy, Inc.	The Franklin County Coal Company	(63,654,909)	(57,266,110)	6,388,799
Murray American Energy, Inc.	The Harrison County Coal Company	50,916,171	77,031,136	26,114,965
Murray American Energy, Inc.	The Marion County Coal Company	34,887,057	58,928,544	24,041,487
Murray American Energy, Inc.	The Marshall County Coal Company	60,412,557	86,648,739	26,236,182
Murray American Energy, Inc.	The Meigs County Coal Company	1,488,914	1,488,914	0
Murray American Energy, Inc.	The Monongalia County Coal Company	33,882,143	53,271,951	19,389,808
Murray American Energy, Inc.	The Muhlenberg County Coal Company, LLC	26,479	(37,745)	(64,224)
Murray American Energy, Inc.	The Muskingum County Coal Company	274,144	293,510	19,365
Murray American Energy, Inc.	The Ohio County Coal Company	38,218,889	52,910,842	14,691,954
Murray American Energy, Inc.	The Ohio Valley Coal Company	10,646,265	15,617,359	4,971,094
Murray American Energy, Inc.	The Ohio Valley Transloading Co.	307,962	426,230	118,268

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Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
Murray American Energy, Inc.	The Washington County Coal Company	41,555,285	48,027,701	6,472,415
Murray American Energy, Inc.	The Western Kentucky Coal Company, LLC	77,664	(22,664)	(100,328)
Murray American Energy, Inc.	UtahAmerican Energy, Inc.	91,890	1,694,130	1,602,240
Murray American Energy, Inc.	West Ridge Resources, Inc.	156	156	0
Murray American River Towing, Inc.	American Energy Corporation	201,280	248,326	47,046
Murray American River Towing, Inc.	AmericanMountaineer Energy, Inc.	0	(39,472)	(39,472)
Murray American River Towing, Inc.	Coal Resources, Inc.	(480,220)	(776,883)	(296,663)
Murray American River Towing, Inc.	Murray American Energy, Inc.	(2,334,698)	(3,177,616)	(842,918)
Murray American River Towing, Inc.	Murray American Transportation, Inc.	2,571,236	14,023,938	11,452,702
Murray American River Towing, Inc.	Murray Energy Corporation	(84,879,821)	(103,065,597)	(18,185,775)
Murray American River Towing, Inc.	Ohio Valley Resources, Inc.	505,000	10,000	(495,000)
Murray American River Towing, Inc.	The American Coal Sales Company	(61,092)	671,027	732,119
Murray American River Towing, Inc.	The Marshall County Coal Company	9,778,275	12,740,832	2,962,558
Murray American River Towing, Inc.	The Monongalia County Coal Company	19,542	(74,717)	(94,259)
Murray American River Towing, Inc.	The Ohio County Coal Company	1,594,663	2,658,740	1,064,077
Murray American River Towing, Inc.	The Ohio Valley Coal Company	(3,188)	(3,188)	0
Murray American River Towing, Inc.	The Ohio Valley Transloading Co.	0	2,750	2,750
Murray American River Towing, Inc.	The Washington County Coal Company	801	801	0
Murray American Transportation, Inc.	American Energy Corporation	0	(1,947)	(1,947)
Murray American Transportation, Inc.	Coal Resources, Inc.	(375,830)	(613,068)	(237,238)
Murray American Transportation, Inc.	Murray American Energy, Inc.	(1,658,418)	(1,791,531)	(133,113)
Murray American Transportation, Inc.	Murray American River Towing, Inc.	(2,571,236)	(14,023,938)	(11,452,702)
Murray American Transportation, Inc.	Murray Energy Corporation	(22,456,138)	(11,610,913)	10,845,225
Murray American Transportation, Inc.	Ohio Valley Resources, Inc.	17,886,706	22,743,519	4,856,813
Murray American Transportation, Inc.	The American Coal Sales Company	(2,405)	50,494	52,899
Murray American Transportation, Inc.	The Harrison County Coal Company	(4)	(4)	0
Murray American Transportation, Inc.	The Marshall County Coal Company	915,379	2,406,379	1,491,000
Murray American Transportation, Inc.	The Monongalia County Coal Company	2,500	(6,741)	(9,241)
Murray American Transportation, Inc.	The Ohio County Coal Company	504,000	927,600	423,600
Murray American Transportation, Inc.	The Ohio Valley Transloading Co.	0	3,215	3,215
Murray Columbian Resources, Inc.	Coal Resources, Inc.	(667)	(667)	0
Murray Columbian Resources, Inc.	Murray Energy Corporation	(26,738)	(27,061)	(323)
Murray Columbian Resources, Inc.	Murray South America, Inc.	27,405	27,405	0
Murray Energy Corporation	Amcoal Holdings, Inc.	(5,225)	(5,225)	0
Murray Energy Corporation	American Compliance Coal, Inc.	(607,558)	(607,558)	0
Murray Energy Corporation	American Energy Corporation	(1,254,985,498)	(1,948,315,234)	(693,329,735)
Murray Energy Corporation	American Equipment & Machine, Inc.	95,581,097	118,983,025	23,401,927
Murray Energy Corporation	American Mine Services, Inc.	13,959,507	25,341,613	11,382,105
Murray Energy Corporation	American Natural Gas, Inc.	22,617,924	23,358,273	740,348
Murray Energy Corporation	AmericanHocking Energy, Inc.	3,372,323	3,390,301	17,978
Murray Energy Corporation	AmericanMountaineer Energy, Inc.	34,673,467	35,508,391	834,925
Murray Energy Corporation	AmericanMountaineer Properties, Inc.	41,642,710	41,642,710	0
Murray Energy Corporation	Anchor Longwall & Rebuild, Inc.	28,474,456	57,426,257	28,951,801
Murray Energy Corporation	Andalex Resources, Inc.	7,005,163	5,963,856	(1,041,307)
Murray Energy Corporation	Avonmore Rail Loading, Inc.	(230,000)	(230,000)	0
Murray Energy Corporation	Belmont Coal, Inc.	580,974	584,318	3,343
Murray Energy Corporation	Belmont County Broadcast Studio, Inc.	(7,768)	(7,537)	231
Murray Energy Corporation	Canterbury Coal Company	4,437,857	5,192,309	754,452
Murray Energy Corporation	Chagrin Executive Office, L.L.C.	242,272	282,918	40,646
Murray Energy Corporation	Coal Resources, Inc.	242,303,227	272,247,222	29,943,994
Murray Energy Corporation	Consolidated Land Company	10,067,031	10,196,352	129,321
Murray Energy Corporation	Corporate Aviation Services, Inc.	8,227,909	8,835,238	607,329
Murray Energy Corporation	Empire Dock, Inc.	6,639,447	7,131,223	491,776
Murray Energy Corporation	Energy Resources, Inc.	(880,908)	(1,248,397)	(367,489)
Murray Energy Corporation	Energy Transportation, Inc.	(20,385)	(20,197)	187
Murray Energy Corporation	Foresight Energy, LP and subsidiaries	53,808	67,446	13,639
Murray Energy Corporation	Genwal Resources, Inc.	11,918,968	12,547,911	628,942
Murray Energy Corporation	Kanawha Transportation Center, Inc.	3,446,169	5,388,073	1,941,904
Murray Energy Corporation	KenAmerican Resources, Inc.	4,514,326	11,422,290	6,907,964
Murray Energy Corporation	Maple Creek Mining, Inc.	185,468,244	185,618,053	149,808
Murray Energy Corporation	Maple Creek Processing, Inc.	241	241	0
Murray Energy Corporation	McLean County Coal Company	(24,272)	(27,171)	(2,899)

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Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
Murray Energy Corporation	Mill Creek Mining Company	11,219,416	11,219,416	0
Murray Energy Corporation	MonValley Transportation Center, Inc.	5,551,551	6,162,522	610,971
Murray Energy Corporation	Murray American Coal Inc.	(43,161,065)	(67,932,563)	(24,771,497)
Murray Energy Corporation	Murray American Energy, Inc.	(1,298,408,910)	(1,203,392,482)	95,016,428
Murray Energy Corporation	Murray American River Towing, Inc.	84,879,821	103,065,597	18,185,775
Murray Energy Corporation	Murray American Transportation, Inc.	22,456,138	11,610,913	(10,845,225)
Murray Energy Corporation	Murray Columbian Resources, Inc.	26,738	27,061	323
Murray Energy Corporation	Murray Equipment & Machine, Inc.	11,837,629	21,628,037	9,790,408
Murray Energy Corporation	Murray Global Commodities Inc.	25,755,510	16,160,708	(9,594,802)
Murray Energy Corporation	Murray Kentucky Energy Services, Inc.	(1,244,385)	(2,678,386)	(1,434,001)
Murray Energy Corporation	Murray Kentucky Energy, Inc.	23,652,514	15,418,631	(8,233,883)
Murray Energy Corporation	Murray Keystone Processing, Inc.	1,832,203	2,168,317	336,113
Murray Energy Corporation	Murray Maple Eagle Coal, LLC.	0	335,263	335,263
Murray Energy Corporation	Murray Metallurgical Coal Holdings, LLC.	0	2,118,226	2,118,226
Murray Energy Corporation	Murray Metallurgical Coal Properties , LLC.	0	1,000,204	1,000,204
Murray Energy Corporation	Murray Oak Grove Coal, LLC.	0	180,080	180,080
Murray Energy Corporation	Murray South America, Inc.	(34,474,570)	(46,115,214)	(11,640,644)
Murray Energy Corporation	Ohio Energy Transportation, Inc.	3,685,454	4,173,649	488,195
Murray Energy Corporation	Ohio Valley Resources, Inc.	773,311,029	687,162,790	(86,148,238)
Murray Energy Corporation	OhioAmerican Energy, Inc.	8,104,583	6,742,584	(1,361,999)
Murray Energy Corporation	Oneida Coal Company, Inc.	219,944	228,996	9,053
Murray Energy Corporation	PennAmerica Coal, Inc.	(3,896,165)	(3,896,266)	(101)
Murray Energy Corporation	PennAmerican Coal, L.P.	15,898,102	15,898,411	309
Murray Energy Corporation	Pennsylvania Transloading, Inc.	(124,086)	(124,086)	0
Murray Energy Corporation	Pinski Corp.	17,757	17,757	0
Murray Energy Corporation	Pleasant Farms, Inc.	(2,019,840)	(2,025,016)	(5,175)
Murray Energy Corporation	Spring Church Coal Company	403,009	402,235	(774)
Murray Energy Corporation	Sunburst Resources, Inc.	51,405	51,405	0
Murray Energy Corporation	TDK Coal Sales, Inc.	101,659	101,573	(86)
Murray Energy Corporation	The American Coal Company	664,523,936	682,463,063	17,939,127
Murray Energy Corporation	The American Coal Sales Company	(45,071,409)	(32,319,714)	12,751,695
Murray Energy Corporation	The Franklin County Coal Company	(739,033)	140,616	879,649
Murray Energy Corporation	The Harrison County Coal Company	83,923,121	62,206,653	(21,716,468)
Murray Energy Corporation	The Marion County Coal Company	144,738,919	194,969,430	50,230,511
Murray Energy Corporation	The Marshall County Coal Company	396,803,963	571,754,021	174,950,058
Murray Energy Corporation	The Meigs County Coal Company	(1,327,259)	(1,323,909)	3,350
Murray Energy Corporation	The Monongalia County Coal Company	340,130,605	394,700,378	54,569,774
Murray Energy Corporation	The Muhlenberg County Coal Company, LLC	95,338	1,145,214	1,049,876
Murray Energy Corporation	The Muskingum County Coal Company	(157,446)	(159,011)	(1,565)
Murray Energy Corporation	The Ohio County Coal Company	48,516,557	185,814,331	137,297,773
Murray Energy Corporation	The Ohio Valley Coal Company	(490,306,668)	(496,399,790)	(6,093,122)
Murray Energy Corporation	The Ohio Valley Transloading Co.	(573,541)	1,072,997	1,646,538
Murray Energy Corporation	The Oklahoma Coal Company	(2,116,814)	(2,104,735)	12,079
Murray Energy Corporation	The Washington County Coal Company	(164,128,289)	(170,424,706)	(6,296,416)
Murray Energy Corporation	The Western Kentucky Coal Company, LLC	139,319	1,773,768	1,634,450
Murray Energy Corporation	Umco Energy, Inc.	725,897	775,781	49,884
Murray Energy Corporation	UtahAmerican Energy, Inc.	185,465,775	171,335,498	(14,130,276)
Murray Energy Corporation	West Ridge Resources, Inc.	(108,606,163)	(106,803,600)	1,802,562
Murray Energy Corporation	West Virginia Resources, Inc.	1,465,876	1,494,351	28,475
Murray Energy Corporation	Western Kentucky Consolidated Resources, LLC.	517,315	(404,623)	(921,938)
Murray Energy Corporation	Western Kentucky Land Holding, LLC.	3,312	3,312	0
Murray Energy Corporation	Western Kentucky Resources, LLC.	66,503	68,653	2,150
Murray Equipment & Machine, Inc.	American Energy Corporation	157,202	1,971,196	1,813,994
Murray Equipment & Machine, Inc.	American Equipment & Machine, Inc.	(960,595)	(1,016,299)	(55,705)
Murray Equipment & Machine, Inc.	Anchor Longwall & Rebuild, Inc.	(8,674)	(8,674)	0
Murray Equipment & Machine, Inc.	Chagrin Executive Office, L.L.C.	(970)	(970)	0
Murray Equipment & Machine, Inc.	Coal Resources, Inc.	(454,221)	(585,994)	(131,773)
Murray Equipment & Machine, Inc.	Foresight Energy, LP and subsidiaries	1,940,000	48,000	(1,892,000)
Murray Equipment & Machine, Inc.	KenAmerican Resources, Inc.	3,470,485	4,104,069	633,584
Murray Equipment & Machine, Inc.	Maple Creek Mining, Inc.	0	21,965	21,965
Murray Equipment & Machine, Inc.	MonValley Transportation Center, Inc.	(120)	31,636	31,756
Murray Equipment & Machine, Inc.	Murray American Coal Inc.	10,907	12,060	1,153

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Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
Murray Equipment & Machine, Inc.	Murray American Energy, Inc.	(3,006)	(1,841)	1,165
Murray Equipment & Machine, Inc.	Murray Energy Corporation	(11,837,629)	(21,628,037)	(9,790,408)
Murray Equipment & Machine, Inc.	Murray Maple Eagle Coal, LLC.	0	24,776	24,776
Murray Equipment & Machine, Inc.	Murray Oak Grove Coal, LLC.	0	857,180	857,180
Murray Equipment & Machine, Inc.	OhioAmerican Energy, Inc.	9,248	9,248	0
Murray Equipment & Machine, Inc.	The American Coal Company	164,533	164,533	0
Murray Equipment & Machine, Inc.	The American Coal Sales Company	(387)	(3,855)	(3,468)
Murray Equipment & Machine, Inc.	The Harrison County Coal Company	757,708	1,746,577	988,869
Murray Equipment & Machine, Inc.	The Marion County Coal Company	782,821	809,028	26,207
Murray Equipment & Machine, Inc.	The Marshall County Coal Company	2,950,047	3,253,210	303,164
Murray Equipment & Machine, Inc.	The Monongalia County Coal Company	159,547	2,641,062	2,481,516
Murray Equipment & Machine, Inc.	The Muhlenberg County Coal Company, LLC	6,800	719,884	713,084
Murray Equipment & Machine, Inc.	The Ohio County Coal Company	278,447	1,139,019	860,572
Murray Equipment & Machine, Inc.	The Ohio Valley Coal Company	(16,571)	(16,571)	0
Murray Equipment & Machine, Inc.	The Washington County Coal Company	558	558	0
Murray Equipment & Machine, Inc.	The Western Kentucky Coal Company, LLC	0	340,496	340,496
Murray Equipment & Machine, Inc.	UtahAmerican Energy, Inc.	460,107	3,128,695	2,668,588
Murray Global Commodities Inc.	Javelin Global Commodities	(1,068,532)	0	1,068,532
Murray Global Commodities Inc.	Murray Energy Corporation	(25,755,510)	(16,160,708)	9,594,802
Murray Global Commodities Inc.	The American Coal Company	(1,944,549)	(1,944,549)	0
Murray Kentucky Energy Services, Inc.	Coal Resources, Inc.	(22,309)	(742,054)	(719,745)
Murray Kentucky Energy Services, Inc.	Corporate Aviation Services, Inc.	(201,695)	(557,742)	(356,047)
Murray Kentucky Energy Services, Inc.	Murray American Energy, Inc.	(457)	(2,156)	(1,700)
Murray Kentucky Energy Services, Inc.	Murray Energy Corporation	1,244,385	2,678,386	1,434,001
Murray Kentucky Energy Services, Inc.	Ohio Valley Resources, Inc.	0	165,000	165,000
Murray Kentucky Energy Services, Inc.	The American Coal Company	(57)	(57)	0
Murray Kentucky Energy Services, Inc.	The Marshall County Coal Company	(404)	(404)	0
Murray Kentucky Energy Services, Inc.	Western Kentucky Consolidated Resources, LLC.	166,667	507,500	340,833
Murray Kentucky Energy, Inc.	Murray Energy Corporation	(23,652,514)	(15,418,631)	8,233,883
Murray Kentucky Energy, Inc.	Murray South America, Inc.	(28,308,416)	(21,445,916)	6,862,500
Murray Kentucky Energy, Inc.	The Muhlenberg County Coal Company, LLC	(2,216)	(2,216)	0
Murray Kentucky Energy, Inc.	The Western Kentucky Coal Company, LLC	(3,240)	(3,240)	0
Murray Kentucky Energy, Inc.	Western Kentucky Consolidated Resources, LLC.	(10,011,606)	(17,143,706)	(7,132,100)
Murray Kentucky Energy, Inc.	Western Kentucky Resources, LLC.	(1,274)	(1,274)	0
Murray Keystone Processing, Inc.	American Energy Corporation	127,258	127,258	0
Murray Keystone Processing, Inc.	Anchor Longwall & Rebuild, Inc.	(2,066)	(2,054)	12
Murray Keystone Processing, Inc.	Canterbury Coal Company	(7,780)	(7,780)	0
Murray Keystone Processing, Inc.	Coal Resources, Inc.	(132,875)	(195,133)	(62,258)
Murray Keystone Processing, Inc.	Murray American Energy, Inc.	(459,373)	(547,919)	(88,546)
Murray Keystone Processing, Inc.	Murray Energy Corporation	(1,832,203)	(2,168,317)	(336,113)
Murray Keystone Processing, Inc.	Ohio Energy Transportation, Inc.	(43,500)	(43,500)	0
Murray Keystone Processing, Inc.	Ohio Valley Resources, Inc.	2,499,759	2,473,886	(25,873)
Murray Keystone Processing, Inc.	The Harrison County Coal Company	116,000	116,000	0
Murray Keystone Processing, Inc.	The Marion County Coal Company	116,212	116,212	0
Murray Keystone Processing, Inc.	The Monongalia County Coal Company	2,540	2,540	0
Murray Keystone Processing, Inc.	The Ohio Valley Coal Company	0	(1,572)	(1,572)
Murray South America, Inc.	American Energy Corporation	(592,028)	(592,028)	0
Murray South America, Inc.	CNR Consolidated	(84,255,039)	(110,605,039)	(26,350,000)
Murray South America, Inc.	Coal Resources, Inc.	(3,960,501)	(5,793,333)	(1,832,832)
Murray South America, Inc.	Corporate Aviation Services, Inc.	(1,235)	(1,235)	0
Murray South America, Inc.	Murray American Energy, Inc.	(1,752,397)	(1,752,397)	0
Murray South America, Inc.	Murray Columbian Resources, Inc.	(27,405)	(27,405)	0
Murray South America, Inc.	Murray Energy Corporation	34,474,570	46,115,214	11,640,644
Murray South America, Inc.	Murray Kentucky Energy, Inc.	28,308,416	21,445,916	(6,862,500)
Murray South America, Inc.	Ohio Valley Resources, Inc.	(27,710,866)	(10,810,866)	16,900,000
Murray South America, Inc.	Western Kentucky Consolidated Resources, LLC.	5,707,677	5,707,677	0
Ohio Energy Transportation, Inc.	American Mine Services, Inc.	15,183	15,183	0
Ohio Energy Transportation, Inc.	Anchor Longwall & Rebuild, Inc.	647,431	1,025,906	378,475
Ohio Energy Transportation, Inc.	Coal Resources, Inc.	(89,200)	(145,441)	(56,241)
Ohio Energy Transportation, Inc.	Empire Dock, Inc.	362,792	362,792	0
Ohio Energy Transportation, Inc.	KenAmerican Resources, Inc.	359,152	424,452	65,300
Ohio Energy Transportation, Inc.	Murray American Energy, Inc.	(406)	(483)	(77)

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Part 2, Question 4: Payments or other transfer of property made within 1 year before filing this case that benefited any insider

Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
Ohio Energy Transportation, Inc.	Murray Energy Corporation	(3,685,454)	(4,173,649)	(488,195)
Ohio Energy Transportation, Inc.	Murray Keystone Processing, Inc.	43,500	43,500	0
Ohio Energy Transportation, Inc.	The Ohio County Coal Company	38	38	0
Ohio Energy Transportation, Inc.	The Ohio Valley Coal Company	(103)	(103)	0
Ohio Energy Transportation, Inc.	The Washington County Coal Company	11	11	0
Ohio Valley Resources, Inc.	American Energy Corporation	2,922,098	5,333,776	2,411,678
Ohio Valley Resources, Inc.	Chagrin Executive Office, L.L.C.	15,346	15,346	0
Ohio Valley Resources, Inc.	Coal Resources, Inc.	0	(470)	(470)
Ohio Valley Resources, Inc.	KenAmerican Resources, Inc.	1,115,000	1,335,000	220,000
Ohio Valley Resources, Inc.	Maple Creek Mining, Inc.	4,672,478	6,069,615	1,397,138
Ohio Valley Resources, Inc.	MonValley Transportation Center, Inc.	10,392,727	11,883,979	1,491,252
Ohio Valley Resources, Inc.	Murray American Coal Inc.	3,550,000	3,840,000	290,000
Ohio Valley Resources, Inc.	Murray American Energy, Inc.	299,412,721	335,138,341	35,725,620
Ohio Valley Resources, Inc.	Murray American River Towing, Inc.	(505,000)	(10,000)	495,000
Ohio Valley Resources, Inc.	Murray American Transportation, Inc.	(17,886,706)	(22,743,519)	(4,856,813)
Ohio Valley Resources, Inc.	Murray Energy Corporation	(773,311,029)	(687,162,790)	86,148,238
Ohio Valley Resources, Inc.	Murray Kentucky Energy Services, Inc.	0	(165,000)	(165,000)
Ohio Valley Resources, Inc.	Murray Keystone Processing, Inc.	(2,499,759)	(2,473,886)	25,873
Ohio Valley Resources, Inc.	Murray South America, Inc.	27,710,866	10,810,866	(16,900,000)
Ohio Valley Resources, Inc.	Ohio Valley Resources, Inc.	0	0	0
Ohio Valley Resources, Inc.	The American Coal Company	(1,218,981)	(1,218,981)	0
Ohio Valley Resources, Inc.	The American Coal Sales Company	916,667	595,000	(321,667)
Ohio Valley Resources, Inc.	The Harrison County Coal Company	(377,579,129)	(450,080,915)	(72,501,786)
Ohio Valley Resources, Inc.	The Marion County Coal Company	(184,239,096)	(224,152,338)	(39,913,242)
Ohio Valley Resources, Inc.	The Marshall County Coal Company	67,423,432	85,098,398	17,674,966
Ohio Valley Resources, Inc.	The Monongalia County Coal Company	(137,903,964)	(162,854,783)	(24,950,819)
Ohio Valley Resources, Inc.	The Ohio County Coal Company	150,608,027	146,533,636	(4,074,391)
Ohio Valley Resources, Inc.	The Ohio Valley Coal Company	47,580,247	49,998,813	2,418,566
Ohio Valley Resources, Inc.	The Ohio Valley Transloading Co.	5,225,367	5,695,803	470,437
Ohio Valley Resources, Inc.	Umco Energy, Inc.	113,444	132,386	18,942
Ohio Valley Resources, Inc.	UtahAmerican Energy, Inc.	940,000	1,040,000	100,000
OhioAmerican Energy, Inc.	American Energy Corporation	(3,021,552)	(3,329,400)	(307,847)
OhioAmerican Energy, Inc.	AmericanMountaineer Energy, Inc.	0	(1,800)	(1,800)
OhioAmerican Energy, Inc.	Anchor Longwall & Rebuild, Inc.	(518,191)	(710,969)	(192,778)
OhioAmerican Energy, Inc.	Coal Resources, Inc.	(523,346)	(820,332)	(296,986)
OhioAmerican Energy, Inc.	KenAmerican Resources, Inc.	0	0	0
OhioAmerican Energy, Inc.	Murray American Energy, Inc.	(1,043)	(1,157)	(114)
OhioAmerican Energy, Inc.	Murray Energy Corporation	(8,104,583)	(6,742,584)	1,361,999
OhioAmerican Energy, Inc.	Murray Equipment & Machine, Inc.	(9,248)	(9,248)	0
OhioAmerican Energy, Inc.	The American Coal Company	1,873,558	1,847,328	(26,230)
OhioAmerican Energy, Inc.	The American Coal Sales Company	(895)	(895)	0
OhioAmerican Energy, Inc.	The Marshall County Coal Company	(3,573,557)	(3,813,107)	(239,550)
OhioAmerican Energy, Inc.	The Ohio County Coal Company	(52,327,667)	(52,333,264)	(5,596)
OhioAmerican Energy, Inc.	The Ohio Valley Coal Company	(81,412)	(164,269)	(82,857)
OhioAmerican Energy, Inc.	The Washington County Coal Company	464	464	0
OhioAmerican Energy, Inc.	UtahAmerican Energy, Inc.	0	0	0
OhioAmerican Energy, Inc.	West Ridge Resources, Inc.	0	0	0
Oneida Coal Company, Inc.	Murray American Energy, Inc.	(107,484)	(109,464)	(1,980)
Oneida Coal Company, Inc.	Murray Energy Corporation	(219,944)	(228,996)	(9,053)
PennAmerica Coal, Inc.	Coal Resources, Inc.	760,800	760,800	0
PennAmerica Coal, Inc.	Maple Creek Mining, Inc.	8,805,880	8,805,880	0
PennAmerica Coal, Inc.	Murray Energy Corporation	3,896,165	3,896,266	101
PennAmerica Coal, Inc.	The American Coal Company	0	0	0
PennAmerican Coal, L.P.	Coal Resources, Inc.	(27,577,054)	(27,577,134)	(80)
PennAmerican Coal, L.P.	Murray Energy Corporation	(15,898,102)	(15,898,411)	(309)
PennAmerican Coal, L.P.	The American Coal Sales Company	0	0	0
Pennsylvania Transloading, Inc.	Murray Energy Corporation	124,086	124,086	0
Pinski Corp.	Murray Energy Corporation	(17,757)	(17,757)	0
Pleasant Farms, Inc.	American Mine Services, Inc.	1,915	5,689	3,774
Pleasant Farms, Inc.	American Natural Gas, Inc.	(12,270)	(12,435)	(165)
Pleasant Farms, Inc.	Anchor Longwall & Rebuild, Inc.	(32,248)	(35,001)	(2,753)
Pleasant Farms, Inc.	Coal Resources, Inc.	(1,961,594)	(1,921,685)	39,908

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Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
Pleasant Farms, Inc.	Murray Energy Corporation	2,019,840	2,025,016	5,175
Pleasant Farms, Inc.	The Ohio Valley Coal Company	(34,937)	(48,885)	(13,948)
Pleasant Farms, Inc.	The Washington County Coal Company	2,232	2,232	0
Spring Church Coal Company	Coal Resources, Inc.	410,634	410,609	(26)
Spring Church Coal Company	Murray Energy Corporation	(403,009)	(402,235)	774
Sunburst Resources, Inc.	Murray Energy Corporation	(51,405)	(51,405)	0
TDK Coal Sales, Inc.	American Energy Corporation	17,411	17,411	0
TDK Coal Sales, Inc.	Coal Resources, Inc.	17,335	17,335	0
TDK Coal Sales, Inc.	Mill Creek Mining Company	(1,630,249)	(1,630,249)	0
TDK Coal Sales, Inc.	Murray Energy Corporation	(101,659)	(101,573)	86
The American Coal Company	Amcoal Holdings, Inc.	(43,572,318)	(44,809,818)	(1,237,500)
The American Coal Company	American Energy Corporation	18,506,415	20,457,810	1,951,395
The American Coal Company	American Equipment & Machine, Inc.	(853,030)	(853,846)	(816)
The American Coal Company	American Mine Services, Inc.	(421,308)	(421,308)	0
The American Coal Company	AmericanMountaineer Energy, Inc.	(301,958)	(297,662)	4,296
The American Coal Company	Anchor Longwall & Rebuild, Inc.	(26,547)	(24,367)	2,181
The American Coal Company	Andalex Resources, Inc.	(2,605,632)	(2,592,111)	13,521
The American Coal Company	Coal Resources, Inc.	(2,186,017)	(2,175,698)	10,319
The American Coal Company	Corporate Aviation Services, Inc.	(11,499)	(11,499)	0
The American Coal Company	Empire Dock, Inc.	2,585	2,585	0
The American Coal Company	Energy Resources, Inc.	(187,385)	(184,769)	2,615
The American Coal Company	Foresight Energy, LP and subsidiaries	(1,952,398)	(633,478)	1,318,920
The American Coal Company	Genwal Resources, Inc.	(930,452)	(917,410)	13,043
The American Coal Company	Javelin Global Commodities	(128,167)	11,833	140,000
The American Coal Company	Kanawha Transportation Center, Inc.	0	105	105
The American Coal Company	KenAmerican Resources, Inc.	(7,720,367)	(7,885,434)	(165,067)
The American Coal Company	MonValley Transportation Center, Inc.	398,373	394,431	(3,942)
The American Coal Company	Murray American Coal Inc.	9,075,474	12,799,100	3,723,626
The American Coal Company	Murray American Energy, Inc.	(1,187,794)	(1,558,182)	(370,388)
The American Coal Company	Murray Energy Corporation	(664,523,936)	(682,463,063)	(17,939,127)
The American Coal Company	Murray Equipment & Machine, Inc.	(164,533)	(164,533)	0
The American Coal Company	Murray Global Commodities Inc.	1,944,549	1,944,549	0
The American Coal Company	Murray Kentucky Energy Services, Inc.	57	57	0
The American Coal Company	Murray Oak Grove Coal, LLC.	0	1,831	1,831
The American Coal Company	Ohio Valley Resources, Inc.	1,218,981	1,218,981	0
The American Coal Company	OhioAmerican Energy, Inc.	(1,873,558)	(1,847,328)	26,230
The American Coal Company	The American Coal Sales Company	(12,716)	(12,716)	0
The American Coal Company	The Franklin County Coal Company	700,303	752,953	52,650
The American Coal Company	The Harrison County Coal Company	(15,178)	(13,478)	1,700
The American Coal Company	The Marion County Coal Company	(1,326,708)	(1,326,708)	0
The American Coal Company	The Marshall County Coal Company	1,596,437	(3,959,828)	(5,556,265)
The American Coal Company	The Meigs County Coal Company	321	321	0
The American Coal Company	The Monongalia County Coal Company	14,601	14,601	0
The American Coal Company	The Muhlenberg County Coal Company, LLC	154	0	(154)
The American Coal Company	The Ohio County Coal Company	(38,053,287)	(53,834,575)	(15,781,288)
The American Coal Company	The Ohio Valley Coal Company	(338,255)	(414,551)	(76,296)
The American Coal Company	The Ohio Valley Transloading Co.	(142,012)	(142,012)	0
The American Coal Company	The Washington County Coal Company	211	211	0
The American Coal Company	UtahAmerican Energy, Inc.	543,722	3,407,727	2,864,005
The American Coal Company	West Ridge Resources, Inc.	(354,210)	(349,264)	4,945
The American Coal Sales Company	Amcoal Holdings, Inc.	43,572,318	44,697,318	1,125,000
The American Coal Sales Company	American Energy Corporation	33,245,237	49,844,055	16,598,818
The American Coal Sales Company	American Equipment & Machine, Inc.	0	154	154
The American Coal Sales Company	American Natural Gas, Inc.	339	339	0
The American Coal Sales Company	AmericanMountaineer Energy, Inc.	0	(1,007)	(1,007)
The American Coal Sales Company	Chagrin Executive Office, L.L.C.	3,972	20,308	16,336
The American Coal Sales Company	Coal Resources, Inc.	(34,849,384)	(39,236,417)	(4,387,033)
The American Coal Sales Company	Consolidated Land Company	0	(35,042)	(35,042)
The American Coal Sales Company	Corporate Aviation Services, Inc.	6,245	6,550	306
The American Coal Sales Company	KenAmerican Resources, Inc.	70,310	185,262	114,952
The American Coal Sales Company	MonValley Transportation Center, Inc.	6,529	7,082	553
The American Coal Sales Company	Murray American Coal Inc.	303	13,169	12,866

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Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
The American Coal Sales Company	Murray American Energy, Inc.	67,449	78,449	10,999
The American Coal Sales Company	Murray American River Towing, Inc.	61,092	(671,027)	(732,119)
The American Coal Sales Company	Murray American Transportation, Inc.	2,405	(50,494)	(52,899)
The American Coal Sales Company	Murray Energy Corporation	45,071,409	32,319,714	(12,751,695)
The American Coal Sales Company	Murray Equipment & Machine, Inc.	387	3,855	3,468
The American Coal Sales Company	Murray Maple Eagle Coal, LLC.	0	8,574	8,574
The American Coal Sales Company	Murray Oak Grove Coal, LLC.	0	77,251	77,251
The American Coal Sales Company	Ohio Valley Resources, Inc.	(916,667)	(595,000)	321,667
The American Coal Sales Company	OhioAmerican Energy, Inc.	895	895	0
The American Coal Sales Company	PennAmerican Coal, L.P.	0	0	0
The American Coal Sales Company	The American Coal Company	12,716	12,716	0
The American Coal Sales Company	The Harrison County Coal Company	59,538	118,532	58,994
The American Coal Sales Company	The Marion County Coal Company	58,195	101,109	42,914
The American Coal Sales Company	The Marshall County Coal Company	16,114	37,939	21,825
The American Coal Sales Company	The Monongalia County Coal Company	27,092	47,080	19,988
The American Coal Sales Company	The Muhlenberg County Coal Company, LLC	1,491	1,977	486
The American Coal Sales Company	The Ohio County Coal Company	13,034	25,126	12,092
The American Coal Sales Company	The Ohio Valley Coal Company	(112,125,735)	(118,423,356)	(6,297,621)
The American Coal Sales Company	The Ohio Valley Transloading Co.	(7,208,294)	(10,187,405)	(2,979,111)
The American Coal Sales Company	The Oklahoma Coal Company	10,130	15,387	5,257
The American Coal Sales Company	The Western Kentucky Coal Company, LLC	596	2,722	2,125
The American Coal Sales Company	UtahAmerican Energy, Inc.	7,498	21,211	13,713
The American Coal Sales Company	Western Kentucky Resources, LLC.	9,470	0	(9,470)
The Franklin County Coal Company	American Equipment & Machine, Inc.	(7,571)	(7,571)	0
The Franklin County Coal Company	Anchor Longwall & Rebuild, Inc.	(132,568)	(194,733)	(62,165)
The Franklin County Coal Company	Coal Resources, Inc.	(67,074)	(122,583)	(55,509)
The Franklin County Coal Company	Empire Dock, Inc.	0	0	0
The Franklin County Coal Company	KenAmerican Resources, Inc.	(41,371)	(41,371)	0
The Franklin County Coal Company	Murray American Energy, Inc.	63,654,909	57,266,110	(6,388,799)
The Franklin County Coal Company	Murray Energy Corporation	739,033	(140,616)	(879,649)
The Franklin County Coal Company	The American Coal Company	(700,303)	(752,953)	(52,650)
The Franklin County Coal Company	The Harrison County Coal Company	(249,291)	(249,291)	0
The Franklin County Coal Company	The Marshall County Coal Company	(125,238)	(125,238)	0
The Franklin County Coal Company	The Meigs County Coal Company	(23,913)	(23,913)	0
The Franklin County Coal Company	The Monongalia County Coal Company	(62,057)	(62,057)	0
The Franklin County Coal Company	The Ohio County Coal Company	(98,408)	(98,408)	0
The Franklin County Coal Company	The Washington County Coal Company	(20,994)	(20,994)	0
The Harrison County Coal Company	American Energy Corporation	9,430	1,500,058	1,490,628
The Harrison County Coal Company	American Equipment & Machine, Inc.	(1,325,677)	(2,987,235)	(1,661,557)
The Harrison County Coal Company	American Mine Services, Inc.	(523,461)	(898,873)	(375,413)
The Harrison County Coal Company	Anchor Longwall & Rebuild, Inc.	(3,724,506)	(5,885,445)	(2,160,939)
The Harrison County Coal Company	Chagrin Executive Office, L.L.C.	(1,544)	(1,544)	0
The Harrison County Coal Company	Coal Resources, Inc.	(4,295,756)	(7,482,057)	(3,186,301)
The Harrison County Coal Company	Corporate Aviation Services, Inc.	(908,350)	(1,179,721)	(271,372)
The Harrison County Coal Company	Javelin Global Commodities	2,934,090	(2,994)	(2,937,084)
The Harrison County Coal Company	MonValley Transportation Center, Inc.	(3,722,599)	(5,919,588)	(2,196,989)
The Harrison County Coal Company	Murray American Coal Inc.	700	1,681	982
The Harrison County Coal Company	Murray American Energy, Inc.	(50,916,171)	(77,031,136)	(26,114,965)
The Harrison County Coal Company	Murray American Transportation, Inc.	4	4	0
The Harrison County Coal Company	Murray Energy Corporation	(83,923,121)	(62,206,653)	21,716,468
The Harrison County Coal Company	Murray Equipment & Machine, Inc.	(757,708)	(1,746,577)	(988,869)
The Harrison County Coal Company	Murray Keystone Processing, Inc.	(116,000)	(116,000)	0
The Harrison County Coal Company	Murray Maple Eagle Coal, LLC.	0	12,805	12,805
The Harrison County Coal Company	Murray Oak Grove Coal, LLC.	0	0	0
The Harrison County Coal Company	Ohio Valley Resources, Inc.	377,579,129	450,080,915	72,501,786
The Harrison County Coal Company	The American Coal Company	15,178	13,478	(1,700)
The Harrison County Coal Company	The American Coal Sales Company	(59,538)	(118,532)	(58,994)
The Harrison County Coal Company	The Franklin County Coal Company	249,291	249,291	0
The Harrison County Coal Company	The Marion County Coal Company	(66,389)	(230,727)	(164,338)
The Harrison County Coal Company	The Marshall County Coal Company	86,280	181,364	95,084
The Harrison County Coal Company	The Meigs County Coal Company	5,974	5,974	0
The Harrison County Coal Company	The Monongalia County Coal Company	(620,541)	(1,000,994)	(380,452)

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Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
The Harrison County Coal Company	The Muskingum County Coal Company	2,332	2,332	0
The Harrison County Coal Company	The Ohio County Coal Company	(838,821)	(849,801)	(10,980)
The Harrison County Coal Company	The Ohio Valley Coal Company	(378,241)	(703,897)	(325,656)
The Harrison County Coal Company	The Washington County Coal Company	751,049	751,029	(20)
The Marion County Coal Company	American Energy Corporation	2,045,645	80,030,656	77,985,011
The Marion County Coal Company	American Equipment & Machine, Inc.	(6,473,473)	(8,019,036)	(1,545,563)
The Marion County Coal Company	American Mine Services, Inc.	(1,591,346)	(6,704,617)	(5,113,271)
The Marion County Coal Company	Anchor Longwall & Rebuild, Inc.	(5,168,485)	(6,927,912)	(1,759,426)
The Marion County Coal Company	Coal Resources, Inc.	(14,853,204)	(21,654,794)	(6,801,590)
The Marion County Coal Company	Corporate Aviation Services, Inc.	(493,690)	(743,928)	(250,238)
The Marion County Coal Company	Javelin Global Commodities	6,006,162	10,865,981	4,859,819
The Marion County Coal Company	KenAmerican Resources, Inc.	1,091	1,091	0
The Marion County Coal Company	MonValley Transportation Center, Inc.	(4,442,330)	(7,014,793)	(2,572,463)
The Marion County Coal Company	Murray American Coal Inc.	6,638	6,638	0
The Marion County Coal Company	Murray American Energy, Inc.	(34,887,057)	(58,928,544)	(24,041,487)
The Marion County Coal Company	Murray Energy Corporation	(144,738,919)	(194,969,430)	(50,230,511)
The Marion County Coal Company	Murray Equipment & Machine, Inc.	(782,821)	(809,028)	(26,207)
The Marion County Coal Company	Murray Keystone Processing, Inc.	(116,212)	(116,212)	0
The Marion County Coal Company	Murray Maple Eagle Coal, LLC.	0	216	216
The Marion County Coal Company	Murray Oak Grove Coal, LLC.	0	1,072	1,072
The Marion County Coal Company	Ohio Valley Resources, Inc.	184,239,096	224,152,338	39,913,242
The Marion County Coal Company	The American Coal Company	1,326,708	1,326,708	0
The Marion County Coal Company	The American Coal Sales Company	(58,195)	(101,109)	(42,914)
The Marion County Coal Company	The Harrison County Coal Company	66,389	230,727	164,338
The Marion County Coal Company	The Marshall County Coal Company	(1,512,829)	(1,507,081)	5,748
The Marion County Coal Company	The Monongalia County Coal Company	(30,008)	(53,947)	(23,939)
The Marion County Coal Company	The Ohio County Coal Company	782,812	709,093	(73,719)
The Marion County Coal Company	The Ohio Valley Coal Company	(1,125,704)	(1,347,225)	(221,520)
The Marion County Coal Company	The Ohio Valley Transloading Co.	(2,445)	(2,445)	0
The Marion County Coal Company	The Washington County Coal Company	70,690	70,670	(20)
The Marion County Coal Company	The Western Kentucky Coal Company, LLC	0	(17)	(17)
The Marion County Coal Company	UtahAmerican Energy, Inc.	0	1,546	1,546
The Marshall County Coal Company	American Energy Corporation	396,315,942	684,755,600	288,439,658
The Marshall County Coal Company	American Equipment & Machine, Inc.	(6,170,503)	(7,823,790)	(1,653,287)
The Marshall County Coal Company	American Mine Services, Inc.	(3,500,302)	(4,632,800)	(1,132,497)
The Marshall County Coal Company	AmericanMountaineer Energy, Inc.	819	819	0
The Marshall County Coal Company	Anchor Longwall & Rebuild, Inc.	(16,199,358)	(26,987,738)	(10,788,380)
The Marshall County Coal Company	Chagrin Executive Office, L.L.C.	(1,548)	(1,548)	0
The Marshall County Coal Company	Coal Resources, Inc.	(11,950,735)	(20,541,250)	(8,590,515)
The Marshall County Coal Company	Corporate Aviation Services, Inc.	(1,183,837)	(1,633,924)	(450,087)
The Marshall County Coal Company	Javelin Global Commodities	0	0	0
The Marshall County Coal Company	KenAmerican Resources, Inc.	38,128	38,530	402
The Marshall County Coal Company	MonValley Transportation Center, Inc.	(5,661,512)	(8,346,870)	(2,685,358)
The Marshall County Coal Company	Murray American Coal Inc.	(98,882)	(98,882)	0
The Marshall County Coal Company	Murray American Energy, Inc.	(60,412,557)	(86,648,739)	(26,236,182)
The Marshall County Coal Company	Murray American River Towing, Inc.	(9,778,275)	(12,740,832)	(2,962,558)
The Marshall County Coal Company	Murray American Transportation, Inc.	(915,379)	(2,406,379)	(1,491,000)
The Marshall County Coal Company	Murray Energy Corporation	(396,803,963)	(571,754,021)	(174,950,058)
The Marshall County Coal Company	Murray Equipment & Machine, Inc.	(2,950,047)	(3,253,210)	(303,164)
The Marshall County Coal Company	Murray Kentucky Energy Services, Inc.	404	404	0
The Marshall County Coal Company	Murray Maple Eagle Coal, LLC.	0	(215)	(215)
The Marshall County Coal Company	Murray Oak Grove Coal, LLC.	0	52,415	52,415
The Marshall County Coal Company	Ohio Valley Resources, Inc.	(67,423,432)	(85,098,398)	(17,674,966)
The Marshall County Coal Company	OhioAmerican Energy, Inc.	3,573,557	3,813,107	239,550
The Marshall County Coal Company	The American Coal Company	(1,596,437)	3,959,828	5,556,265
The Marshall County Coal Company	The American Coal Sales Company	(16,114)	(37,939)	(21,825)
The Marshall County Coal Company	The Franklin County Coal Company	125,238	125,238	0
The Marshall County Coal Company	The Harrison County Coal Company	(86,280)	(181,364)	(95,084)
The Marshall County Coal Company	The Marion County Coal Company	1,512,829	1,507,081	(5,748)
The Marshall County Coal Company	The Monongalia County Coal Company	164,233	173,339	9,106
The Marshall County Coal Company	The Ohio County Coal Company	203,981	3,290,170	3,086,189
The Marshall County Coal Company	The Ohio Valley Coal Company	(1,931,747)	(2,689,076)	(757,329)

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Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
The Marshall County Coal Company	The Ohio Valley Transloading Co.	6,263	6,263	0
The Marshall County Coal Company	The Washington County Coal Company	17,215	17,215	0
The Marshall County Coal Company	The Western Kentucky Coal Company, LLC	685	0	(685)
The Marshall County Coal Company	UtahAmerican Energy, Inc.	(1,285)	12,158	13,442
The Marshall County Coal Company	Western Kentucky Consolidated Resources, LLC.	0	0	0
The Meigs County Coal Company	Coal Resources, Inc.	(968)	(968)	0
The Meigs County Coal Company	Murray American Energy, Inc.	(1,488,914)	(1,488,914)	0
The Meigs County Coal Company	Murray Energy Corporation	1,327,259	1,323,909	(3,350)
The Meigs County Coal Company	The American Coal Company	(321)	(321)	0
The Meigs County Coal Company	The Franklin County Coal Company	23,913	23,913	0
The Meigs County Coal Company	The Harrison County Coal Company	(5,974)	(5,974)	0
The Meigs County Coal Company	The Muskingum County Coal Company	(2,332)	(2,332)	0
The Meigs County Coal Company	The Ohio County Coal Company	(78,078)	(78,078)	0
The Meigs County Coal Company	The Washington County Coal Company	(3,031)	(3,031)	0
The Monongalia County Coal Company	American Energy Corporation	(37,791)	73,652,178	73,689,968
The Monongalia County Coal Company	American Equipment & Machine, Inc.	(3,160,497)	(4,479,850)	(1,319,352)
The Monongalia County Coal Company	American Mine Services, Inc.	(1,265,345)	(2,023,513)	(758,169)
The Monongalia County Coal Company	Anchor Longwall & Rebuild, Inc.	(6,366,316)	(10,096,363)	(3,730,047)
The Monongalia County Coal Company	Coal Resources, Inc.	(11,528,769)	(16,174,642)	(4,645,873)
The Monongalia County Coal Company	Corporate Aviation Services, Inc.	(374,902)	(608,849)	(233,947)
The Monongalia County Coal Company	Javelin Global Commodities	5,719,557	521,475	(5,198,082)
The Monongalia County Coal Company	KenAmerican Resources, Inc.	64,938	71,560	6,622
The Monongalia County Coal Company	Maple Creek Mining, Inc.	4,200	4,200	0
The Monongalia County Coal Company	MonValley Transportation Center, Inc.	(3,558,818)	(5,538,307)	(1,979,488)
The Monongalia County Coal Company	Murray American Coal Inc.	265	265	0
The Monongalia County Coal Company	Murray American Energy, Inc.	(33,882,143)	(53,271,951)	(19,389,808)
The Monongalia County Coal Company	Murray American River Towing, Inc.	(19,542)	74,717	94,259
The Monongalia County Coal Company	Murray American Transportation, Inc.	(2,500)	6,741	9,241
The Monongalia County Coal Company	Murray Energy Corporation	(340,130,605)	(394,700,378)	(54,569,774)
The Monongalia County Coal Company	Murray Equipment & Machine, Inc.	(159,547)	(2,641,062)	(2,481,516)
The Monongalia County Coal Company	Murray Keystone Processing, Inc.	(2,540)	(2,540)	0
The Monongalia County Coal Company	Murray Maple Eagle Coal, LLC.	0	133	133
The Monongalia County Coal Company	Murray Oak Grove Coal, LLC.	0	4,914	4,914
The Monongalia County Coal Company	Ohio Valley Resources, Inc.	137,903,964	162,854,783	24,950,819
The Monongalia County Coal Company	The American Coal Company	(14,601)	(14,601)	0
The Monongalia County Coal Company	The American Coal Sales Company	(27,092)	(47,080)	(19,988)
The Monongalia County Coal Company	The Franklin County Coal Company	62,057	62,057	0
The Monongalia County Coal Company	The Harrison County Coal Company	620,541	1,000,994	380,452
The Monongalia County Coal Company	The Marion County Coal Company	30,008	53,947	23,939
The Monongalia County Coal Company	The Marshall County Coal Company	(164,233)	(173,339)	(9,106)
The Monongalia County Coal Company	The Ohio County Coal Company	(916,828)	(984,135)	(67,307)
The Monongalia County Coal Company	The Ohio Valley Coal Company	(386,474)	(710,728)	(324,254)
The Monongalia County Coal Company	The Washington County Coal Company	13,820	13,803	(16)
The Monongalia County Coal Company	UtahAmerican Energy, Inc.	0	(3,805,454)	(3,805,454)
The Muhlenberg County Coal Company, LLC	Coal Resources, Inc.	(5,046)	(4,357)	688
The Muhlenberg County Coal Company, LLC	Foresight Energy, LP and subsidiaries	0	0	0
The Muhlenberg County Coal Company, LLC	KenAmerican Resources, Inc.	(441)	(5,455)	(5,014)
The Muhlenberg County Coal Company, LLC	MonValley Transportation Center, Inc.	0	(9,530)	(9,530)
The Muhlenberg County Coal Company, LLC	Murray American Energy, Inc.	(26,479)	37,745	64,224
The Muhlenberg County Coal Company, LLC	Murray Energy Corporation	(95,338)	(1,145,214)	(1,049,876)
The Muhlenberg County Coal Company, LLC	Murray Equipment & Machine, Inc.	(6,800)	(719,884)	(713,084)
The Muhlenberg County Coal Company, LLC	Murray Kentucky Energy, Inc.	2,216	2,216	0
The Muhlenberg County Coal Company, LLC	Murray Oak Grove Coal, LLC.	0	643	643
The Muhlenberg County Coal Company, LLC	The American Coal Company	(154)	0	154
The Muhlenberg County Coal Company, LLC	The American Coal Sales Company	(1,491)	(1,977)	(486)
The Muhlenberg County Coal Company, LLC	The Ohio Valley Coal Company	(1,760)	(7,386)	(5,626)
The Muhlenberg County Coal Company, LLC	The Western Kentucky Coal Company, LLC	1,313,612	800,446	(513,166)
The Muhlenberg County Coal Company, LLC	Western Kentucky Coal Resources, LLC.	282	282	0
The Muhlenberg County Coal Company, LLC	Western Kentucky Consolidated Resources, LLC.	13,053,164	480,446	(12,572,718)
The Muhlenberg County Coal Company, LLC	Western Kentucky Resources, LLC.	(501,688)	(1,171,836)	(670,148)
The Muhlenberg County Coal Company, LLC	Western Kentucky River Loadout, LLC.	(93,185)	(227,671)	(134,486)
The Muskingum County Coal Company	Murray American Energy, Inc.	(274,144)	(293,510)	(19,365)

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Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
The Muskingum County Coal Company	Murray Energy Corporation	157,446	159,011	1,565
The Muskingum County Coal Company	The Harrison County Coal Company	(2,332)	(2,332)	0
The Muskingum County Coal Company	The Meigs County Coal Company	2,332	2,332	0
The Ohio County Coal Company	American Energy Corporation	157,408,421	390,001,084	232,592,663
The Ohio County Coal Company	American Equipment & Machine, Inc.	(4,417,479)	(13,362,893)	(8,945,414)
The Ohio County Coal Company	American Mine Services, Inc.	(948,052)	(1,590,926)	(642,874)
The Ohio County Coal Company	Anchor Longwall & Rebuild, Inc.	(8,397,041)	(13,155,809)	(4,758,768)
The Ohio County Coal Company	Chagrin Executive Office, L.L.C.	(1,543)	(1,575)	(32)
The Ohio County Coal Company	Coal Resources, Inc.	(8,382,754)	(14,421,751)	(6,038,996)
The Ohio County Coal Company	Corporate Aviation Services, Inc.	(702,320)	(974,548)	(272,228)
The Ohio County Coal Company	KenAmerican Resources, Inc.	6,030	(356,005)	(362,036)
The Ohio County Coal Company	Maple Creek Mining, Inc.	0	0	0
The Ohio County Coal Company	MonValley Transportation Center, Inc.	(2,066,437)	(3,277,759)	(1,211,323)
The Ohio County Coal Company	Murray American Coal Inc.	3,008	3,008	0
The Ohio County Coal Company	Murray American Energy, Inc.	(38,218,889)	(52,910,842)	(14,691,954)
The Ohio County Coal Company	Murray American River Towing, Inc.	(1,594,663)	(2,658,740)	(1,064,077)
The Ohio County Coal Company	Murray American Transportation, Inc.	(504,000)	(927,600)	(423,600)
The Ohio County Coal Company	Murray Energy Corporation	(48,516,557)	(185,814,331)	(137,297,773)
The Ohio County Coal Company	Murray Equipment & Machine, Inc.	(278,447)	(1,139,019)	(860,572)
The Ohio County Coal Company	Murray Oak Grove Coal, LLC.	0	3,982	3,982
The Ohio County Coal Company	Ohio Energy Transportation, Inc.	(38)	(38)	0
The Ohio County Coal Company	Ohio Valley Resources, Inc.	(150,608,027)	(146,533,636)	4,074,391
The Ohio County Coal Company	OhioAmerican Energy, Inc.	52,327,667	52,333,264	5,596
The Ohio County Coal Company	The American Coal Company	38,053,287	53,834,575	15,781,288
The Ohio County Coal Company	The American Coal Sales Company	(13,034)	(25,126)	(12,092)
The Ohio County Coal Company	The Franklin County Coal Company	98,408	98,408	0
The Ohio County Coal Company	The Harrison County Coal Company	838,821	849,801	10,980
The Ohio County Coal Company	The Marion County Coal Company	(782,812)	(709,093)	73,719
The Ohio County Coal Company	The Marshall County Coal Company	(203,981)	(3,290,170)	(3,086,189)
The Ohio County Coal Company	The Meigs County Coal Company	78,078	78,078	0
The Ohio County Coal Company	The Monongalia County Coal Company	916,828	984,135	67,307
The Ohio County Coal Company	The Ohio Valley Coal Company	(1,108,354)	(1,878,432)	(770,078)
The Ohio County Coal Company	The Ohio Valley Transloading Co.	(4,000)	(4,000)	0
The Ohio County Coal Company	The Washington County Coal Company	123,253	123,253	0
The Ohio County Coal Company	UtahAmerican Energy, Inc.	406	(310)	(716)
The Ohio Valley Coal Company	American Energy Corporation	10,684,134	25,668,997	14,984,863
The Ohio Valley Coal Company	American Equipment & Machine, Inc.	(224)	(224)	0
The Ohio Valley Coal Company	American Mine Services, Inc.	43,891	106,371	62,480
The Ohio Valley Coal Company	American Natural Gas, Inc.	822	2,265	1,443
The Ohio Valley Coal Company	AmericanMountaineer Energy, Inc.	0	(397)	(397)
The Ohio Valley Coal Company	Anchor Longwall & Rebuild, Inc.	(468,453)	(411,094)	57,360
The Ohio Valley Coal Company	Chagrin Executive Office, L.L.C.	5,618,135	5,841,133	222,998
The Ohio Valley Coal Company	Coal Resources, Inc.	61,515,601	65,591,676	4,076,075
The Ohio Valley Coal Company	Corporate Aviation Services, Inc.	(1,600)	(264)	1,336
The Ohio Valley Coal Company	Empire Dock, Inc.	2	2	0
The Ohio Valley Coal Company	Kanawha Transportation Center, Inc.	(1,637,899)	(3,611,200)	(1,973,301)
The Ohio Valley Coal Company	KenAmerican Resources, Inc.	11,198	31,446	20,247
The Ohio Valley Coal Company	Maple Creek Mining, Inc.	12,723,657	13,311,562	587,906
The Ohio Valley Coal Company	MonValley Transportation Center, Inc.	(445)	(936,445)	(936,000)
The Ohio Valley Coal Company	Murray American Energy, Inc.	(10,646,265)	(15,617,359)	(4,971,094)
The Ohio Valley Coal Company	Murray American River Towing, Inc.	3,188	3,188	0
The Ohio Valley Coal Company	Murray Energy Corporation	490,306,668	496,399,790	6,093,122
The Ohio Valley Coal Company	Murray Equipment & Machine, Inc.	16,571	16,571	0
The Ohio Valley Coal Company	Murray Keystone Processing, Inc.	0	1,572	1,572
The Ohio Valley Coal Company	Ohio Energy Transportation, Inc.	103	103	0
The Ohio Valley Coal Company	Ohio Valley Resources, Inc.	(47,580,247)	(49,998,813)	(2,418,566)
The Ohio Valley Coal Company	OhioAmerican Energy, Inc.	81,412	164,269	82,857
The Ohio Valley Coal Company	Pleasant Farms, Inc.	34,937	48,885	13,948
The Ohio Valley Coal Company	The American Coal Company	338,255	414,551	76,296
The Ohio Valley Coal Company	The American Coal Sales Company	112,125,735	118,423,356	6,297,621
The Ohio Valley Coal Company	The Harrison County Coal Company	378,241	703,897	325,656
The Ohio Valley Coal Company	The Marion County Coal Company	1,125,704	1,347,225	221,520

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Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
The Ohio Valley Coal Company	The Marshall County Coal Company	1,931,747	2,689,076	757,329
The Ohio Valley Coal Company	The Monongalia County Coal Company	386,474	710,728	324,254
The Ohio Valley Coal Company	The Muhlenberg County Coal Company, LLC	1,760	7,386	5,626
The Ohio Valley Coal Company	The Ohio County Coal Company	1,108,354	1,878,432	770,078
The Ohio Valley Coal Company	The Ohio Valley Transloading Co.	59,471	204,471	145,000
The Ohio Valley Coal Company	The Washington County Coal Company	142,408	283,314	140,906
The Ohio Valley Coal Company	The Western Kentucky Coal Company, LLC	0	6,898	6,898
The Ohio Valley Coal Company	UtahAmerican Energy, Inc.	6,895	6,895	0
The Ohio Valley Transloading Co.	American Energy Corporation	79,994	224,754	144,760
The Ohio Valley Transloading Co.	Anchor Longwall & Rebuild, Inc.	(177,388)	(199,804)	(22,416)
The Ohio Valley Transloading Co.	Chagrin Executive Office, L.L.C.	151	151	0
The Ohio Valley Transloading Co.	Coal Resources, Inc.	(1,070,384)	(1,642,675)	(572,290)
The Ohio Valley Transloading Co.	MonValley Transportation Center, Inc.	(422,261)	(557,243)	(134,982)
The Ohio Valley Transloading Co.	Murray American Energy, Inc.	(307,962)	(426,230)	(118,268)
The Ohio Valley Transloading Co.	Murray American River Towing, Inc.	0	(2,750)	(2,750)
The Ohio Valley Transloading Co.	Murray American Transportation, Inc.	0	(3,215)	(3,215)
The Ohio Valley Transloading Co.	Murray Energy Corporation	573,541	(1,072,997)	(1,646,538)
The Ohio Valley Transloading Co.	Ohio Valley Resources, Inc.	(5,225,367)	(5,695,803)	(470,437)
The Ohio Valley Transloading Co.	The American Coal Company	142,012	142,012	0
The Ohio Valley Transloading Co.	The American Coal Sales Company	7,208,294	10,187,405	2,979,111
The Ohio Valley Transloading Co.	The Marion County Coal Company	2,445	2,445	0
The Ohio Valley Transloading Co.	The Marshall County Coal Company	(6,263)	(6,263)	0
The Ohio Valley Transloading Co.	The Ohio County Coal Company	4,000	4,000	0
The Ohio Valley Transloading Co.	The Ohio Valley Coal Company	(59,471)	(204,471)	(145,000)
The Oklahoma Coal Company	Coal Resources, Inc.	(525,627)	(493,732)	31,895
The Oklahoma Coal Company	Murray Energy Corporation	2,116,814	2,104,735	(12,079)
The Oklahoma Coal Company	The American Coal Sales Company	(10,130)	(15,387)	(5,257)
The Oklahoma Coal Company	The Oklahoma Coal Company	0	0	0
The Washington County Coal Company	American Energy Corporation	(252)	(252)	0
The Washington County Coal Company	American Natural Gas, Inc.	45	45	0
The Washington County Coal Company	Anchor Longwall & Rebuild, Inc.	(376,109)	(838,607)	(462,498)
The Washington County Coal Company	Canterbury Coal Company	(1,330)	(1,330)	0
The Washington County Coal Company	Coal Resources, Inc.	(80,977)	(89,187)	(8,209)
The Washington County Coal Company	Kanawha Transportation Center, Inc.	0	1,277	1,277
The Washington County Coal Company	KenAmerican Resources, Inc.	1,675	1,675	0
The Washington County Coal Company	Maple Creek Mining, Inc.	(13,795)	(12,910)	886
The Washington County Coal Company	MonValley Transportation Center, Inc.	(1,673)	71,916	73,588
The Washington County Coal Company	Murray American Energy, Inc.	(41,555,285)	(48,027,701)	(6,472,415)
The Washington County Coal Company	Murray American River Towing, Inc.	(801)	(801)	0
The Washington County Coal Company	Murray Energy Corporation	164,128,289	170,424,706	6,296,416
The Washington County Coal Company	Murray Equipment & Machine, Inc.	(558)	(558)	0
The Washington County Coal Company	Ohio Energy Transportation, Inc.	(11)	(11)	0
The Washington County Coal Company	OhioAmerican Energy, Inc.	(464)	(464)	0
The Washington County Coal Company	Pleasant Farms, Inc.	(2,232)	(2,232)	0
The Washington County Coal Company	The American Coal Company	(211)	(211)	0
The Washington County Coal Company	The Franklin County Coal Company	20,994	20,994	0
The Washington County Coal Company	The Harrison County Coal Company	(751,049)	(751,029)	20
The Washington County Coal Company	The Marion County Coal Company	(70,690)	(70,670)	20
The Washington County Coal Company	The Marshall County Coal Company	(17,215)	(17,215)	0
The Washington County Coal Company	The Meigs County Coal Company	3,031	3,031	0
The Washington County Coal Company	The Monongalia County Coal Company	(13,820)	(13,803)	16
The Washington County Coal Company	The Ohio County Coal Company	(123,253)	(123,253)	0
The Washington County Coal Company	The Ohio Valley Coal Company	(142,408)	(283,314)	(140,906)
The Washington County Coal Company	UtahAmerican Energy, Inc.	449	449	0
The Western Kentucky Coal Company, LLC	Coal Resources, Inc.	(6,212)	(7,974)	(1,762)
The Western Kentucky Coal Company, LLC	KenAmerican Resources, Inc.	148	638	490
The Western Kentucky Coal Company, LLC	MonValley Transportation Center, Inc.	0	(25,914)	(25,914)
The Western Kentucky Coal Company, LLC	Murray American Energy, Inc.	(77,664)	22,664	100,328
The Western Kentucky Coal Company, LLC	Murray Energy Corporation	(139,319)	(1,773,768)	(1,634,450)
The Western Kentucky Coal Company, LLC	Murray Equipment & Machine, Inc.	0	(340,496)	(340,496)
The Western Kentucky Coal Company, LLC	Murray Kentucky Energy, Inc.	3,240	3,240	0
The Western Kentucky Coal Company, LLC	Murray Metallurgical Coal Holdings, LLC.	0	(5,348)	(5,348)

MURRAY ENERGY HOLDINGS CO., et al.
Case No. 19-56885 (JEH)

Part 2, Question 4: Payments or other transfer of property made within 1 year before filing this case that benefited any insider

Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
The Western Kentucky Coal Company, LLC	The American Coal Sales Company	(596)	(2,722)	(2,125)
The Western Kentucky Coal Company, LLC	The Marion County Coal Company	0	17	17
The Western Kentucky Coal Company, LLC	The Marshall County Coal Company	(685)	0	685
The Western Kentucky Coal Company, LLC	The Muhlenberg County Coal Company, LLC	(1,313,612)	(800,446)	513,166
The Western Kentucky Coal Company, LLC	The Ohio Valley Coal Company	0	(6,898)	(6,898)
The Western Kentucky Coal Company, LLC	Western Kentucky Coal Resources, LLC.	32,253	32,253	0
The Western Kentucky Coal Company, LLC	Western Kentucky Consolidated Resources, LLC.	25,863,957	13,440,307	(12,423,650)
The Western Kentucky Coal Company, LLC	Western Kentucky Land Holding, LLC.	1,857	1,857	0
The Western Kentucky Coal Company, LLC	Western Kentucky Rail Loadout, LLC.	6,920	7,593	673
The Western Kentucky Coal Company, LLC	Western Kentucky Resources, LLC.	(1,780,787)	(3,173,737)	(1,392,951)
The Western Kentucky Coal Company, LLC	Western Kentucky River Loadout, LLC.	(1,902,143)	(5,614,399)	(3,712,256)
Umco Energy, Inc.	American Energy Corporation	117,607	117,607	0
Umco Energy, Inc.	Coal Resources, Inc.	(42)	(42)	0
Umco Energy, Inc.	Murray Energy Corporation	(725,897)	(775,781)	(49,884)
Umco Energy, Inc.	Ohio Valley Resources, Inc.	(113,444)	(132,386)	(18,942)
UtahAmerican Energy, Inc.	American Energy Corporation	(6,481)	(25,293)	(18,812)
UtahAmerican Energy, Inc.	American Equipment & Machine, Inc.	(3,054,187)	(8,429,387)	(5,375,200)
UtahAmerican Energy, Inc.	American Mine Services, Inc.	(74,570)	(273,854)	(199,284)
UtahAmerican Energy, Inc.	Anchor Longwall & Rebuild, Inc.	(6,614)	(7,915)	(1,301)
UtahAmerican Energy, Inc.	Andalex Resources, Inc.	(5,827,231)	(4,165,981)	1,661,250
UtahAmerican Energy, Inc.	Coal Resources, Inc.	(3,104,873)	(5,268,489)	(2,163,616)
UtahAmerican Energy, Inc.	Corporate Aviation Services, Inc.	(650,536)	(650,536)	0
UtahAmerican Energy, Inc.	Genwal Resources, Inc.	191,615	274,061	82,447
UtahAmerican Energy, Inc.	Javelin Global Commodities	4,131,219	229,806	(3,901,414)
UtahAmerican Energy, Inc.	KenAmerican Resources, Inc.	(46,711)	(46,711)	0
UtahAmerican Energy, Inc.	MonValley Transportation Center, Inc.	(27,711)	(168,359)	(140,647)
UtahAmerican Energy, Inc.	Murray American Coal Inc.	(626,884)	(626,884)	0
UtahAmerican Energy, Inc.	Murray American Energy, Inc.	(91,890)	(1,694,130)	(1,602,240)
UtahAmerican Energy, Inc.	Murray Energy Corporation	(185,465,775)	(171,335,498)	14,130,276
UtahAmerican Energy, Inc.	Murray Equipment & Machine, Inc.	(460,107)	(3,128,695)	(2,668,588)
UtahAmerican Energy, Inc.	Ohio Valley Resources, Inc.	(940,000)	(1,040,000)	(100,000)
UtahAmerican Energy, Inc.	OhioAmerican Energy, Inc.	0	0	0
UtahAmerican Energy, Inc.	The American Coal Company	(543,722)	(3,407,727)	(2,864,005)
UtahAmerican Energy, Inc.	The American Coal Sales Company	(7,498)	(21,211)	(13,713)
UtahAmerican Energy, Inc.	The Marion County Coal Company	0	(1,546)	(1,546)
UtahAmerican Energy, Inc.	The Marshall County Coal Company	1,285	(12,158)	(13,442)
UtahAmerican Energy, Inc.	The Monongalia County Coal Company	0	3,805,454	3,805,454
UtahAmerican Energy, Inc.	The Ohio County Coal Company	(406)	310	716
UtahAmerican Energy, Inc.	The Ohio Valley Coal Company	(6,895)	(6,895)	0
UtahAmerican Energy, Inc.	The Washington County Coal Company	(449)	(449)	0
UtahAmerican Energy, Inc.	West Ridge Resources, Inc.	7,243,188	6,801,106	(442,082)
West Ridge Resources, Inc.	Andalex Resources, Inc.	1,986	1,986	0
West Ridge Resources, Inc.	Coal Resources, Inc.	(48,216)	(82,716)	(34,500)
West Ridge Resources, Inc.	Murray American Energy, Inc.	(156)	(156)	0
West Ridge Resources, Inc.	Murray Energy Corporation	108,606,163	106,803,600	(1,802,562)
West Ridge Resources, Inc.	OhioAmerican Energy, Inc.	0	0	0
West Ridge Resources, Inc.	The American Coal Company	354,210	349,264	(4,945)
West Ridge Resources, Inc.	UtahAmerican Energy, Inc.	(7,243,188)	(6,801,106)	442,082
West Virginia Resources, Inc.	American Energy Corporation	156,192	156,192	0
West Virginia Resources, Inc.	Anchor Longwall & Rebuild, Inc.	105,764	163,453	57,689
West Virginia Resources, Inc.	Canterbury Coal Company	260	260	0
West Virginia Resources, Inc.	Coal Resources, Inc.	(21,047,483)	(21,056,425)	(8,943)
West Virginia Resources, Inc.	Murray Energy Corporation	(1,465,876)	(1,494,351)	(28,475)
Western Kentucky Coal Resources, LLC.	The Muhlenberg County Coal Company, LLC	(282)	(282)	0
Western Kentucky Coal Resources, LLC.	The Western Kentucky Coal Company, LLC	(32,253)	(32,253)	0
Western Kentucky Coal Resources, LLC.	Western Kentucky Consolidated Resources, LLC.	0	(638)	(638)
Western Kentucky Coal Resources, LLC.	Western Kentucky Resources, LLC.	(3,250)	(3,250)	0
Western Kentucky Consolidated Resources, LLC.	Foresight Energy, LP and subsidiaries	3,349,891	614,854	(2,735,037)
Western Kentucky Consolidated Resources, LLC.	KenAmerican Resources, Inc.	(83,094)	4,124,882	4,207,976
Western Kentucky Consolidated Resources, LLC.	Murray Energy Corporation	(517,315)	404,623	921,938
Western Kentucky Consolidated Resources, LLC.	Murray Kentucky Energy Services, Inc.	(166,667)	(507,500)	(340,833)
Western Kentucky Consolidated Resources, LLC.	Murray Kentucky Energy, Inc.	10,011,606	17,143,706	7,132,100

MURRAY ENERGY HOLDINGS CO., et al.
Case No. 19-56885 (JEH)

Part 2, Question 4: Payments or other transfer of property made within 1 year before filing this case that benefited any insider

Debtor	Account Description - Due (to)/from	10/31/2018 Balance	10/31/2019 Balance	Net Change
Western Kentucky Consolidated Resources, LLC.	Murray Oak Grove Coal, LLC.	0	925	925
Western Kentucky Consolidated Resources, LLC.	Murray South America, Inc.	(5,707,677)	(5,707,677)	0
Western Kentucky Consolidated Resources, LLC.	The Marshall County Coal Company	0	0	0
Western Kentucky Consolidated Resources, LLC.	The Muhlenberg County Coal Company, LLC	(13,053,164)	(480,446)	12,572,718
Western Kentucky Consolidated Resources, LLC.	The Western Kentucky Coal Company, LLC	(25,863,957)	(13,440,307)	12,423,650
Western Kentucky Consolidated Resources, LLC.	Western Kentucky Coal Resources, LLC.	0	638	638
Western Kentucky Consolidated Resources, LLC.	Western Kentucky Land Holding, LLC.	24,507	25,145	638
Western Kentucky Consolidated Resources, LLC.	Western Kentucky Rail Loadout, LLC.	531,165	2,749,953	2,218,789
Western Kentucky Consolidated Resources, LLC.	Western Kentucky Resources Financing, LLC.	153,846	154,484	638
Western Kentucky Consolidated Resources, LLC.	Western Kentucky Resources, LLC.	(12,321,826)	11,584,938	23,906,764
Western Kentucky Consolidated Resources, LLC.	Western Kentucky River Loadout, LLC.	1,891,057	8,647,558	6,756,502
Western Kentucky Land Holding, LLC.	Murray Energy Corporation	(3,312)	(3,312)	0
Western Kentucky Land Holding, LLC.	The Western Kentucky Coal Company, LLC	(1,857)	(1,857)	0
Western Kentucky Land Holding, LLC.	Western Kentucky Consolidated Resources, LLC.	(24,507)	(25,145)	(638)
Western Kentucky Land Holding, LLC.	Western Kentucky Resources, LLC.	27,416	27,416	0
Western Kentucky Rail Loadout, LLC.	Murray Maple Eagle Coal, LLC.	0	(21,301)	(21,301)
Western Kentucky Rail Loadout, LLC.	The Western Kentucky Coal Company, LLC	(6,920)	(7,593)	(673)
Western Kentucky Rail Loadout, LLC.	Western Kentucky Consolidated Resources, LLC.	(531,165)	(2,749,953)	(2,218,789)
Western Kentucky Rail Loadout, LLC.	Western Kentucky Resources Financing, LLC.	185,000	185,000	0
Western Kentucky Rail Loadout, LLC.	Western Kentucky Resources, LLC.	299,600	854,700	555,100
Western Kentucky Rail Loadout, LLC.	Western Kentucky River Loadout, LLC.	0	0	0
Western Kentucky Resources Financing, LLC.	Western Kentucky Consolidated Resources, LLC.	(153,846)	(154,484)	(638)
Western Kentucky Resources Financing, LLC.	Western Kentucky Rail Loadout, LLC.	(185,000)	(185,000)	0
Western Kentucky Resources Financing, LLC.	Western Kentucky Resources, LLC.	338,693	338,693	0
Western Kentucky Resources, LLC.	Coal Resources, Inc.	(36,244)	0	36,244
Western Kentucky Resources, LLC.	KenAmerican Resources, Inc.	1,493	435	(1,057)
Western Kentucky Resources, LLC.	Murray Energy Corporation	(66,503)	(68,653)	(2,150)
Western Kentucky Resources, LLC.	Murray Kentucky Energy, Inc.	1,274	1,274	0
Western Kentucky Resources, LLC.	The American Coal Sales Company	(9,470)	0	9,470
Western Kentucky Resources, LLC.	The Muhlenberg County Coal Company, LLC	501,688	1,171,836	670,148
Western Kentucky Resources, LLC.	The Western Kentucky Coal Company, LLC	1,780,787	3,173,737	1,392,951
Western Kentucky Resources, LLC.	Western Kentucky Coal Resources, LLC.	3,250	3,250	0
Western Kentucky Resources, LLC.	Western Kentucky Consolidated Resources, LLC.	12,321,826	(11,584,938)	(23,906,764)
Western Kentucky Resources, LLC.	Western Kentucky Land Holding, LLC.	(27,416)	(27,416)	0
Western Kentucky Resources, LLC.	Western Kentucky Rail Loadout, LLC.	(299,600)	(854,700)	(555,100)
Western Kentucky Resources, LLC.	Western Kentucky Resources Financing, LLC.	(338,693)	(338,693)	0
Western Kentucky Resources, LLC.	Western Kentucky River Loadout, LLC.	0	1,482	1,482
Western Kentucky River Loadout, LLC.	The Muhlenberg County Coal Company, LLC	93,185	227,671	134,486
Western Kentucky River Loadout, LLC.	The Western Kentucky Coal Company, LLC	1,902,143	5,614,399	3,712,256
Western Kentucky River Loadout, LLC.	Western Kentucky Consolidated Resources, LLC.	(1,891,057)	(8,647,558)	(6,756,502)
Western Kentucky River Loadout, LLC.	Western Kentucky Rail Loadout, LLC.	0	0	0
Western Kentucky River Loadout, LLC.	Western Kentucky Resources, LLC.	0	(1,482)	(1,482)

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 3, Question 7: Legal actions, administrative proceedings, court actions, executions, attachments, or governmental audits

Case Title	Case Number	Nature of case	Court or agency's name and address	Status Of Case
American Lung Association, Et Al V. EPA, Et Al	19-1140	Petition For Review	UNITED STATES COURT OF APPEALS FOR DISTRICT OF COLUMBIA CIRCUIT 333 CONSTITUTION AVENUE, NW WASHINGTON, DC 20001	On appeal
Iliana Sebreros, Individually And On Behalf Of The Heirs And The Estate Of Alejandro Ramirez,	160905749	Wrongful Death	THIRD DISTRICT FOR SALT LAKE CITY, UT 450 STATE ST SALT LAKE CITY, UT 84111	Pending
In Re: FirstEnergy Solutions Corp., Et Al.	18-50757	Bankruptcy	US BANKRUPTCY COURT NORTHERN DISTRICT OF OHIO 2 S MAIN STREET AKRON, OH 44308	Concluded
Jetson Mitchell & Sherman Rider V. Murray Energy Corporation, The American Coal Company, Inc., And Doe Defendants 1-20	3:17-CV-444	Litigation	UNITED STATES DISTRICT COURT FOR THE SOUTHERN DISTRICT OF ILLINOIS 750 MISSOURI AVENUE EAST SAINT LOUIS, IL 62201	Pending
M.S., Individually, And M.S., As Next Friend Of The Minor Child, S.M. V. Jonathan Murray, Et Al.	19-C-173	Litigation	CIRCUIT COURT OF OHIO COUNTY, WV 1500 CHAPLINE ST WHEELING, WV 26003	Pending
Murray Energy Corp., Et. Al. V. Patrick Cassidy, Et. Al.	2:18CV00440	Breach Of Contract	U.S. DISTRICT COURT, SOUTHERN DISTRICT OF OH; 85 MARCONI BLVD ROOM 121 COLUMBUS, OH 43215	Pending
Murray Energy Corporation V. EPA, Et Al	15-1396	Petition For Review	UNITED STATES COURT OF APPEALS FOR DISTRICT OF COLUMBIA CIRCUIT 333 CONSTITUTION AVENUE, NW WASHINGTON, DC 20001	On appeal
Murray Energy Corporation V. EPA, Et Al	16-1127	Petition For Review	UNITED STATES COURT OF APPEALS FOR DISTRICT OF COLUMBIA CIRCUIT 333 CONSTITUTION AVENUE, NW WASHINGTON, DC 20001	On appeal
Murray Energy Corporation V. EPA, Et Al	16-1218	Petition For Review	UNITED STATES COURT OF APPEALS FOR DISTRICT OF COLUMBIA CIRCUIT 333 CONSTITUTION AVENUE, NW WASHINGTON, DC 20001	On appeal

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 3, Question 7: Legal actions, administrative proceedings, court actions, executions, attachments, or governmental audits

Case Title	Case Number	Nature of case	Court or agency's name and address	Status Of Case
Murray Energy Corporation V. United States Environmental Protection Agency	15-1385	Environmental	UNITED STATES COURT OF APPEALS FOR THE DISTRICT OF COLUMBIA CIRCUIT LEWIS F. POWELL JR. COURTHOUSE & ANNEX 1100 EAST MAIN STREET, SUITE 501 RICHMOND, VA 23219	Pending
Murray Energy Corporation V. United States Environmental Protection Agency	16-1406	Environmental	UNITED STATES COURT OF APPEALS FOR THE DISTRICT OF COLUMBIA CIRCUIT LEWIS F. POWELL JR. COURTHOUSE & ANNEX 1100 EAST MAIN STREET, SUITE 501 RICHMOND, VA 23219	Pending
Murray Energy Corporation V. United States Environmental Protection Agency, Et Al.	1:15-cv-110 IMK (N.D. WV)	Environmental	DISTRICT COURT FOR THE NORTHERN DISTRICT OF WEST VIRGINIA 1125 CHAPLINE STREET, SUITE 3000 WHEELING, WV 26003	Pending
Murray Energy Corporation, Et Al. V. Environmental Protection Agency, Et Al.	15A778	Regulatory	UNITED STATES SUPREME COURT OF APPEALS 1 FIRST ST NE WASHINGTON, DC 20543	On appeal
Murray Energy Corporation, Et Al. V. Gina McCarthy Administrator, United States Environmental Protection Agency ("U.S. EPA")	5:14-CV-39	Environmental	DISTRICT COURT FOR THE NORTHERN DISTRICT OF WEST VIRGINIA 1125 CHAPLINE STREET, SUITE 3000 WHEELING, WV 26003	Concluded
Murray Energy Corporation, Et Al. V. Mine Safety & Health Administration, Et Al.	2:15-CV-448	Regulatory	UNITED STATES DISTRICT COURT FOR THE SOUTHERN DISTRICT OF OHIO, EAST DIVISION 170 N HIGH ST COLUMBUS, OH 43215	Pending
Murray Energy Corporation, Et Al. V. The New York Times Company	17-C-70	Defamation	CIRCUIT COURT OF MARSHALL COUNTY, WEST VIRGINIA 600 7TH STREET #106 MOUNDSVILLE, WV 26041	Concluded
Murray Energy Corporation, Et Al. V. Time Warner, Inc., Home Box Office, Inc., Et Al.	17-C-124	Defamation	CIRCUIT COURT OF MARSHALL COUNTY, WV 511 6TH STREET MOUNDSVILLE, WV 26041	Concluded

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 3, Question 7: Legal actions, administrative proceedings, court actions, executions, attachments, or governmental audits

Case Title	Case Number	Nature of case	Court or agency's name and address	Status Of Case
Nicholas Riggle, Et Al., Plaintiffs Vs. Murray Energy Corporation Et Al., Defendants.	17-5906	Personal Injury	COURT OF COMMON PLEAS OF ALLEGHENY COUNTY, PENNSYLVANIA 414 GRANT STREET PITTSBURGH, PA 15219	Pending
Nicholas Riggle, Et Al., V. Murray Energy Corporation, Et Al.	19-C-129	Property	CIRCUIT COURT OF MARSHALL COUNTY, WEST VIRGINIA 600 7TH STREET #106 MOUNDSVILLE, WV 26041	Pending
Nii V. Robert E. Murray And Murray Energy Corporation Et Al.	16CV0480	Harassment/Employment	BELMONT COUNTY COURT OF COMMON PLEAS, BELMONT COUNTY, OHIO 101 W. MAIN STREET SAINT CLAIRSVILLE, OH 43950	Pending
Robert And Dawn Montag V. The Ohio Valley Coal Company, Et Al.	18 BE 0050	Property	BELMONT COUNTY COURT OF COMMON PLEAS, BELMONT COUNTY, OHIO 101 W. MAIN STREET SAINT CLAIRSVILLE, OH 43950	Pending
Robert And Dawn Montag V. The Ohio Valley Coal Company, Murray Energy Corporation And Tubaugh Remodeling LLC	16-cv-220	Property	BELMONT COUNTY COURT OF COMMON PLEAS, BELMONT COUNTY, OHIO 101 W. MAIN STREET SAINT CLAIRSVILLE, OH 43950	On appeal
Terry Sargent V. Murray Energy Corporation, Murray Kentucky Energy, And Western Kentucky Coal Resources	474-2019-00812	Sex Discrimination/Harassment	U.S. EEOC 131 M STREET, NE FOURTH FLOOR, SUITE 4NWO2F WASHINGTON, DC 20507 -0100	Pending
Terry Sargent V. Murray Energy Corporation, Murray Kentucky Energy, And Western Kentucky Coal Resources	474-2019-00813	Sex Discrimination/Harassment	U.S. EEOC 131 M STREET, NE FOURTH FLOOR, SUITE 4NWO2F WASHINGTON, DC 20507 -0100	Pending
Terry Sargent V. Murray Energy Corporation, Murray Kentucky Energy, And Western Kentucky Coal Resources	474-2019-00814	Sex Discrimination/Harassment	U.S. EEOC 131 M STREET, NE FOURTH FLOOR, SUITE 4NWO2F WASHINGTON, DC 20507 -0100	Pending

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 3, Question 7: Legal actions, administrative proceedings, court actions, executions, attachments, or governmental audits

Case Title	Case Number	Nature of case	Court or agency's name and address	Status Of Case
Tetrick Heirs And Guy Corporation V. AmericanMountaineer Energy, Inc. And Murray Energy Corporation	1:17-CV-205	Breach Of Contract	NORTHERN DISTRICT OF WEST VIRGINIA, CLARKSBURG, WV 500 W PIKE ST CLARKSBURGH, WV 26301	Pending
Thomas Tillman V. Murray Energy Corporation, Et Al.	19-CV-	Personal Injury	BELMONT COUNTY COURT OF COMMON PLEAS, BELMONT COUNTY, OHIO 101 W. MAIN STREET SAINT CLAIRSVILLE, OH 43950	Pending
U.S. Department Of Labor On Behalf Of Jason Todd (2) V. Murray Energy Corporation, The Marion County Coal Company, And Robert E. Murray	WEVA-2019-0426-D/MSHA CASE NO. MORG-CD-2018-08	Labor Charge	MINE SAFETY AND HEALTH ADMINISTRATION 1331 PENNSYLVANIA AVENUE, NW, SUITE 520N WASHINGTON, DC 20004	Pending
West Virginia Et Al. V. United States Environmental Protection Agency	15-1366	Environmental	UNITED STATES COURT OF APPEALS FOR THE DISTRICT OF COLUMBIA CIRCUIT LEWIS F. POWELL JR. COURTHOUSE & ANNEX 1100 EAST MAIN STREET, SUITE 501 RICHMOND, VA 23219	Concluded
WPP LLC V. Murray American Energy, Inc., Et Al., CNX RCPC, CNX Land, Murray Energy Corporation, CONSOL Energy, Inc. And CONSOL Gas	15-C-814	Breach Of Contract	CIRCUIT COURT OF CABELL COUNTY, WEST VIRGINIA 750 5TH AVE #202, HUNTUNGTON, WV 25701	Pending
WPP LLC V. Murray American Energy, Inc., Et Al., CNX RCPC, CNX Land, Murray Energy Corporation, CONSOL Energy, Inc. And CONSOL Gas	15-C-816	Breach Of Contract	CIRCUIT COURT OF CABELL COUNTY, WEST VIRGINIA 750 5TH AVE #202, HUNTUNGTON, WV 25701	Pending
WPP LLC V. Murray American Energy, Inc., Et Al., CNX RCPC, CNX Land, Murray Energy Corporation, CONSOL Energy, Inc. And CONSOL Gas	15-C-817	Breach Of Contract	CIRCUIT COURT OF CABELL COUNTY, WEST VIRGINIA 750 5TH AVE #202, HUNTUNGTON, WV 25701	Pending
WPP LLC V. Murray American Energy, Inc., Et Al., CNX RCPC, CNX Land, Murray Energy Corporation, CONSOL Energy, Inc. And CONSOL Gas	15-C-818	Breach Of Contract	CIRCUIT COURT OF CABELL COUNTY, WEST VIRGINIA 750 5TH AVE #202, HUNTUNGTON, WV 25701	Pending

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 4, Question 9: List all gifts or charitable contributions the debtor gave to a recipient within 2 years before filing this case unless the aggregate value of the gifts to that recipient is less than $1,000

Creditor's Name & Address	Recipients relationship to debtor	Description of the gifts or contributions	Dates given	Value
1863 PAC, LTD PO BOX 481 MARTINSBURG, WV 25402	N/A	Cash Contribution	06/28/2018	$72,000.00
1863 PAC, LTD PO BOX 481 MARTINSBURG, WV 25402	N/A	Cash Contribution	10/26/2018	$30,000.00
ADVANCE CALIFORNIA 2308 MT VERNON AVE STE 762 ALEXANDRIA, VA 22301	N/A	Cash Contribution	05/30/2018	$150,000.00
AMERICAN COAL COUNCIL 1101 PENNSYLVANIA AVE NW STE 300 WASHINGTON, DC 20004	N/A	Sponsorship	01/09/2019	$8,500.00
AMERICAN HEART ASSOCIATION GREAT RIVERS AFFILIATE-AR PO BOX 50065 PRESCOTT, AZ 86304-5065	N/A	Sponsorship	12/04/2017	$15,000.00
AMERICAN HEART ASSOCIATION GREAT RIVERS AFFILIATE-AR PO BOX 50065 PRESCOTT, AZ 86304-5065	N/A	Sponsorship	11/14/2018	$15,000.00
ANDREW MISTAK (ADDRESS ON FILE)	N/A	Cash Contribution	04/02/2019	$5,000.00
BELMONT COUNTY FARM BUREAU INC. 100 COLONEL DRIVE BARNESVILLE, OH 43713	N/A	Cash Contribution	04/05/2019	$1,000.00
BELMONT COUNTY STUDENT SERVICES 349 35TH STREET BELLAIRE, OH 43906	N/A	Cash Contribution	04/09/2019	$1,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	12/28/2017	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	02/01/2018	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	03/01/2018	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	03/29/2018	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	05/03/2018	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	06/01/2018	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	07/11/2018	$100,000.00

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Part 4, Question 9: List all gifts or charitable contributions the debtor gave to a recipient within 2 years before filing this case unless the aggregate value of the gifts to that recipient is less than $1,000

Creditor's Name & Address	Recipients relationship to debtor	Description of the gifts or contributions	Dates given	Value
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	08/31/2018	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	09/05/2018	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	09/06/2018	$91,340.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	10/03/2018	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	11/02/2018	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	11/28/2018	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	03/04/2019	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	03/04/2019	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	03/04/2019	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	04/04/2019	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	05/06/2019	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	06/03/2019	$100,000.00
BOY SCOUTS OF AMERICA 1325 WEST WALNUT HILL LANE IRVING, TX 75015-2079	VARIOUS	Cash Sponsorship	06/24/2019	$5,000.00
CATO INSTITUTE 1000 MASSACHUSETTS AVE NW WASHINGTON, DC 20077-0172	N/A	Cash Sponsorship	10/05/2018	$5,000.00
CENTER FOR THE STUDY OF CO2 AND GLOBAL CHANGE 5219 S RESEDA STREET GILBERT, AZ 85298	N/A	Cash Contribution	11/13/2017	$10,000.00
CENTER FOR THE STUDY OF CO2 AND GLOBAL CHANGE 5219 S RESEDA STREET GILBERT, AZ 85298	N/A	Cash Contribution	01/15/2018	$40,000.00

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Creditor's Name & Address	Recipients relationship to debtor	Description of the gifts or contributions	Dates given	Value
CENTER FOR THE STUDY OF CO2 AND GLOBAL CHANGE 5219 S RESEDA STREET GILBERT, AZ 85298	N/A	Cash Contribution	10/04/2018	$10,000.00
CFACT COMMITTEE FOR A CONSTRUCTIVE TOMORR PO BOX 430 ABINGDON, MD 21009-0430	N/A	Cash Contribution	10/05/2018	$5,000.00
CFG ACTION MONTANA C/O HOLLOWAY CONSULTING INC 1530 WILSON BLVD., SUITE 440 ARLINGTON, VA 22209-2447	N/A	Cash Contribution	08/23/2018	$20,000.00
CHRISTOPHER HUMPAL (ADDRESS ON FILE)	N/A	Cash Contribution	03/28/2018	$5,000.00
COMMUNITY FOUNDATION FOR THE OHIO V 1310 MARKET STREET WHEELING, WV 26003	N/A	Cash Contribution	04/03/2018	$1,000.00
COMPETITIVE ENTERPRISE INSTITUTE 1310 L STREET, NW , 7TH FLOOR WASHINGTON, DC 20005	N/A	Cash Contribution	05/01/2018	$50,000.00
COMPETITIVE ENTERPRISE INSTITUTE 1310 L STREET, NW , 7TH FLOOR WASHINGTON, DC 20005	N/A	Cash Contribution	10/01/2018	$50,000.00
COMPETITIVE ENTERPRISE INSTITUTE 1310 L STREET, NW , 7TH FLOOR WASHINGTON, DC 20005	N/A	Cash Contribution	02/01/2019	$50,000.00
COMPETITIVE ENTERPRISE INSTITUTE 1310 L STREET, NW , 7TH FLOOR WASHINGTON, DC 20005	N/A	Cash Contribution	07/02/2019	$50,000.00
CYSTIC FIBROSIS FOUNDATION 4550 MONTGOMERY AVE., SUITE 1100 N BETHESDA, MD 20814	N/A	Cash Contribution	03/22/2018	$1,000.00
EAST RICHLAND EVANGELICAL FRIENDS CHURCH 67885 FRIENDS CHURCH ROAD ST. CLAIRSVILLE, OH 43950	N/A	Cash Contribution	04/24/2019	$250,000.00
EAST RICHLAND EVANGELICAL FRIENDS CHURCH 67885 FRIENDS CHURCH ROAD ST. CLAIRSVILLE, OH 43950	N/A	Cash Contribution	06/03/2019	$250,000.00

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EAST RICHLAND EVANGELICAL FRIENDS CHURCH 67885 FRIENDS CHURCH ROAD ST. CLAIRSVILLE, OH 43950	N/A	Cash Contribution	1/2018 - 5/2019	$189,575.00
EBENEZER BAPTIST CEMETERY C/O THOMAS W JOHNSON PO BOX 555 BETHESDA, OH 43719	N/A	Cash Sponsorship	11/15/2017	$8,600.00
EBENEZER BAPTIST CEMETERY C/O THOMAS W JOHNSON PO BOX 555 BETHESDA, OH 43719	N/A	Cash Contribution	03/28/2019	$6,700.00
EPWORTH PARK CHAUTAUQUA ASSEMBLY PA BOARD P.O. BOX 25 BETHESDA, OH 43719	N/A	Cash Contribution	03/06/2018	$2,475.00
EPWORTH PARK CHAUTAUQUA ASSEMBLY PA BOARD P.O. BOX 25 BETHESDA, OH 43719	N/A	Cash Contribution	05/10/2018	$2,250.00
EPWORTH PARK CHAUTAUQUA ASSEMBLY PA BOARD P.O. BOX 25 BETHESDA, OH 43719	N/A	Cash Contribution	07/09/2018	$1,417.50
EPWORTH PARK CHAUTAUQUA ASSEMBLY PA BOARD P.O. BOX 25 BETHESDA, OH 43719	N/A	Cash Contribution	07/18/2018	$2,902.50
EPWORTH PARK CHAUTAUQUA ASSEMBLY PA BOARD P.O. BOX 25 BETHESDA, OH 43719	N/A	Cash Contribution	08/09/2018	$1,350.00
EPWORTH PARK CHAUTAUQUA ASSEMBLY PA BOARD P.O. BOX 25 BETHESDA, OH 43719	N/A	Cash Contribution	09/11/2018	$2,866.50
FREEDOM WORKS FOUNDATION, INC. ATTN: PARISSA SEDGHI FORNWALT 111 K ST. NE SUITE 600 WASHINGTON, DC 20002	N/A	Cash Contribution	08/15/2018	$25,000.00
FREEDOM WORKS FOUNDATION, INC. ATTN: PARISSA SEDGHI FORNWALT 111 K ST. NE SUITE 600 WASHINGTON, DC 20002	N/A	Cash Contribution	10/12/2018	$25,000.00

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Creditor's Name & Address	Recipients relationship to debtor	Description of the gifts or contributions	Dates given	Value
FRIENDS OF COAL LADIES AUXILIARY PO BOX 1109 BECKLEY, WV 25802	N/A	Cash Contribution	11/13/2017	$5,000.00
FRIENDS OF COAL LADIES AUXILIARY PO BOX 1109 BECKLEY, WV 25802	N/A	Cash Contribution	10/26/2018	$1,000.00
FRIENDS OF JUVENILE DRUG COURT INC 114 SOUTH BUTLER STREET ST.CLAIRSVILLE, OH 43950	N/A	Cash Contribution	11/10/2017	$10,000.00
FRIENDS OF JUVENILE DRUG COURT INC 114 SOUTH BUTLER STREET ST.CLAIRSVILLE, OH 43950	N/A	Cash Sponsorship	02/20/2019	$6,000.00
GLENWOOD INC. 150 GLENWOOD LANE BIRMINGHAM, AL 35242	N/A	Cash Sponsorship	04/11/2018	$2,750.00
GLENWOOD INC. 150 GLENWOOD LANE BIRMINGHAM, AL 35242	N/A	Cash Sponsorship	03/22/2019	$2,750.00
GOVERNMENT ACCOUNTABILITY & OVERSIG 324 LOGTRAC ROAD STANDSVILLE, VA 22973	N/A	Cash Contribution	06/07/2018	$100,000.00
GOVERNMENT ACCOUNTABILITY & OVERSIG 324 LOGTRAC ROAD STANDSVILLE, VA 22973	N/A	Cash Contribution	09/12/2018	$100,000.00
GOVERNMENT ACCOUNTABILITY & OVERSIG 324 LOGTRAC ROAD STANDSVILLE, VA 22973	N/A	Cash Contribution	01/02/2019	$100,000.00
HARDWORKING AMERICANS COMMITTEE ATTN RANDALL THOMPSON 3250 FOLEY GLEN DRIVE FENTON, MI 48430	N/A	Cash Contribution	04/18/2018	$30,000.00
HARDWORKING OHIOANS, INC. PO BOX 6105 COLUMBUS, OH 43206	N/A	Cash Contribution	10/26/2018	$100,000.00
HAZEN LODGE #251 F.&A.M. BOX 433 BETHESDA, OH 43719	N/A	Cash Sponsorship	05/31/2019	$1,000.00
HEARTLAND AMERICA INC PO BOX 91754 WASHINGTON, DC 20090	N/A	Cash Contribution	04/18/2018	$15,000.00
HEBREW ACADEMY OF CLEVELAND 1860 SOUTH TAYLOR ROAD CLEVELAND HEIGHTS, OH 44118	N/A	Cash Contribution	02/14/2019	$2,500.00

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Creditor's Name & Address	Recipients relationship to debtor	Description of the gifts or contributions	Dates given	Value
INTERNATIONAL CLIMATE SCIENCE COALI 28 TIVERTON DRIVE OTTAWA, ON K2E 6L5 CANADA	N/A	Cash Contribution	03/13/2018	$20,000.00
INTERNATIONAL CLIMATE SCIENCE COALI 28 TIVERTON DRIVE OTTAWA, ON K2E 6L5 CANADA	N/A	Cash Contribution	10/01/2018	$20,000.00
INTERNATIONAL CLIMATE SCIENCE COALI 28 TIVERTON DRIVE OTTAWA, ON K2E 6L5 CANADA	N/A	Cash Contribution	04/05/2019	$20,000.00
JETS BOOSTER CLUB 66859 BELMONT MORRISTOWN ROAD BELMONT, OH 43718	N/A	Cash Contribution	05/28/2019	$1,000.00
JUDICIAL WATCH 425 THIRD STREET SW, SUITE 800 WASHINGTON, DC 20024	N/A	Cash Contribution	06/22/2018	$1,000.00
JUDICIAL WATCH 425 THIRD STREET SW, SUITE 800 WASHINGTON, DC 20024	N/A	Cash Contribution	06/22/2018	$1,000.00
KENTUCKY COAL ASSOCIATION 880 CORPORATE DRIVE #101 LEXINGTON, KY 40503	N/A	Cash Sponsorship	08/27/2018	$5,000.00
KENTUCKY TOMORROW INC PO BOX 22142 LOUISVILLE, KY 40252	N/A	Cash Contribution	10/25/2018	$5,000.00
KEYSTONE STRONG 13520 MCLEAREN RD., NO. 711024 HERNDON, VA 20171	N/A	Cash Contribution	08/23/2018	$50,000.00
MARSHALL COUNTY EDUCATION FOUNDATIO PO BOX 578 MOUNDSVILLE, WV 26041	N/A	Cash Contribution	05/28/2019	$10,000.00
MISSOURI RISING ACTION 1500 WILSON BLVD., 5TH FLOOR ARLINGTON, VA 22209	N/A	Cash Contribution	09/20/2018	$60,000.00
MOVING WEST VIRGINIA FORWARD BICPAC PO BOX 2711 CHARLESTON, WV 25330	N/A	Cash Contribution	09/27/2018	$30,000.00
NATIONAL MINING HALL OF FAME & MUSE PO BOX 981 LEADVILLE, CO 80461	N/A	Cash Sponsorship	05/31/2018	$16,000.00

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Creditor's Name & Address	Recipients relationship to debtor	Description of the gifts or contributions	Dates given	Value
NATIONAL MINING HALL OF FAME & MUSE PO BOX 981 LEADVILLE, CO 80461	N/A	Cash Sponsorship	08/02/2019	$35,000.00
NEWARK ICE HOCKEY ASSOCIATION C/O RANDY KILL 936 SHARON VALLEY RD NEWARK, OH 43055	N/A	Cash Contribution	03/19/2019	$3,000.00
NM INVESTMENT SERVICES LLC 3000 K STREET NW, SUITE 600 WASHINGTON, DC 20007-5109	N/A	Cash Contribution	01/03/2019	$50,000.00
OHIO CANCER RESEARCH ASSOCIATES 85 EAST GAY STREET SUITE 700 COLUMBUS, OH 43215	N/A	Cash Contribution	03/26/2018	$17,000.00
OHIO CANCER RESEARCH ASSOCIATES 85 EAST GAY STREET SUITE 700 COLUMBUS, OH 43215	N/A	Cash Contribution	03/04/2019	$17,000.00
OHIO CHRISTIAN ALLIANCE EDUCATION FUND PO BOX 3076 AKRON, OH 44309	N/A	Cash Contribution	07/06/2018	$20,000.00
OHIO CHRISTIAN ALLIANCE EDUCATION FUND PO BOX 3076 AKRON, OH 44309	N/A	Cash Contribution	12/12/2018	$10,000.00
OHIO CHRISTIAN ALLIANCE EDUCATION FUND PO BOX 3076 AKRON, OH 44309	N/A	Cash Contribution	09/04/2019	$10,000.00
OHIO FOUNDATION OF INDEPENDENT COLL 250 EAST BROAD STREET, SUITE 1700 COLUMBUS, OH 43215-3722	N/A	Cash Contribution	02/16/2018	$50,000.00
OHIO FOUNDATION OF INDEPENDENT COLL 250 EAST BROAD STREET, SUITE 1700 COLUMBUS, OH 43215-3722	N/A	Cash Contribution	06/24/2019	$50,000.00
OHIO RIVER SWEEP 5735 KELLOGG AVENUE CINCINNATI, OH 45230	N/A	Cash Contribution	02/08/2018	$2,000.00
OHIO RIVER SWEEP 5735 KELLOGG AVENUE CINCINNATI, OH 45230	N/A	Cash Sponsorship	03/26/2019	$2,000.00
OHIO RIVER VALLEY COUNCIL BOY SCOUTS OF AMERICA PO BOX 6186 WHEELING, WV 26003	N/A	Cash Sponsorship	11/06/2017	$16,782.00

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Creditor's Name & Address	Recipients relationship to debtor	Description of the gifts or contributions	Dates given	Value
OHIO RIVER VALLEY COUNCIL BOY SCOUTS OF AMERICA PO BOX 6186 WHEELING, WV 26003	N/A	Cash Contribution	11/08/2017	$100,000.00
OHIO RIVER VALLEY COUNCIL BOY SCOUTS OF AMERICA PO BOX 6186 WHEELING, WV 26003	N/A	Cash Sponsorship	06/12/2018	$25,000.00
OHIO RIVER VALLEY COUNCIL BOY SCOUTS OF AMERICA PO BOX 6186 WHEELING, WV 26003	N/A	Cash Contribution	04/08/2019	$75,000.00
OHIO RIVER VALLEY COUNCIL BOY SCOUTS OF AMERICA PO BOX 6186 WHEELING, WV 26003	N/A	Cash Sponsorship	04/08/2019	$25,000.00
OHIO RIVER VALLEY COUNCIL BOY SCOUTS OF AMERICA PO BOX 6186 WHEELING, WV 26003	N/A	Cash Contribution	05/28/2019	$5,000.00
OUR HOME OUR FIGHT PO BOX 641306 CHICAGO, IL 60664	N/A	Cash Sponsorship	04/05/2018	$15,000.00
POWHATAN VOLUNTEER FIRE DEPARTMENT STATION 33 104 MELLOTT STREET POWHATAN POINT, OH 43942	N/A	Cash Contribution	10/10/2018	$1,000.00
REPUBLICAN ATTORNEYS GENERAL ASSOCI 1747 PENNSYLVANIA AVE NW STE 800 WASHINGTON, DC 20006	N/A	Cash Sponsorship	04/04/2019	$10,000.00
REPUBLICAN GOVERNORS ASSOCIATION 1747 PENNSYLVANIA AVE NW, STE 250 WASHINGTON, DC 20006	N/A	Cash Contribution	10/25/2018	$10,000.00
REPUBLICAN PARTY OF CUYAHOGA CO C/O THE PAROSKA GROUP 2206 SUPERIOR VIADUCT, SUITE 401 CLEVELAND, OH 44113	N/A	Cash Contribution	03/27/2018	$10,000.00
RMCMI ROCKY MOUNTAIN COAL MINING IN 3900 S. WADSWORTH BLVD., STE 365 LAKEWOOD, CO 80235	N/A	Cash Sponsorship	10/10/2018	$10,000.00
RMCMI ROCKY MOUNTAIN COAL MINING IN 3900 S. WADSWORTH BLVD., STE 365 LAKEWOOD, CO 80235	N/A	Cash Contribution	03/20/2019	$1,000.00

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SALVATION ARMY OF GREATER CLEVELAND MAJOR LURLENE KAY JOHNSON P.O. BOX 15149 CLEVELAND, OH 44115-0149	N/A	Cash Contribution	11/09/2018	$100,000.00
SENATE LEADERSHIP FUND 1130 CONNECTICUT AVE. NW, SUITE 120 WASHINGTON, DC 20036	N/A	Cash Contribution	07/25/2018	$15,000.00
SENATE LEADERSHIP FUND 1130 CONNECTICUT AVE. NW, SUITE 120 WASHINGTON, DC 20036	N/A	Cash Contribution	07/25/2018	$15,000.00
SENATE LEADERSHIP FUND 1130 CONNECTICUT AVE. NW, SUITE 120 WASHINGTON, DC 20036	N/A	Cash Contribution	07/25/2018	$15,000.00
SENATE LEADERSHIP FUND 1130 CONNECTICUT AVE. NW, SUITE 120 WASHINGTON, DC 20036	N/A	Cash Contribution	09/20/2018	$50,000.00
SOCIETY FOR MINING, METALLURGY AND EXPLORATION FOUNDATION 12999 EAST ADAM AIRCRAFT CIRCLE ENGLEWOOD, CO 80112-4167	N/A	Cash Sponsorship	09/24/2018	$50,000.00
SOCIETY FOR MINING, METALLURGY AND EXPLORATION 8307 SHAFFER PKWY LITTLETON, CO 80127-4102	N/A	Cash Contribution	03/08/2018	$4,306.00
SOCIETY FOR MINING, METALLURGY AND EXPLORATION 8307 SHAFFER PKWY LITTLETON, CO 80127-4102	N/A	Cash Contribution	07/10/2018	$5,000.00
SOCIETY FOR MINING, METALLURGY AND EXPLORATION 8307 SHAFFER PKWY LITTLETON, CO 80127-4102	N/A	Cash Contribution	07/12/2018	$2,500.00
SOCIETY FOR MINING, METALLURGY AND EXPLORATION 8307 SHAFFER PKWY LITTLETON, CO 80127-4102	N/A	Cash Contribution	08/30/2018	$213,780.00
SOCIETY FOR MINING, METALLURGY AND EXPLORATION 8307 SHAFFER PKWY LITTLETON, CO 80127-4102	N/A	Cash Sponsorship	11/15/2018	$5,000.00

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SOCIETY FOR MINING, METALLURGY AND EXPLORATION 8307 SHAFFER PKWY LITTLETON, CO 80127-4102	N/A	Cash Sponsorship	03/26/2019	$2,530.00
ST. RITA SCHOOL 33200 BALDWIN ROAD SOLON, OH 44139	N/A	Cash Contribution	01/19/2018	$3,000.00
TENNESSEANS FOR A BETTER TOMORROW ROBYN KNECHT 1010 WISCONSIN AVE., NW, SUITE 570 WASHINGTON, DC 20007	N/A	Cash Contribution	09/20/2018	$50,000.00
TEXANS ARE, INC. C/O LAUREN LOFSTROM 107 S WEST STREET, STE. 746 ALEXANDRIA, VA 22314-2891	N/A	Cash Contribution	08/23/2018	$20,000.00
THE HEARTLAND INSTITUTE 3939 NORTH WILKE ROAD ARLINGTON HEIGHTS, IL 60004	N/A	Cash Contribution	03/26/2018	$30,000.00
THE HEARTLAND INSTITUTE 3939 NORTH WILKE ROAD ARLINGTON HEIGHTS, IL 60004	N/A	Cash Contribution	05/02/2018	$50,000.00
THE HEARTLAND INSTITUTE 3939 NORTH WILKE ROAD ARLINGTON HEIGHTS, IL 60004	N/A	Cash Contribution	09/28/2018	$50,000.00
THE LINSLY SCHOOL, INC. 60 KNOX LANE WHEELING, WV 26003	N/A	Cash Contribution	10/03/2018	$10,000.00
THE LINSLY SCHOOL, INC. 60 KNOX LANE WHEELING, WV 26003	N/A	Cash Sponsorship	02/11/2019	$2,500.00
THE OHIO STATE UNIVERSITY FOUNDATIO 1480 WEST LANE AVENUE COLUMBUS, OH 43221	N/A	Cash Sponsorship	04/17/2019	$125,000.00
THE SALVATION ARMY OF BELLAIRE MAJOR LOUIS PATRICK 315 37TH STREET BELLAIRE, OH 43906	N/A	Cash Contribution	10/22/2018	$5,000.00
TRANSPARENCY IN GOVERNMENT PAC 7 APPLEGREEN LN THE HILLS, TX 78738	N/A	Cash Contribution	09/13/2018	$50,000.00
VILLAGE OF BETHESDA 112 SOUTH MAIN STREET BETHESDA, OH 43719	N/A	Cash Contribution	12/18/2018	$3,500.00
WASHINGTON COAL CLUB 2600 VIRGINIA AVE., NW, SUITE 505 WASHINGTON, DC 20037	N/A	Cash Sponsorship	01/16/2019	$2,500.00

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WAYNESBURG UNIVERSITY 51 WEST COLLEGE STREET WAYNESBURG, PA 15370	N/A	Cash Sponsorship	05/30/2018	$20,000.00
WEST VIRGINIA COAL ASSOCIATION INC P.O. BOX 3923 CHARLESTON, WV 25339	N/A	Cash Contribution	04/18/2018	$50,000.00
WEST VIRGINIA'S FUTURE PAC PO BOX 11024 CHARLESTON, WV 25339	N/A	Cash Contribution	06/28/2018	$72,000.00
WHEELING COUNTRY DAY SCHOOL 8 PARK ROAD WHEELING, WV 26003	N/A	Cash Sponsorship	04/11/2018	$2,000.00
WHEELING COUNTRY DAY SCHOOL 8 PARK ROAD WHEELING, WV 26003	N/A	Cash Contribution	12/26/2018	$75,000.00
WHEELING COUNTRY DAY SCHOOL 8 PARK ROAD WHEELING, WV 26003	N/A	Cash Contribution	05/20/2019	$2,500.00
WHEELING SYMPHONY SOCIETY INC 1025 MAIN STREET SUITE 811 WHEELING, WV 26003	N/A	Cash Contribution	12/07/2017	$25,000.00
WHEELING SYMPHONY SOCIETY INC 1025 MAIN STREET SUITE 811 WHEELING, WV 26003	N/A	Cash Contribution	07/13/2018	$1,500.00
WHEELING SYMPHONY SOCIETY INC 1025 MAIN STREET SUITE 811 WHEELING, WV 26003	N/A	Cash Sponsorship	12/04/2018	$25,000.00
WILLIAM E. WILLIAMS (ADDRESS ON FILE)	N/A	Cash Contribution	04/10/2018	$2,000.00

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 6, Question 11: Payments related to bankruptcy

Creditor's Name and Address	Email or website address	Who made the payment if not debtor?	If not money describe any property transferred	Dates	Total amount or value
ALVAREZ & MARSAL NORTH AMERICA, LLC 600 MADISON AVENUE NEW YORK, NY 10022	https://www.alvarezandmarsal.com/			09/20/2019	$451,613.44
ALVAREZ & MARSAL NORTH AMERICA, LLC 600 MADISON AVENUE NEW YORK, NY 10022	https://www.alvarezandmarsal.com/			09/27/2019	$451,613.43
ALVAREZ & MARSAL NORTH AMERICA, LLC 600 MADISON AVENUE NEW YORK, NY 10022	https://www.alvarezandmarsal.com/			10/02/2019	$509,629.00
ALVAREZ & MARSAL NORTH AMERICA, LLC 600 MADISON AVENUE NEW YORK, NY 10022	https://www.alvarezandmarsal.com/			10/10/2019	$288,931.00
ALVAREZ & MARSAL NORTH AMERICA, LLC 600 MADISON AVENUE NEW YORK, NY 10022	https://www.alvarezandmarsal.com/			10/15/2019	$331,930.00
ALVAREZ & MARSAL NORTH AMERICA, LLC 600 MADISON AVENUE NEW YORK, NY 10022	https://www.alvarezandmarsal.com/			10/23/2019	$388,391.00
ALVAREZ & MARSAL NORTH AMERICA, LLC 600 MADISON AVENUE NEW YORK, NY 10022	https://www.alvarezandmarsal.com/			10/25/2019	$475,888.00
CLEAR THINKING GROUP LLC 401 TOWNE CENTRE DRIVE HILLSBOROUGH, NJ 08844	https://www.clearthinkinggroup.com/			10/16/2019	$150,000.00
DAVIS POLK & WARDWELL LLP 450 LEXINGTON AVE. NEW YORK, NY 10017	https://www.davispolk.com/			09/09/2019	$100,000.00
DINSMORE & SHOHL LLP 255 EAST FIFTH ST SUITE 1900 CINCINNATI, OH 45202	https://www.dinsmore.com/			10/25/2019	$200,000.00
EVERCORE GROUP LLC EVERCORE BD INVESTCO LLC 55 E 52ND ST. NEW YORK, NY 10055	https://www.evercore.com/			10/10/2019	$264,146.35
HOULIHAN LOKEY 10250 CONSTELLATION BLVD 5TH FLOOR LOS ANGELES, CA 90067	https://www.hl.com/			10/03/2019	$300,000.00

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 6, Question 11: Payments related to bankruptcy

Creditor's Name and Address	Email or website address	Who made the payment if not debtor?	If not money describe any property transferred	Dates	Total amount or value
KIRKLAND & ELLIS LLP 601 LEXINGTON AVE. NEW YORK, NY 10022	https://www.kirkland.com/			02/15/2019	$108,257.89
KIRKLAND & ELLIS LLP 601 LEXINGTON AVE. NEW YORK, NY 10022	https://www.kirkland.com/			03/08/2019	$40,689.11
KIRKLAND & ELLIS LLP 601 LEXINGTON AVE. NEW YORK, NY 10022	https://www.kirkland.com/			09/06/2019	$250,000.00
KIRKLAND & ELLIS LLP 601 LEXINGTON AVE. NEW YORK, NY 10022	https://www.kirkland.com/			09/13/2019	$500,000.00
KIRKLAND & ELLIS LLP 601 LEXINGTON AVE. NEW YORK, NY 10022	https://www.kirkland.com/			10/01/2019	$652,349.01
KIRKLAND & ELLIS LLP 601 LEXINGTON AVE. NEW YORK, NY 10022	https://www.kirkland.com/			10/03/2019	$500,000.00
KIRKLAND & ELLIS LLP 601 LEXINGTON AVE. NEW YORK, NY 10022	https://www.kirkland.com/			10/15/2019	$792,793.57
KIRKLAND & ELLIS LLP 601 LEXINGTON AVE. NEW YORK, NY 10022	https://www.kirkland.com/			10/17/2019	$750,000.00
KIRKLAND & ELLIS LLP 601 LEXINGTON AVE. NEW YORK, NY 10022	https://www.kirkland.com/			10/23/2019	$850,000.00
KIRKLAND & ELLIS LLP 601 LEXINGTON AVE. NEW YORK, NY 10022	https://www.kirkland.com/			10/25/2019	$1,000,000.00
LATHAM & WATKINS LLP PO BOX 2130 CAROL STREAM, IL 60132-2130	https://www.lw.com/			09/20/2019	$13,724.50
LATHAM & WATKINS LLP PO BOX 2130 CAROL STREAM, IL 60132-2130	https://www.lw.com/			10/03/2019	$385,000.00
PRIME CLERK ONE GRAND CENTRAL PLACE 60 EAST 42ND STREET, SUITE 1440 NEW YORK, NY 10165	https://www.primeclerk.com/			10/16/2019	$100,000.00
PRIME CLERK ONE GRAND CENTRAL PLACE 60 EAST 42ND STREET, SUITE 1440 NEW YORK, NY 10165	https://www.primeclerk.com/			10/25/2019	$27,034.45

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 6, Question 11: Payments related to bankruptcy

Creditor's Name and Address	Email or website address	Who made the payment if not debtor?	If not money describe any property transferred	Dates	Total amount or value
WILLKIE FARR & GALLAGHER LLP	https://www.willkie.com/			10/28/2019	$150,000.00

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 25: Other businesses in which the debtor has or has had an interest

Business Name & Address	Describe the nature of the business	Employer identification number	Date business existed From	Date business existed To
AMCOAL HOLDINGS, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	34-1867389	06/12/1998	Present
AMERICAN COMPLIANCE COAL, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	34-1797161	05/24/1994	Present
AMERICAN ENERGY CORPORATION 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	31-1550443	04/12/1993	Present
AMERICAN EQUIPMENT & MACHINE, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Petroleum and Coal Products Manufacturing	34-1632808	10/31/1988	Present
AMERICAN MINE SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Petroleum and Coal Products Manufacturing	46-3389502	08/07/2013	Present
AMERICAN NATURAL GAS, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Natural Gas Distribution	27-0654094	07/28/2009	Present
AMERICANMOUNTAINEER ENERGY, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	26-3553404	06/30/2008	Present
BELMONT COAL, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	31-1536602	04/12/1993	Present
CONSOLIDATED LAND COMPANY 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	34-1769562	04/12/1993	Present
EMPIRE DOCK, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	27-0332407	11/29/1995	Present
FORESIGHT ENERGY GP LLC METROPOLITAN SQUARE BUILDING 211 NORTH BROADWAY SUITE 2600 ST. LOUIS, MO 63102	Coal Mining	90-0788332	04/16/2015	Present
FORESIGHT ENERGY LP METROPOLITAN SQUARE BUILDING 211 NORTH BROADWAY SUITE 2600 ST. LOUIS, MO 63102	Coal Mining	80-0778894	04/16/2015	Present
KANAWHA TRANSPORTATION CENTER, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Security Services	34-1682102	02/25/1991	Present

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 25: Other businesses in which the debtor has or has had an interest

Business Name & Address	Describe the nature of the business	Employer identification number	Date business existed From	Date business existed To
MURRAY AMERICAN COAL, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	47-3295883	3/2/2015	Present
MURRAY AMERICAN MINERALS, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	81-4274943	10/17/2016	Present
MURRAY AMERICAN RESOURCES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	34-1875051	09/22/1998	Present
MURRAY AMERICAN RIVER TOWING, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	46-4293881	11/26/2013	Present
MURRAY ENERGY SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Dormant Entity	81-4279795	10/31/2016	01/31/2017
MURRAY EQUIPMENT & MACHINE, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Petroleum and Coal Products Manufacturing	47-1711788	08/27/2014	Present
MURRAY GLOBAL COMMODITIES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	47-4230675	06/08/2015	Present
MURRAY KENTUCKY ENERGY SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	82-4039675	01/12/2018	Present
MURRAY KENTUCKY ENERGY, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	82-4020295	01/12/2018	Present
MURRAY METALLURGICAL COAL PROPERTIES II, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	83-4455958	03/28/2019	Present
MURRAY METALLURGICAL COAL PROPERTIES, LLC 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	83-4312504	03/28/2019	Present
MURRAY SOUTH AMERICA, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	46-2065263	09/17/2012	Present
MURRAY UTAH ENERGY SERVICES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	82-3350080	10/23/2017	Present
MURRAY UTAH ENERGY, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	82-2861412	09/19/2017	Present

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 25: Other businesses in which the debtor has or has had an interest

Business Name & Address	Describe the nature of the business	Employer identification number	Date business existed From	Date business existed To
OHIO ENERGY TRANSPORTATION, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	45-3126348	08/26/2011	Present
OHIO VALLEY RESOURCES, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	34-1586391	03/29/1988	Present
OHIOAMERICAN ENERGY, INCORPORATED 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	20-3044610	02/01/2005	Present
UTAHAMERICAN ENERGY, INC. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Coal Mining	34-1874726	07/30/1998	Present

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26a: List all accountants and bookkeepers who maintained the debtor's books and records within 2 years before filing this case.

Name & Address	Dates of service From	Dates of service To
JACOB M. ROELEN, CONTROLLER (ADDRESS ON FILE)	06/01/2015	Present
JEREMY J. HARRISON (ADDRESS ON FILE)	06/01/2015	Present
ROBERT D. MOORE (ADDRESS ON FILE)	05/01/1993	Present

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26c: Firms or individuals who were in possession of the debtor's books of account and records when this case is filed.

Name and Address	If any books of account and records are unavailable explain why
JACOB M. ROELEN, CONTROLLER (ADDRESS ON FILE)	
JEREMY J. HARRISON (ADDRESS ON FILE)	
ROBERT D. MOORE (ADDRESS ON FILE)	

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
683 CAPITAL MANAGEMENT 3 COLUMBUS CIRCLE SUITE 2205 NEW YORK, NY 10019
ABERDEEN TRUST HOLDINGS LTD 1900 MARKET STREET SUITE 200 PHILADELPHIA, PA 19103
ACCIPITER CAPITAL MANAGEMENT, LLC 3801 PGA BLVD. PALM BEACH GARDENS, FL 33408
ADAGE CAPITAL MANAGEMENT 200 CLARENDON STREET 52ND FLOOR BOSTON, MA 02116
ALCENTRA 160 QUEEN VICTORIA STREET LONDON EC4V 4LA UNITED KINGDOM
ALDEN GLOBAL CAPITAL 885 3RD AVENUE NEW YORK, NY 10022
ALLIANZ GLOBAL INVESTORS 1633 BROADWAY NEW YORK, NY 10019
ALTA FUNDAMENTAL 777 THIRD AVENUE, SUITE 19A NEW YORK, NY 10017
AMERICAN ELECTRIC POWER PO BOX 371496 PITTSBURGH, PA 15250-7496
AMIA CAPITAL 33 KING STREET LONDON SW1Y 6RJ UNITED KINGDOM
AMSOUTH 1900 FIFTH AVENUE NORTH BIRMINGHAM, AL 35203
AMTRUST FINANCIAL 59 MAIDEN LANE NEW YORK, NY 10038
AMUNDI SMITH BREEDEN 280 SOUTH MANGUM STREET, SUITE 301 DURHAM, NC 27701
AMZAK CAPITAL 980 NORTH FEDERAL HIGHWAY SUITE 315 BOCA RATON, FL 33432
ANGELO GORDON ANGELO, GORDON & CO., L.P. 245 PARK AVENUE NEW YORK, NY 10167

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
APOLLO APOLLO GLOBAL MANAGEMENT, INC. 9 WEST 57TH STREET, 43RD FLOOR NEW YORK, NY 10019
APPALOOSA 51 JOHN F. KENNEDY PKWY. SHORT HILLS, NJ 07078
ARBOUR LANE CAPITAL MANAGEMENT 777 3RD AVENUE, 14TH FLOOR NEW YORK, NY 10017
ARENA CAPITAL 12121 WILSHIRE BOULEVARD, SUITE 1010 LOS ANGELES, CA 90025
ARENA INVESTORS LP 405 LEXINGTON AVENUE 59TH FLOOR NEW YORK, NY 10174
ARES MANAGEMENT 2000 AVENUE OF THE STARS 12TH FLOOR LOS ANGELES, CA 90067
ARGO 90 PITTS BAY ROAD PEMBROKE HM 08
ARGO SURETY 90 PITTS BAY ROAD PEMBROKE HM 08
ARISTEIA CAPITAL ONE GREENWICH PLAZA GREENWICH, CT 06830
ARMORY FUNDS LLC 1230 ROSECRANS AVE., #660 MANHATTAN BEACH, CA 90266
ARTISAN ARTISAN PARTNERS 875 E. WISCONSIN AVENUE SUITE 800 MILWAUKEE, WI 53202
ASPEN C/O RT SPECIALTY 50 W MONROE 30TH FLOOR CHICAGO, IL 60606
ASTON HILL 399 PARK AVENUE 10TH FLOOR NEW YORK, NY 10022
ATHOS CAPITAL 77 KING STREET WEST SUITE 2110, PO BOX 92 TORONTO, ON M5K 1G8
AURORA CAPITAL 10877 WILSHIRE BOULEVARD 21ST FLOOR LOS ANGELES, CA 90024

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
AVM ADDRESS UNKNOWN
B. RILEY CAPITAL MANAGEMENT 111 WEST MONROE STREET THIRD FLOOR CHICAGO, IL 60603-4014
BAIN CAPITAL SENIOR LOAN FUND LP BAIN CAPITAL CREDIT LP BAIN CAPITAL DISTRESSED AND SPECIAL SITUATIONS 2016 (EU MASTER), L.P 200 CLARENDON STREET BOSTON, MA 02116
BALYASNY ASSET MGMT CALLE POETA JOAN MARAGALL 3, 1º IZQ ANTIGUA CALLE CAPITAN HAYA MADRID
BANK OF AMERICA, N.A. BANK OF AMERICA, N.A. ATTN: CASSIE GOODNIGHT 214 NORTH TRYON STREET CHARLOTTE, NC 28255
BANK OF NEW YORK MELLON ATTN: BETH SLABY, VICE PRESIDENT DEFAULT ADMINISTRATION GROUP 500 ROSS ST 12TH FLOOR PITTSBURGH, PA 15262
BARCLAYS 444 W. LAKE STREET 50TH FLOOR CHICAGO, IL 60606
BARRINGS LLC 1 CHURCHILL PLACE LONDON E14 5HP UNITED KINGDOM
BAYSIDE CAPITAL HIG 1450 BRICKELL AVENUE 31ST FLOOR MIAMI, FL 33131
BEACH POINT 1620 26TH STREET SUITE 6000N SANTA MONICA, CA 90404
BEF INVESTMENTS 300 SOUTH TRYON STREET SUITE 2500 CHARLOTTE, NC 28202
BENEFIT STREET PARTNERS CLO II LTD BENEFIT STREET PARTNERS ATTN: SERGE KOZMIN 50 KENNEDY PLAZA 18TH FLOOR PROVIDENCE, RI 02903
BENNETT MANAGMENT 2 STAMFORD PLAZA SUITE 1501 281 TRESSER BLVD STAMFORD, CT 06901

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
BLACK DIAMOND CLO 2016-1 LTD BLACK DIAMOND CAPITAL MANAGEMENT ONE SOUND SHORE DRIVE SUITE 200 GREENWICH, CT 06830
BLACKGOLD CAPITAL 109 NORTH POST OAK LANE SUITE 500 HOUSTON, TX 77024
BLACKROCK 100 WEST 58TH STREET SUITE 2B NEW YORK, NY 10019
BLUE BAY ASSET MANAGEMENT 750 WASHINGTON BOULEVARD SUITE 802 STAMFORD, CT 06901
BLUEBAY 77 GROSVENOR STREET LONDON W1K 3JR UNITED KINGDOM
BLUECREST 40 EAST 52ND STREET NEW YORK, NY 10022
BMO 40 GROSVENOR PLACE LONDON SW1X 7AW UNITED KINGDOM
BNP PARIBAS EUROPA-ALLEE 12 FRANKFURT AM MAIN 60327
BOLDERWOOD CAPITAL MANAGEMENT 477 MADISON AVENUE, SIXTH FLOOR NEW YORK, NY 10022
BRIGADE CAPITAL MANAGEMENT LP 399 PARK AVENUE, SUITE 1600 NEW YORK, NY 10022
BROOKFIELD ASSET MANAGEMENT BROOKFIELD PLACE, SUITE 300 181 BAY STREET TORONTO, ON M5J 2T3
BROWNSTONE INVESTMENT GROUP 505 FIFTH AVENUE, 10TH FLOOR NEW YORK, NY 10017
CALIBRE GROUP LLC 707 GRANT STREET, SUITE 2320 PITTSBURGH, PA 15219
CANTOR FITZGERALD 110 EAST 59TH STREET NEW YORK, NY 10022
CANYON PARTNERS 2000 AVENUE OF THE STARS 11TH FL LOS ANGELES, CA 90067

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
CAPITAL GROUP 333 S. HOPE STREET 53RD FLOOR LOS ANGELES, CA 90071
CAPITALSOURCE 4598 SOLUTIONS CENTER CHICAGO, IL 60677-4005
CARVAL INVESTORS 9320 EXCELSIOR BOULEVARD 7TH FLOOR MINNEAPOLIS, MN 55343
CASERN CAPITAL ADDRESS UNKNOWN
CASPIAN HLSC1 LLC ATTN: SUSAN LANCASTER 767 FITH AVE,. 45TH FLOOR NEW YORK, NY 10153
CASTLE HILL ADDRESS UNKNOWN
CASTLELAKE 4600 WELLS FARGO CENTER 90 SOUTH SEVENTH STREET MINNEAPOLIS, MN 55402
CATALUR CAPITAL MANAGEMENT, LP 477 MADISON AVENUE, SIXTH FLOOR NEW YORK, NY 10022
CATERPILLAR FINANCIAL SERVICES 2120 W END AVE NASHVILLE, TN 37203-0990
CEDARVIEW CAPITAL 21255 BURBANK BLVD., SUITE 400 WOODLAND HILLS, CA 91367
CENTERBRIDGE 375 PARK AVENUE NEW YORK, NY 10152-0002
CETUS CAPITAL ONE PENN PLAZA 45TH FLOOR NEW YORK, NY 10119
CF CAPITAL CORPORATION WORLD TRADE CENTER 10 MONTREAL SQUARE, 1ST FLOOR, ENTRANCE F BUCHAREST 1 11469
CHENAVARI INVESTMENT MANAGERS 80 VICTORIA STREET LONDON SW1E 5JL UNITED KINGDOM
CIT GROUP/CAPITAL FINANCE INC CHURCH STREET STATION PO BOX 4339 NEW YORK, NY 10261-4339

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
CITADEL INVESTMENT GROUP 131 SOUTH DEARBORN STREET CHICAGO, IL 60603
CITI 1 LANDMARK SQUARE # 420 STAMFORD, CT 06901
CKC CAPITAL 60 EAST 42ND STREET SUITE 2340 NEW YORK, NY 10165
CLARKSON INVESTMENT SERVICES COMMODITY QUAY ST KATHARINE DOCKS LONDON E1W 1BF UNITED KINGDOM
CLUTTERBUCK FUNDS LLC 388 GREENWICH STREET NEW YORK, NY 10013
COLUMBIA MANAGEMENT GROUP 200 PUBLIC SQUARE SUITE 2910 CLEVELAND, OH 44114
COLUMN PARK 3 COLUMBUS CIRCLE NEW YORK, NY 10019
CONTRARIAN CAPITAL 411 WEST PUTNAM AVENUE SUITE 425 GREENWICH, CT 06830
COURAGECAP 4400 HARDING ROAD, SUITE 503 NASHVILLE, TN 37205
COV CREDIT ADDRESS UNKNOWN
COVE KEY MANAGEMENT LP 430 W 7TH STREET, STE 219104 KANSAS CITY, MO 64105-1407
COWEN 599 LEXINGTON AVENUE 20TH FLOOR NEW YORK, NY 10022
CQS CAPITAL STRUCTURE 5847 SAN FELIPE STREET SUITE 1560 HOUSTON, TX 77057
CREDIT SUISSE AG 4TH FLOOR ONE STRAND LONDON WC2N 5HR UNITED KINGDOM
CREDIT VALUE PARTNERS 49 WEST PUTNAM AVENUE GREENWICH, CT 06830

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
CRESCENT CAPITAL HIGH INCOME FUND LP CRESCENT CAPITAL GROUP LP ATTN: TIM BRENHAM 10 HUDSON YARDS NEW YORK, NY 10001
CROSS SOUND 10 WESTPORT ROAD BUILDING C, FLOOR 2 WILTON, CT 06897
CROSSOCEAN PARTNERS 20 HORSENECK LANE GREENWICH, CT 06830
CVC 20 AVENUE MONTEREY L-2163 LUXEMBOURG
D. E. SHAW & CO. L.P. 1166 AVENUE OF THE AMERICAS, 9TH FLOOR NEW YORK, NY 10036
DALTON INVESTMENTS LLC UETLIBERGSTRASSE 231 P.O. BOX 700 ZURICH CH 8070
DAVIDSON KEMPNER CAPITAL 520 MADISON AVENUE, 30TH FLOOR NEW YORK, NY 10022
DDJ CAPITAL MGMT. STONY BROOK OFFICE PARK 130 TURNER STREET BUILDING 3, SUITE 600 WALTHAM, MA 02453
DELAWARE INVESTMENTS 2005 MARKET STREET ONE COMMERCE SQUARE PHILADELPHIA, PA 19103-7094
DEUTSCHE BANK AG, NEW YORK 5022 GATE PARKWAY, SUITE 400 JACKSONVILLE, FL 32256
DG CAPITAL 460 PARK AVENUE 22ND FLOOR NEW YORK, NY 10022
DIAMETER CAPITAL 1601 CLOVERFIELD BLVD, SUITE 5050 N SANTA MONICA, CA 90404
DICHOTOMY CAPITAL 826 SCARSDALE AVE SCARSDALE, NY 10583
DOUBLELINE 333 S. GRAND AVE. 18TH FLOOR LOS ANGELES, CA 90071
DSC MERIDIAN CAPITAL 888 SEVENTH AVENUE NEW YORK, NY 10106

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
DUANE PARK CAPITAL MANAGEMENT LP 24 W 40TH STREET 5TH FLOOR NEW YORK, NY 10018
DUCERA PARTNERS LLC 499 PARK AVENUE FLOOR 16 NEW YORK, NY 10022
DUKE ENERGY BUSINESS SERVICES LLC 526 SOUTH CHURCH STREET SUITE EC-03T CHARLOTTE, NC 28202
DUKE ENERGY CAROLINAS, LLC ATTENTION: MANAGER - COAL ORIGINATION 526 S. CHURCH STREET MAIL CODE: EC02F CHARLOTTE, NC 28202
DUKE ENERGY FLORIDA, LLC P.O. BOX 14041 ST. PETERSBURG, FL 33733
DUKE ENERGY INDIANA, LLC 1000 EAST MAIN STREET PLAINFIELD, IN 46168
DUKE ENERGY KENTUCKY, INC. 526 SOUTH CHURCH STREET CHARLOTTE, NC 28202
DUKE ENERGY PROGRESS, LLC 526 SOUTH CHURCH STREET ECO2F CHARLOTTE, NC 28201
E.ON E.ON SE BRÜSSELER PLATZ 1 ESSEN 45131
EATON VANCE LOAN HOLDING LTD EATON VANCE ATTN: MORGAN WOODS TWO INTERNATIONAL PLACE 9TH FLOOR BOSTON, MA 02110
ECHELON INVESTMENT PARTNERS LP 621 NW 53RD ST, SUITE 240 BOCA RATON, FL 33487
ELLINGTON MANAGEMENT GROUP 53 FOREST AVE OLD GREENWICH, CT 06870
ELLIOTT ASSOCIATES LP 40 WEST 57TH STREET 30TH FLOOR NEW YORK, NY 10019
ELLIS LAKE CAPITAL LLC 800 3RD AVENUE 26TH FLOOR NEW YORK, NY 10022
ENCINA BUSINESS CREDIT LLC 123 NORTH WACKER DRIVE, SUITE 2400 CHICAGO, IL 60606

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
ENCINA EQUIPMENT FINANCE SPV LLC 83 WOOSTER HEIGHTS ROAD SUITE 125 DANBURY, CT 06810
ERP ADDRESS UNKNOWN
ETON PARK CAPITAL MANAGEMENT 200 E. 18TH ST AUSTIN, TX 78701
EVERETT CAPITAL 112 JERMYN STREET ST JAMES'S LONDON SW1Y 6LS
FIDELITY MANAGEMENT & RESEARCH COMPANY 245 SUMMER STREET BOSTON, MA 02210
FIFTH STREET MANAGEMENT LLC 777 WEST PUTNAM AVENUE 3RD FLOOR GREENWICH, CT 06830
FIFTH THIRD BANK ATTN: COLLEEN TITCHWORTH 38 FOUNTAIN SQUARE PLAZA CINCINNATI, OH 45263
FINEPOINT CAPITAL LP 500 BOYLSTON STREET, 24TH FLOOR BOSTON, MA 02116
FIR TREE 55 WEST 46TH STREET 29TH FLOOR NEW YORK, NY 10036
FORESIGHT ENERGY, LP AND SUBSIDIARIES METROPOLITAN SQUARE BUILDING 211 NORTH BROADWAY SUITE 2600 ST LOUIS, MO 63102
FORT WASHINGTON 303 BROADWAY SUITE 1200 CINCINNATI, OH 45202
FOXHILL CAPITAL PARTNERS LLC LOGGERHEAD PLAZA 14255 HIGHWAY 1 SUITE 240 JUNO BEACH, FL 33408
FPA FIRST PACIFIC ADVISORS, LP 11601 WILSHIRE BOULEVARD SUITE 1200 LOS ANGELES, CA 90025
FRANKLIN ADDRESS UNKNOWN

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
FRANKLIN TEMPLETON INVESTMENTS 3344 QUALITY DRIVE RANCHO CORDOVA, CA 95670-7313
FTN FINANCIAL 444 MADISON AVE 9TH FLOOR NEW YORK, NY 10022
GALLATIN LOAN MANAGEMENT 1290 AVENUE OF THE AMERICAS SUITE 914 NEW YORK, NY 10104
GARDNER LEWIS 285 WILMINGTON-WEST CHESTER PIKE CHADDS FORD, PA 19317
GATEWAY CREDIT PARTNERS 299 PARK AVENUE 21ST FLOOR NEW YORK, NY 10171
GCM GROSVENOR 900 NORTH MICHIGAN AVENUE SUITE 1100 CHICAGO, IL 60611
GLOBAL CREDIT ADVISERS GLOBAL CREDIT ADVISERS, LLC 100 PARK AVENUE 35TH FLOOR NEW YORK, NY 10017
GLUSKIN SHEFF BAY ADELAIDE CENTRE 333 BAY STREET SUITE 5100 TORONTO, ON M5H 2R2
GMO IMPLEMENTATION FUND GMO ATTN: JEFF FRIEDMAN 40 ROWES WHARF BOSTON, MA 02111
GMP SECURITIES 145 KING STREET WEST SUITE 300 TORONTO, ON M5H 1J8
GOLDENTREE ASSET MANAGEMENT LP 300 PARK AVENUE 21ST FLOOR NEW YORK, NY 10022
GOLDMAN, SACHS & CO. ATTN: GREG SCADUTO LETTERS OF CREDIT – CORPORATE LOAN OPERATIONS 2001 ROSS AVENUE, 29TH FLOOR DALLAS, TX 75201
GRAHAM CAPITAL MANAGEMENT GRAHAM CAPITAL MANAGEMENT, L.P. HEADQUARTERS 40 HIGHLAND AVENUE ROWAYTON, CT 06853

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

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Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
GREYWOLF CAPITAL MANAGEMENT LP GREYWOLF CAPITAL MANAGEMENT LP HEADQUARTERS 4 MANHATTANVILLE ROAD SUITE 201 PURCHASE, NY 10577
GROUSE RIDGE CAPITAL 601 PITTSBURGH ROAD BUTLER, PA 16002
GSO CAPITAL BLACKSTONE GSO 345 PARK AVENUE NEW YORK, NY 10154
GUARDIAN CAPITAL LP COMMERCE COURT WEST 199 BAY STREET - SUITE 3100 PO BOX 201 TORONTO, ON M5L 1E8
GUGGENHEIM GUGGENHEIM NEW YORK HQ 330 MADISON AVENUE NEW YORK, NY 10017
HARTFORD INVESTMENT MANAGEMENT CO HARTFORD INVESTMENT MANAGEMENT COMPANY ONE HARTFORD PLAZA HARTFORD, CT 06155
HAWKEYE CAPITAL 1251 AVENUE OF THE AMERICAS NEW YORK, NY 10020
HBC HUDSON BAY CAPITAL MANAGEMENT LP 777 THIRD AVENUE 30TH FLOOR NEW YORK, NY 10017
HBK ONE BRYANT PARK SUITE 4000 NEW YORK, NY 10036
HIGHLAND CAPITAL 300 CRESCENT COURT SUITE 700 DALLAS, TX 75201
HPS INVESTMENT PARTNERS 40 WEST 57TH STREET 33RD FLOOR NEW YORK, NY 10019
HSBC MORTGAGE CORPORATION ATTN: PAYOFF DEPT. 2929 WALDEN AVENUE DEPEW, NY 14043
HUNTINGTON NATIONAL BANK ATTN: AARON COX 7 EASTON OVAL COLUMBUS, OH 43219
HUTCHIN HILL CAPITAL 888 SEVENTH AVENUE NEW YORK, NY 10106

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
IMPERIAL CAPITAL ATTN: JESSIE MARSHALL, VICE PRESIDENT 10100 SANTA MONICA BLVD., SUITE 2400 LOS ANGELES, CA 90067
INTL FCSTONE CREDIT TRADING 155 EAST 44TH STREET SUITE 900 NEW YORK, NY 10017
IRONSIDES PARTNERS SPECIAL SITUATIO FUND III 46226 NATIONAL RD ST.CLAIRSVILLE, OH 43950
IWD CAPITAL MANAGEMENT LLC ADDRESS UNKNOWN
J.H. LANE PARTNERS MASTER FUND, LP J.H. LANE PARTNERS MASTER FUND ATTN: HASKEL GINSBERG 126 EAST 56TH STREET, SUITE 1620 NEW YORK, NY 10022
JACKSON VALLEY FUND ONE MAIN STREET SUITE 202 CHATHAM, NJ 07928
JAMES RIVER CAPITAL CORP 58 BROAD STREET ROAD MANAKIN-SABOT, VA 23103
JAVELIN GLOBAL COMMODITIES (UK) LTD. 7 HOWICK PLACE LONDON SW1P 1BB UNITED KINGDOM
JEFFERIES & COMPANY, INC. 520 MADISON AVENUE, 12TH FL. NEW YORK, NY 10022-4213
JHL CAPITAL GROUP JHL CAPITAL GROUP LLC 900 NORTH MICHIGAN AVENUE SUITE 1700 CHICAGO, IL 60611
JLP INSTITUTIONAL CREDIT MASTER FUN WALKERS CORPORATE LIMITED, CAYMAN C GEORGE TOWN, GRAND CAYMAN KY1-9008 CAYMAN ISLANDS
JONES ROAD CAPITAL MANAGEMENT JONES ROAD CAPITAL MANAGEMENT, L.P. 757 THIRD AVENUE SUITE 1801 NEW YORK, NY 10017
JAVELIN GLOBAL COMMODITIES LTD. ATTENTION: PETER BRADLEY 7 HOWICK PLACE LONDON SW1P 1BB UNITED KINGDOM

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
KENNEDY LEWIS KENNEDY LEWIS INVESTMENT MANAGEMENT LLC 80 BROAD STREET 22ND FLOOR NEW YORK, NY 10004
KENTUCKY UTILITIES COMPANY ONE QUALITY ST LEXINGTON, KY 40507
KING STREET CAPITAL KING STREET CAPITAL MANAGEMENT, L.P. 65 E 55TH ST NEW YORK, NY 10022
KLIRMARK KLIRMARK CAPITAL LTD. AMOT ATRIUM TOWER 2 JABOTINSKI ST. RAMAT GAN 5250501
KLS KLS DIVERSIFIED ASSET MANAGEMENT LP 452 FIFTH AVENUE 22ND FLOOR NEW YORK, NY 10018
KNIGHTHEAD CAPITAL MANAGEMENT LLC KNIGHTHEAD CAPITAL MANAGEMENT, LLC ATTN: EDWARD P. MASSARO 1140 AVENUE OF THE AMERICAS; 12TH FLOOR NEW YORK, NY 10036
LATHAM & WATKINS LLP PO BOX 2130 CAROL STREAM, IL 60132-2130
LATIGO PARTNERS 450 PARK AVE # 1200 NEW YORK, NY 10022
LEXANT CAPITAL CORP 7353 NETHERSOLE DRIVE CLEVELAND, OH 44130
LINDEN ADVISORS LP 590 MADISON AVENUE 15TH FLOOR NEW YORK, NY 10022
LION POINT CAPITAL 250 WEST 55TH STREET 33RD FLOOR NEW YORK, NY 10019
LMI LIBERTY MUTUAL INSURANCE 175 BERKELEY STREET BOSTON, MA 02116
LOEWS CORPORATION 667 MADISON AVENUE NEW YORK, NY 10065-8087
LOGEN ASSET MANAGEMENT 599 LEXINGTON AVENUE 38TH FLOOR NEW YORK, NY 10022

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Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
LOUISVILLE GAS & ELECTRIC COMPANY KENTUCKY UTILITIES COMPANY 220 WEST MAIN STREET LOUISVILLE, KY 40232-2010
MACKAY SHIELDS ATTN: JOHN W. AKKERMAN 1345 AVENUE OF THE AMERICAS NEW YORK, NY 10105
MACQUARIE EQUIPMENT CAPITAL INC. 3100 WEST END AVE SUITE 325 NASHVILLE, TN 37203
THE MANGROVE PARTNERS MASTER FUND, LTD. MANGROVE PARTNERS ATTN: WARD DIETRICH 645 MADISON AVE 14TH FL NEW YORK, NY 10022
MAPLE ROCK CAPITAL PARTNERS INC ATTN: KRISTY DUCHAK 770 TAMALPAIS DR #221 CORTE MADERA, CA 94925
MARATHON ASSET MANAGEMENT MARATHON ASSET MANAGEMENT, LP ONE BRYANT PARK 38TH FLOOR NEW YORK, NY 10036
MARBLE RIDGE MARBLE RIDGE CAPITAL LP 1250 BROADWAY SUITE 2601 NEW YORK, NY 10001
MARINER CAPITAL MARINER CAPITAL ADVISORS 5700 W. 112TH ST. SUITE 500 OVERLAND PARK, KS 66211
MARNELL MANAGEMENT MARNELL MANAGEMENT LLC 30445 NORTHWESTERN HIGHWAY SUITE 146 FARMINGTON HILLS, MI 48334
MCGINTY ROAD 60 SOUTH 6TH STREET SUITE 3720 MINNEAPOLIS, MN 55402
MEDORA PARTNERS MEDORA PARTNERS LLC 379 WEST BROADWAY 5TH FLOOR NEW YORK, NY 10012
MERAKI ADVISORS ZÜMRÜTEVLER MAH. EMEK CAD. FUAYE TURKUAZ SITESI NO: 243 A17 BLOK D: 7 ISTANBUL

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Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
MHR FUND MANAGEMENT LLC MHR FUND MANAGEMENT LLC 1345 AVENUE OF THE AMERICAS 42ND FLOOR NEW YORK, NY 10105
MILLSTREET CAPITAL MANAGEMENT MILLSTREET CAPITAL MANAGEMENT LLC 399 BOYLSTON STREET SUITE 501 BOSTON, MA 02116
MOCKINGBIRD CREDIT PARTNERS MOCKINGBIRD CREDIT PARTNERS, LLC 3333 WELBORN STREET SUITE 320 DALLAS, TX 75219
MONARCH ALTERNATIVE CAPITAL LP 535 MADISON AVENUE NEW YORK, NY 10022
MONT BLANC CAPITAL MONT BLANC CAPITAL MANAGEMENT AG WALDMANNSTRASSE 8 ZURICH CH - 8001
MOODY'S INVESTORS SERVICES PO BOX 102597 ATLANTA, GA 30368-0597
MORGAN STANLEY SENIOR FUNDING INC MORGAN STANLEY ATTN: STEPHANIE CELI 1 NEW YORK PLAZA 41ST FLOOR NEW YORK, NY 10004
MSD PARTNERS L.P. 645 FIFTH AVENUE 21ST FLOOR NEW YORK, NY 10022-5910
MUDRICK CAPITAL 527 MADISON AVENUE 6TH FLOOR NEW YORK, NY 10022
MUZINICH & CO MUZINICH & CO., INC. 450 PARK AVENUE NEW YORK, NY 10022
NAPIER PARK GLOBAL CAPITAL 280 PARK AVENUE 3RD FLOOR NEW YORK, NY 10017
NATIONS EQUIPMENT FINANCE 501 MERRITT SEVEN NORWALK, CT 06851
NATIXIS SECURITIES AMERICAS LLC 1251 AVENUE OF THE AMERICAS NEW YORK, NY 10020
NEUBERGER BERMAN 1290 AVENUE OF THE AMERICAS NEW YORK, NY 10104

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Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
NEW GENERATIONS ADVISORS, LLC 13 ELM STREET, SUITE 2 MANCHESTER, MA 01994
NICOLA WEALTH MANAGEMENT 1508 WEST BROADWAY 5TH FLOOR VANCOUVER, BC V6J 1W8
NN INVESTMENT PARTNERS SCHENKKADE 65 POSTBUS 90470 THE HAGUE 2595 AS
NOKOTA MANAGEMENT LP 1330 AVENUE OF THE AMERICAS NEW YORK, NY 10019
NOMURA WORLDWIDE PLAZA 309 WEST 49TH STREET NEW YORK, NY 10019-7316
NORTHWESTERN MUTUAL 720 EAST WISCONSIN AVE. MILWAUKEE, WI 53202
NUT TREE CAPITAL MANAGEMENT TWO PENN PLAZA 24TH FLOOR NEW YORK, NY 10121
NUVEEN HIGH INCOME BOND FUND 46226 NATIONAL RD ST.CLAIRSVILLE, OH 43950
OAK HILL 263 TRESSER BOULEVARD 15TH FLOOR STAMFORD, CT 06901
OAKTREE CAPITAL OAKTREE CAPITAL MANAGEMENT, L.P. 333 SOUTH GRAND AVE. 28TH FLOOR LOS ANGELES, CA 90071
OCH-ZIFF CAPITAL MANAGEMENT 9 WEST 57TH STREET 39TH FLOOR NEW YORK, NY 10019
OCO CAPITAL PARTNERS LP 810 SEVENTH AVENUE 33RD FLOOR NEW YORK, NY 10019
ODEON CAPITAL 750 LEXINGTON AVENUE 27TH FLOOR NEW YORK, NY 10022
OFI GLOBAL ASSET MANAGEMENT OFI GLOBAL ASSET MANAGEMENT 225 LIBERTY STREET NEW YORK, NY 10281-1008

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

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Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
OHA CREDIT PARTNERS IX LTD OAK HILL ADVISORS, L.P. 1114 AVENUE OF THE AMERICAS 27TH FLOOR NEW YORK, NY 10036
OMEGA ADVISORS 1 NEW YORK PLAZA NEW YORK, NY 10004
ONEX CREDIT PARTNERS 161 BAY STREET TORONTO, ON M5J 2S1
OPPENHEIMER & CO. INC. 85 BROAD ST NEW YORK, NY 10004
OPPENHEIMER FUNDS INC. 225 LIBERTY STREET 11TH FLOOR NEW YORK, NY 10281
ORIGIN BANK 3921 ELM STREET CHOUDRANT, LA 71227
OSTRA CAPITAL 180 VARICK STREET SUITE 1008 NEW YORK, NY 10014
OWL CREEK ASSET MANAGEMENT 640 5TH AVENUE 21ST FLOOR NEW YORK, NY 10019
PACIFIC LIFE & ANNUITY SERVICES INC 700 NEWPORT CENTER DRIVE NEWPORT BEACH, CA 92660
PALMER SQUARE CAPITAL SPECIAL SITUATIONS FUND L.P. PALMER SQUARE CAPITAL MANAGEMENT LLC ATTN: MATT BLOOMFIELD 2000 SHAWNEE MISSION PKWY SUITE 300 MISSION WOODS, KS 66250
PALOMA PARTNERS 2 AMERICAN LANE GREENWICH, CT 06831
PANNING CAPITAL MANAGEMENT 510 MADISON AVENUE 23RD FLOOR NEW YORK, NY 10022
PAR IV 50 TICE BOULEVARD # 317 WOODCLIFF LAKE, NJ 07677
PARQUET CAPITAL 143 NEWBURY ST 6TH FLOOR BOSTON, MA 02116
PENTWATER CAPITAL MANAGEMENT LP 1001 10TH AVE SOUTH SUITE 216 NAPLES, FL 34102

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Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
PGIM PRUDENTIAL TOWER 655 BROAD STREET NEWARK, NJ 07102
PHOENIX INVESTMENT ADVISER LLC THE GRAYBAR BUILDING 420 LEXINGTON AVENUE SUITE 2040 NEW YORK, NY 10170
PIMCO 430 W 7TH STREET, STE 219104 KANSAS CITY, MO 64105-1407
PINE RIVER CAPITAL MANAGEMENT L.P. 601 CARLSON PARKWAY 7TH FLOOR MINNETONKA, MN 55305
PINEBRIDGE PARK AVENUE TOWER 65 EAST 55TH STREET NEW YORK, NY 10022
PINPOINT ASSET MANAGEMENT SWF, NO. 100 CENTURY AVENUE PUDONG DISTRICT SHANGHAI
PNC BANK PO BOX 856177 LOUISVILLE, KY 40285-6177
POINT72 72 CUMMINGS POINT ROAD STAMFORD, CT 06902
POLYGON 4 SLOANE TERRANCE LONDON SW1X9DQ UNITED KINGDOM
PROSHARES 7501 WISCONSIN AVE SUITE 1000E BETHESDA, MD 20814
PRUDENTIAL 213 WASHINGTON STREET NEWARK, NJ 07102-2992
PSAM 1350 AVENUE OF THE AMERICAS 21ST FLOOR NEW YORK, NY 10019
PUTNAM INVESTMENTS P.O. BOX 219697 KANSAS CITY, MO 64121-9697
R.W. PRESSPRICH & CO 452 5TH AVENUE 12TH FLOOR NEW YORK, NY 10018

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Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
RBC CAPITAL MARKETS LLC NICHOLAS ONKEN - CORPORATE ACTIONS 60 SOUTH 6TH STREET, MAIL STOP P09 MINNEAPLIS, MN 55402
REDWOOD CAPITAL 910 SYLVAN AVENUE ENGLEWOOD CLIFFS, NJ 07632
REGIONS FINANCIAL CORPORATION 1900 FIFTH AVENUE NORTH BIRMINGHAM, AL 35203
RESFUEL 1900 FIFTH AVENUE NORTH BIRMINGHAM, AL 35203
RIMROCK CAPITAL MANAGEMENT LLC 100 INNOVATION DRIVE SUITE 200 IRVINE, CA 92617
RIVER BIRCH CAPITAL GRACE BUILDING 1114 NEW YORK, NY 10036
ROBERT W. BAIRD P.O. BOX 0672 MILWAUKEE, WI 53202
ROCKWOOD CASUALTY INS CO 654 MAIN STREET ROCKWOOD, PA 15561
ROYSTONE CAPITAL MANAGEMENT 810 SEVENTH AVENUE 33RD FLOOR NEW YORK, NY 10019
SAGUARO CAPITAL 6501 EAST GREENWAY PARKWAY S103 SCOTTSDALE, AZ 85254
SCHRODERS 1 LONDON WALL PLACE LONDON EC2Y 5AU UNITED KINGDOM
SCOGIN CAPITAL 660 MADISON AVENUE 20TH FLOOR NEW YORK, NY 10065
SCOTTS COVE CAPITAL MGMT 400 MADISON AVENUE 10TH FLOOR NEW YORK, NY 10017
SEAPORT GROUP 360 MADISON AVENUE 22ND FLOOR NEW YORK, NY 10017
SEIX INVESTMENT ADVISORS ONE MAYNARD DRIVE SUITE 3200 PARK RIDGE, NJ 07656

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Name & Address
SERENGETI ASSET MANAGEMENT 632 BROADWAY 12TH FLOOR NEW YORK, NY 10012
SHENKMAN CAPITAL MANAGEMENT INC 461 FIFTH AVENUE 22ND FLOOR NEW YORK, NY 10017
SILVER POINT TWO GREENWICH PLAZA GREENWICH, CT 06830
SMITH COVE 919 THIRD AVENUE NEW YORK, NY 10022
SOLUS ALTERNATIVE ASSET MANAGEMENT LP 410 PARK AVENUE 11TH FLOOR NEW YORK, NY 10022
SOROS FUND MANAGEMENT LLC 250 WEST 55TH STREET 29TH FLOOR NEW YORK, NY 10019
SOUTHPAW ASSET MANAGEMENT 2 GREENWICH OFFICE PARK, FIRST FLOOR GREENWICH, CT 06831
SP GLOBAL RATINGS 55 WATER STREET NEW YORK, NY 10041
SPECTRUM GROUP 1250 BROADWAY, 19TH FLOOR NEW YORK, NY 10001
STANDARD PARTNERS MANAGEMENT 331 MADISON AVENUE NEW YORK, NY 10017
STIFEL NICOLAUS & COMPANY ATTN: ROBERT HAVILAND, MANAGING DIRECTOR 787 7TH AVENUE, 4TH FLOOR NEW YORK, NY 10019
STONE HARBOR 31 W. 52ND STREET 16TH FLOOR NEW YORK, NY 10019
SUMMIT PARTNERS 222 BERKELEY STREET, 18TH FLOOR BOSTON, MA 02116
SUNBURY GEN LP 1900 FIFTH AVENUE NORTH BIRMINGHAM, AL 35203
SUNCOKE ENERGY 1011 WARRENVILLE ROAD, 6TH FLOOR LISLE, IL 60532
SYMPHONY ASSET MANAGEMENT 555 CALIFORNIA STREET, SUITE 3100 SAN FRANCISCO, CA 94104

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Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
T. ROWE PRICE 100 EAST PRATT STREET BALTIMORE, MD 21202
TAAL CAPITAL 1 BEACON STREET, SUITE 21300 BOSTON, MA 02108
TACONIC 280 PARK AVENUE, 5TH FLOOR NEW YORK, NY 10017
TALAMOD ASSET MANAGEMENT TRAMMELL CROW CENTER 2001 ROSS AVENUE, SUITE 4350 DALLAS, TX 75201
TANNENBAUM TENNENBAUM CAPITAL PARTNERS, LLC 2951 28TH STREET SUITE 1000 SANTA MONICA, CA 90405
TANNOR CAPITAL MANAGEMENT LLC 3536 LOS PINOS DRIVE SANTA BARBARA, CA 93105
TEGEAN CAPITAL THE CHRYSLER BUILDING 405 LEXINGTON AVENUE, 29TH FLOOR NEW YORK, NY 10174
TENNENBAUM 2951 28TH STREET, SUITE 1000 SANTS MONICA, CA 90405
TENNESSEE VALLEY AUTHORITY RACHEL MORTON, ASSET MANAGEMENT SPECIALTIST COAL & GAS SERVICES, POWER OPS 1101 MARKET ST., 2D-C CHATTANOOGA, TN 37402
TEXAS EMPLOYEE RETIREMENT SYSTEM 444 MADISON AVENUE 40TH FLOOR NEW YORK, NY 10022
THE COURY FIRM 260 FORBES AVENUE, SUITE 1600 PITTSBURGH, PA 15222
THE MEC GROUP INC 1705 SPYGLASS CIRCLE PALOS HEIGHTS, IL 60463
THIRD POINT LLC 390 PARK AVENUE NEW YORK, NY 10022
THREE COURT LP 60 MADISON AVENUE, SUITE 1101 NEW YORK, NY 10010
TIAA INVESTMENTS 8500 ANDREW CARNEGIE BOULEVARD CHARLOTTE, NC 28262

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Name & Address

TIGER HILL ADVISORS
25 SACKVILLE STREET
LONDON W1S 3AX
UNITED KINGDOM

TITAN OPPORTUNITIES FUND
1246 CRABAPPLE ROAD
SUITE 202-429
ALPHARETTA, GA 30004

TONKA CAPITAL PARTNERS
4165 SHORELINE DRIVE SUITE 226
SPRING PARK, MN 55384

TRESVISTA FINANCIAL SERVICES
TOWER 49, 18-102, 12 EAST 49TH STREET
NEW YORK, NY 10017

TRIARII CAPITAL MANAGEMENT
175 FEDERAL ST, SUITE 509
BOSTON, MA 02110

TRICADIA
780 THIRD AVE., 29TH FL.
NEW YORK, NY 10017

TRILOGY CAPITAL
990 BISCAYNE BLVD.
SUITE 1203
MIAMI, FL 33132

TRS ADVISORS LLC
570 LEXINGTON AVENUE 22ND FLOOR
NEW YORK, NY 10022

UBS
ATTN: PETER QUIGLEY, VICE PRESIDENT – WEALTH MANAGEMENT
2310 RT 34
2ND FLOOR
MANASQUAN, NJ 08736

UNIGESTION
8C AVENUE DE CHAMPEL
PO BOX 387
GENEVA 12 1211

VERDE ASSET MANAGEMENT
RUA LEOPOLDO COUTO DE MAGALHAES JUNIOR 700
11TH FLOOR
ITAIM BIBI 04542-000

VOLTERRA CAPITAL
2550 GREAT AMERICA WAY SUITE 350
SANTA CLARA, CA 95054

VOYA FINANCIAL
230 PARK AVENUE
NEW YORK, NY 10169

WARLANDER ASSET MANAGEMENT
250 WEST 55TH STREET 33RD FLOOR
NEW YORK, NY 10019

WAVERTON INVESTMENT MANAGEMENT
16 BABMAES STREET
LONDON SW1Y 6AH
UNITED KINGDOM

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

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Part 13, Question 26d: List all financial institutions, creditors, and other parties, including mercantile and trade agencies, to whom the debtor issued a financial statement within 2 years before filing this case.

Name & Address
WEISS ASSET MANAGEMENT 222 BERKELEY STREET, 16TH FLOOR BOSTON, MA 02116
WEISS MULTI-STRATEGY ADVISERS LLC 320 PARK AVENUE 20TH FLOOR NEW YORK, NY 10022
WELLINGTON 280 CONGRESS STREET BOSTON, MA 02210
WELLS FARGO ADVISORS ONE NORTH JEFFERSON AVE. ST. LOUIS, MO 63103
WESTERN ASSET 385 EAST COLORADO BOULEVARD PASADENA, CA 91101
WESTFIELD INVESTMENT 50 CARDINAL DRIVE, SUITE 103 WESTFIELD, NJ 07090
WEXFORD CAPITAL 777 SOUTH FLAGLER DRIVE SUITE 602 EAST WEST PALM BEACH, FL 33401
WHITEBOX 3033 EXCELSIOR BLVD #300 MINNEAPOLIS, MN 55416
WOLVERINE ASSET MANAGEMENT 175 W. JACKSON BLVD. SUITE 200 CHICAGO, IL 60604
XL CATLIN 200 LIBERTY STREET NEW YORK, NY 10281
YORK CAPITAL MANAGEMENT 767 FIFTH AVENUE, 17TH FLOOR NEW YORK, NY 10153

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Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 28: Debtor's officers, directors, managing members, general partners, members in control, controlling shareholders, or other people in control of the debtor at the time of the filing of this case.

Name and Address	Position and nature of any interest	% of interest if any
GENERAL. RICHARD L. LAWSON (ADDRESS ON FILE)	Director	
HENRY W. FAYNE (ADDRESS ON FILE)	Director	
JAMES R. TURNER, JR. (ADDRESS ON FILE)	Senior Vice President	
MARK COX (ADDRESS ON FILE)	Director	
MICHAEL O. MCKOWN (ADDRESS ON FILE)	Secretary, Senior Vice President, Law & Administration	
MURRAY ENERGY HOLDINGS CO. 46226 NATIONAL ROAD ST. CLAIRSVILLE, OH 43950	Shareholder	100.00%
PAUL B. PICCOLINI (ADDRESS ON FILE)	Vice President - Human Resources & Employee Relations	
ROBERT D. MOORE (ADDRESS ON FILE)	President, Chief Executive Officer, Chief Financial Officer, Chief Operating Officer & Director	
ROBERT E. MURRAY (ADDRESS ON FILE)	Chairman	
ROBERT EDWARD MURRAY (ADDRESS ON FILE)	Executive Vice President - Marketing & Sales	
RYAN M. MURRAY (ADDRESS ON FILE)	Vice President – Operations	

Debtor Name: Murray Energy Corporation

Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 29: Within 1 year before the filing of this case, did the debtor have officers, directors, managing members, general partners, members in control of the debtor, or shareholders in control of the debtor who no longer hold these positions?

Name and address	Position and nature of any interest	Period during which position or interest was held From	Period during which position or interest was held To
BILLY J. CORNELIUS (ADDRESS ON FILE)	Senior Vice President - Marketing and Sales	08/15/2012	01/15/2019
ROBERT E. MURRAY (ADDRESS ON FILE)	President and Chief Executive Officer	02/24/2001	10/28/2019

Debtor Name: Murray Energy Corporation Case Number: 19-57017 (JEH)

Statement of Financial Affairs for Non-Individuals Filing for Bankruptcy

Part 13, Question 30: Payments, distributions, or withdrawals credited or given to insiders

Name and address of recipient	Relationship to debtor	Amount of money or description and value of property	Dates	Reason for providing the value

Please refer to Statement of Financial Affairs Question 4.

Checklist for Online Medicare, Retirement, & Spouses Applications

The information below will help you gather the information you may need to create a *my* Social Security account and complete the online Medicare, Retirement, and Spouse's applications. We recommend you print this page to use while gathering your information.

Create a *my* Social Security Account

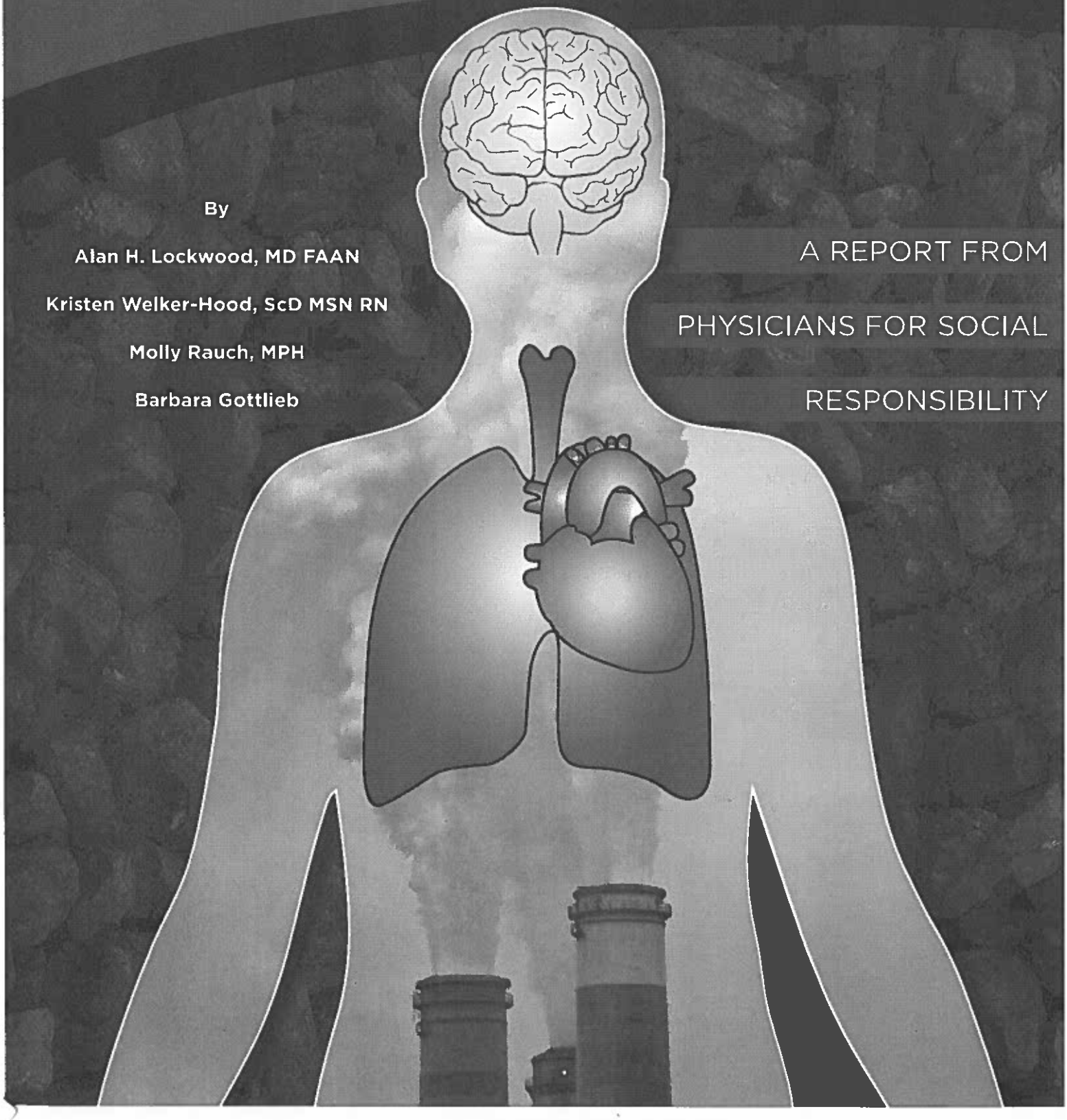
You are required to login to your existing *my* Social Security account, or attempt to create one. To create an account, we will ask you a series of identity questions for verification. You may want to have certain items on hand to be prepared for additional security questions, such as, but not limited to: **mobile phone (for the purpose of receiving texts and emails), credit card, W-2, and tax forms.**

File for Benefits Online – The Information You Need	*Medicare Only*	*Retirement & Spouses*
Date and Place of Birth If you were born outside the United States or its territories: • Name of your birth country at the time of your birth (it may have a different name now) • Permanent Resident Card number (if you are not a U.S citizen)	X	X
MEDICAID Number (State Health Insurance) - Start and End Dates	X	
Current Heath Insurance • Employment start and end dates for the current employer (of you or your spouse) who provides your health insurance coverage through a Group Health Plan • Start and end dates for the Group Health Insurance provided by you (or your spouse's) current employer	X	
Marriage and Divorce • Name of current spouse • Name of prior spouse (if the marriage lasted more than 10 years or ended in death) • Spouse(s) date of birth and SSN (optional) • Beginning and ending dates of marriage(s) • Place of marriage(s) (city, state or country, if married outside the U.S.)		X
Names and Dates of Birth of Children Who: • Became disabled prior to age 22, or • Are under age 18 and are unmarried, or • Are aged 18 to 19 and still attending secondary school full time		X
U.S. Military Service • Type of duty and branch • Service period dates		X
Employer Details for Current Year and Prior 2 Years (not self-employment) • View your Social Security Statement online at ***www.socialsecurity.gov/myaccount*** • Employer name • Employment start and end dates		X
Self-Employment Details for Current Year and Prior 2 Years • View your Social Security Statement online at ***www.socialsecurity.gov/myaccount*** • Business type • Total net income		X
Direct Deposit - Domestic bank (USA) • Account type and number • Bank routing number **Direct Deposit** - International bank (non-USA) • International Direct Deposit (IDD) bank country • Bank name, bank code, and currency • Account type and number, branch/transit number		X

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Exhibit 388a

COAL's ASSAULT *on* HUMAN HEALTH



By

Alan H. Lockwood, MD FAAN

Kristen Welker-Hood, ScD MSN RN

Molly Rauch, MPH

Barbara Gottlieb

A REPORT FROM

PHYSICIANS FOR SOCIAL

RESPONSIBILITY

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For an electronic copy of this report, please see **www.psr.org/coalreport**.

ABOUT PHYSICIANS FOR SOCIAL RESPONSIBILITY

PSR has a long and respected history of physician-led activism to protect the public's health. Founded in 1961 by a group of physicians concerned about the impact of nuclear proliferation, PSR shared the 1985 Nobel Peace Prize with International Physicians for the Prevention of Nuclear War for building public pressure to end the nuclear arms race. Today, PSR's members, staff, and state and local chapters form a nationwide network of key contacts and trained medical spokespeople who can effectively target threats to global survival. Since 1991, when PSR formally expanded its work by creating its environment and health program, PSR has addressed the issues of global warming and the toxic degradation of our environment. PSR presses for policies to curb global warming, ensure clean air, generate a sustainable energy future, prevent human exposures to toxic substances, and minimize toxic pollution of air, food, and drinking water.

NOVEMBER 2009

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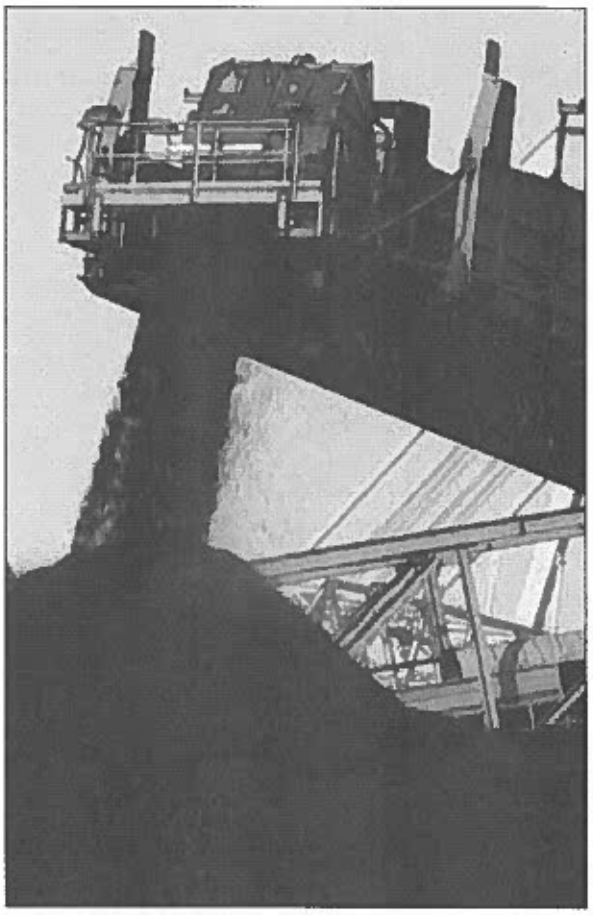
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Executive Summary

Coal pollutants affect all major body organ systems and contribute to four of the five leading causes of mortality in the U.S.: heart disease, cancer, stroke, and chronic lower respiratory diseases. This conclusion emerges from our reassessment of the widely recognized health threats from coal. Each step of the coal lifecycle—mining, transportation, washing, combustion, and disposing of post-combustion wastes—impacts human health. Coal combustion in particular contributes to diseases affecting large portions of the U.S. population, including asthma, lung cancer, heart disease, and stroke, compounding the major public health challenges of our time. It interferes with lung development, increases the risk of heart attacks, and compromises intellectual capacity.

Oxidative stress and inflammation are indicated as possible mechanisms in the exacerbation and development of many of the diseases under review. In addition, the report addresses another, less widely recognized health threat from coal: the contribution of coal combustion to global warming, and the current and predicted health effects of global warming.



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THE LIFE CYCLE OF COAL

Electricity provides many health benefits worldwide and is a significant contributor to economic development, a higher standard of living, and an increased life expectancy.[1] But burning coal to generate electricity harms human health and compounds many of the major public health problems facing the industrialized world. Detrimental health effects are associated with every aspect of coal's life cycle, including mining, hauling,

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preparation at the power plant, combustion, and the disposal of post-combustion wastes. In addition, the discharge of carbon dioxide into the atmosphere associated with burning coal is a major contributor to global warming and its adverse effects on health worldwide.

Coal mining leads U.S. industries in fatal injuries[2] and is associated with chronic health problems among miners, such as black lung disease, which causes permanent scarring of the lung tissues.[3] In addition to the miners themselves, communities near coal mines may be adversely affected by mining operations due to the effects of blasting, the collapse of abandoned mines, and the dispersal of dust from coal trucks. Surface mining also destroys forests and groundcover, leading to flood-related injury and mortality, as well as soil erosion and the contamination of water supplies. Mountaintop removal mining involves blasting down to the level of the coal seam—often hundreds of feet below the surface—and depositing the resulting rubble in adjoining valleys. This surface mining technique, used widely across southern Appalachia, damages freshwater aquatic ecosystems and the surrounding environment by burying streams and headwaters.[4]

Coal combustion emissions damage the respiratory, cardiovascular, and nervous systems and contribute to four of the top five leading causes of death in the U.S.

After removal of coal from a mine, threats to public health persist. When mines are abandoned, rainwater reacts with exposed rock to cause the oxidation of metal sulfide minerals. This reaction releases iron, aluminum, cadmium, and copper into the surrounding water system[5] and can contaminate drinking water.[6]

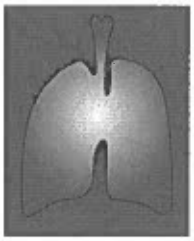
Coal washing, which removes soil and rock impurities before coal is transported to power plants, uses polymer chemicals and large quantities of water and creates a liquid waste called slurry. Slurry ponds can leak or fail, leading to injury and death, and slurry injected underground into old mine shafts can release arsenic, barium, lead, and manganese into nearby wells, contaminating local water supplies. Once coal is mined and washed, it must be transported to power plants. Railroad engines and trucks together release over 600,000 tons of nitrogen oxide and 50,000 tons of particulate matter into the air every year in the process of hauling coal, largely through diesel exhaust.[7] Coal trains and trucks also release coal dust into the air, exposing nearby communities to dust inhalation.[8]

The storage of post-combustion wastes from coal plants also threatens human health. There are 584 coal ash dump sites in the U.S.,[9] and toxic residues have migrated into water supplies and threatened human health at dozens of these sites.[10]

The combustion phase of coal's lifecycle exacts the greatest toll on human health. Coal combustion releases a combination of toxic chemicals into the environment and contributes significantly to global warming. Coal combustion releases sulfur dioxide, particulate matter (PM), nitrogen oxides, mercury, and dozens of other substances known to be hazardous to human health. Coal combustion contributes to smog through the release of oxides of nitrogen, which react with volatile organic compounds in the presence of sunlight to produce ground-level ozone, the primary ingredient in smog.

Table ES.1 (pages x–xi) describes the major health effects linked to coal combustion emissions. These health effects damage the respiratory, cardiovascular, and nervous systems and contribute to four of the top five leading causes of death in the U.S.: heart disease, cancer, stroke, and chronic lower respiratory diseases. Although it is difficult to ascertain the proportion of this disease burden that is attributable to coal pollutants, even very modest contributions to these major causes of death are likely to have large effects at the population level, given high incidence rates. Coal combustion is also responsible for more than 30% of total U.S. carbon dioxide pollution, contributing significantly to global warming and its associated health impacts.

RESPIRATORY EFFECTS OF COAL POLLUTION



Pollutants produced by coal combustion act on the respiratory system to cause a variety of adverse health effects. Air pollutants—among them nitrous oxide (NO_2) and very small particles, known as $PM_{2.5}$—adversely affect lung development, reducing forced expiratory volume (FEV) among children.[11] This reduction of FEV, an indication of lung function, often precedes the subsequent development of other pulmonary diseases.

Air pollution triggers attacks of asthma, a respiratory disease affecting more than 9% of all children in the U.S. Children are particularly susceptible to the development of pollution-related asthma attacks. This may be due to their distinct breathing patterns, as well as how much time they spend outside. It may also be due to the immaturity of their enzyme and immune systems, which assist in detoxifying pollutants, combined with incomplete pulmonary development.[12] These factors appear to act in concert to make children highly susceptible to airborne pollutants such as those emitted by coal-fired power plants.[13]

Asthma exacerbations have been linked specifically to exposure to ozone, a gas produced when NO_2 reacts with volatile organic compounds in the presence of sunlight and heat.[14] The risk to children of experiencing ozone-related asthma exacerbations is greatest among those with severe asthma. That risk exists even when ambient ozone levels fall within the limits set by the EPA to protect public health.

Coal pollutants trigger asthma attacks in combination with individual genetic characteristics.[15] This gene-environment interaction means that some individuals are more susceptible to the respiratory health effects of coal pollution. The genetic polymorphisms that appear to make people more susceptible include those that control inflammation and those that deal with oxidative stress, or the presence of highly reactive molecules, known as free radicals, in cells. (See text box.)

OXIDATIVE STRESS

Oxygen free radicals in biological systems are a normal cellular constituent and play critical roles in the control of many cellular functions. (Free radicals are atoms or molecules that contain at least one unpaired electron in an atomic or molecular orbit and are therefore unstable and highly reactive.)

The concentration of oxygen free radicals can be increased through exposure to environmental substances such as air pollution, tobacco smoke, pesticides, and solvents. When their concentration is excessive, these highly reactive molecules damage lipids, proteins, DNA, cell membranes, and other cellular components. "Oxidative stress" is the term used to describe that physiological state.

Oxidative stress is an important contributing factor in a variety of diseases, including atherosclerosis, hypertension, rheumatoid arthritis, diabetes mellitus, and neurodegenerative disorders such as Alzheimer's disease and Parkinson's disease, as well as normal aging. It is one of several mechanisms implicated in the pathogenesis of diseases caused or made worse by coal pollutants, such as cardiovascular and pulmonary disease.

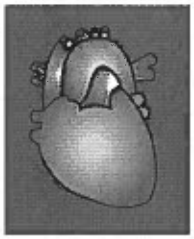
Valko M, Leibfritz D, Moncol J, Cronin MTD, Mazur M, Telser J. Free radicals and antioxidants in normal physiological functions and human disease. Int J Biochem and Cell Biology 2007; 39: 44–84.

Coal pollutants play a role in the development of chronic obstructive pulmonary disease (COPD), a lung disease characterized by permanent narrowing of airways. Coal pollutants may also cause COPD exacerbations, in part through an immunologic response—i.e., inflammation.[16,17,18] PM exposure disposes the development of inflammation on the cellular level, which in turn can lead to exacerbations of COPD. COPD is the fourth leading cause of mortality in the U.S.

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Exposures to ozone and PM are also correlated with the development of[19] and mortality from[20, 21, 22] lung cancer, the leading cancer killer in both men and women.

CARDIOVASCULAR EFFECTS OF COAL POLLUTION

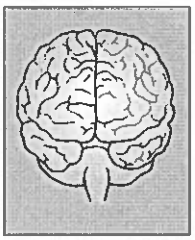


Pollutants produced by coal combustion damage the cardiovascular system. Coronary heart disease (CHD) is a leading cause of death in U.S., and air pollution is known to negatively impact cardiovascular health.[23] The mechanisms by which air pollution causes cardiovascular disease have not been definitively identified but are thought to be the same as those for respiratory disease: pulmonary inflammation and oxidative stress. Studies in both animals and humans support this theory, showing that pollutants produced by coal combustion lead to cardiovascular disease, such as arterial occlusion (artery blockages, leading to heart attacks) and infarct formation (tissue death due to oxygen deprivation, leading to permanent heart damage).

Recent research suggests that nitrogen oxides and $PM_{2.5}$, along with other pollutants, are associated with hospital admissions for potentially fatal cardiac rhythm disturbances.[24] The concentration of $PM_{2.5}$ in ambient air also increases the probability of hospital admission for acute myocardial infarction,[25] as well as admissions for ischemic heart diseases, disturbances of heart rhythm, and congestive heart failure.[26] Additionally, cities with high NO_2 concentrations had death rates four times higher than those with low NO_2 concentrations.[27] These studies show important immediate effects of coal pollutants on indicators of acute cardiovascular illness.

There are cardiovascular effects from long-term exposure as well. Exposure to chronic air pollution over many years increases cardiovascular mortality.[28] This relationship remains significant even while controlling for other risk factors, such as smoking. Conversely, long-term improvements in air pollution reduce mortality rates. Reductions in $PM_{2.5}$ concentration in 51 metropolitan areas were correlated with significant increases in life expectancy,[29] suggesting that air quality improvements mandated by the Clean Air Act have measurably improved the health of the U.S. population. Reducing exposure to the pollutants emitted by coal combustion is therefore an important aspect of improving cardiovascular health for the population at large.

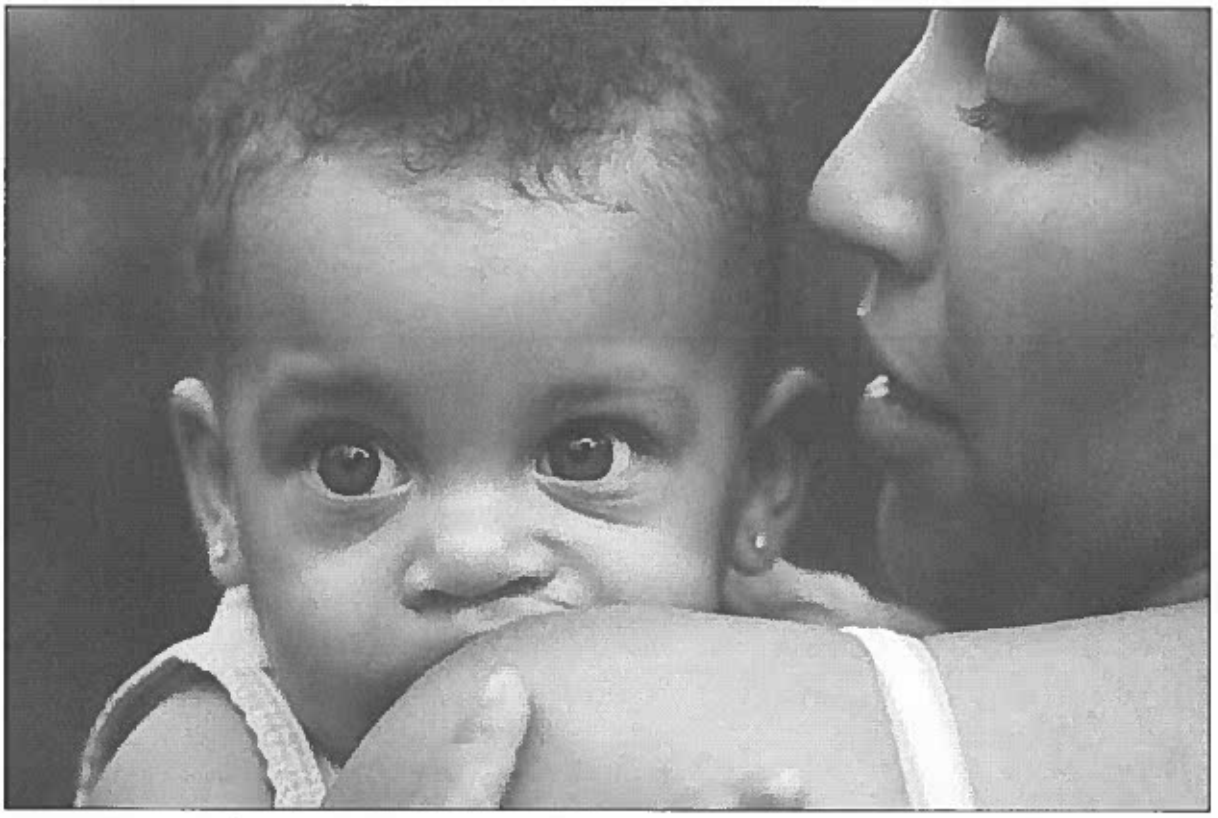
NERVOUS SYSTEM EFFECTS OF COAL POLLUTION



In addition to the respiratory and cardiovascular systems, the nervous system is also a target for coal pollution's health effects. The same mechanisms that are thought to mediate the effect of air pollutants on coronary arteries also apply to the arteries that nourish the brain. These include stimulation of the inflammatory response and oxidative stress, which in turn can lead to stroke and other cerebral vascular disease.

Several studies have shown a correlation between coal-related air pollutants and stroke. In Medicare patients, ambient levels of $PM_{2.5}$ have been correlated with hospital admission rates for cerebrovascular disease,[30] and PM_{10} has been correlated with hospital admission for ischemic stroke.[31] (Eighty-seven percent of all strokes are ischemic.) $PM_{2.5}$ has also been associated with an increase in the risk of—and death from—a cerebrovascular event among post-menopausal women.[32] Even though a relatively small portion of all strokes appear to be related to the ambient concentration of PM, the fact that nearly 800,000 people in the U.S. have a stroke each year makes even a small increase in risk a health impact of great importance.[33]

Coal pollutants also act on the nervous system to cause loss of intellectual capacity, primarily through mercury. Coal contains trace amounts



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of mercury that, when burned, enter the environment. Mercury increases in concentration as it travels up the food chain, reaching high levels in large predatory fish. Humans, in turn, are exposed to coal-related mercury primarily through fish consumption. Coal-fired power plants are responsible for approximately one-third of all mercury emissions attributable to human activity.[34]

A nationwide study of blood samples in 1999–2000 showed that 15.7% of women of childbearing age have blood mercury levels that would cause them to give birth to children with mercury levels exceeding the EPA's maximum acceptable dose for mercury.[35] This dose was established to limit the number of children with mercury-related neurological and developmental impairments. Researchers have estimated that between 317,000 and 631,000 children are born in the U.S. each year with blood mercury levels high enough to impair performance on neurodevelopmental tests and cause lifelong loss of intelligence.[36]

A continued reliance on coal combustion for electricity will contribute to the predicted health consequences of global warming.

GLOBAL WARMING AND COAL POLLUTION

Coal damages the respiratory, cardiovascular, and nervous systems through pollutants acting directly on the body. But coal combustion also has indirect health effects, through its contribution to greenhouse gas emissions. Global warming is already negatively impacting public health and is predicted to have widespread and severe health consequences in the future. Because coal-fired power plants account for more than one third of CO_2 emissions in the U.S.,[37] coal is a major contributor to the predicted health impacts of global warming.

The effects of global warming already in evi-

Table ES.1: Coal's contributions to major health effects

	Disease or condition	Symptoms or result	Most-vulnerable populations	Total disease burden (coal is a suspected contributing factor in an unknown number of cases)	Coal pollutants implicated
RESPIRATORY	Asthma exacerbations	Coughing, wheezing, shortness of breath, and breathlessness with a range of severity from mild to requiring hospitalization	Children, adults	Number of visits to office-based physicians for asthma: 10.6 million in 2006. Number of hospitalizations with asthma listed first as diagnosis: 440,000.[38] School days missed per year attributable to asthma: 11.8 million.[39]	NO_2 Ozone Particulate Matter (PM)[40,41,42]
RESPIRATORY	Asthma development	New cases of asthma, resulting in coughing, wheezing, shortness of breath, and breathlessness with a range of severity from mild to requiring hospitalization	Children	Children with asthma: 6.7 million (9.1%). Adults with asthma: 16.2 million (7.3%).[43]	Suspected but not confirmed:[44,45,46] NO_2 Ozone $PM_{2.5}$
RESPIRATORY	Chronic Obstructive Pulmonary Disease (COPD)	Emphysema with chronic obstructive bronchitis; permanent narrowing of airways; breathlessness; chronic cough	Smokers, adults	Adults with COPD diagnosis in 2006: 12.1 million.[47] Deaths in 2005: 126,000.[48] Fourth leading cause of mortality in U.S.	NO_2 PM[49,50,51]
RESPIRATORY	Stunted lung development	Reductions in lung capacity; risk factor for development of asthma and other respiratory diseases	Children	Unknown	NO_2 $PM_{2.5}$[52]
RESPIRATORY	Infant mortality (relevant organ system uncertain; may be respiratory)	Death among infants age < 1 year	Infants	Deaths in 2005: 28,384. Almost 25% may have had respiratory causes: 2,234 deaths attributed to Sudden Infant Death Syndrome (SIDS), and 4,698 deaths attributed to short gestation and low birth weight.[53]	NO_2 PM[54,55]
RESPIRATORY	Lung cancer	Shortness of breath, wheezing, chronic cough, coughing up blood, pain, weight loss[56]	Smokers, adults	Deaths in 2005: 159,217. Leading cause of cancer mortality in U.S. among both men and women.[57]	PM[58,59,60]
CARDIOVASCULAR	Cardiac arrhythmias	Abnormal rate or rhythm of the heart; palpitation or fluttering; may cause fatigue, dizziness, lightheadedness, fainting, rapid heartbeat, shortness of breath, and chest pain[61]	Adults, hypertensives, diabetics, those with cardiovascular disease	Unknown	NO_2 $PM_{2.5}$[62]
CARDIOVASCULAR	Acute myocardial infarction	Chest pain or discomfort; heart attack	Adults, diabetics, hypertensives	Deaths in 2006: 141,462.[63] Cases in 2006: 7.9 million.[64]	$PM_{2.5}$[65]
CARDIOVASCULAR	Congestive heart failure	Shortness of breath, fatigue, edema (swelling) due to impaired ability of heart to pump blood; can result from narrowed arteries, past heart attack, and high blood pressure; can lead to death[66]	Adults, hypertensives, diabetics, those with cardiovascular disease	Deaths in 2006: 60,337.[67] Number of people living with heart failure: 5.7 million. New cases diagnosed each year: 670,000.[68]	$PM_{2.5}$[69]

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Table ES.1: Coal's contributions to major health effects, *continued*

	Disease or condition	Symptoms or result	Most-vulnerable populations	Total disease burden (coal is a suspected contributing factor in an unknown number of cases)	Coal pollutants implicated
NEUROLOGICAL	Ischemic stroke	Artery supplying blood to the brain becomes blocked due to blood clot or narrowing;[70] may cause sudden numbness or weakness, especially on one side of body, confusion, trouble speaking, trouble seeing, trouble walking, dizziness, severe headache;[71] effects can be transitory or persistent	Elderly, hypertensives, diabetics	Deaths in 2005: 143,579. Number of strokes occurring each year: 795,000. NOTE: 87% of all strokes are ischemic; statistics are for all strokes.[72]	NO_2 $PM_{2.5}$ PM_{10} SO_2[73,74,75,76]
	Developmental delay	Reduced IQ; mental retardation; clinical impairment on neurodevelopmental scales; permanent loss of intelligence	Fetuses, infants, children	Babies born each year with cord blood concentrations of mercury >5.8 µg/L, the level above which mercury exposure has been shown to reduce IQ: 637,233 (15.7% of all babies born).[77]	Mercury[78]

dence include increases in global average land and ocean surface temperatures; increases in snow melt and receding glaciers; increases in the mean sea level; and changes in precipitation.[79] These global climate changes are already affecting human health. The World Health Organization estimated global warming to be responsible for 166,000 deaths in 2000, due to additional mortality from malaria, malnutrition, diarrhea, and drowning.[80]

In the future, global warming is expected to continue to harm human health. More frequent heat waves are projected to lead to a rise in heat exhaustion and heat stroke, potentially resulting in death, especially among elderly and poor urban dwellers. Declining air and water quality, an increase in infectious diseases, and a shrinking food supply are expected to contribute to disease and malnutrition, increase the migration of affected populations, and increase armed conflict and global instability. Table ES.2 (page xiii) describes the predicted health effects of global warming.

A continued reliance on coal combustion for electricity production will contribute to the predicted health consequences of global warming.

Carbon capture and sequestration (CCS) has been promoted as an effective way to keep CO_2 emissions out of the atmosphere, but substantial research and development are required before it can be used on the scale needed to mitigate global warming. Even then, the danger remains that CCS storage areas, whether underground or under the ocean, could leak, negating the value of CO_2 capture and storage. CCS also incurs other threats to health, including the danger of asphyxiation in the case of a large-scale CO_2 leak and the acidification of ocean waters. Moreover, the application of CCS would require continued coal mining, transportation, combustion, and waste storage, thus prolonging the emission of coal's toxic pollutants that harm human health.

POLICY RECOMMENDATIONS

The U.S. is at a crossroads for determining its future energy policy. While the U.S. relies heavily on coal for its energy needs, the health consequences of that reliance are multiple and have widespread and damaging impact. Coal combustion contributes to diseases already affecting large portions of the U.S. population, including asthma, heart disease, and stroke, thus compounding the major public health challenges of our time. Coal

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combustion also releases significant amounts of carbon dioxide into the atmosphere. Unless we address coal, the U.S. will be unable to achieve the reductions in carbon emissions necessary to stave off the worst health impacts of global warming. Based on that assessment, PSR finds it essential to translate our concern for human health into recommendations for public policy.

- Emissions of carbon dioxide should be cut as deeply and as swiftly as possible, with the objective of reducing CO_2 levels to 350 parts per million, through two simultaneous strategies:
  - Strong climate and energy legislation that establishes hard caps on global warming pollution coming from coal plants.
  - The Clean Air Act (CAA). Carbon dioxide and other greenhouse gas emissions from coal plants have been designated pollutants under the CAA. The EPA should be fully empowered to regulate carbon dioxide under the CAA so that coal's contribution to global warming can be brought to an end.
- There should be no new construction of coal-fired power plants, so as to avoid increasing health-endangering emissions of carbon dioxide, as well as criteria pollutants and hazardous air pollutants.
- The U.S. should dramatically reduce fossil fuel power plant emissions of sulfur dioxide and nitrogen oxides so that all localities are in attainment for national ambient air quality standards.
- The EPA should establish a standard, based on Maximum Achievable Control Technology, for mercury and other hazardous air pollutant emissions from electrical generation.
- The nation must develop its capacity to generate electricity from clean, safe, renewable sources so that existing coal-fired power plants may be phased out without eliminating jobs or compromising the nation's ability to meet its energy needs. In place of investment in coal (including subsidies for the extraction and combustion of coal and for capture of carbon and other pollutants), the U.S. should fund energy efficiency, conservation measures, and clean, safe, renewable energy sources such as wind energy, solar, and wave power.

Unless we address coal, the U.S. will be unable to achieve the reductions in carbon emissions necessary to stave off the worst health impacts of global warming.

These steps comprise a medically defensible energy policy: one that takes into account the public health impacts of coal while meeting our need for energy. When our nation establishes a health-driven energy policy, one that replaces our dependence on coal with clean, safe alternatives, we will prevent the deterioration of global public health caused by global warming while reaping the rewards in improvements to respiratory, cardiovascular, and neurological health.

Table ES.2: Predicted health effects of global warming

Predicted human health effects	Contributing factors	Global warming mechanism	Most-vulnerable populations
Heat cramps, heat syncope, heat exhaustion, heat stroke	Heat waves	• Greenhouse effect	Children, the elderly, urban dwellers, those with underlying conditions such as cardiovascular disease, obesity, and respiratory disease
Diarrhea spread by water-borne bacteria including E Coli, Shigella, and cholera	Flooding, infrastructure damage	• Increase in extreme weather events and storm surges • Sea level rise	Children most vulnerable to death from diarrheal disease
Drowning	Flooding	• Increase in extreme weather events and storm surges • Sea level rise	Children, the elderly
Exacerbations of asthma, chronic obstructive pulmonary disease, and other respiratory diseases	Worsening air quality, heat waves	• Greenhouse effect • Heat increases production of ground-level ozone • Heat increases electricity demand and resulting particulate emissions from fossil fuel combustion • Airborne allergens (such as pollen) predicted to increase with global warming	Children, the elderly, those with preexisting respiratory disease
Infectious diseases: Malaria, dengue fever, yellow fever, West Nile virus, Lyme disease, and other insect-borne infections, as well as rodent-borne infections	Increased ranges and populations of disease-carrying insects and rodents	• Warming climate expands geographic range of insect and rodent vectors • High temperatures boost reproductive rates, lengthen breeding season, and increase bite frequency of insect vectors • High temperatures boost parasite development	Children, those with impaired immune systems, the developing world
Heart disease, heart attacks, congestive heart failure and other cardiovascular diseases	Worsening air quality	• Heat increases production of ground-level ozone • Heat increases electricity demand and resulting particulate emissions from fossil fuel combustion	Adults and the elderly
Hunger, malnutrition, starvation, famine	Reduced crop yields; crop damage; crop failure; disruptions in forestry, livestock, fisheries	• Changes in the water cycle leading to drought • Heat decreases reproductive lifecycle of some major food crops • Expanded range of some insect pests • Increase in extreme weather events • Changes in ecology of plant pathogens • Loss of agricultural land due to sea level rise	Children, the poor
Mass migration; violence; war	Societal instability; infrastructure damage; reduced crop yields	• All of the above	Children, the elderly, those with other underlying medical conditions
Mental health problems	All of the above	• All of the above	Varied

See sources on page xvi.

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NOTES

1 Markandya A, Wilkinson P. Electricity generation and health. Lancet 2007;370:979–990.

2 Centers for Disease Control and Prevention. Available from: http://www.cdc.gov/NIOSH/Mining/statistics/pdfs/pp3.pdf.

3 Rappaport E. Coal Mine Safety. CRS Report for Congress, 2006: RS22461.

4 EPA Region 3. Mountaintop mining/valley fills in Appalachia final programmatic environmental impact statement. Oct 2005: EPA-9-03-R-05002. Available from: http://www.epa.gov/Region3/mtntop/pdf/mtm-vf_fpeis_full-document.pdf.

5 EPA Office of Solid Waste. Acid mine drainage prediction technical document. 1994: EPA530-R-94-036. Available from: http://www.epa.gov/osw/nonhaz/industrial/special/mining/techdocs/amd.pdf.

6 Lashof DA, Delano D, Devine J et al. Coal in a changing climate. 2007: Natural Resources Defense Council. Available from: http://www.nrdc.org/globalwarming/coal/coalclimate.pdf.

7 Lashof DA, Delano D, Devine J et al. Coal in a changing climate. 2007: Natural Resources Defense Council. Available from: http://www.nrdc.org/globalwarming/coal/coalclimate.pdf.

8 Aneja VP. Characterization of particulate matter (PM10) in Roda, Virginia. Unpublished report to the Virginia Air Pollution Control Board. Undated. Available from: http://www.eenews.net/public/25/10670/features/documents/2009/04/23/document_pm_01.pdf.

9 See http://www.earthjustice.org/library/references/09ccw-survey-summary-results.pdf.

10 EPA. Human and ecological risk assessment of coal combustion wastes: draft, August 6, 2007. Available from: http://www.earthjustice.org/library/reports/epa-coal-combustion-waste-risk-assessment.pdf.

11 Gauderman WJ, Avol E, Gilliland F et al. The effect of air pollution on lung development from 10 to 18 years of age. N Engl J Med 2004; 351(11):1057–1067.

12 Bateson TF, Schwartz J. Children's response to air pollutants. J Toxicol Environ Health Part A 2008; 71(3):238–243.

13 Trasande L, Thurston GD. The role of air pollution in asthma and other pediatric morbidities. J Allergy Clin Immunol 2005; 115(4):689–699.

14 Gent JF, Triche EW, Holford TR et al. Association of low-level ozone and fine particles with respiratory symptoms in children with asthma. JAMA 2003; 290(14):1859–1867.

15 Yang IA, Fong KM, Zimmerman PV, Holgate ST, Holloway JW. Genetic susceptibility to the respiratory effects of air pollution. Thorax 2008; 63(6):555–563.

16 Halonen JI, Lanki T, Yli-Tuomi T, Kulmala M, Tiittanen P, Pekkanen J. Urban air pollution, and asthma and COPD hospital emergency room visits. Thorax 2008; 63(7):635–641.

17 Peel JL, Tolbert PE, Klein M et al. Ambient air pollution and respiratory emergency department visits. Epidemiology 2005; 16(2):164–174.

18 Dominici F, Peng RD, Bell ML et al. Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. JAMA 2006; 295(10):1127–1134.

19 Beeson WL, Abbey DE, Knutsen SF. Long-term concentrations of ambient air pollutants and incident lung cancer in California adults: results from the Adventist Health Study on Smog. Environ Health Perspect 1998; 106(12):813–823.

20 Beeson WL, Abbey DE, Knutsen SF. Long-term concentrations of ambient air pollutants and incident lung cancer in California adults: results from the Adventist Health Study on Smog. Environ Health Perspect 1998; 106(12):813–823.

21 Dockery DW, Pope CA, III, Xu X et al. An association between air pollution and mortality in six U.S. cities. N Engl J Med 1993; 329(24):1753–1759.

22 Pope CA, III, Burnett RT, Thun MJ et al. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. JAMA 2002; 287(9):1132–1141.

23 Brook RD, Franklin B, Cascio W et al. Air pollution and cardiovascular disease: a statement for healthcare professionals from the Expert Panel on Population and Prevention Science of the American Heart Association. Circulation 2004; 109(21):26552671.

24 Peters A, Liu E, Verrier RL et al. Air pollution and incidence of cardiac arrhythmia. Epidemiology 2000; 11(1):11–17.

25 Peters A, Dockery DW, Muller JE, Mittleman MA. Increased particulate air pollution and the triggering of myocardial infarction. Circulation 2001; 103(23):2810–2815.

26 Dominici F, Peng RD, Bell ML et al. Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. JAMA 2006; 295(10):1127–1134.

27 Katsouyanni K, Touloumi G, Samoli E et al. Confounding and effect modification in the short-term effects of ambient particles on total mortality: results from 29 European cities within the APHEA2 project. Epidemiology 2001; 12(5):521–531.

28 Dockery DW, Pope CA, III, Xu X et al. An association between air pollution and mortality in six U.S. cities. N Engl J Med 1993; 329(24):1753–1759.

29 Pope CA, III, Ezzati M, Dockery DW. Fine-particulate air pollution and life expectancy in the United States. N Engl J Med 2009; 360(4):376–386.

30 Dominici F, Peng RD, Bell ML et al. Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. JAMA 2006; 295(10):1127–1134.

31 Wellenius GA, Schwartz J, Mittleman MA. Air pollution and hospital admissions for ischemic and hemorrhagic stroke among medicare beneficiaries. Stroke 2005; 36(12):2549–2553.

32 Miller KA, Siscovick DS, Sheppard L et al. Long-term exposure to air pollution and incidence of cardiovascular events in women. N Engl J Med 2007;356(5):447–58.

33 American Heart Assn Statistics Committee and Stroke Statistics Subcommittee. Heart Disease and Stroke Statistics—2009 Update. Circulation 2009; 119:e21-e181.

34 EPA Office of Air Quality Planning & Standards and Office of Research and Development. Mercury study report to Congress. Volume II: an inventory of anthropogenic mercury emissions in the United States; Dec 1997: EPA-452/R-97-004.

35 Centers for Disease Control and Prevention. Third national report on human exposure to environmental chemicals. 2005: NCEH 05-0570.

R04301

36 Trasande L, Landrigan PJ, Schechter C. Public health and economic consequences of methyl mercury toxicity to the developing brain. Environ Health Perspect 2005; 113(5):590–596.

37 Energy Information Administration. Emissions of greenhouses gases report. 2008: DOE/EIA-0573(2007).

38 Centers for Disease Control and Prevention. Available from: http://www.cdc.gov/nchs/fastats/asthma.htm.

39 National Association of School Nurses. Issue Brief: Asthma Management in the School Setting. Available from: http://www.nasn.org/Default.aspx?tabid=264.

40 Gent JF, Triche EW, Holford TR et al. Association of low-level ozone and fine particles with respiratory symptoms in children with asthma. JAMA 2003; 290(14):1859–1867.

41 Trasande L, Thurston GD. The role of air pollution in asthma and other pediatric morbidities. J Allergy Clin Immunol 2005; 115(4):689–699.

42 Peel JL, Tolbert PE, Klein M et al. Ambient air pollution and respiratory emergency department visits. Epidemiology 2005; 16(2):164–174.

43 Centers for Disease Control and Prevention. Available from: http://www.cdc.gov/nchs/fastats/asthma.htm.

44 Gilmour MI, Jaakkola MS, London SJ et al. How exposure to environmental tobacco smoke, outdoor air pollutants, and increased pollen burdens influences the incidence of asthma. Env Health Perspect 2006; 114(4):627–633.

45 Brauer M, Hoek G, van VP et al. Air pollution from traffic and the development of respiratory infections and asthmatic and allergic symptoms in children. Am J Respir Crit Care Med 2002; 166(8):1092–1098.

46 McConnell R, Berhane K, Gilliland F et al. Asthma in exercising children exposed to ozone: a cohort study. Lancet 2002; 359(9304):386–391.

47 American Lung Association. Available from: http://www.lungusa.org/site/apps/nlnet/content3.aspx?c=dvLUK9O0E&b=4294229&ct=5296599.

48 Centers for Disease Control and Prevention (CDC). Deaths from chronic obstructive pulmonary disease—United States, 2000–2005. MMWR Morb Mortal Wkly Rep. 2008 Nov 14;57(45):1229–32.

49 Halonen JI, Lanki T, Yli-Tuomi T, Kulmala M, Tiittanen P, Pekkanen J. Urban air pollution, and asthma and COPD hospital emergency room visits. Thorax 2008; 63(7):635–641.

50 Peel JL, Tolbert PE, Klein M et al. Ambient air pollution and respiratory emergency department visits. Epidemiology 2005; 16(2):164–174.

51 Dominici F, Peng RD, Bell ML et al. Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. JAMA 2006; 295(10):1127–1134.

52 Gauderman WJ, Avol E, Gilliland F et al. The effect of air pollution on lung development from 10 to 18 years of age. N Engl J Med 2004; 351(11):1057–1067.

53 Mathews TJ, MacDorman MF. Infant mortality statistics from the 2005 period linked birth/infant death data set. National Vital Statistics Reports 57(2).

54 Ritz B, Wilhelm M, Zhao Y. Air pollution and infant death in southern California, 1989–2000. Pediatrics 2006; 118(2):493–502.

55 Bateson TF, Schwartz J. Children's response to air pollutants. J Toxicol Environ Health Part A 2008; 71(3):238–243.

56 Centers for Disease Control and Prevention. Available from: http://www.cdc.gov/cancer/lung/basic_info/survivorship.htm.

57 Centers for Disease Control and Prevention. Available from: http://www.cdc.gov/cancer/lung/statistics/index.htm.

58 Beeson WL, Abbey DE, Knutsen SF. Long-term concentrations of ambient air pollutants and incident lung cancer in California adults: results from the AHSMOG study. Environ Health Perspect 1998; 106(12):813–823.

59 Dockery DW, Pope CA, III, Xu X et al. An association between air pollution and mortality in six U.S. cities. N Engl J Med 1993; 329(24):1753–1759.

60 Pope CA, III, Burnett RT, Thun MJ et al. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. JAMA 2002; 287(9):1132–1141.

61 American Heart Association. Available from: http://americanheart.org/presenter.jhtml?identifier=15.

62 Peters A, Liu E, Verrier RL et al. Air pollution and incidence of cardiac arrhythmia. Epidemiology 2000; 11(1):11–17.

63 Heron M, Hoyert DL et al. Deaths: final data for 2006. National Vital Statistics Reports 57(14). Available from: http://www.cdc.gov/nchs/data/nvsr/nvsr57/nvsr57_14.pdf.

64 American Heart Association. Available from: http://www.americanheart.org/presenter.jhtml?identifier=4478.

65 Peters A, Dockery DW, Muller JE, Mittleman MA. Increased particulate air pollution and the triggering of myocardial infarction. Circulation 2001; 103(23):2810–2815.

66 American Heart Association. Available from: http://www.americanheart.org/presenter.jhtml?identifier=4585.

67 Heron M, Hoyert DL et al. Deaths: final data for 2006. National Vital Statistics Reports 57(14). Available from: http://www.cdc.gov/nchs/data/nvsr/nvsr57/nvsr57_14.pdf.

68 American Heart Association. Available from: http://www.americanheart.org/presenter.jhtml?identifier=1486.

69 Dominici F, Peng RD, Bell ML et al. Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. JAMA 2006; 295(10):1127–1134.

70 Centers for Disease Control and Prevention. Available from: http://www.cdc.gov/Stroke/about_stroke.htm.

71 American Heart Association. Available from: http://www.americanheart.org/presenter.jhtml?identifier=3053#Stroke.

72 American Heart Association. Heart Disease and Stroke Statistics, 2009 Update At-A-Glance. Available from: http://www.americanheart.org/downloadable/heart/1240250946756LS-1982%20Heart%20and%20Stroke%20Update.042009.pdf.

73 Wellenius GA, Schwartz J, Mittleman MA. Air pollution and hospital admissions for ischemic and hemorrhagic stroke among medicare beneficiaries. Stroke 2005; 36(12):2549–2553.

74 Miller KA, Siscovick DS, Sheppard L et al. Long-term exposure to air pollution and incidence of cardiovascular events in women. N Engl J Med 2007;356(5):447–58.

75 Hong YC, Lee JT, Kim H et al. Effects of air pollutants on stroke mortality. Environ Health Perspect 2002;110(2):187–91.

R04302

76 Tsai SS, Goggins WB, Chiu HF, Yang CY. Evidence for an association between air pollution and daily stroke admissions in Kaohsiung, Taiwan. Stroke 2003;34(11):2612–6.

77 Trasande L, Landrigan PJ, Schechter C. Public health and economic consequences of methyl mercury toxicity to the developing brain. 2005: Environ Health Perspect 2005;113(5):590–596.

78 Committee on the toxicological effects of mercury. Toxicological Effects of Methylmercury. Washington, D.C.: National Research Council, National Academy Press, 2000.

79 IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, RK and Reisinger, A (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

80 Patz JA, Campbell-Lendrum D, Holloway T, Foley JA. Impact of regional climate change on human health. Nature 2005 Nov 17;438:310–317.

SOURCES FOR TABLE ES.2

Battisti DS, Naylor RL. Historical warnings of future food insecurity with unprecedented seasonal heat. Science 2009: Jan 9;323(5911):240–4.

Bernard SM, Samet JM, Grambsch A, et al. The potential impacts of climate variability and change on air pollution-related health effects in the United States. Environ Health Perspect 2001: 109(Suppl 2), 199–209.

Brownstein JS, Holford TR, Fish D. Effect of climate change on Lyme disease risk in North America. EcoHealth 2005;2:38–46.

Checkley W, Epstein LD, Gilman RH, Figueroa D, Cama RI, Patz JA, Black RE. Effect of El Niño and ambient temperature on hospital admissions for diarrhoeal diseases in Peruvian children. Lancet 2000 Feb 5;355(9202):442–50.

Costello A, Abbas M, Allen A, et al. Lancet and University College London Institute for Global Health Commission: managing the health effects of climate change. Lancet 2009; 373: 1693–1733.

Luber G, McGeehin M. Climate change and extreme heat events. Am J Prev Med 2008 Nov;35(5):429–35.

Parker C, Shapiro SM. Climate chaos: your health at risk: what you can do to protect yourself and your family. Westport, CT: Praeger; 2008.

Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE, editors. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press; 2007.

Patz JA, Campbell-Lendrum D, Holloway T, Foley JA. Impact of regional climate change on human health. Nature 2005 Nov 17;438:310–317.

Patz JA, McGeehin MA, Bernard SM, et al. The potential health impacts of climate variability and change for the United States: executive summary of the report of the health sector of the U.S. National Assessment. Environ Health Perspect 2000: 108(4), 367-376.

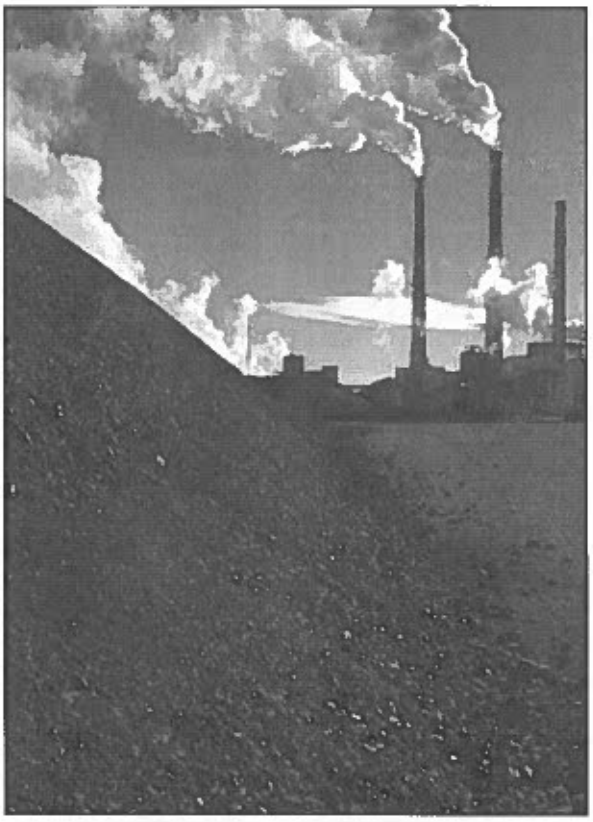
Shea KM, American Academy of Pediatrics Committee on Environmental Health. Global climate change and children's health. Pediatrics 2007 Nov;120(5):e1359-67.

St. Louis ME, Hess JJ. Climate change: impacts on and implications for global health. Am J Prev Med 2008 Nov;35(5):527–38.

1. *Introduction*

Almost half of the energy used to generate electricity in the United States comes from burning coal, as shown in Figure 1.1. Coal is a major component of the economy and forms the center around which political, economic, health, and environmental considerations coalesce. The U.S. holds extensive coal reserves, although how much of that coal is accessible at a commercially viable cost is subject to debate. The high-end estimate 491 billion tons, which would be enough to last as much as 250 years at the current rate of consumption, earned the U.S. the title of the "Saudi Arabia of Coal."[1] In 2006, the electric power industry burned 1.026 billion tons of coal (see Figure 1.2). The electric industry currently plans to build as many as 100 new coal plants, adding to the approximately 600 large coal-burning power plants already in existence.

Using coal has a variety of major adverse impacts on health. Mining, transporting, burning, and disposing of the products of coal combustion all place human health at risk. With the passage of time, more and more adverse health effects have been attributed to the increasing reliance on coal. Studies of the health effects of hazardous air pollutants date clearly to 1872 with the publication of *Air and Rain: the Beginning of Chemical Climatology* by Robert Angus Smith. Since then, there have been a number of sentinel events that link episodes of severe air pollution to a variety of illnesses.[2] In October, 1948, almost half of the 14,000 residents of Donora, Pennsylvania were sickened when



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atmospheric conditions trapped toxic emissions from a nearby smelter: 20 died and 400 required hospitalization. In 1952, the infamous "killer fog" in London, lasting four days, sent death rates and hospital admissions soaring. Overall hospital admissions increased by 43%; those due to respiratory diseases rose by 163%. Almost 12,000 deaths

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were attributed to this environmental disaster caused, in part, by burning coal.

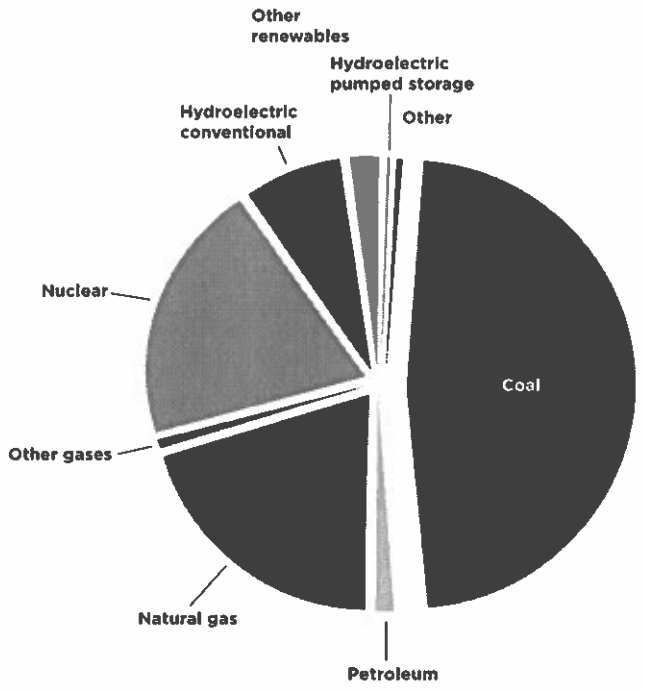
The link between burning coal and adverse health was made strikingly clear in Dublin, Ireland in the 1990s.[3] Because of increases in the cost of fuel oil in the 1980s, Dubliners switched from oil to bituminous coal to heat their homes and provide hot water. Subsequent increases in air pollution were associated with an increase in in-hospital deaths due to respiratory diseases. This led the Irish government to ban the marketing, sale, and distribution of bituminous coal on September 1, 1990. In the year that followed, black smoke concentrations declined by 70% (35.6 μg/m³), respiratory deaths fell by 15.5%, and cardiovascular deaths fell by 10.3%. Approximately 450 lives were calculated to be saved that year by this measure, and hundreds of acute illnesses were prevented. Although burning coal was not the only cause of these illnesses, burning coal was clearly a major factor in the production of the complex mixture of airborne pollutants that had protean adverse effects on human health.

For each TerraWatt hour of electricity generated by coal, 24.5 deaths are expected in addition to 225 serious illnesses and 13,288 minor illnesses.

Many of coal's pollutants were identified by the U.S. Environmental Protection Agency in its 1998 report Report to Congress.[4] This report identified as many as 67 different hazardous air pollutants (HAPS) emitted from coal plants, but did not address particulates or oxides of nitrogen and sulfur (NO_x and SO_x), now referred to as criteria pollutants. Particulates, mercury, NO_x, SO_x, and the pollutants they give rise to, such as ozone, are now recognized as posing the greatest threats to health, and are the focus of much of this report.

Recent peer-reviewed reports provide estimates of the morbidity and mortality associated with burning coal. European data reported by Markandaya and Wilkinson show that for each TerraWatt hour of electricity generated (1 TWh = 10^{12} Watt hours), 24.5 deaths are expected (95% CI = 6.1–98) in addition to 225 serious illnesses (95% CI = 56.2–899) and 13,288 minor illnesses (95% CI = 3,322–53,150).[5] Burning lignite, a softer form of coal that yields more pollutants than bituminous coal, raises these numbers to 32.6 deaths (95% CI = 8.2–130), 298 serious illnesses (95% CI = 74.6–1,193), and 17,676 minor illnesses (95% CI = 4,419–70,704). To give these data perspective, consider the fact that nearly half of the 4,160 TWh of electricity generated in the United States in 2007 came from coal-fired power plants.[6] If these estimates are applied to the U.S., as many as 50,000 deaths per year may be attributable to burning coal. Although differences in population density between Europe and the U.S. are substantial and there are large boundaries on the 95% con-

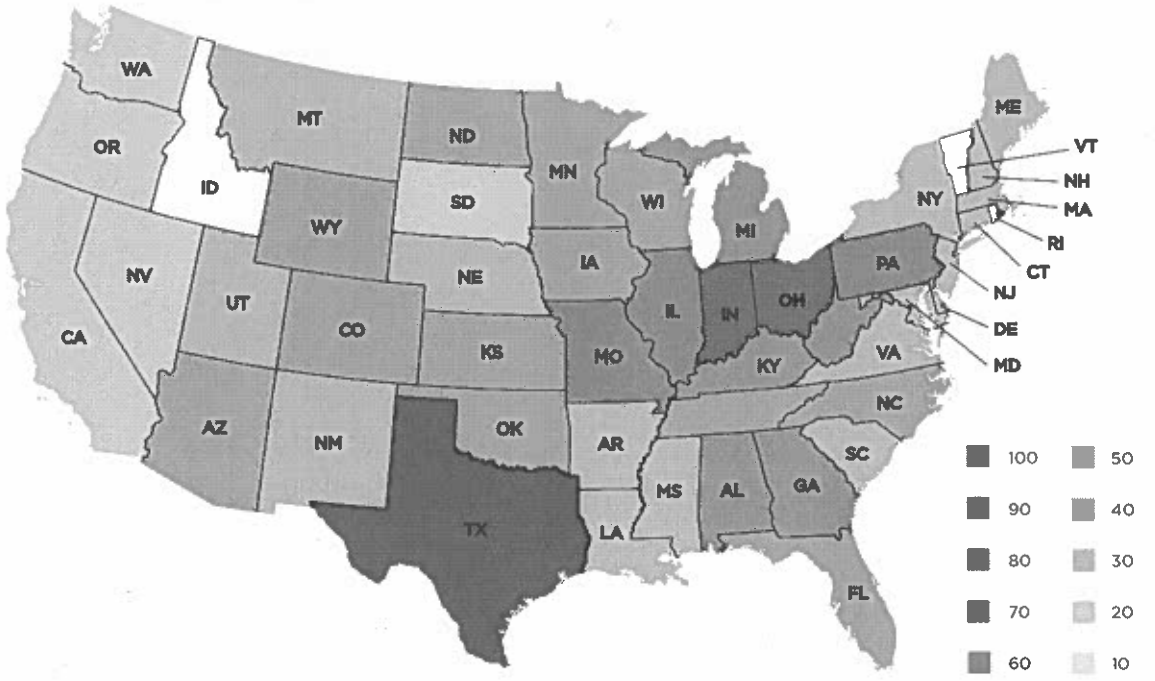
Figure 1.1: Sources of energy used for generation of electricity, 2006



Source: U.S. Energy Information Administration. Available from http://www.eia.doe.gov.

Figure 1.2: Coal consumption by U.S. utilities, 2006 (millions of tons)

By-state coal consumption by coal fired power plants. Texas led the nation, with states in the Ohio Valley that are close to coal fields and water transportation following closely behind.



Source: U.S. Energy Information Administration. Available from: http://www.eia.doe.gov/cneaf/coal/page/acr/table26.html.

fidence limits associated with these data, it is clear that burning coal has major adverse health effects.

In seeking to describe relationships between health and any single pollutant or any single source of the pollutant, notably burning coal, difficulties arise due to multiple sources of the pollutant in question and multiple health impacts. This is a particular issue with regard to SO_x, NO_x, and particulates, as there are many important sources of these pollutants in addition to burning coal. This is less of a problem in regard to mercury, where coal is the acknowledged largest single source of emissions. Thus, in this report we draw on literature that goes beyond that in which authors limit themselves to coal as the sole source of the pollutant in question.

In describing the health effects of coal combustion, this report utilizes an organ-system approach rather than a pollutant-based review. By considering coal's impact on the respiratory system, the cardiovascular system, and the central nervous system, we replace a piecemeal approach with a fuller and more integrated assessment of coal's overall effect on human health. To the best of our knowledge, this approach has not been taken in previous reviews of coal's health implications. To minimize bias, whenever possible we cite contemporary peer-reviewed medical literature and reports published by governmental agencies such as the U.S. Environmental Protection Agency and the Department of Energy. We hope that this report will provide physicians, other healthcare providers,

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policy-makers, and concerned citizens with the information they need to make informed choices that affect the future of burning coal to produce electrical energy.

NOTES

1 Goodell J. Big coal: the dirty secret behind America's energy future. Boston: Houghton Mifflin; 2006.

2 Simkhovich BZ, Kleinman MT, Kloner RA. Air pollution and cardiovascular injury epidemiology, toxicology, and mechanisms. J Am Coll Cardiol 2008; 52(9):719–726.

3 Clancy L, Goodman P, Sinclair H, Dockery DW. Effect of air-pollution control on death rates in Dublin, Ireland: an intervention study. Lancet 2002; 360(9341):1210–1214.

4 EPA. Study of Hazardous Air Pollutant Emissions from Electric Utility Steam Generating Units–Final Report to Congress. 1998: EPA-453/R-98-004a.

5 Markandaya A, Wilkinson P. Energy and Health 2: Electricity Generation. Lancet 2007; 370:979–990.

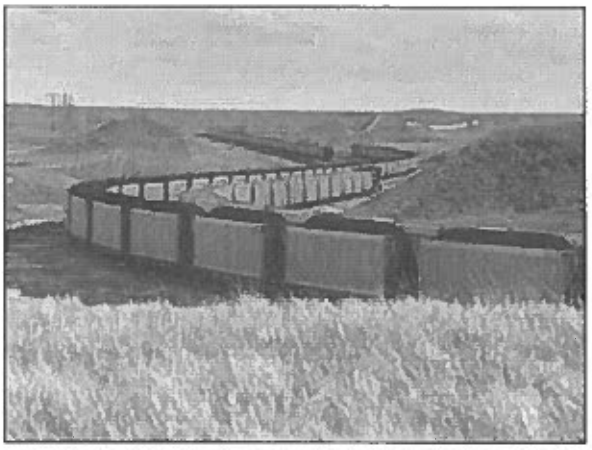
6 Energy Information Administration. Electric power industry 2007: year in review. Available from: http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html.

2. *Coal's Life Cycle*

Although people have burned coal for hundreds of years, the demand for coal exploded during the industrial revolution. Initially, coal powered the steam engine and therefore became the essential fuel for transportation during the nineteenth century, when steamships and railroads flourished. By fueling the steam shovel, coal became the vehicle for its own excavation. By the middle of the 1800s, coal replaced charcoal in the production of iron and steel, thus filling another key role in driving industrialization. Coal became a source of energy for the generation of electricity at the end of the 1800s.

Oil eventually replaced coal as the fuel of choice in the transportation industry. However, coal has once again become the dominant source of energy for the generation of electricity. Because more than 25% of the world's recoverable coal reserves are in the U.S. and because it is cheap, there has been a recent resurgence of coal as an energy source among utilities.[1] This modern coal boom is exemplified by the dozens of new coal plants currently in the planning or construction stage.

Today coal is the predominant source of energy used to produce electricity. Almost half of the energy used to generate electricity in the U.S. in 2007 came from coal, mined in such states as Wyoming, West Virginia, Kentucky, and Pennsylvania.[2] In addition to its major role in the generation of electricity, large amounts of coal are used by the steel industry. According to the World Coal Institute,



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almost 70% of global steel production is dependent on coal.[3]

Coal is formed from fossilized prehistoric plants subjected to heat and pressure over millions of years. Coal is classified into four main types, or ranks, based on moisture and carbon content: lignite, sub-bituminous, bituminous, and anthracite (see Table 2.1). High-carbon coals produce the most energy when burned and low-carbon coals produce the least. Lignite is the lowest rank of coal, having the highest moisture content and the lowest energy content. Sub-bituminous coal is the next highest rank, with a lower moisture content and higher carbon content than lignite. Harder, black coals are higher in rank and include bituminous coal, the most abundant form of coal in the U.S., and anthracite, the hardest, richest in carbon and the rarest. Impurities such as sulfur and heavy

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Table 2.1: The ranks of coal

Rank	Appearance	Percent carbon content	Uses	Percent of world reserves	Percent of U.S. production	Largest U.S. producers
Lignite	Brown, soft, flaky	25–35	Power generation	17	7	Texas, North Dakota
Sub-bituminous	Brownish-black, soft	35–45	Power generation, cement manufacture, industrial uses	30	44	Wyoming (Powder River Basin)
Bituminous	Black, hard	45–86	Power generation, cement manufacture, industrial uses	52	49	West Virginia, Kentucky, Pennsylvania
Anthracite	Black, hard, glossy	86–97	Domestic/industrial uses	1	Less than 0.5	Pennsylvania

metals are incorporated into coals as they are formed and are released when coals are burned or cleaned.

Electricity generation provides many benefits worldwide, and is synonymous with economic development, higher standards of living, and increased life expectancy.[4] However there are major health costs associated with the use of coal. Detrimental health effects are associated with every aspect of its life cycle, including mining, hauling, preparation at the power plant, combustion, and the disposition of post-combustion wastes. This section reviews in brief the human health effects of coal's life cycle.

MINING

Coal is extracted from underground and surface mines. The two main types of underground mines in the U.S. are longwall mines and room-and-pillar mines. In longwall mines, long sections of coal are removed without the use of supporting structures. This may lead to the subsidence of the land above. In room-and-pillar mines, sections of rock are not excavated (the "pillars") in order to provide structural support for the adjoining areas where all the coal is removed (the "rooms"). Both types of mines involve excavating shafts hundreds of feet deep, the installation of elevators, massive conveyance machinery, and air circulation technology.

Surface mining accounts for 69% of the coal mined in the U.S.[5] Used when the coal seam is close to the surface (less than 200 feet deep), it is cheaper than underground mining and often high-yield. In this method, vegetation, topsoil, and rock are blasted and removed down to the level of the coal seam, which is then mined. The top ten coal-producing mines in the U.S. are surface mines in the Powder River Basin of Wyoming.[6] "Mountaintop removal" is the name given to another type of surface mining, used to reach coal seams in mountainous terrain. It involves blasting down to the level of the coal seam—often hundreds of feet below the surface—and depositing the resulting rubble in adjoining valleys.

Coal mining leads U.S. industries in fatal injuries.[7] According to the National Institute for Occupational Safety and Health, the 2006 fatality rate in coal mining was 49.5 per 100,000 workers, more than 11 times greater than that in all private industry (4.2 per 100,000).[8] There were 47 occupational fatalities in coal mining in 2006, 34 in 2007, and 30 in 2008.[9] Underground coal mining is more dangerous than surface mining. Of 47 coal mining fatalities in 2006, 37 occurred in underground mining operations. The nonfatal injury rate in mining, of 3.9 per 100 full time workers in 2001, compares favorably to other private sector workers, where the average incidence rate of nonfatal injury was 5.4 in 2001.[10]

Coal mining is also associated with chronic health problems among miners. Black lung disease is caused by inhalation of respirable coal mine dust, which causes lung tissue scarring.

Although technology and prevention strategies have improved incidence and mortality rates in the past century, black lung disease still disables large numbers of ex-miners and claims many lives each year.[11] According to the National Institute of Occupational Safety and Health, black lung disease has been responsible for approximately 10,000 deaths in the past 10 years.

In addition to the miners themselves, communities proximate to coal mines may be adversely affected by mining operations. Injuries and even deaths may result from physical damage to surrounding communities due to blasting at surface mines and subsidence of underground mines. Surface mining also destroys forests and groundcover, leading to flood-related injury and mortality, as well as soil erosion and the contamination of water supplies. Rubble, or "overburden," is deposited on the surface, destroying plants and animals and introducing into the food web trace minerals and metals once deeply buried. One study of West Virginians found that people living in high coal-producing counties had higher rates of cardiopulmonary disease, chronic obstructive pulmonary disease, hypertension, lung disease, and kidney disease compared to people living in low coal-producing counties,[12] raising the possibility that coal mining operations may exacerbate a range of chronic health conditions among people living in nearby communities.

Coal mining operations may exacerbate a range of chronic health conditions among people living in nearby communities.

Flooding and contamination of water supplies are of particular concern in Appalachia, where mountaintop removal mining is widespread. The Environmental Protection Agency estimated in 2005 that mountaintop removal mining had adversely impacted 1,200 miles of streams in a study area that included parts of Kentucky, West Virginia, Virginia, and Tennessee. These 1,200 miles represented 2% of streams in the study area. The study further concluded that 724 miles of streams had been directly buried by valley fill related to mountaintop removal mining through 2001.[13] There are no official current estimates of the extent of the practice, but one advocacy organization estimated that by 2005, more than 450 mountain summits had been destroyed by mountaintop removal mining.[14] The human health effects of burying streams under piles of rubble have not been quantified, but include flood-related injury and mortality and contamination of drinking water and surface water resources with arsenic and other pollutants.[15]

After removal of coal from a mine, threats to public health persist. When mines are abandoned, rainwater reacts with exposed rock to cause the oxidation of metal sulfide minerals. These reactions generate acid and release contaminants such as heavy metals into the surrounding water system.[16] Red, orange, or yellow sediments in streams near abandoned mines are markers for this acidic mine drainage. The degraded water resulting from acid mine drainage renders the water undrinkable, and can corrode culverts and bridges.[17]

WASHING AND TRANSPORT

Coal is usually washed before it is transported to power plants to separate it from soil and rock impurities. Washing uses polymer chemicals and large quantities of water, and creates a liquid waste called slurry or sludge that must be stored. The slurry is the consistency of cement, and in addition to water, mud, and polymer chemicals, it contains heavy metals such as arsenic and mercury that are common in mined rock. Mine operators construct dams to impound the slurry in ponds, or inject it back into closed mines. Both slurry disposal strategies—the construction of surface impoundments and underground injection into closed mines—may leach chemicals into groundwater supplies. This is an aspect of mining that has not been examined closely.[18] In addition, both of these waste storage strategies can leak or break. Impoundment failures in the past have caused death and injury, including the 1972 Buffalo Creek, West Virginia, impoundment failure that killed 125 people and

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injured 1,000. More recently, an impoundment breach in 2000 of about 250 million gallons of slurry near Inez, Kentucky, disrupted local water supplies but did not cause injuries or deaths.[19] Slurry injected underground into old mine shafts has the potential to release arsenic, barium, lead, and manganese into nearby wells, contaminating local water supplies.

Once coal is mined and washed, it must be transported to power plants. Coal is hauled to plants by train, truck, barge, and conveyor. Trains are the most economical way to move coal long distances and play the largest role in coal transport. In 2005, railroads accounted for 70% of coal shipments to power plants.[20] Together, railroad engines and trucks release over 600,000 tons of nitrogen oxide and 50,000 tons of particulate matter into the air every year in the process of hauling coal,[21] largely through diesel exhaust. Diesel engines currently produce approximately 1.8 million tons of NOx and 63,000 tons of small particles (less than 2.5 microns in diameter) each year.[22] These emissions adversely impact many organ systems, as this report will detail. Coal trains and trucks also release coal dust into the air as they move, degrading air quality and exposing nearby communities to dust inhalation.[23]

COMBUSTION

It is during the combustion phase of coal's lifecycle that our dependence on coal energy exacts the greatest toll on human health. Coal combustion releases over 70 harmful chemicals into the environment and contributes significantly to global warming (see Table 2.2). This section describes the pollutants emitted by coal combustion.

Coal combustion creates both solid and gaseous byproducts. Gas byproducts are emitted into the atmosphere through smokestacks. Some solids go into the atmosphere as well. Other solids are left behind at the plant as solid waste, also called coal ash. Some of the pollutants entering the air stay in the atmosphere for long periods; others fall to the earth and in turn pollute soil and water bodies. Some substances are not directly harmful but undergo chemical reactions in the atmosphere that create harmful secondary pollutants.

The pollutant composition of coal varies according to the geologic conditions of its formation. For example, plants that once lived and died in sea water formed coal with high sulfur content, while plants buried under fresh water formed low-sulfur coal. Thus, coals from different ranks and even from different mines differ not only in heat production and carbon content but also in pollutant composition. Such differences may affect local air quality concerns, as power plants may produce different pollution emissions depending on which coals are being burned.[24]

Notwithstanding local differences in pollutant composition, coal combustion causes pollution nationwide. Though coal supplies roughly 50% of the nation's electricity, it produces a disproportionate share of electric utility-related pollution. Coal plants emit approximately 87% of total utility-related nitrogen oxide pollution, 94% of utility-related sulfur dioxide pollution, and 98% of all utility-related mercury pollution.[25] Even across economic sectors, coal plants are responsible for a large share of human-caused air pollution: they are the single largest source of sulfur dioxide, mercury, and air toxic emissions and the second largest source of nitrogen oxide pollution.[26,27] Coal combustion is also responsible for more than 30% of total U.S. carbon dioxide pollution, contributing significantly to global warming.

Criteria air pollutants are a class of ubiquitous, harmful pollutants designated under the Clean Air Act. They are the only pollutants for which the EPA sets legal limits, called the National Ambient Air Quality Standards, on the amounts allowed in ambient air. These standards are based on health risk considerations. There are six criteria pollutants: nitrogen oxides, ozone, sulfur oxides, particulate matter, lead, and carbon monoxide. Coal combustion produces significant quantities of nitrogen oxides, sulfur oxides, and particulate matter, and contributes to the production of ground-level ozone.

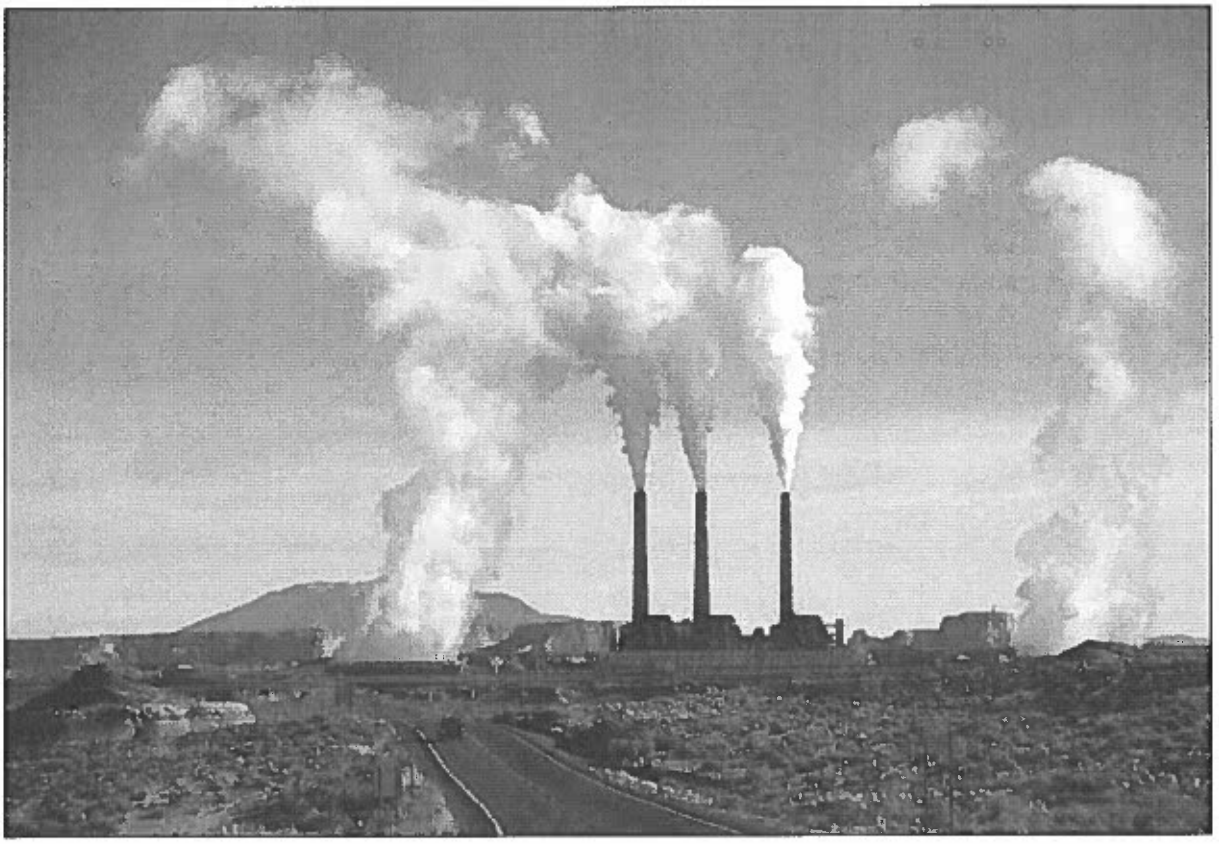
Coal-fired power plants are second only to automobiles as the largest source of nitrogen oxide

Table 2.2: The health effects of power plant pollutants

Pollutant	What is it?	How is it produced?	Health effects	Most vulnerable populations
Ozone	Ozone is a highly corrosive, invisible gas	Ozone is formed when nitrogen oxides (NOx) react with other pollutants in the presence of sunlight.	Rapid shallow breathing, airway irritation, coughing, wheezing, shortness of breath. Makes asthma worse. May be related to premature birth, cardiac birth defects, low birth weight, and stunted lung growth.	Children, elderly, people with asthma or other respiratory disease. People who exercise outdoors.
Sulfur Dioxide (SO_2)	SO_2 is a highly corrosive, invisible gas. Sulfur occurs naturally in coal.	SO_2 is formed in the gases when coal is burned. SO_2 reacts in the air to form sulfuric acid, sulfates, and in combination with NO_x, acidic particles.	Coughing, wheezing, shortness of breath, nasal congestion and inflammation. Makes asthma worse. SO_2 gas can destabilize heart rhythms. Low birth weight, increased risk of infant death.	Children and adults with asthma or other respiratory disease.
Particulate Matter (PM)	A mixture of small solid particles (soot) and tiny sulfuric acid droplets. Small particles are complex and harmful mixtures of sulfur, nitrogen, carbon, acids, metals, and airborne toxics.	Directly emitted from coal burning. Formed from SO_2 and NO_x in the atmosphere.	PM crosses from the lung into the bloodstream resulting in inflammation of the cardiac system, a root cause of cardiac disease including heart attack and stroke leading to premature death. PM exposure is also linked to low birth weight, premature birth, chronic airway obstruction and remodeling, and sudden infant death.	Elderly, children, people with asthma.
Nitrogen Oxides (NO_x)	A family of chemical compounds including nitrogen oxide and nitrogen dioxide. Nitrogen occurs naturally in coal.	NO_x is formed when coal is burned. In the atmosphere can convert to nitrates and form fine acidic particles. Reacts in the presence of sunlight to form ozone smog.	NO_x decreases lung function and is associated with respiratory disease in children. Converts to ozone and acidic PM particles in the atmosphere.	Elderly, children, people with asthma.
Mercury	A metal that occurs naturally in coal.	Mercury is released when coal is burned.	Developmental effects in babies that are born to mothers who ate contaminated fish while pregnant. Poor performance on tests of the nervous system and learning. In adults, may affect blood pressure regulation and heart rate.	Fetuses and children are directly at risk. Pregnant women, children, and women of childbearing age need to avoid mercury exposure.
Carbon Dioxide	Coal has the highest carbon content of any fossil fuel.	Carbon dioxide is formed when coal is burned.	Indirect health effects associate with climate change including the spread of infectious disease, higher atmospheric ozone levels, and increased heat- and cold-related illnesses.	People of color, children, people with asthma.

Source: Clean Air Task Force. Cradle to grave: the environmental impacts of coal. June 2006.

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pollution, producing 18% of total U.S. nitrogen oxide emissions.[28] Nitrogen oxides are respiratory irritants.[29] They also pose a serious health risk as ozone precursors. Ground level ozone, also known as smog, is formed when nitrogen oxides react with volatile organic compounds in the presence of heat and sunlight. According to the American Lung Association, 175.4 million Americans live in counties with unhealthy ozone levels, representing more than half of the total U.S. population.[30] Ground level ozone is one of the nation's most pervasive air pollutants, and is particularly harmful to children and the elderly.

Sulfur occurs naturally in coal. Upon combustion, sulfur dioxide, a respiratory irritant, is emitted from coal plants and once in ambient air forms acid rain and particulate pollution. Coal-fired power plants are responsible for two thirds of the nation's sulfur dioxide emissions.[31]

Particle pollution is a complex combination of solids and aerosols suspended in the ambient air. It is categorized by researchers by size: PM_{10}, less than 10 microns in diameter, and $PM_{2.5}$, less than 2.5 microns in diameter. (By comparison, a human hair is about 70 microns in diameter.) Particle pollution is linked to asthma attacks as well as cellular inflammation, a risk factor for a range of chronic diseases. It has been estimated that coal plants in the U.S. will release 217,000 tons of PM_{10} and 110,000 tons of $PM_{2.5}$ in 2010.[32] These emissions estimates do not include secondary particle pollution, formed by the condensation of atmospheric gases such as oxides of nitrogen and sulfur with other pollutants, many of which are also released by coal plants.

The criteria pollutants produced by coal combustion carry large costs to society. The National Research Council has estimated the external costs associated with emissions of nitrogen oxides, sulfur dioxide, and PM from coal-fired power plants in the U.S. at $62 billion in 2005.[33]

In addition to the emissions of criteria pollutants, coal combustion is also a major source

of Hazardous Air Pollutants (HAPs), a class of harmful pollutants for which emissions limits, as opposed to allowable ambient air levels, are set by the EPA. These emissions limits are dictated by the technologies available to control pollution instead of by health risk considerations. There are 189 HAPs designated under the Clean Air Act.

In EPA smokestack tests released in 1998, coal plants were found to emit 67 different HAPs, many of which are known or probable human carcinogens, neurotoxins that can harm brain development, and reproductive toxins. These 67 HAPs include arsenic, beryllium, cadmium, chromium, lead, manganese, mercury, nickel, hydrogen chloride, hydrogen fluoride, acrolein, dioxins, formaldehyde, and radionuclides.[34] Based on exposure and risk estimates, the EPA identified four coal-related HAPs as posing potential risks to human health: mercury, dioxins, arsenic, and nickel. Mercury is the HAP of greatest concern emitted through coal combustion, due to its impacts on the nervous system. In 2007, electric utilities were responsible for more than 70% of all mercury air emissions.[35] Almost all of this mercury came from coal combustion.

Table ES.1 (see pages x–xi) describes the major health effects linked to coal combustion emissions. These health effects damage the respiratory, cardiovascular, and nervous systems and contribute to four of the top five leading causes of death in the U.S.: heart disease, cancer, stroke, and chronic lower respiratory diseases. These health effects are discussed further in subsequent sections. Although it is difficult to ascertain the proportion of this disease burden that is attributable to coal pollutants, even very modest contributions to these major causes of death are likely to have large effects at the population level, given high incidence rates.

POST-COMBUSTION WASTES

Coal's health effects extend beyond combustion. The potential hazards posed by post-combustion wastes are not a new problem, but one that has received little attention. In 2007, in response to complaints by interest groups, the EPA surveyed a number of sites where coal ash slurry, the residue left after burning coal, is stored. It found that damage to human health or the environment was inflicted at nine of the sites and potential damage was present at another 25.[36] A subsequent risk assessment showed that toxic residues from coal ash storage sites had migrated into water supplies and threatened human health at approximately 24 sites.[37] Then in December, 2008, a spill of approximately one billion gallons of coal ash slurry in Tennessee inundated hundreds of acres and threatened to contaminate drinking water and waterways with toxic metals, including lead and arsenic. Thus, coal poses risks to health from the point it is extracted from the ground, through combustion, and even afterwards as a toxic waste.

NOTES

1 Goodell J. Big coal: the dirty secret behind America's energy future. Boston: Houghton Mifflin; 2006.

2 Energy Information Administration. Annual Coal Report: 2007. 2009: DOE/EIA-0584 (2007).

3 World Coal Institute. Coal and Steel. 2009. Available from: http://www.worldcoal.org/bin/pdf/original_pdf_file/coal_steel_report(03_06_2009).pdf .

4 Markandya A, Wilkinson P. Electricity generation and health. Lancet 2007;370:979–990.

5 National Mining Association, Most Requested Statistics, updated Nov 2008. Available from: http://www.nma.org/pdf/c_most_requested.pdf.

6 Energy Information Administration. Available from: http://www.eia.doe.gov/cneaf/coal/page/acr/table9.html.

7 National Institute of Occupational Safety and Health. Worker health chartbook 2004. 2004: 2004-146. Available from: http://www.cdc.gov/niosh/docs/2004-146/detail/imagedetail.asp@imgid304.htm.

8 Centers for Disease Control and Prevention. Available from: http://www.cdc.gov/NIOSH/Mining/statistics/pdfs/pp3.pdf.

9 Mine Safety and Health Administration. Available from: http://www.msha.gov/fatals/fabc.htm.

10 National Institute of Occupational Safety and Health. Worker health chartbook 2004. 2004: 2004-146. Available from: http://www.cdc.gov/niosh/docs/2004-146/detail/imagedetail.asp@imgid304.htm.

11 Rappaport E. Coal mine safety. CRS Report for Congress, 2006: RS22461. Available from: http://ncseonline.org/NLE/CRSreports/06Jul/RS22461.pdf.

12 Hendryx M, Ahern MM. Relations between health indicators and residential proximity to coal mining in West Virginia. Am J Public Health 2008;98:669–671.

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13 EPA. Mountaintop mining/valley fills in Appalachia final programmatic environmental impact statement. October 2005: EPA-9-03-R-05002. Available from: http://www.epa.gov/Region3/mtntop/pdf/mtm-vf_fpeis_full-document.pdf.

14 Appalachian Voices map, 2009. Available from: http://www.ilovemountains.org/resources/.

15 Appalachian Coalfield Delegation. Position paper on sustainable energy. Paper delivered to the United Nations Commission on Sustainable Development 15th Session, 2007. Available from: http://www.civilsocietyinstitute.org/media/pdfs/CSD_position_paper_FINAL.pdf.

16 EPA Office of Solid Waste. Acid mine drainage prediction technical document. 1994: EPA530-R-94-036. Available from: http://www.epa.gov/osw/nonhaz/industrial/special/mining/techdocs/amd.pdf.

17 Lashof DA, Delano D, Devine J et al. Coal in a changing climate. Natural Resources Defense Council, 2007.

18 Smith V. Critics question safety of storing coal slurry. Associated Press, 21 March 2009.

19 National Research Council Committee on Coal Waste Impoundments. Coal waste impoundments: risks, responses, and alternatives. Washington, D.C.: National Academy Press; 2002.

20 Kaplan SM. Rail transportation of coal to power plants: reliability issues. Congressional Research Service. 2007: RL34186.

21 Lashof DA, Delano D, Devine J et al. Coal in a changing climate. Natural Resources Defense Council, 2007.

22 EPA regulatory announcement. EPA finalizes more stringent emissions standards for locomotives and marine compression-ignition engines. March 2008. Available from: http://www.epa.gov/otaq/regs/nonroad/420f08004.htm.

23 Ancja VP. Characterization of particulate matter (PM10) in Roda, Virginia. Unpublished report to the Virginia Air Pollution Control Board. Undated. Available from: http://www.eenews.net/public/25/10670/features/documents/2009/04/23/document_pm_01.pdf.

24 Levy JI, Baxter LK, Schwartz J. Uncertainty and variability in health-related damages from coal-fired power plants in the United States. Risk Anal. 2009 Jul;29(7):1000-14.

25 EPA. National air quality and emissions trends report, 2003 special edition. 2003: EPA 454/R-03-005. Appendix A. Available from: http://www.epa.gov/air/airtrends/aqtrnd03/.

26 EPA. National air quality and emissions trends report, 2003 special edition. 2003: EPA 454/R-03-005. Appendix A. Available from: http://www.epa.gov/air/airtrends/aqtrnd03/.

27 EPA. U.S. EPA Toxics Release Inventory reporting year 2005 public data release. 2007. Section B. Available from: http://www.epa.gov/tri/tridata/tri05/index.htm.

28 EPA. National air quality and emissions trends report, 2003 special edition. 2003: EPA 454/R-03-005. Appendix A. Available from: http://www.epa.gov/air/airtrends/aqtrnd03/.

29 Agency for Toxic Substances and Disease Registry. ToxFAQs for nitrogen oxides. Available from: http://www.atsdr.cdc.gov/tfacts175.html

30 American Lung Association. State of the air: 2009. Executive summary. Available from: http://www.stateoftheair.org/2009/key-findings/executive-summary.html

31 Clean Air Task Force. Cradle to grave: the environmental impacts from coal. June 2001.

32 Abt Associates, Computer Sciences Corporation, EH Pechan Associates. Power plant emissions: particulate matter-related health damages and the benefits of alternative emission reduction scenarios. Clean Air Task Force, 2004. Available from: http://www.abtassociates.com/reports/Final_Power_Plant_Emissions_June_2004.pdf.

33 Committee on Health, Environmental, and Other External Costs and Benefits of Energy Production and Consumption; National Research Council. Hidden costs of energy: unpriced consequences of energy production and use. Washington DC: National Academies Press; 2009.

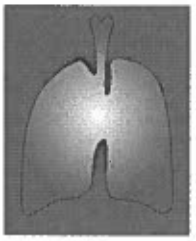
34 EPA. Study of hazardous air pollutant emissions from electric utility steam generating units—final report to Congress. February 1998. EPA-453/R-98-004a.

35 EPA. 2007 TRI Public Data Release. Available from: http://www.epa.gov/tri/tridata/tri07/index.htm.

36 EPA Office of Solid Waste. Coal combustion waste damage case assessments, July 9, 2007. Available from: http://www.publicintegrity.org/assets/pdf/CoalAsh-Doc1.pdf.

37 EPA. Human and ecological risk assessment of coal combustion wastes: Draft, August 6, 2007. Available from: http://www.earthjustice.org/library/reports/epa-coal-combustion-waste-risk-assessment.pdf.

3. *Coal's Effects on the Respiratory System*

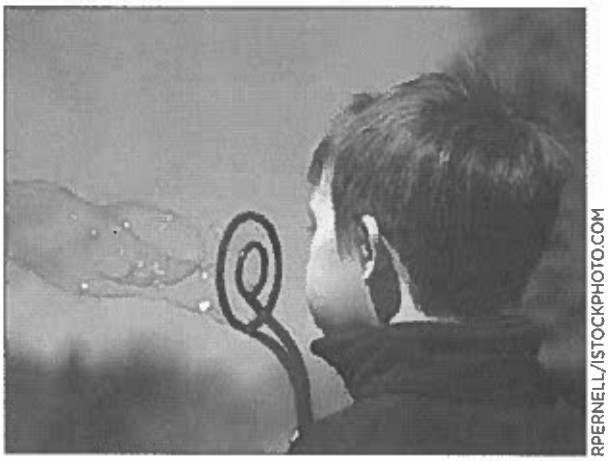


Virtually all airborne pollutants gain access to the body via the respiratory tract. Thus, it is no surprise that this important system is affected significantly by pollutants discharged into the atmosphere by electrical utilities that burn coal. These effects fall into several classes: *de novo* production of a condition, such as asthma, that did not exist prior to an exposure; an exacerbation of a previously-existing illness, again, such as asthma; and the development or progression of a chronic illness such as asthma, lung cancer, chronic obstructive pulmonary disease (COPD), and emphysema.

Data from the California Children's Health study have shown that air pollutants have clinically and statistically significant adverse effects on lung development.[1] In this prospective study, 1759 children were enrolled when they were in the fourth grade, when they were approximately 10 years old, and followed until age 18. Various measures of lung function were made periodically and correlated with their exposure to various pollutants. During normal development, the amount of air that can be forcibly exhaled in one second (FEV_1) increases with age. After controlling for various factors that could potentially confound the results, the investigators found that the FEV_1 failed to increase as predicted among children exposed to NO_2, acid vapor, and $PM_{2.5}$. Using a reduction of FEV_1 to 80% or less of the predicted value, children exposed to the highest levels of particulates were almost five times more likely to fall into the abnormal range than those with the lowest exposures. This impact on lung development is likely to be an additional risk factor for the subsequent development of other pulmonary diseases, such as asthma and chronic obstructive pulmonary disease.

ASTHMA

Asthma is a chronic disease of the lungs characterized by inflammation and narrowing of the airways. Patients with asthma experience recurrent episodes of dyspnea (shortness of breath), a sensation of tightness in the chest, wheezing, and coughing that typically occurs at night or early in the morning. Airway inflammation in asthmatics



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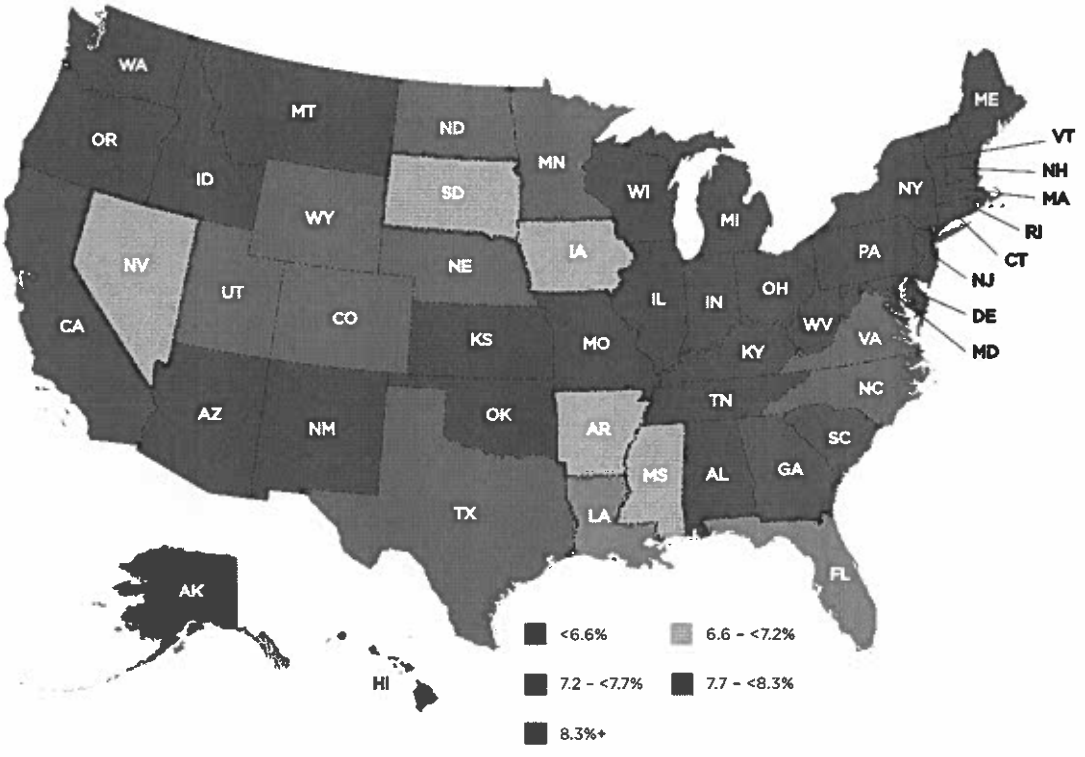
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causes swelling that narrows a bronchial tree that has been previously sensitized to inhaled irritants, including many air pollutants. Exposure to an inhaled irritant causes further narrowing of the airways and the production of mucus that makes airways even narrower. During severe attacks, the lungs fail to perform their task of exchanging carbon dioxide, produced by metabolic processes in the body, for oxygen. This can lead to hypoxia (low blood oxygen level), hypercarbia (high blood carbon dioxide level), and respiratory acidosis (acidification of the blood caused by carbon dioxide retention) that may, in turn, cause cardiac arrhythmias and death. There are about 22 million asthmatics in the U.S., including 6 million children.[2] The Centers for Disease Control and Prevention report that the number of persons with asthma increased by 84% from 1980 to 2004. As shown in Figure 3.1, more than half of the states report that 8.6% or more of its inhabitants have asthma. These high-asthma states are clustered in the northeast and Midwest.

During an asthma attack, the airway is constricted due to inflammation and contraction or spasm of the muscles that surround the airway. This is associated with swelling of the tissues of the airway caused by triggers, or stimuli, which in turn cause an immune response. Asthmatics are more sensitive to these triggers than non-asthmatics, a condition known as hypersensitivity. There are many triggers, including dust, smoke, pollen, and volatile organic compounds. Some of the

Figure 3.1: CDC asthma prevalence by state

Adult self-reported current asthma prevalence rate by state, Behavioral Risk Factor Surveillance System 2007



Note: Ranges are based on quintiles of the overall prevalence estimates from year 2000 data.

Source: Air Pollution and Respiratory Health Branch, National Center for Environmental Health, Centers for Disease Control and Prevention

OXIDATIVE STRESS

The possibility that oxygen, or reactive forms of oxygen, might be toxic to certain cellular functions emerged in the 1950s. Subsequent research has focused on the importance of highly reactive forms of oxygen, known as oxygen free radicals, in biological systems. We now know that some of these free radicals exert critical controls over normal cellular metabolic process and cellular signaling. "Oxidative stress" is the term used to describe the physiological state characterized by an excessive concentration of these oxidizing free radical molecules.

Oxidative stress is one of several mechanisms implicated in the pathogenesis of diseases caused or made worse by pollutants formed by burning coal.

Free radicals are defined as atoms or molecules that contain at least one unpaired electron in an atomic or molecular orbit and are therefore unstable and highly reactive. Examples of reactive oxygen species (ROS) include the superoxide anion radical, formed by the addition of an electron to molecular oxygen (O_2); the hydroxyl radical, the neutral form of the hydroxl ion; and peroxyl radicals, the simplest of which is the hydroperoxyl radical, composed of one molecule of hydrogen and two molecules of oxygen. More complex peroxyl radicals have an organic group (abbreviated by an R) substituted for the hydrogen molecule.

ROS are a normal cellular constituent and play critical roles in the control of many cellular functions. However, the concentration of ROS can be increased through exposure to environmental substances such as air pollution, tobacco smoke, pesticides, and solvents. When the ROS concentration is excessive, these highly reactive molecules damage lipids, proteins, DNA, cell membranes, and other cellular components, producing oxidative stress, an important contributing factor in a variety of diseases.

In a contemporary review Valko, et al., summarize the current state of knowledge of oxygen free radicals and their importance in the production of a variety of diseases including cardiovascular and pulmonary disease, as well as other conditions including atherosclerosis, hypertension, rheumatoid arthritis, diabetes mellitus, neurodegenerative disorders such as Alzheimer's disease and Parkinson's disease, and normal aging.

Valko M, Leibfritz D, Moncol J, Cronin MTD, Mazur M, Telser J. Free radicals and antioxidants in normal physiological functions and human disease. Int J Biochem and Cell Biology 2007;39:44–84.

pollutants discharged by coal fired power plants may act as triggers and produce an asthma attack. These pollutants include sulfur dioxide, nitrogen oxides, and particulate matter. In addition, the carbon dioxide emissions from coal accelerate global warming, which is likely to increase the concentration in air of pollen from some plants, such as ragweed, and thereby contribute to the development of additional asthma attacks.

Genetic variability accounts for some of the differences in the sensitivity of individuals to asthma triggers.[3] Genetic studies have shown differences in the susceptibility to ozone that are due to polymorphisms (subtle differences in genes that control the expression of a trait) in the genes responsible for dealing with oxidative stress. Oxidative stress is created when oxygen ions, free radicals, or other reactive species are produced in excess of the body's ability to remove these molecules. Oxidative stress may be an important mechanism for the production of a variety of diseases (see text box). Genetic polymorphisms responsible for controlling the inflammatory response also increase an individual's susceptibility to the respiratory effects of ozone. Thus, the probability that an individual will develop asthma depends on exposure to a trigger, such as ozone, and the individual's susceptibility to that trigger, i.e., a complex combination and interaction between genetic and environmental factors. For a review of the genetic susceptibility

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to the effects of air pollutants, such as ozone, particulates, nitrogen dioxide, and sulfur dioxide, on respiratory function see Yang, et al.[4]

Children appear to be more susceptible to the development of pollution-related asthma attacks than adults. There are several explanations for this increase in susceptibility. According to a review by Bateson and Schwartz, the susceptibility of children to the effects of air pollution is multifactorial and includes the following.[5] 1) Children have different rhythmic patterns of breathing than adults. 2) They are predominantly mouth-breathers, thereby bypassing the filtering effects of the nasal passages. This allows pollutants to travel deeper into the lungs. 3) They have a larger lung surface area per unit weight than adults. 4) They spend more time out of doors, particularly in the afternoons and during the summer months when ozone and other pollutant levels are the highest. 5) Children also have higher ventilation rates. i.e., volume of air per minute per unit body weight compared to adults. 6) When active, children may ignore early symptoms of an asthma exacerbation and fail to seek treatment, leading to attacks of increased severity. There are other factors that are important. The diameter of the airways in children is smaller than in adults and therefore airways may be more susceptible to the effects of the airway narrowing that is characteristic of asthmatic attacks. These factors, combined with the possible adverse impact of pollutants on lung development and the immaturity of enzyme and immune systems that detoxify pollutants, may all contribute to an increase in the sensitivity of children to pollutants produced by burning coal.[6]

CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD), CHRONIC BRONCHITIS AND EMPHYSEMA

Asthma is a reversible condition. When permanent damage to the airway occurs, a chronic obstructive airway condition is present.

COPD is a condition characterized by narrowing of the airway passages. Unlike asthma, these changes are permanent rather than reversible. Like asthma, exposures to pollutants that produce an immunological response are critical in the pathogenesis of the condition. The response in larger airways is referred to as chronic bronchitis. A cough that produces sputum is characteristic of chronic bronchitis. In the alveoli, the inflammatory response leads to a destruction of tissue, or emphysema. These two conditions usually co-exist. Exacerbations of COPD may be triggered by pollutants or infections. Although current and ex-smokers account for 80–85% of all patients with COPD, exposure to air pollutants, including those that are produced by burning coal, plays an important role in the pathogenesis of acute exacerbations and the development of COPD.

PULMONARY INFLAMMATION AND AIR POLLUTANTS

Inflammation of pulmonary tissues is a critical element in the pathophysiology of illness caused by air pollution. Reactive oxygen species, such as free radicals and oxygen ions, appear to be central to this process. To avoid some of the difficulties associated with in vitro studies, several investigators have studied the response to particulate pollution in experimental animals. Roberts, et al., instilled particles into the lungs of rats treated with a compound (dimethylthiourea) that is believed to blunt the response to reactive oxygen species.[7] After treatment, the lungs of the animals were lavaged (rinsed with saline) and biomarkers of pulmonary injury were measured. Treated animals exhibited less evidence of damage to their lungs such as toxicity to cells, cytokine gene expression (genes that control cellular communications), pulmonary inflammation and other markers of pulmonary injury. In a subsequent study, Rhoden, et al., instilled standardized urban air particles (active agent) or saline (placebo control) into the lungs of rats.[8] Half of the animals in each group were treated with a reactive oxygen species inhibitor. Pretreatment with the inhibitor blocked the deleterious effects of the particles, as shown by reductions in several markers of pulmonary inflammation. These studies show that common

air pollutants such as particulates interfere with a variety of basic cellular mechanisms and dispose to the development of inflammation, a process that leads to diseases such as asthma, COPD, and emphysema.

These two studies are representative of many that have been performed using a variety of agents and techniques. Although performed in animals and not humans, they are consistent with a larger body of scientific evidence that helps establish a cause-and-effect relationship between particulates and pulmonary disease. As noted above, inflammation is a critical element in the pathogenesis of attacks of asthma and exacerbations of COPD. It matters little whether the inflammation is caused by particulates or other pollutants.

Additional evidence to support the hypothesis that air pollutants produce oxidative stress is derived from many studies. Recently, Fitzpatrick, et al., studied 65 children with severe asthma, including 35 with a reduction in baseline airway function as shown by a forced expiratory volume of less than 80% of that predicted, i.e., their ability to move air rapidly out of the lung was impaired.[9] Bronchoalveolar lavage (rinsing the airway with saline) was performed and metabolites and enzymes related to oxidative stress were measured. In the asthmatics, the concentration of glutathione, an antioxidant that protects cells from free radicals, was reduced and the concentration of the oxidized form (glutathione disulfide) was increased. This made the children less able to withstand oxidative stress and more susceptible to the development of an asthmatic attack.

OZONE, AIR POLLUTION, AND ASTHMA

Ozone, a highly reactive gas that consists of three atoms of oxygen (O_3), is formed by the reaction of volatile organic compounds (VOCs) with oxides of nitrogen (NO_x) in the presence of sunlight. Coal combustion does not produce ozone directly, but both the NO_x and the VOCs released by coal plants are essential contributors to the formation of ground-level ozone, the primary ingredient in urban smog. Ozone is a powerful oxidizing agent



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that irritates the lungs at concentrations typically encountered in urban settings, particularly in summer months. There are many studies linking increases in ozone to asthma and other pulmonary diseases (see Trasande and Thurston for review[10]).

One of the most compelling studies linking ozone with asthma exacerbations was performed by Gent, et al.,[11] who examined the effects of relatively low ozone levels on asthmatic children. Those authors conducted a prospective cohort study of 271 children younger than 12 who had physician-diagnosed asthma. The children were divided almost equally into groups who did or did not use daily maintenance medications. Rigorous statistical techniques were used to examine the relationship between ozone levels below EPA standards, respiratory symptoms, and the use of rescue medications as charted by the children's mothers on daily calendars. The authors found a significant association between ozone levels and symptoms, as well as the use of rescue medications in the children who used daily maintenance medications. No significant relationships were found between ozone levels and symptoms or medication use in the children who did not take daily maintenance medications. Thus, it appears that the threat to children posed by ozone is greatest among those with severe asthma, even when ambient ozone levels fall within the limits set by the EPA to protect public health.

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Peel, et al., studied the relationship between a one standard deviation increase in ambient air pollutant levels and emergency room visits for various respiratory problems, including asthma.[12] They found the strongest association between increases in 24-hour PM_{10} levels, 24-hour increases in 10–100 nm particle concentrations, and 1-hour NO_2 concentrations and asthma attacks that occurred six to eight days after the peak. There were shorter delays between peaks of PM_{10}, ozone, NO_2, and carbon monoxide and emergency room visits for upper respiratory infections. During warm months, there was a 2.6% increase in asthma admissions after a 25 ppb increase in the ozone concentration. To give the 25 ppb increase perspective, the EPA eight-hour exposure standard in 2008 was set at 75 ppb. This study is one of many that establish a statistically rigorous link between a peak in the concentration of an air pollutant and the onset of a disease or disease symptom.

Increases in the risk of death from respiratory causes, including sudden infant death, were correlated with the concentration of PM_{10} and NO_2.

The evidence linking ozone levels to the development of asthma is less compelling than that linking ozone to asthma exacerbations. Gilmour, et al., reviewed five studies that address this issue.[15] A Dutch study of over 4,000 children enrolled at birth and followed for two years, focused on NO_2 and $PM_{2.5}$ attributed to traffic, found small but statistically significant associations between pollutant peaks and the development of symptoms of asthma.[14,15] Although this study focused on traffic as the source of the pollutants, burning coal can't be ignored as a source of NO_2 and $PM_{2.5}$. There were similar results from a second study of children in that age group from the Netherlands, Germany, and Sweden. The Children's Health Study of more than 6,000 children from southern California evaluated a wide range of ozone, particulates, oxides of nitrogen, and acids.[16] A significant association between ozone and asthma was confined to those children who participated in three or more sports. This result may be the consequence of the increases in the amount of air breathed per unit of time associated with exercise and the consequent increases in exposure to pollutants. Gilmour, et al., conclude that the results of all five of the studies they reviewed "support a modest increase in the risk for air pollution in relation...to asthma."[17]

The increase in susceptibility to pollutants among children appears to translate into pollution-related increases in infant mortality. Ritz, et al., reported increases in the risk of death from respiratory causes, including sudden infant death, with rises in the concentration of carbon monoxide, PM_{10}, and NO_2.[18] Bateson and Schwartz also cite a study reporting between 4 and 7 fewer infant deaths per 100,000 live births with a reduction in the concentration of total suspended particles of 1 $\mu g/m^3$.[19] To give this number perspective, Pope, et al., reported that there was a mean reduction in the $PM_{2.5}$ concentration of 6.52 $\pm$ 2.9 $\mu g/m^3$ in major U.S. metropolitan areas in the time interval between 1979–83 and 1999–2000.[20]

AIR POLLUTION AND COPD

Smoking tobacco is the most important risk factor for the development of COPD. Most authors report that approximately 85% of all cases of COPD can be attributed to this single, preventable cause. Data that have emerged during the past several years have shown that there is a smaller but important link between air pollution, including pollutants produced by burning coal, and the subsequent development of COPD exacerbations.

In a study of the residents of Helsinki, Finland, where coal-derived air pollutants account for a relatively small portion of total pollutant levels, pooled asthma and COPD emergency room visits increased on those days when there were increases in $PM_{2.5}$, coarse particles, and gaseous pollutants.[21] The Atlanta, Georgia, study of Peel, et al., found that when NO_2 or carbon monoxide increased by one standard deviation, emergency room visits for COPD increased by 2–3%.[22] Finally, in a study of hospitalization rates among Medicare enrollees, a 10 $\mu g/m^3$ increase in the concentration of $PM_{2.5}$

particles was associated with a same-day increase in COPD admissions of 2.5% (95% confidence interval (CI) = 2.1–3.2%).[23] These three studies of three different populations using different criteria all link increases in air pollutants to increases in exacerbations of COPD. Although they did not focus on pollutants derived exclusively from the combustion of coal, the pollutants they studied included those produced by coal burned by electrical utilities as well other sources.

LUNG CANCER

The National Cancer Institute estimates that in 2008 there were 215,020 new cases of lung cancer, the leading U.S. cancer killer in both men and women, with 161,840 deaths. While smoking tobacco, radon and other radioactive gases, secondhand smoke, asbestos, arsenic, nickel compounds, and other airborne organic compounds have been identified as risk factors for developing lung cancer, data from three large epidemiological studies show that air pollution may also be a risk factor.

First among these was a study of Seventh Day Adventists who lived in California.[24] This cohort of over 6,300 non-smoking white adults was followed from 1977 to 1992 and monitored for the development of lung cancer. These data were combined with monthly ambient air pollution data in various zip codes. For men, the interquartile range (the middle 50% of the range) increase for ozone of 100 ppb was associated with an increase in the relative risk (RR) for lung cancer of 3.56 (95% CI = 1.35–9.42). Lung cancer increases were also associated with significant increases in PM_{10} (RR = 5.21, 95% CI = 1.94–13.99) and for SO_2 (RR = 2.66, 95% CI = 1.62–4.39). Smaller increases among women were also found, however only the association with SO_2 was statistically significant. The difference between men and women was thought to be due to greater exposures among men.

In the Harvard Six Cities study, lung cancer death was positively associated with air pollution. The adjusted mortality rate ratio due to lung cancer for the most to least polluted cities was 1.26 (95% CI = 1.08–1.47).[25,26]

Complementary data were found in the American Cancer Society study.[27] This epidemiological study began with 1.3 million adults in 1982. From that set, approximately 500,000 adults were matched with air pollution data for their appropriate metropolitan area and vital statistics data through the end of 1998. Fine particulate increases of 10 $\mu g/m^3$ were associated with an 8% increase in lung cancer mortality. Increases in the concentration of oxides of sulfur were also associated with increases in lung cancer mortality.

These three large prospective epidemiological studies provide evidence that air pollution, particularly that due to particulates and ozone, may affect mortality due to lung cancer. Since some of the pollutants studied are formed directly or indirectly as the consequence of burning coal, it is possible that burning coal places those exposed to coal-related pollutants at greater risk for developing lung cancer.

NOTES

1 Gauderman WJ, Avol E, Gilliland F et al. The effect of air pollution on lung development from 10 to 18 years of age. N Engl J Med 2004; 351(11):1057–1067.

2 National Heart Lung and Blood Institute fact sheet. What is asthma? Available from: http://www.nhlbi.nih.gov/health/dci/Diseases/Asthma/Asthma_WhatIs.html.

3 Yang IA, Fong KM, Zimmerman PV, Holgate ST, Holloway JW. Genetic susceptibility to the respiratory effects of air pollution. Thorax 2008; 63(6):555–563.

4 Yang IA, Fong KM, Zimmerman PV, Holgate ST, Holloway JW. Genetic susceptibility to the respiratory effects of air pollution. Thorax 2008; 63(6):555–563.

5 Bateson TF, Schwartz J. Children's response to air pollutants. J Toxicol Environ Health Part A 2008; 71(3):238–243.

6 Trasande L, Thurston GD. The role of air pollution in asthma and other pediatric morbidities. J Allergy Clin Immunol 2005; 115(4):689–699.

7 Roberts ES, Richards JH, Jaskot R, Dreher KL. Oxidative stress mediates air pollution particle-induced acute lung injury and molecular pathology. Inhal Toxicol 2003; 15(13):1327–1346.

8 Rhoden CR, Ghelfi E, Gonzalez-Flecha B. Pulmonary inflammation by ambient air particles is mediated by superoxide anion. Inhal Toxicol 2008; 20(1):11–15.

9 Fitzpatrick AM, Teague WG, Holguin F, Yeh M, Brown LA. Airway glutathione homeostasis is altered in children with severe asthma: evidence for oxidant stress. J Allergy Clin Immunol 2009; 123(1):146–152.

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10 Trasande L, Thurston GD. The role of air pollution in asthma and other pediatric morbidities. J Allergy Clin Immunol 2005; 115(4):689–699.

11 Gent JF, Triche EW, Holford TR et al. Association of low-level ozone and fine particles with respiratory symptoms in children with asthma. JAMA 2003; 290(14):1859-1867.

12 Peel JL, Tolbert PE, Klein M et al. Ambient air pollution and respiratory emergency department visits. Epidemiol 2005; 16(2):164–174.

13 Gilmour MI, Jaakkola MS, London SJ et al. How exposure to environmental tobacco smoke, outdoor air pollutants, and increased pollen burdens influences the incidence of asthma. Envi Health Perspect 2006; 114(4):627–633.

14 Brauer M, Hoek G, van Vliet P et al. Air pollution from traffic and the development of respiratory infections and asthmatic and allergic symptoms in children. Am J Respir Crit Care Med 2002; 166(8):1092–1098.

15 Gilmour MI, Jaakkola MS, London SJ et al. How exposure to environmental tobacco smoke, outdoor air pollutants, and increased pollen burdens influences the incidence of asthma. Envi Health Perspect 2006; 114(4):627-633.

16 McConnell R, Berhane K, Gilliland F et al. Asthma in exercising children exposed to ozone: a cohort study. Lancet 2002; 359(9304):386–391.

17 Gilmour MI, Jaakkola MS, London SJ et al. How exposure to environmental tobacco smoke, outdoor air pollutants, and increased pollen burdens influences the incidence of asthma. Envi Health Perspect 2006; 114(4):627–633.

18 Ritz B, Wilhelm M, Zhao Y. Air pollution and infant death in southern California, 1989-2000. Pediatrics 2006; 118(2): 493–502.

19 Bateson TF, Schwartz J. Children's response to air pollutants. J Toxicol Environ Health Part A 2008; 71(3):238–243.

20 Pope CA, III, Ezzati M, Dockery DW. Fine-particulate air pollution and life expectancy in the United States. N Engl J Med 2009; 360(4):376–386.

21 Halonen JI, Lanki T, Yli-Tuomi T, Kulmala M, Tiittanen P, Pekkanen J. Urban air pollution, and asthma and COPD hospital emergency room visits. Thorax 2008; 63(7):635–641.

22 Peel JL, Tolbert PE, Klein M et al. Ambient air pollution and respiratory emergency department visits. Epidemiology 2005; 16(2):164–174.

23 Dominici F, Peng RD, Bell ML et al. Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. JAMA 2006; 295(10):1127–1134.

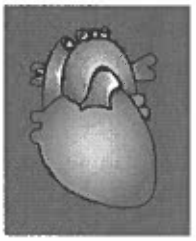
24 Beeson WL, Abbey DE, Knutsen SF. Long-term concentrations of ambient air pollutants and incident lung cancer in California adults: results from the Adventist Health Study on Smog. Environ Health Perspect 1998; 106(12):813–823.

25 Beeson WL, Abbey DE, Knutsen SF. Long-term concentrations of ambient air pollutants and incident lung cancer in California adults: results from the Adventist Health Study on Smog. Environ Health Perspect 1998; 106(12):813–823.

26 Dockery DW, Pope CA, III, Xu X et al. An association between air pollution and mortality in six U.S. cities. N Engl J Med 1993; 329(24):1753–1759.

27 Pope CA, III, Burnett RT, Thun MJ et al. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. JAMA 2002; 287(9):1132–1141.

4. *Coal's Effects on the Cardiovascular System*

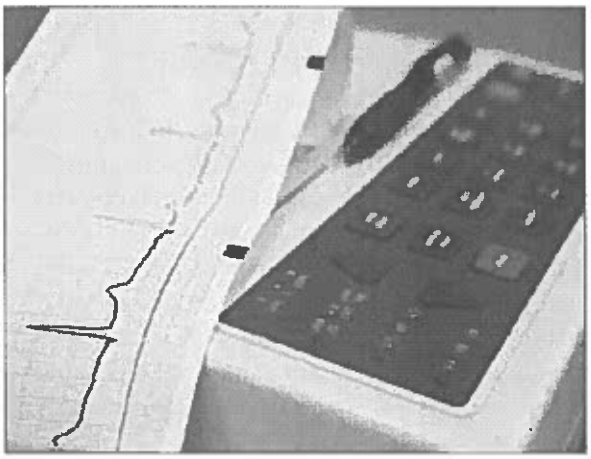


The American Heart Association (AHA), along with other organizations, has issued guidelines designed to aid health professionals as they seek to achieve primary and secondary prevention of the morbidity and mortality due to diseases of the cardiovascular system. Traditionally, these guidelines have focused on the control of hypertension, cholesterol levels, smoking, and other factors. More recently, these guidelines have been expanded to deal with lifestyle choices, such as diet, exercise, and avoidance of second-hand smoke. Controlling these risk factors has been the most important factor in the declines in death rates attributable to coronary heart disease over the past decades. However, because of accumulating evidence and a persistent concern that air pollutants are also linked to adverse cardiovascular health outcomes, the AHA convened an expert panel to evaluate this threat. The results of their deliberations, the single most authoritative review of this topic, were published in 2004.[1] In this section, we build on that prior publication, including studies published since it was written.

CARDIOVASCULAR DISEASE

Although death rates from coronary heart disease (CHD) have declined substantially during the past several decades, CHD remains a leading cause of death in the United States. Tables 4.1 and 4.2 summarize incidence rate and prevalence data from the National Heart Lung and Blood Institute 2009 Chartbook.[2] By any standard, the control of risk factors associated with CHD has important public health consequences even though the incidence and prevalence of CHD have fallen.

Figure 4.1 summarizes the pathophysiological mechanisms by which air pollutants, particularly particulate matter (PM), cause cardiovascular disease. Pulmonary inflammation and the presence of reactive oxygen species (ions, free radicals formed from oxygen) are both thought to be important mechanisms in the pathogenesis of cardiovascular disease. By convention, and for purposes of monitoring air to evaluate compliance with air quality standards, the PMs of greatest concern are those with a diameter of 2.5 μm or less ($PM_{2.5}$). These



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Table 4.1: Cardiovascular disease prevalence in the U.S. population, 2004 data

Hypertension	79,400,000
Coronary heart disease	15,800,000
Acute myocardial infarct	7,900,000
Angina pectoris	8,900,000
Congestive heart failure	5,200,00

Source: National Heart Lung and Blood Institue 2009

Table 4.2: Cardiovascular disease incidence rate and recurrence rate in the U.S. population, 2004 data (per year)

Myocardial infarct	1,200,000
First event	700,000
Recurrent event	500,000
Congestive heart failure	550,000
First event	550,000

Source: National Heart Lung and Blood Institute 2009

small particles are the most likely to penetrate deeply into the lungs, reach the alveoli, and initiate the pathophysiological sequences leading to acute and chronic manifestations of CHD.

The mechanisms depicted in Figure 4.1 suggest numerous possible therapeutic interventions. Reducing the exposure to airborne pollutants is the most obvious of these and forms the rationale for PSR's Code Black campaign to prevent the licensing and construction of new coal-fired power plants. Substantial efforts, beyond the scope of this report, are being invested in controlling the immunological and inflammatory responses and oxidative stress associated with the inhalation of pollutants.

IMMEDIATE IMPACTS OF AIR POLLUTANTS ON THE CARDIOVASCULAR SYSTEM

In a study supporting the hypothetical pathogenic mechanisms outlined in Figure 4.1, Brook, et al., evaluated the effects of fine particles and ozone on the diameter of the brachial artery in 25 healthy adults.[3] The behavior of brachial arteries is thought to be representative of the behavior of coronary and cerebral arteries. This double-blind, randomized, crossover study evaluated the cardiovascular response to a two-hour inhalation of fine particles (approximately 150 $\mu g/m^3$) and ozone (120 ppb). These concentrations, which are encountered routinely in urban settings, resulted in a significant reduction in the diameter of the brachial artery, implying narrowing of other arteries. In spite of this evidence, important questions remain, e.g., are these participants representative of the population at greatest risk (screened healthy controls versus patients with significant coronary artery disease)?

Animal studies are well suited to studying pulmonary inflammation and oxidative stress, mechanisms that may be important in cardiac disease pathogenesis. Roberts, et al., instilled particles into the lungs of animals pretreated with a drug (dimethylthiourea) believed to blunt the response to reactive oxygen species.[4] The treated animals showed less evidence of pulmonary injury, as evidenced by a blunted inflammatory response and other markers of pulmonary damage. There was also a reduction in the activity of genes controlling cytokines. Cytokines, molecules involved in cellular signaling and communication, are critical in the development and control of immunological responses. In a similar study, Rhoden, et al., instilled standardized urban air particles into the lungs of rats and measured the formation of superoxide ions, a reactive oxygen species.[5] Again, pretreatment with an inhibitor blocked the adverse effects of the particles, as shown by measured reductions in the level of several markers of lung inflammation. In a study of hyperlipidemic rabbits, Suwa, et al., found that a four-week exposure to PM_{10} was associated with acceleration of atherosclerosis, an increase in the turnover of cells in atherosclerotic

Figure 4.1: Pathophysiological mechanisms by which air pollution causes cardiovascular disease

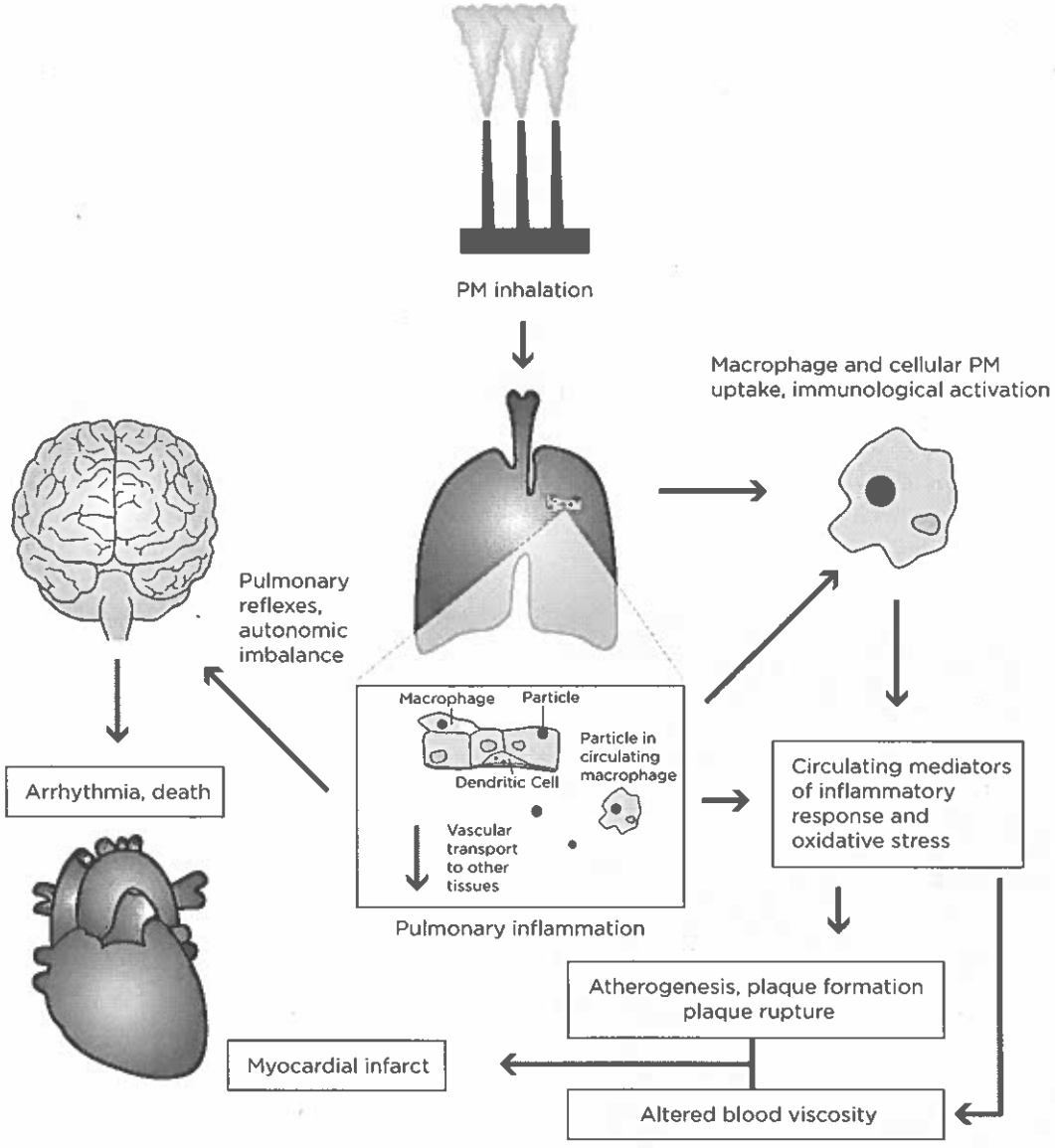


Figure legend:

Particles produced by burning coal are inhaled. Small particles, particularly those that are 2.5 µm or less in diameter, travel deep into the lungs, reaching the alveoli. Particles in the alveoli may have one of several fates: uptake by macrophages with subsequent stimulation of the inflammatory response and the immune system; uptake by dendritic cells, another pathway to immune system activation; or direct entry into the vascular compartment and subsequent transfer to other organs. Pulmonary reflexes, stimulated by inflammation, lead to imbalance of the autonomic nervous system and may potentiate cardiac arrhythmias such as ventricular fibrillation and atrial fibrillation. Inflammation and oxidative stress are important elements in the production and rupture of atherosclerotic plaques in coronary and cerebral arteries and may lead to myocardial or cerebral infarction. Increases in the viscosity of the blood also increase the risk of infarction of the heart or brain.

plaques, and an increase in the total lipid content of aortic lesions.[6] These selected studies show that pollutants produced by the combustion of coal have powerful effects on physiological processes that lead to disease endpoints, such as arterial occlusion and infarct formation.

Acute outcome studies typically focus on a single event, e.g., admission due to acute myocardial infarction or the discharge of an implanted cardioverter defibrillator (ICD). These events have a distinct time-of-occurrence that can found in hospital emergency room records or examination of defibrillator data extracted after a discharge. By examining these data in relationship to air quality data collected by monitoring stations, researchers have been able to examine the relationship between air pollution and hospital admissions for cardiovascular disease. Because of such studies, Peters, et al., hypothesized that there might be a link between transient increases in pollutant levels and therapeutic discharges of ICDs.[7] ICDs are permanently implanted in patients judged to be at risk for sudden death due to cardiac arrhythmias. These devices monitor heart rhythms continuously. When a rhythm disturbance such as ventricular fibrillation or ventricular tachycardia is detected, the ICD begins to pace or defibrillate the heart. Defibrillation is transient but quite painful, and patients are instructed to seek medical attention after an event. Modern ICDs typically include memory chips that store information for variable times. When the patient seeks medical attention after a discharge, technicians are able to retrieve relevant data, including the nature and time of the arrhythmia and the ICD discharge. Peters and her colleagues analyzed the ICD records from 100 events recorded in a single clinic in eastern Massachusetts and sought links between events and peaks in pollutant levels measured in that region. They considered daily average pollutant levels on the day of the event and one, two, and three days prior to the event. They found that an increase in the NO_2 concentration was followed by an increase in the probability of an ICD discharge two days later (odds ratio 1.8, 95% confidence interval (CI) = 1.1–2.9). Patients who experienced 10 or more ICD discharges (presumably an indication of more severe disease) exhibited associations with NO_2, CO, black carbon, and $PM_{2.5}$. Although they regarded this as a pilot study, they concluded that peaks in air pollution levels were associated with fatal or potentially fatal cardiac arrhythmias. They buttressed this claim by reviewing the results of animal studies linking pollutants to cardiac arrhythmias.

By examining how defibrillator discharges relate to air quality, researchers can explore how cardiovascular disease relates to air pollution.



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Peters and her colleagues also investigated the relationship between acute myocardial infarctions (MI) and air pollutants.[8] In this study, a total of 772 records of patient interviews conducted within four days of an acute MI (a step that minimizes recall bias) were evaluated in the context of air

pollutant concentrations. By pairing the data from the day of the MI with three other control sets measured at exactly the same time of the day (on days when the subject did not have an MI), patients served as their own controls. Compared to control periods, there was an increase in the probability of an MI in association with elevations in $PM_{2.5}$ levels measured two hours before the MI (odds ratio for an increase in $PM_{2.5}$ of 25 $\mu g/m^3$ was 1.48, 95% CI = 1.09–2.02). In addition, there was a delayed response to a peak occurring a full day before an event (odds ratio for the same increase in $PM_{2.5}$ was 1.69, 95% CI = 1.13–2.34).

Two large studies using health outcomes such as mortality in relation to day-to-day changes in ambient air pollution levels have been critical in defining the health effects associated with pollutants. In a U.S. study, Dominici, et al., used ambient $PM_{2.5}$ concentrations and hospital admission rates in the Medicare National Claims History Files to look for associations between particulate levels and admissions for ischemic heart diseases, disturbances of heart rhythm, and congestive heart failure.[9] The data included 204 urban counties with a total of 11.5 million Medicare enrollees who lived an average of 5.9 miles from a $PM_{2.5}$ monitor. Using injuries as control, they found increases in all categories, with the largest found for congestive heart failure, where a 1.28% increase was found for an increase of 10 $\mu g/m^3$ in $PM_{2.5}$ concentration. Increases in admissions for ischemic heart disease, heart failure, and disturbances of heart rhythm tended to be higher in those 75 years or older than in those 65–74. Additional details are shown in Table 4.3. The greatest effects were observed in the northeastern U.S. where coal-fired power plants are most plentiful. Although the increases in the rates appear small, on the order of a single percent, the large number of Medicare enrollees translates the result into a very large effect when measured in terms of total hospital admissions, patient morbidity and mortality, and the cost of health care and lost opportunities.

Katsouyanni, et al., reported the short-term effects of PM_{10} on the health of the residents of

Table 4.3: Percent change in hospitalization rate per 10 $\mu g/m^3$ increase in $PM_{2.5}$ for all Medicare enrollees age > 65 years

Admission diagnosis	Lag days*	Percent rate increase (95% confidence interval)
Ischemic heart disease	2	0.44 (0.02–0.86)
Heart rhythm abnormality	0	0.57 (-0.01–1.15)
Heart failure	0	1.28 (0.78–1.78)

* Number of days between peak and greatest effect of $PM_{2.5}$

Source: Dominici F, Peng RD, Bell ML et al. Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. JAMA 2006; 295(10):1127–1134.

29 European cities with a total population of over 43 million, extending over a period of approximately 5 years.[10] Unlike the U.S. study, they included all age groups. However, the results were remarkably similar to those observed in the U.S. Medicare population. They report a 0.6% increase (95% CI = 0.4–0.8%) in the daily number of deaths for a 10 $\mu g/m^3$ increase in the PM_{10} concentration. They also found important modifiers of the PM_{10}-associated death rate, particularly with regard to NO_2 levels. Cities with high NO_2 concentrations had death rates that were approximately four times higher than found in cities with low NO_2 concentrations. Death rates in cities with warm climates were about 2.8 times higher than in cities with cold climates.

These examples extracted from the literature describing the effects of air pollution on acute morbidity and mortality are consistent: the small studies focused on individuals as well as large studies that rely on data extracted from large databases show adverse effects of pollutants on indicators of acute cardiovascular illness.

LONG-TERM IMPACT OF AIR POLLUTANTS ON THE CARDIOVASCULAR SYSTEM

Two studies linking the chronic effects of air pollutants on cardiovascular mortality are particularly relevant. The first of these is the Harvard Six Cities

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study, reported by Dockery, et al.[11] This prospective cohort study followed over 8,100 adults for 14–16 years. The mortality rate in the most polluted city was 1.26% higher than the rate in the least polluted city (95% CI = 1.08–1.47%). This elevated rate persisted after controlling for important lifestyle confounders, including smoking cigarettes. Pope, et al., linked individual risk factor data from about 500,000 adults, metropolitan area air pollution data, and vital statistics and cause-of-death data. They found that an increase in the particulate concentration of 10 $\mu g/m^3$ was associated with a 6% increase in the risk of death due to cardiopulmonary causes. Because coal is a significant source of particulate pollution, these studies indicate that coal combustion has serious long-term impacts on the cardiovascular health of the U.S. population.

MITIGATING THE EFFECTS OF AIR POLLUTION

With the passage of the Clean Air Act in 1955 (with major revisions in 1970, 1977, and 1990), the U.S. embarked on a process to improve air quality in order to improve health. Pope, et al., evaluated the effects of the regulations and corresponding improvements in health in a recent paper.[12] In this study, the authors compared life expectancy in the late 1970s–early 1980s to life expectancy in the late 1990s–early 2000s in 211 counties in 51 metropolitan areas where fine particulate concentration data were available. They report a 0.61 + 0.20 year (+ standard error) increase in life expectancy after a decrease of 10 $\mu g/m^3$ in fine particle concentration. The two cities with the largest changes were Pittsburgh, PA, and Buffalo, NY, where major steel industries that consumed large amounts of coal were closed. A number of variables that could have confounded the results, such as smoking and socioeconomic class, did not have significant effects. This study showed that significant and measurable improvements in life expectancy followed the improvements in air quality mandated by the Clean Air Act.

NOTES

1 Brook RD, Franklin B, Cascio W et al. Air pollution and cardiovascular disease: a statement for healthcare professionals from the Expert Panel on Population and Prevention Science of the American Heart Association. Circulation 2004; 109(21):26552671.

2 National Heart Lung and Blood Institute. Morbidity & mortality: 2007 chart book on cardiovascular, lung, and blood diseases. 2009. NHLBI.

3 Brook RD, Brook JR, Urch B, Vincent R, Rajagopalan S, Silverman F. Inhalation of fine particulate air pollution and ozone causes acute arterial vasoconstriction in healthy adults. Circulation 2002; 105(13):1534–1536.

4 Roberts ES, Richards JH, Jaskot R, Dreher KL. Oxidative stress mediates air pollution particle-induced acute lung injury and molecular pathology. Inhal Toxicol 2003; 15(13):1327–1346.

5 Rhoden CR, Ghelfi E, Gonzalez-Flecha B. Pulmonary inflammation by ambient air particles is mediated by superoxide anion. Inhal Toxicol 2008; 20(1):11–15.

6 Suwa T, Hogg JC, Quinlan KB, Ohgami A, Vincent R, van Eeden SF. Particulate air pollution induces progression of atherosclerosis. J Am Coll Cardiol 2002, 39(6):935–942.

7 Peters A, Liu E, Verrier RL et al. Air pollution and incidence of cardiac arrhythmia. Epidemiology 2000; 11(1):11–17.

8 Peters A, Dockery DW, Muller JE, Mittleman MA. Increased particulate air pollution and the triggering of myocardial infarction. Circulation 2001; 103(23):2810–2815.

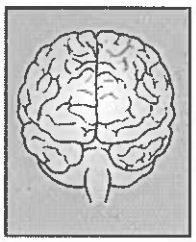
9 Dominici F, Peng RD, Bell ML et al. Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. JAMA 2006; 295(10):1127–1134.

10 Katsouyanni K, Touloumi G, Samoli E et al. Confounding and effect modification in the short-term effects of ambient particles on total mortality: results from 29 European cities within the APHEA2 project. Epidemiology 2001; 12(5):521–531.

11 Dockery DW, Pope CA, III, Xu X et al. An association between air pollution and mortality in six U.S. cities. N Engl J Med 1993; 329(24):1753–1759.

12 Pope CA, III, Ezzati M, Dockery DW. Fine-particulate air pollution and life expectancy in the United States. N Engl J Med 2009, 360(4):376–386.

5. *Coal's Effects on the Nervous System*



It is easy to understand that burning coal is likely to have an adverse impact on respiratory health: we inhale the products of combustion. It is less obvious that burning coal has important effects on the nervous system, particularly the brain. Cerebral vascular disease, i.e., stroke, and loss of intellectual capacity due to mercury are the two most important neurological consequences of burning coal.

THE BRAIN AND POLLUTION

The human brain is the organ that most clearly distinguishes us from other species. Our abilities to think abstractly, produce and enjoy music, art and literature, inquire about the nature of the universe, and a host of similar activities related to brain function are what makes us human. This uniquely human organ is also highly susceptible to disruption by what may appear to be relatively trivial acute or chronic abnormalities. Although the normal brain weighs 1,300–1,400 grams (about three pounds), the extremely high metabolic rate of the brain and the absence of significant energy stores within the brain mandate a high constant rate of blood flow in order to insure normal function and survival. When the body is at rest, between 15 and 20% of the cardiac output goes to the brain. Thus, even transient interruptions of the blood, oxygen, or glucose supplies to the brain may result in severe, permanent brain injury or brain death.

The complexity of the brain, coupled with its susceptibility to the effects of metabolic or physiological derangements or both, frequently leads to abnormalities of brain function that may be undetectable in an individual, but may have an enormous impact on the population as a whole. This, in turn, has public health consequences. This is illustrated in Figures 5.1 and 5.2, where the impact of a five-point decrement in IQ is depicted. The average IQ score is 100 and 95% of all individuals have IQ scores that fall between 70, the score below which one is considered to be retarded, and 130, the score above which one is considered to have superior intelligence. This is shown in Figure 5.1. Figure 5.2 demonstrates the effect of an across-the-board five-point decrement in IQ. For an individual, this



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Figure 5.1: Normal IQ distribution

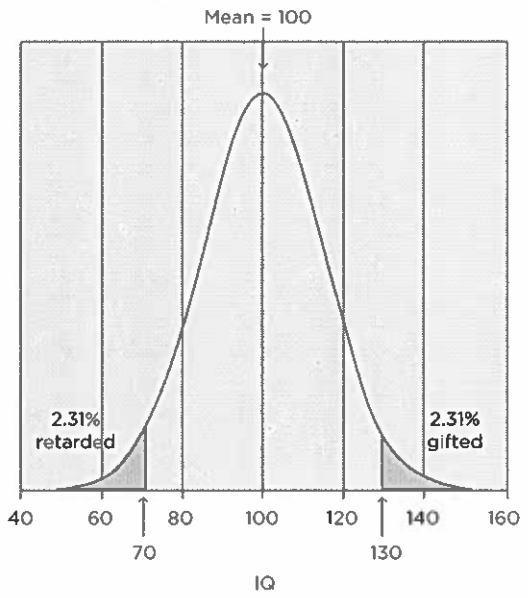
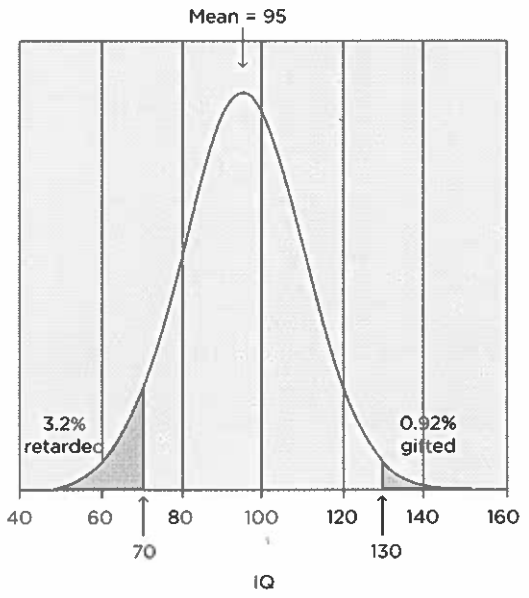


Figure 5.2: Change in IQ distribution with 5 point decrement



relatively small change would hardly be noticed. However, in a large population, substantial numbers of individuals are removed from the superior intelligence category and others are pushed down into the retarded category. The result is a smaller pool of individuals with outstanding intellects and a larger pool of individuals who require special resources to be able to function. It is this reality that makes it important to protect and preserve the brain's full potential.

CEREBRAL VASCULAR DISEASE

The same pathophysiological mechanisms that affect the coronary arteries and cause myocardial infarcts also apply to the arteries that nourish the brain, as shown in Figure 5.3. These common mechanisms include: stimulation of the inflammatory response in cerebral vessels leading to atherosclerotic plaque formation, rupture, and arterial occlusion; oxidative stress; and alterations in blood viscosity. In addition, arrhythmias may cause transient reductions of the cardiac output and cause hypoperfusion of the brain. The effects of reductions in the cardiac output are most prominent at the boundaries between major arteries (so-called watershed areas of the brain), and distal to sites of severe arterial stenosis.

The term stroke refers to a variety of acute cerebrovascular events including ischemic stroke, caused by occlusion of a cerebral artery by an atherosclerotic plaque or an embolus; cerebral hemorrhage, usually caused by rupture of a small artery in the brain; subarachnoid hemorrhage, often due to rupture of an aneurysm; or some other acute event due to a vascular cause. In the narrative that follows, unless otherwise stated, we will use the term stroke to mean an ischemic stroke caused by occlusion of a cerebral artery by an atherosclerotic plaque, the most common cause of stroke.

Although there have been major improvements in primary and secondary prevention of strokes in the past several decades, due to better care of

patients with hypertension and diabetes as well as improvements in smoking cessation efforts, stroke is still an important cause of death in the U.S. Current estimates indicate that the stroke death rate for men is 33.1 per 100,000 and 26.1 per 100,000 for women.[1]

Three large studies and several smaller studies have shown a correlation between air pollutants and acute strokes.

In their study of the relationship between fine particles ($PM_{2.5}$ or less) and hospital admission rates in the Medicare population, Domenici, et al., reported a 0.81% increase in the hospitalization rate for cerebrovascular disease (ICD 9 codes 430–438, 95% CI = 0.31–1.32%) for a 10 $\mu g/m^3$ increase.[2] This relationship was significant only on lag day zero (no lag between a peak and the admission) and not evident on lag days one and two. As with many of the other outcomes they considered in addition to cerebrovascular disease, this association was strongest in eastern parts of the U.S. when compared to western regions. This may be related to differences in the composition of PM due to the large number of coal-fired power plants in the east compared to the west.

In a second study of the Medicare population, Wellenius, et al., sought relationships between hospital admissions from 1986 to 1993 for ischemic and hemorrhagic strokes and increases in various air pollutants in nine major U.S. cities.[3] Admissions data were obtained from the Centers for Medicare and Medicaid Services and pollutant levels were obtained from the EPA. Pollutant levels are shown in Table 5.1. Note that PM_{10} levels were measured and not $PM_{2.5}$ levels as would be the case for more contemporary studies. They report that for an interquartile percentile increase in the PM_{10} concentration, there was a corresponding 1.03% increase in the admissions for ischemic stroke (95% CI = 0.04–2.04%) on the day of the increase. Similar results were observed for CO, NO_2, and SO_2 for ischemic strokes only. They did not find significant associations between pollutant levels and hemorrhagic strokes.

Figure 5.3: Pathophysiological mechanisms by which air pollution causes neurological disease

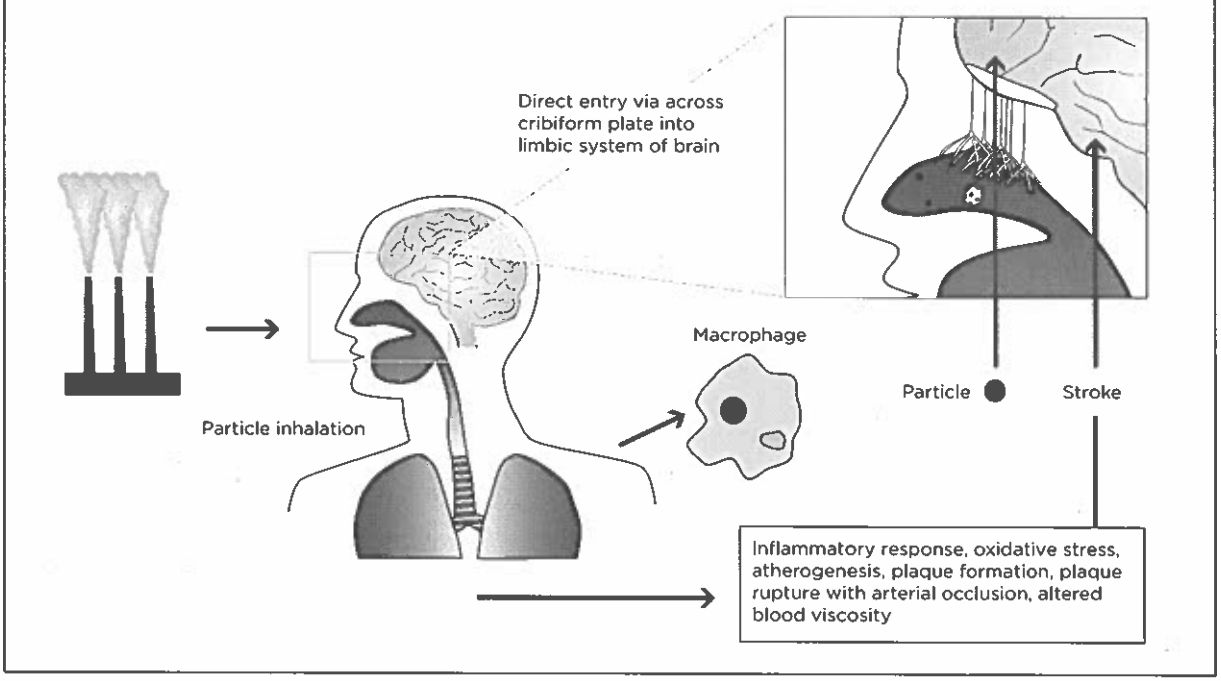


Table 5.1: Concentrations of various air pollutants in 9 U.S. cities

Pollutant	Percentile 25th	50th	75th
PM_{10} µg/m³	18.88	28.36	41.84
CO ppm	0.73	1.02	1.44
NO_2 ppb	18.05	23.54	29.98
SO_2 ppb	3.57	6.22	10.26

Source: Wellenius GA, Schwartz J, Mittleman MA. Air pollution and hospital admissions for ischemic and hemorrhagic stroke among medicare beneficiaries. Stroke 2005; 36(12):2549–2553.

Finally, data from post-menopausal women enrolled in the Women's Health Initiative and collected in 2000 show that for each increase of 10 µg/m³ in the $PM_{2.5}$ concentration, there was a 35% increase in the risk of a cerebrovascular event and an 83% increase in the risk of death from a cerebrovascular event.[4] The hazard ratio for the time to an acute cerebrovascular event, an indicator of relative risk, was reported as 1.35 (95% CI = 1.08–1.68). This observational study of post-menopausal women without a prior history of cardiovascular disease gains strength from the fact that the authors reviewed actual medical records, rather than relying on data from central databases. The restriction to this cohort of women loses some strength because the results may not be generalizable to men or younger women. They did not find any association between stroke and other air pollutants, including SO_2, NO_2, CO and O_3.

Two other studies conducted under more restricted circumstances have shown direct relationships between air pollutants and stroke. In a 2002 study of stroke mortality in Korea, Hong, et al., reported significant and increasing risk for death due to ischemic but not hemorrhagic stroke as same-day PM concentrations increased through four quartiles.[5] These authors also found significant temporal relationships between pollutants and stroke: same-day sulfur dioxide concentrations and ischemic stroke, a one-day lag between carbon monoxide and stroke, and a three-day lag between an ozone peak and stroke. In a more complex study of over 23,000 stroke admissions in Taiwan, Tsai, et al., reported significant positive associations between PM_{10}, NO_2, SO_2, CO, and O_3 when considered singly, and primary intracerebral hemorrhage and ischemic stroke admissions on days when the temperature was 20°C or greater.[6] On cooler days, the correlation between CO and ischemic stroke was the only factor that persisted. When they considered two pollutants together, there was a significant correlation between PM_{10} and NO_2 and both types of stroke.

In summary, even though a relatively small portion of all strokes appear to be related to concentration of PM, the fact that nearly 800,000 people in the U.S. have a stroke each year[7,8] makes the number of strokes attributable to PM a risk factor of importance. These studies emphasize the importance of measures designed to minimize PM concentrations in the air, including preventing the construction of new coal-fired power plants and developing and utilizing more effective technologies to reduce emissions from existing plants.

MERCURY

Coal contains trace amounts of mercury. When burned, this mercury evaporates and is emitted into the environment unless stringent control technologies are used to reduce those emissions. Coal-fired power plants are responsible for approximately one third of all emissions of mercury attributable to human activity, as shown in Table 5.2, making them the largest single source of mercury emissions. The 2007 Toxics Release Inventory listed point source releases of 7,935 pounds of mercury and 117,243 pounds of mercury compounds.[9] Point sources are stationary, single-site sources of a pollutant, such as a smoke stack at a power plant.

The mercury cycle is shown in Figure 5.4. Once mercury enters the atmosphere, it returns to the earth via rainfall, entering waterways. Mercury and other persistent toxicants in lakes and streams led various states, tribes, and territories to issue 3,221 advisories in 2004 urging caution when consuming fish from specific bodies of water, up from 3,089

Table 5.2: Anthropogenic sources of mercury

Source	Tons per year	Percent of total
Combustion	137.9	86.9
Electrical utilities	52.0	32.8
Municipal incinerators	29.6	18.7
Industrial boilers	28.4	17.9
Medical waste incinerators*	16.0	10.1
Other manufacturing	15.8	10.0

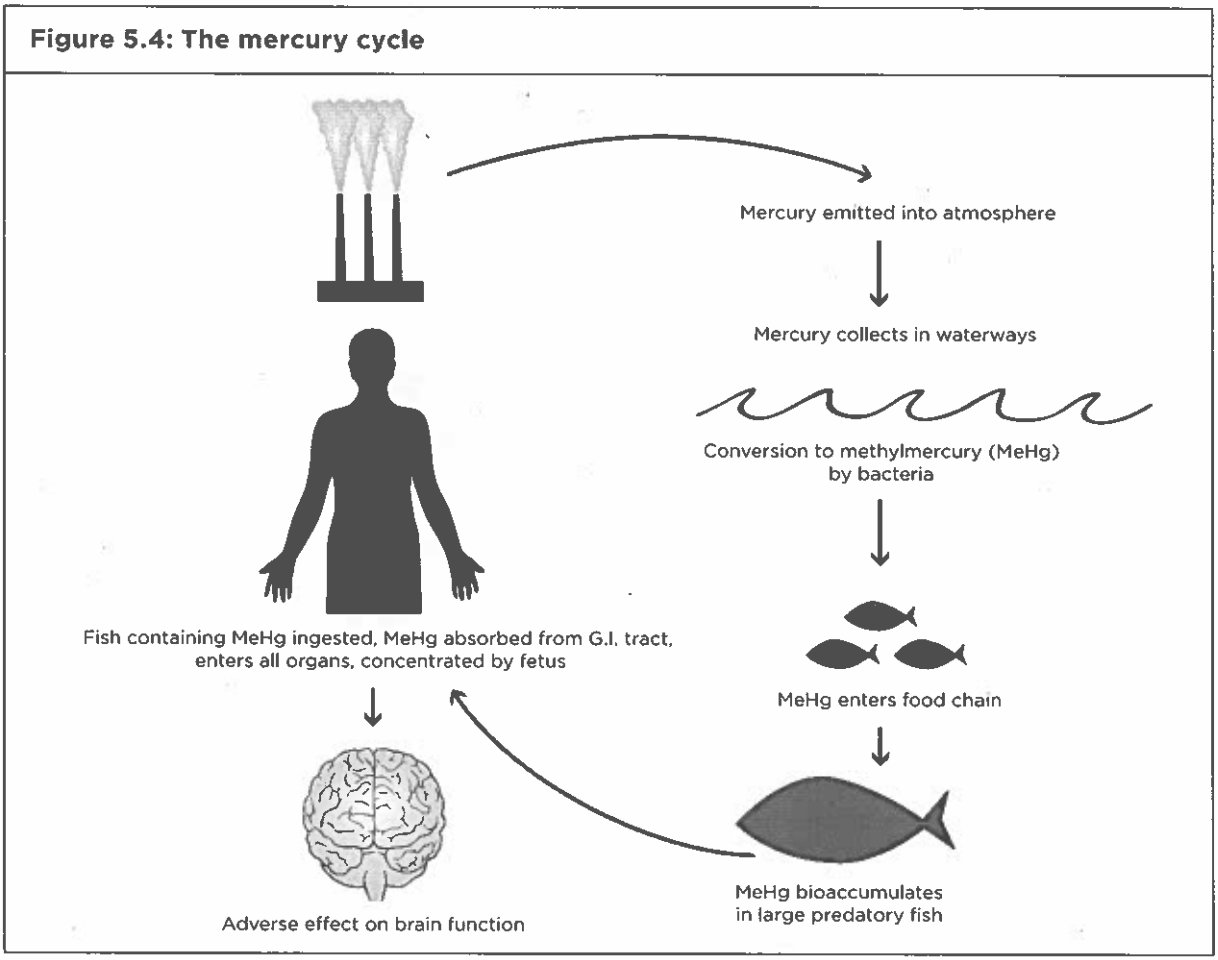
* Mercury emissions from medical waste incinerators are almost certainly lower at present due to regulations that have altered medical waste disposal methods.

Source: EPA Office of Air Quality Planning & Standards and Office of Research and Development. Mercury study report to Congress. Volume II: an inventory of anthropogenic mercury emissions in the United States; Dec 1997: EPA-452/R-97-004.

the year before.[10] In the water, bacteria convert elemental mercury into methylmercury (MeHg), a form that is persistent and bioaccumulates. The concentration of MeHg increases as it passes up the food chain, reaching high levels in large predatory fish. The fish with the highest mercury concentrations are large tuna, swordfish, king mackerel, and tile fish. Marine mammals that eat fish also may have a large mercury burden. Humans are exposed to coal-related mercury primarily through fish consumption.

Since mercury is recycled in the environment and substantial amounts are released during volcanic eruptions, opponents of stricter mercury controls attempt to downplay the importance of coal-related emissions. Nevertheless, minimizing or eliminating coal-related mercury emissions is an important and concrete action that can be taken

Figure 5.4: The mercury cycle



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to prevent additional amounts of mercury from entering the environment and affecting health.

In the 1950s, outbreaks of mercury poisoning in Minamata and Niigata, Japan, were caused by eating fish contaminated with mercury from industrial discharges. As a result, there were 3,000 confirmed cases and 600 deaths. A second outbreak occurred in Iraq, caused by eating seed-grain that had been treated with a fungicide containing MeHg.[11] This caused 649 deaths among 6,530 affected individuals. Until recently, a dose-response curve, derived from these exposures and interpolated to more typical blood mercury levels, served as the basis for determining the permissible daily intake of mercury.[12] Because of deficiencies in these data and their analysis, alternate populations were examined in great detail.

Based on three large-scale, prospective studies of cohorts children exposed *in utero* to MeHg in the Seychelles, the Faroe Islands, and New Zealand, the National Research Council recommended establishing a benchmark dose of 58 µg/L of mercury in the cord blood of newborns. The benchmark dose is the lower 95% confidence interval for an estimated dose that results in doubling the prevalence of children with neurodevelopmental test scores that are in the clinically impaired range.[13] This somewhat arbitrary choice is thought to provide an adequate margin of safety and to provide a rational basis for regulatory actions. Based on the National Research Council recommendations, the EPA applied a ten-fold safety factor, which is typical for EPA regulatory actions, and set the reference dose (RfD), the maximum tolerable daily dose, at 0.1 microgram of mercury per kilogram of body weight per day, the amount believed to lead to a mercury concentration of 5.8 µg/L mercury in cord blood.[14] To translate this standard into a practical form, it is necessary to know the maternal mercury blood level and the maternal-fetal mercury ratio. Fetal mercury levels are approximately 1.7 times those in the mother.[15]

Between 316,588 and 631,233 children are born in the U.S. each year with blood mercury levels high enough to cause lifelong loss of intelligence.

Based on the 1999-2000 National Health and Nutrition Examination Survey data,[16] approximately 15.7% of all American women of childbearing age were found to have blood mercury levels that would cause them to give birth to children with cord blood mercury levels of 5.8 µg/L mercury or more, i.e., above the target concentration. (Subsequent modeling by Stern suggested that the maternal:fetal ratio was overestimated in the earlier study.[17] However, direct measurements in a Swedish cohort suggest that the original ratio may be correct.[18]) Using these data and conservative estimates of blood mercury levels and their effect on intellectual performance, Trasande, et al., estimated that between 316,588 and 631,233 children are born in the U.S. each year with blood mercury levels high enough to impair performance on neurodevelopmental tests.[19] These authors further concluded that this lifelong diminution in intelligence costs society $8.7 billion per year (range $2.2–$43.8 billion in 2000 dollars). These cost estimates contrast sharply with others as low as $10 million dollars attributed to U.S. power plants by Griffiths, et al.[20]

HEALTH EFFECTS ON THE HORIZON

In prior sections, we have reviewed the peer-reviewed evidence published in leading medical journals that links pollutants produced by coal-burning power plants to diseases of the pulmonary, cardiovascular, and nervous systems. Emerging data that are based on smaller samples, and are therefore more speculative, suggest that there may be links between coal-derived pollutants and other diseases, such as Alzheimer's disease (AD) and diabetes mellitus, two of the most prevalent, costly, and debilitating chronic diseases of adults. If these early observations are upheld by more rigorous studies of large populations using contemporary epidemiological and statistical methods, such as those we refer to in earlier sections,

the public health implications will be enormous. Therefore, because of their possible importance, we will consider these potential links briefly.

ALZHEIMER'S DISEASE

The evidence linking air pollution and AD comes from studies comparing brains of dogs and humans living in highly polluted versus non-polluted cities in Mexico.[21,22] Animal data suggest that $PM_{2.5}$ crosses the nasal mucosa and enters the limbic system of the brain via the olfactory nerve.[23,24] Once in the brain, these PM cause inflammation and appear to lead to the deposition of amyloid, a neuropathological feature characteristic of AD. The authors suggest that "exposure to urban air pollution may cause brain inflammation and accelerate the accumulation of β-amyloid42, a putative mediator of neurodegeneration and AD pathogenesis." Similar findings were reported in animal experiments in which several strains of transgenic mice were exposed to PM.[25] The possible link between airborne pollutants and neurodegenerative diseases has not been firmly established. However it is potentially important because of the large and growing number of patients with AD and the disease's financial and societal impact.

DIABETES MELLITUS

The prevalence of diabetes mellitus (DM), particularly Type II DM, is increasing. In 2002, Lockwood observed a statistically significant relationship between the by-state prevalence of diabetes and the by-state air emissions of pollutants reported in the Toxics Release Inventory.[26]

In 2005, Brook postulated several mechanisms by which the inhalation of particulates might lead to the development of insulin resistance, a condition in which the body produces insulin but does not use it properly, thereby increasing the risk for the development of DM.[27] Again, the process begins with the inhalation of small particles that stimulate pulmonary inflammation and the generation of reactive oxygen species and oxidative stress. Subsequent pathways that involve the autonomic nervous system, the adrenal gland, and others are thought to lead to the development of insulin resistance and subsequently, to DM. This hypothesis gained credence with the publication of a paper linking NO_2 exposure with DM in women.[28] A positive relationship was found between NO_2 exposure and DM after controlling for several potential confounding factors such as age and body mass index. The authors conclude that their results "suggest that common air pollutants are associated with DM." That report used NO_2 levels as a surrogate marker for traffic-related air pollutants, including PM. Since substantial amounts of NO_2 and PM are emitted when coal is burned, there may be a link between NO_2 and PM derived from coal and DM.

DIABETES MELLITUS AND ALZHEIMER'S DISEASE

Converging evidence suggests that insulin resistance is a risk factor for a number of dementia-related conditions including Type II DM and impaired glucose tolerance, obesity, inflammation, ischemia, hypertension, cardiovascular disease, and abnormal lipid metabolism including hypercholesterolemia. To some extent, these associations blur the distinction between vascular causes of dementia and AD.[29] The putative mechanisms linking AD and DM include inflammation and oxidative stress. As discussed throughout this report, these two mechanisms are intimately related to exposure to various air pollutants, particularly fine particles, including those produced by burning coal.

SUMMARY

It is possible that the protean adverse health effects of burning coal may extend beyond those that are well established to include other common and costly chronic diseases. This possibility warrants vigilance and further investigation.

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NOTES

1 American Heart Assn Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics - 2009 update. Circulation 2009; 119:e21–e181.

2 Dominici F, Peng RD, Bell ML et al. Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. JAMA 2006; 295(10):1127–1134.

3 Wellenius GA, Schwartz J, Mittleman MA. Air pollution and hospital admissions for ischemic and hemorrhagic stroke among medicare beneficiaries. Stroke 2005; 36(12):2549–2553.

4 Miller KA, Siscovick DS, Sheppard L et al. Long-term exposure to air pollution and incidence of cardiovascular events in women. N Engl J Med 2007;356(5):447–58.

5 Hong YC, Lee JT, Kim H et al. Effects of air pollutants on stroke mortality. Environ Health Perspect 2002;110(2):187–91.

6 Tsai SS, Goggins WB, Chiu HF, Yang CY. Evidence for an association between air pollution and daily stroke admissions in Kaohsiung, Taiwan. Stroke 2003;34(11):2612–6.

7 American Heart Assn Statistics Committee and Stroke Statistics Subcommittee. Heart Disease and Stroke Statistics—2009 Update. Circulation 2009; 119:e21–e181.

8 Craft S. The Role of Metabolic disorders in Alzheimer Disease and Vascular Dementia: Two Roads Converged. Arch Neurol 2009; 66(3):300–305.

9 EPA Toxics Release Inventory. Available from: http://www.epa.gov/triexplorer/chemical.htm.

10 EPA. Fish Advisories 2007. Available from: http://www.epa.gov/waterscience/fish.

11 Davidson PW, Myers GJ, Weiss B. Mercury exposure and child development outcomes. Pediatrics 2004; 113(4 Suppl):1023–1029.

12 Cox C, Clarkson TW, Marsh DO et al. Dose-response analysis of infants prenatally exposed to methyl mercury: an application of a single compartment model to single-strand hair analysis. Environ Res 1989; 49(2):318–332.

13 Committee on the toxicological effects of mercury. Toxicological effects of methylmercury. Washington, D.C.: National Academy Press; 2000.

14 Committee on the toxicological effects of mercury. Toxicological effects of methylmercury. Washington, D.C.: National Academy Press; 2000.

15 Stern AH, Smith AE. An assessment of the cord blood:maternal blood methylmercury ratio: implications for risk assessment. Environ Health Perspect 2003; 111(12):1465–1470.

16 Centers for Disease Control and Prevention. Third national report on human exposure to environmental chemicals. 2005: NCEH 05-0570.

17 Stern AH. A revised probabilistic estimate of the maternal methyl mercury intake dose corresponding to a measured cord blood mercury concentration. Environ Health Perspect 2005; 113(2):155–163.

18 Bjornberg KA, Vahter M, Berglund B, Niklasson B, Blennow M, Sandborgh-Englund G. Transport of methylmercury and inorganic mercury to the fetus and breast-fed infant. Environ Health Perspect 2005; 113(10):1381–1385.

19 Trasande L, Landrigan PJ, Schechter C. Public health and economic consequences of methyl mercury toxicity to the developing brain. Environ Health Perspect 2005; 113(5):590–596.

20 Griffiths C, McGartland A, Miller M. A comparison of the monetized impact of IQ decrements from mercury emissions. Environ Health Perspect 2007; 115(6):841-847.

21 Calderon-Garciduenas L, Reed W, Maronpot RR et al. Brain inflammation and Alzheimer's-like pathology in individuals exposed to severe air pollution. Toxicol Pathol 2004; 32(6):650–658.

22 Peters A, Veronesi B, Calderon-Garciduenas L et al. Translocation and potential neurological effects of fine and ultrafine particles a critical update. Part Fibre Toxicol 2006; 3:13.

23 Calderon-Garciduenas L, Maronpot RR, Torres-Jardon R et al. DNA damage in nasal and brain tissues of canines exposed to air pollutants is associated with evidence of chronic brain inflammation and neurodegeneration. Toxicol Pathol 2003; 31(5):524–538.

24 Oberdorster G, Sharp Z, Atudorei V et al. Translocation of inhaled ultrafine particles to the brain. Inhal Toxicol 2004; 16(6-7):437–445.

25 Peters A, Veronesi B, Calderon-Garciduenas L et al. Translocation and potential neurological effects of fine and ultrafine particles a critical update. Part Fibre Toxicol 2006; 3:13.

26 Lockwood AH. Diabetes and air pollution. Diabetes Care 2002; 25:1487–1488.

27 Brook RD. You are what you breathe: evidence linking air pollution and blood pressure. Curr Hypertens Rep 2005; 7(6):427–434.

28 Brook RD, Jerrett M, Brook JR, Bard RL, Finkelstein MM. The relationship between diabetes mellitus and traffic-related air pollution. JOEM 2008; 50(1):32–38.

29 Craft S. The role of metabolic disorders in Alzheimer disease and vascular dementia: two roads converged. Arch Neurol 2009; 66(3):300–305.

6. *Coal, Global Warming, and Health*

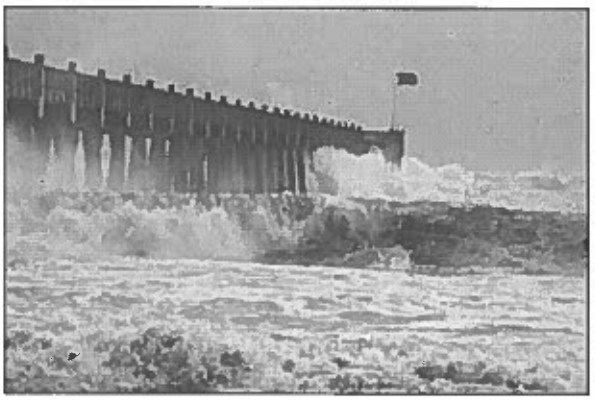
COAL'S CONTRIBUTION TO GLOBAL WARMING

In previous sections we have discussed the relationship between coal plant pollutants and human health. Here, we address coal's contribution to global warming, and the likely impacts of that warming on human health.

With very high carbon dioxide emissions due to combustion, and significant methane emissions from mining activities, coal is a major contributor to the buildup of greenhouse gases in the atmosphere. These gases allow solar energy to reach the planet's surface but delay that energy's escape into space, effectively trapping heat in the lower atmosphere.[1]

Atmospheric concentrations of greenhouse gases have increased markedly since 1750 as a result of human activities, especially the combustion of fossil fuels. Carbon dioxide (CO_2) is the most abundant greenhouse gas, and almost all U.S. CO_2 emissions (close to 98%) are due to fossil fuel combustion.[2] The level of atmospheric CO_2 now far exceeds pre-industrial values: Whereas the preindustrial level was 280 ppm, it is now approximately 385 ppm[3] (see Figure 6.1). China emits the most greenhouse gas of any country, but the U.S. emits the most greenhouse gas per capita.[4] Historically, the U.S. is responsible for over one-quarter of all anthropogenic greenhouse gases emitted globally.[5]

Coal-fired power plants are a major greenhouse gas source in the U.S., accounting for more than



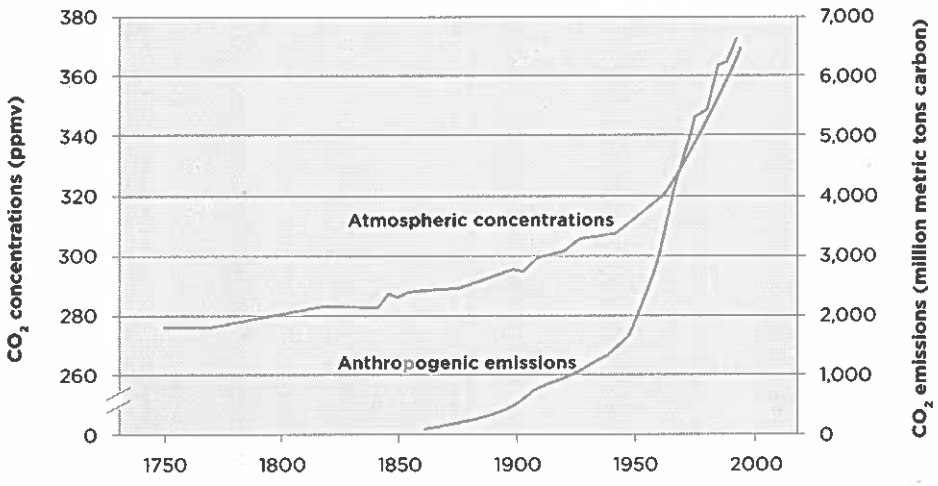
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one-third of our nation's CO_2 emissions (see Figure 6.2).[6] Within the electricity sector, coal generates roughly 50% of the electricity[7] yet emits over 80% of the sector's total emissions.[8] This disproportionate carbon footprint is due to the high carbon content of coal relative to other fossil fuels such as natural gas.

Methane emissions from coal mining are another important component of greenhouse gases.[9] Methane is produced when coal is formed and released when it is mined. Because methane is an occupational hazard in underground coal mines—it may explode or asphyxiate miners—it must be removed and ventilated into the atmosphere or burned. About 60% of methane emissions are now related to human activities,[10,11] with nearly 10% of that derived from coal mining and the remainder attributable largely to animal husbandry, waste management, and natural gas systems (see

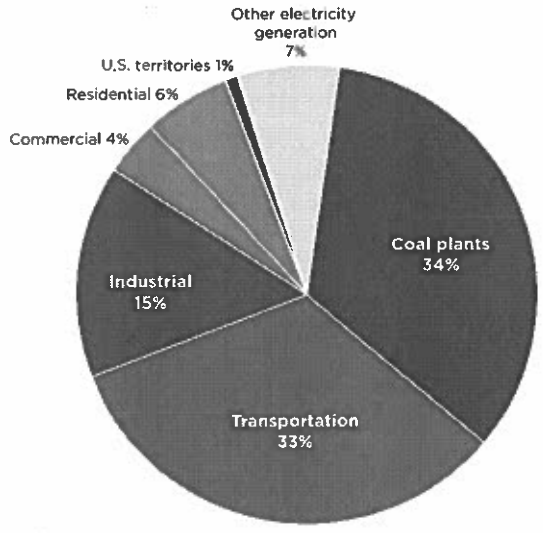
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Figure 6.1: CO_2 emissions and CO_2 concentrations (1750–2000)



Source: Oak Ridge National Laboratory. Carbon Dioxide Information Analysis Center. Available from: http://cdiac.esd.ornl.gov.

Figure 6.2: U.S. CO_2 emissions by source, 2007



Source: U.S. EPA. Inventory of U.S. greenhouse gas emissions and sinks: 1990–2007. 2009: EPA-430/R-09-004. Available from: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

Figure 6.3).[12] Although methane has a short lifetime in the atmosphere—9 to 15 years, compared to CO_2's 100 years or more—it is approximately 23 times more effective than CO_2 in trapping heat in the atmosphere.[13,14]

GLOBAL WARMING'S IMPACT ON HUMAN HEALTH

The accumulation of greenhouse gases in the atmosphere is making itself felt on earth in the form of increases in global average land and ocean surface temperatures, increases in snow melt and receding glaciers, thawing of permafrost, increases in the mean sea level, and changes in precipitation.[15] These effects create conditions that threaten human health directly and indirectly.

The high temperatures associated with global warming have direct implications for human health. Historically, global average temperatures have been quite stable. However, since 1909 the average temperature has risen 0.74°C (1.33°F).[16] In the U.S., the number of heat waves in the eastern and western regions rose by about 20%

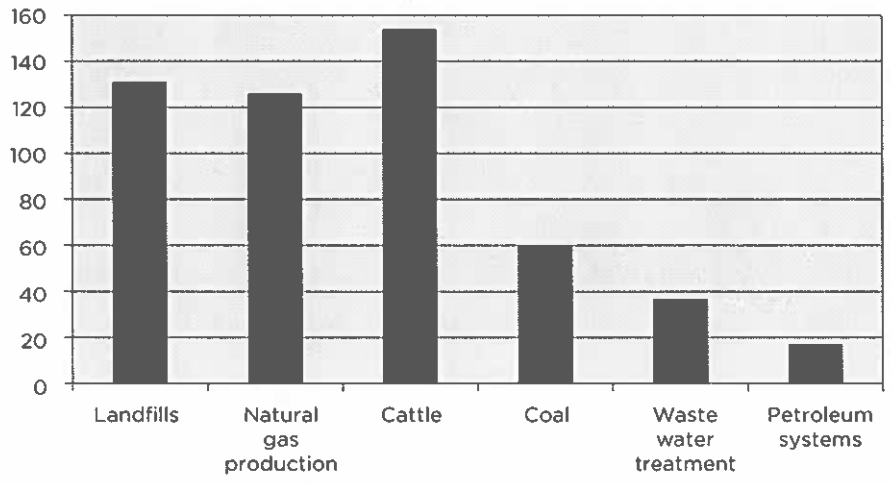
between 1949 and 1995.[17] Prolonged exposure to high temperatures can cause heat cramps, heat syncope, heat exhaustion, and heat stroke, which often leads to death. Advanced age is the most significant risk factor for heat-related deaths in the U.S., as the elderly are often less mobile, frequently home-bound and socially isolated, and may have thermoregulatory problems associated with multiple co-morbidities and medications that put them at higher risk for death during intense heat waves.[18] In addition, excessive heat exposure disproportionately affects people with certain pre-existing medical conditions, including cardiovascular disease, respiratory illnesses, and obesity.

It is difficult to quantify the number of deaths that result from heat waves, as heat-related deaths may be attributed to pre-existing conditions. However it is known that in 2003, between 22,000 and 35,000 people died as a direct result of the heat wave that swept Europe.[19,20] While it is impossible to attribute any specific heat wave to global warming, Stott, et al., concluded with a certainty of more than 90% that global warming more than doubled the probability of that heat wave occurring.[21]

In addition to the health effects directly associated with rising temperatures, global warming causes a profusion of interconnected public health problems.[22] Extreme-weather events and changing patterns of precipitation increase mortality from drowning. Flooding and infrastructure damage, along with temperature rise, increase the prevalence of insect- and water-borne diseases such as diarrhea, malaria, and dengue fever. High temperatures and continued fossil fuel consumption worsen air quality, impacting respiratory and cardiovascular health. Changing patterns of precipitation, rising temperatures, and extreme weather events cause crop damage and crop failure, affecting global food security. Competition for scarce resources such as food and water are predicted to cause mass migrations of environmental refugees, social destabilization, and war, while social destabilization and increasing global health problems are predicted to increase the risk of mental

Figure 6.3: Methane sources

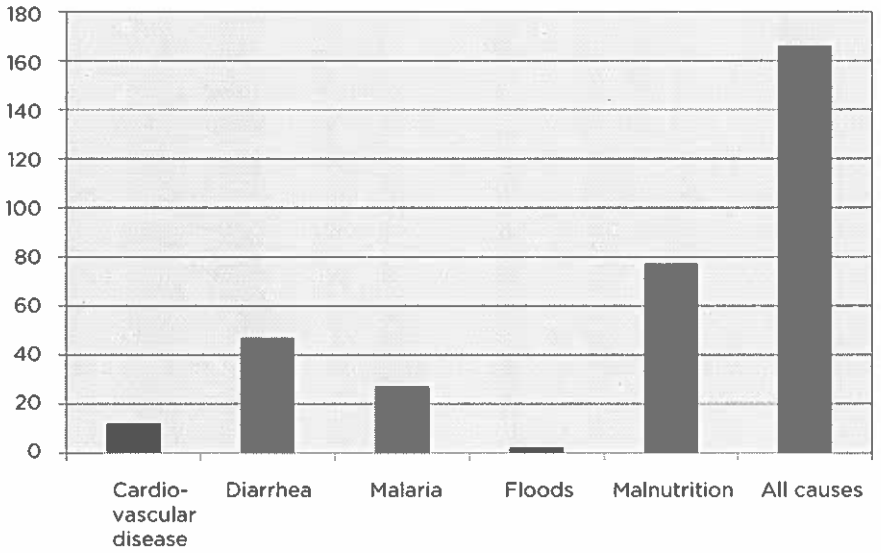
Methane emissions (Tg CO_2 equivalents). Contributions from coal include both active and abandoned mines. Contributions from cattle include emissions due to enteric fermentation and manure management.



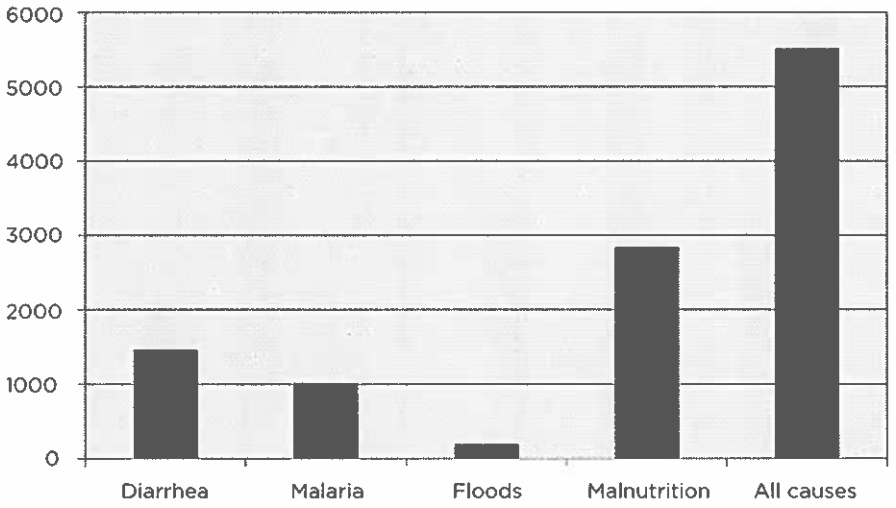
Source: U.S. EPA. Available from: http://www.epa.gov/methane/sources.html.

Figure 6.4: Morbidity and mortality due to global warming

Deaths in thousands due to global warming in 2000 compared to baseline climate recorded in 1961–1990



Morbidity, expressed in thousands of DALYs*



*DALYs = disability-adjusted life years, a measure of disease burden that combines years of life lost with years of life lived with illness or disability.

Source: 2004 World Health Organization data cited in Patz JA, Campbell-Lendrum D, Holloway T, Foley JA. Impact of regional climate change on human health. Nature 2005 Nov 17;438:310–317.

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health problems, further adding to the burden on healthcare resources.

Many of these health effects are already evident. The World Health Organization (WHO) has quantified the annual impact of global warming on some health outcomes. WHO has estimated that global warming was responsible for 166,000 deaths in the year 2000 alone, due to additional mortality from malaria, malnutrition, diarrhea, and drowning. In addition, WHO estimated that in 2000, global warming caused increases in diarrhea, malaria, cardiovascular disease, and malnutrition that led to the loss of more than five million life years to disability from illness or premature death,[23] as shown in Figure 6.4.

The health burden of global warming, already large, is predicted to increase. Table ES-2 (see page xiii) shows the predicted health effects of global warming, the mechanisms that would drive these effects, and the populations most vulnerable to their implications.

RESPONDING TO GLOBAL WARMING

Events and activities that affect climate may not make themselves visible at once; rather, their impact may manifest years later. This is especially true of gradual phenomena such as the buildup of greenhouse gases in the atmosphere. The global warming effects that we currently experience were set in motion by greenhouse gases emitted over the past 250 years. By the same token, the greenhouse gases that we emit today might not affect us noticeably at the moment; they will manifest later—and, due to their persistence in the atmosphere and the substantial amount of heat absorbed by the oceans, will continue to be felt for decades to millennia to come. This delay in the felt consequences of current actions is known as "lag" in the climate system.[24]

Steps that would prevent further global warming include replacing coal-based generation of electricity with clean, non-fossil fuel energy sources.

The rise in average global temperatures has set in motion cycles of mutually reinforcing warming events. One example is the melting of polar ice. Polar ice melt reduces the amount of light-colored surface area that reflects the sun's rays, while expanding larger areas of dark land and ocean that absorb heat. This adds to overall warming, resulting in more ice melting. Rising temperatures in northern regions also cause the permafrost to melt. Permafrost is permanently frozen soil, sediment, or rock that remains at or below 0°C for at least two years. Because it is so cold, it can tolerate the introduction of considerable heat without thawing. However, when it does thaw, it releases potentially vast amounts of methane frozen in the mud and ice. Because methane is a potent greenhouse gas, this also accelerates global warming. Thus, one warming phenomenon feeds another, creating positive feedback cycles.[25]

These and other feedback cycles push us closer to a "tipping point": a point at which the accumulation of small changes in a steady state will force a change in that state that is sudden, significant, and usually irreversible.[26] In regard to climate, the tipping point will be reached when the gradual changes set in motion by burning fossil fuels—the accumulation of greenhouse gases, rising temperatures, and positive feedback loops—overwhelm our ability to offset them. At that point, the momentum of global warming will become irreversible on a human time scale. Therefore, action must be taken now to prevent such a scenario.

There are two categories of action that must be taken in response to global warming: mitigation and adaptation. Mitigation means preventing further global warming; it encompasses steps that would slow and stop the emission of greenhouse gases.[27] Significant forms of mitigation include replacing coal-based generation of electricity with clean, non-fossil fuel energy sources such as wind and solar; substituting non-fossil fuels for the gas and diesel we burn in vehicles; and reducing the need for energy by achieving increases in energy efficiency and conservation.

Adaptation refers to steps that would reduce vulnerability to the actual or expected negative

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effects of climate change, such as building cities and healthcare infrastructure that can withstand extreme weather events, preparing emergency response plans, and developing drought-resistant crops.[28] With the effects of climate change already being felt, adaptation is necessary to protect vulnerable people and nations. At the same time, as a societal response adaptation is insufficient. If we continue to emit large amounts of greenhouse gases, global warming will continue and its effects will intensify. Eventually the damage wrought by floods, storms and sea level rise, drought and desertification, disease and hunger, habitat destruction and human displacement will overcome our capacity to protect ourselves. While adaptation measures are necessary, focusing our energies there to protect public health is insufficient. Adaptation does not prevent the triggering of climate tipping points such as those described above. The true protection of health and of life ultimately lies in prevention.

Lag in the climate system, especially when considered in conjunction with positive feedback

CARBON CAPTURE AND SEQUESTRATION

Carbon capture and sequestration (CCS) technology involves capturing the CO_2 from coal emissions, compressing it until it forms a liquid, and transporting the liquid CO_2 through pipelines to a geologically appropriate underground storage area where it would be stored ("sequestered") permanently.

Viewed through a public health lens, CCS poses several obstacles which would have to be resolved before it could be considered a viable option:

Concentrated CO_2 can be lethal. Concentrated CO_2 can asphyxiate people, as demonstrated in 1986 by the spontaneous release of CO_2 at Lake Nyos, Cameroon, that killed 1,700 people. Care must be taken to avoid pooling or leakage of CO_2 during both transport and storage.[29]

Permanent storage may not be possible. Storage would have to be leak-proof for geological periods of time.[30] If at any point in time stored CO_2 escaped into the atmosphere, it would contribute to global warming. If it were to leak into underground aquifers, it could dissolve and release contaminants such as arsenic, lead, mercury, and organic compounds, or could alter water acidity, affecting water quality.[31]

CCS would perpetuate coal pollution. During the time that CCS technology is being developed and safety and liability issues are being addressed, carbon emissions from coal plants would continue unabated. Even if CCS technology were successful, it would sustain the dependence on coal for the generation of electricity, perpetuating the release of other pollutants into the atmosphere, including particulates, sulfur dioxides, nitrogen oxides, and mercury, and contributing to the health-related problems associated with coal mining and the long-term storage of both pre- and post-combustion coal wastes.

CCS would divert funds from clean energy. The cost of research, development, construction, and implementation of CCS would be high.[32] The pipelines alone, reaching from every coal-powered plant in the country to appropriate storage areas, would require the construction of an extensive infrastructure system.[33] Funds spent on CCS development, construction, and deployment would be unavailable for investment in clean, safe energy from non-carbon-based sources.

Given the costs and difficulty of implementing CCS on a timeline and a scale that would effectively mitigate the health effects of global warming, the unreliability of permanent storage for geological periods of time, and the costs to health from coal's traditional pollutants, PSR has concluded that CCS is not a preferred option for developing the nation's energy future.

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loops and tipping points, has implications for our response to global warming. Even if CO_2 emissions cease today, average global temperatures will continue to rise. Therefore, current readings of CO_2 levels do not provide a full appraisal of the damage we have already inflicted on the climate system. This in turn means that we must be conservative in regard to future greenhouse gas emissions: Since the full impact of the emissions we have already released have not yet been felt, we should be cautious in assuming that we can predict the impacts of additional emissions.

The dynamics of climate change mean that we cannot take an unhurried approach to stopping global warming. We may be nearing climate tipping points; when we reach them, no human action or agency will be able to stop the climate change we will have set in motion. We must take action now, while there is still time to protect health and well-being on the planet.

NOTES

1 National Climatic Data Center. Global warming: frequently asked questions. 2008. Available from: http://www.ncdc.noaa.gov/oa/climate/globalwarming.html.

2 Energy Information Administration. Emissions of greenhouses gases report. 2008: DOE/EIA-0573(2007). Available from: http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html.

3 Pachauri RK and Reisinger A (eds). Climate Change 2007—Synthesis Report: Contribution of Working Groups I, II and III to the Fourth Assessment Report of the IPCC. Cambridge: Cambridge University Press; 2007.

4 Energy Information Administration. Emissions of greenhouses gases report. 2008: DOE/EIA-0573(2007). Available from: http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html.

5 Hansen J, Sato M, Ruedy R et al. Dangerous human-made interference with climate: a GISS modelE study. Atmos Chem Phys. 2007;7:2287–2312.

6 Energy Information Administration. Emissions of greenhouses gases report. 2008: DOE/EIA-0573(2007). Available from: http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html.

7 Energy Information Administration. Annual energy review 2008. Table 8.2a. Available from: http://www.eia.doe.gov/aer/envir.html.

R04344

8 Energy Information Administration. Annual energy review 2008. Table 12.7b. Available from: http://www.eia.doe.gov/aer/envir.html.

9 U.S. Climate Change Science Program. Methane as a greenhouse gas. 2006. Available from: http://www.climatescience.gov/infosheets/highlight1/CCSP-H1-methane18jan2006.pdf.

10 U.S. Geological Survey. Coalbed methane–an untapped energy resource and an environmental concern—USGS Fact Sheet FS-019-97. 1997. Available from: http://energy.usgs.gov/factsheets/Coalbed/coalmeth.html.

11 Denman KL, Brasseur G, Chidthaisong A, et al. Couplings between changes in the climate system and biogeochemistry. In: Climate Change 2007—The Physical Science Basis: Working Group I Contribution to the Fourth Assessment Report of the IPCC. Cambridge: Cambridge University Press; 2007.

12 EPA. Methane web page. Available from: http://www.epa.gov/methane/sources.html.

13 US Climate Change Science Program. Methane as a greenhouse gas. 2006. Available from: http://www.climatescience.gov/infosheets/highlight1/CCSP-H1-methane18jan2006.pdf

14 EPA. Methane to markets partnership: frequent questions. April 2009. Available from: http://www.epa.gov/methanetomarkets/faq.htm#3.

15 Pachauri RK and Reisinger A (eds). Climate Change 2007—Synthesis Report: Contribution of Working Groups I, II and III to the Fourth Assessment Report of the IPCC. Cambridge: Cambridge University Press; 2007.

16 Solomon S, Qin D, Manning M, et al (eds). Summary for Policymakers. In: Climate Change 2007—The Physical Science Basis: Working Group I Contribution to the Fourth Assessment Report of the IPCC. Cambridge: Cambridge University Press; 2007.

17 Gaffen DJ, Ross R. Increased summertime heat stress in the U.S. Nature 1998;396:529–30.

18 Luber G, McGeehin M. Climate change and extreme heat events. Am J Prev Med 2008 Nov;35(5):429–35.

19 Kosatsky T. The 2003 European heat waves. Euro Surveill 2005; 10: 148–149.

20 Epstein P. Climate change and human health. New Eng J Med 2005; 353: 1433–1436.

21 Stott PA, Stone DA, and Allen MR. Human contribution to the European heat wave of 2003. Nature 2004; 432: 610–614.

22 Costello A, Abbas M, Allen A, et al. Lancet and University College London Institute for Global Health Commission: managing the health effects of climate change. Lancet 2009; 373: 1693–1733.

23 Patz JA, Campbell-Lendrum D, Holloway T, Foley JA. Impact of regional climate change on human health. Nature 2005 Nov 17;438:310–317.

24 Solomon S, Qin D, Manning M, et al (eds). Climate Change 2007—The Physical Science Basis: Working Group I Contribution to the Fourth Assessment Report of the IPCC. Cambridge: Cambridge University Press; 2007.

25 U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Abrupt climate change. Reston, Virginia: U.S. Geological Survey; 2008. Available from: http://www.climatescience.gov/Library/sap/sap3-4/final-report/.

26 Epstein PR, Mills E (eds). Climate change futures: health, ecological, and economic dimensions. Center for Health and the Global Environment, Harvard Medical School 2005. Available from: http://www.climatechangefutures.org/pdf/CCF_Report_Final_10.27.pdf.

27 Metz B, Davidson OR, Bosch PR, Dave R, Meyer LA (eds). Climate Change 2007 —Mitigation of Climate Change: Working Group III contribution to the Fourth Assessment Report of the IPCC. Cambridge: Cambridge University Press; 2007.

28 Schmidt CW. Beyond mitigation: planning for climate change adaptation. Environ Health Perspect 2009 Jul;117(7):A306–9.

29 International Energy Agency, Greenhouse Gas R&D Programme. Natural releases of CO_2. Undated. Available from: http://www.ieagreen.org.uk/glossies/naturalreleases.pdf.

30 Markandya A, Wilkinson P. Electricity generation and health. Lancet 2007;370:979–990.

31 Socolow R, Hotinski R, Greenblatt JB, Pacala S. Solving the climate problem: technologies available to curb CO_2 emissions. Environment 2004;46(10):8–19.

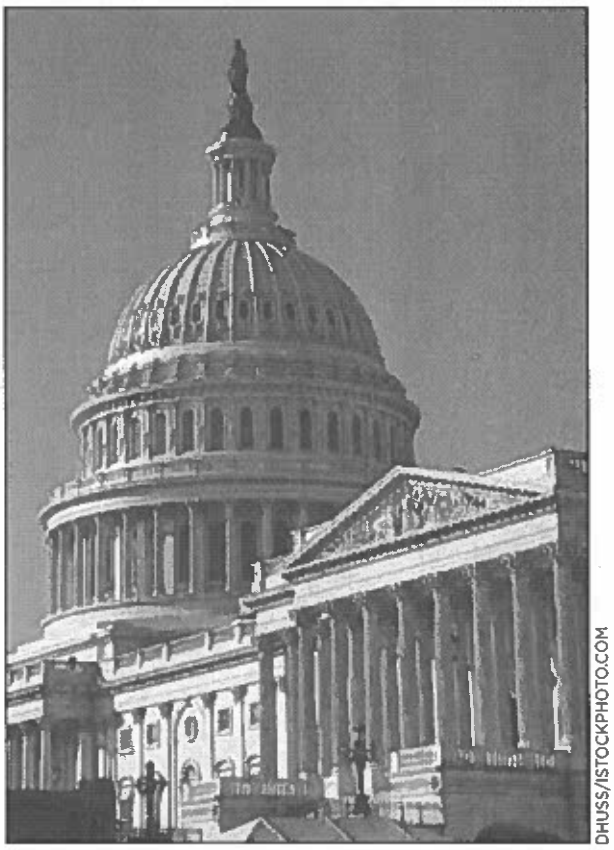
32 International Energy Agency. Technology roadmap: carbon capture and storage. 2009. Available from: http://www.iea.org/Papers/2009/CCS_Roadmap.pdf.

33 Metz B, Davidson O, de Coninck HC, Loos M, Meyer LA (eds). Carbon dioxide capture and storage: special report of Working Group III of the IPCC. Cambridge: Cambridge University Press; 2005.

7. *Policy Recommendations*

The U.S. is at a crossroads for determining its future energy policy. While the U.S. relies heavily on coal for its energy needs, the health consequences of that reliance are multiple and have widespread and damaging impact. Coal combustion contributes to diseases already affecting large portions of the U.S. population, including asthma, heart disease, and stroke, compounding major public health challenges of our time. It interferes with lung development, increases the risk of heart attacks, and compromises intellectual capacity. Coal pollutants affect all major body organ systems and contribute to four of the five leading causes of mortality in the U.S.: heart disease, cancer, stroke, and chronic lower respiratory diseases. Although it is difficult to ascertain the proportion of this disease burden that is attributable to coal combustion, even very modest contributions to these major causes of death are likely to have large effects at the population level, given high incidence rates.

The health effects of coal are not limited to diseases caused by combustion byproducts. Utilizing coal for energy also harms human health through the processes of mining, washing, transport, and post-combustion waste storage. Moreover, coal combustion is the largest point-source emitter of CO_2 in the U.S., contributing to the buildup of greenhouse gases that causes global warming. Although global warming is often framed as an environmental problem, it is likely to have significant public health consequences on a global scale, including increases in heat stroke, diarrhea, malaria, drowning, food shortages, mental health problems, and war. Many of these effects are already apparent. Reducing our nation's dependence on coal is essential if we are to achieve the reductions in carbon emissions necessary to stave off the worst health effects of global warming.



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Based on that assessment, PSR finds it essential to translate our concern for human health into

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recommendations for public policy. The first of those recommendations is that emissions of CO_2 be cut as deeply and as swiftly as possible, with the objective of reducing CO_2 levels in the atmosphere to 350 parts per million. The reduction of CO_2 emissions, an urgent necessity for achieving satisfactory health outcomes, should be pursued through two simultaneous strategies: 1) strong climate and energy legislation that establishes hard caps on global warming pollution coming from coal plants; and 2) the Clean Air Act. Since its enactment, the Clean Air Act (CAA) as implemented by the EPA has been effective in reducing a wide variety of air pollutants, from nitrous oxides to volatile organic compounds. CO_2 and other greenhouse gases emitted by coal plants have been designated pollutants under the CAA. The EPA should be fully empowered to regulate these gases under the CAA so that coal's contribution to global warming can be brought to an end.

A medically defensible energy policy must take into account the public health impacts of coal while meeting our need for energy.

Secondly, PSR recommends that there be no new construction of coal-fired power plants, so as to avoid increasing health-endangering emissions of CO_2 as well as criteria pollutants and hazardous air pollutants. CO_2 emissions from coal could increase 60% by 2030 if current plans to invest hundreds of billions of dollars in new and old coal-fired power plants are realized. Those emissions would push greenhouse gas levels ever higher, potentially reaching a tipping point at which we would face the most extreme health consequences of global warming. For these reasons, PSR chapters across the nation have contributed to the effort to halt the permitting of new coal plants, adding the medical voice to licensing deliberations and helping to influence a number of decisions not to construct new plants.

The U.S. should dramatically reduce fossil fuel power plant emissions of sulfur dioxide and nitrogen oxides so that all localities are in attainment for national ambient air quality standards. In addition, we should establish a standard, enforceable by the EPA and based on Maximum Achievable Control Technology, for mercury and other hazardous air pollutant emissions from electrical generation.

Finally, the nation must develop its capacity to generate electricity from clean, safe, renewable sources so that existing coal-fired power plants may be phased out without eliminating jobs or compromising the nation's ability to meet its energy needs. In place of investment in coal (including subsidies for the extraction and combustion of coal and for capture of carbon and other pollutants), the U.S. should fund the improvement of energy efficiency, the expansion of conservation measures, and the research, development, and implementation of clean, safe, renewable energy sources such as wind energy, solar, and wave power.

These steps comprise a medically defensible energy policy: one that takes into account the public health impacts of coal while meeting our need for energy. When our nation establishes a health-driven energy policy, one that replaces our dependence on coal with clean, safe alternatives, we will prevent deterioration of global public health caused by global warming while reaping the rewards in improvements to respiratory, cardiovascular, and neurological health.



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US Affiliate of International Physicians for the Prevention of Nuclear War

Exhibit 389

From:	Andrew Rehn
To:	EPA.PublicHearingCom; Lieberoff, Barb
Cc:	Albert Ettinger; Cindy Skrukrud; Sabrina Hardenbergh; Jan thomas; Cameron J. Smith; Jane Cogie; Amanda Pankau; Jann.Stephen@epa.gov
Subject:	[External] IL0077666 Pond Creek Mine Post-Hearing Comments from PRN, SC, SAFE
Date:	Friday, January 17, 2020 3:56:25 PM
Attachments:	IL0077666 Post Hearing Comments_PRN SC SAFE.pdf

Dear Ms. Lieberoff and other Illinois EPA officials;

On behalf of Prairie Rivers Network, Sierra Club and Southern Illinoisans Against Fracturing Our Environment, attached are post-hearing comments regarding the proposed NPDES Permit IL0077666 for the Pond Creek mine. As these comments will explain, the proposed permit plainly cannot be legally granted by the Illinois Environmental Protection Agency (IEPA) based on the current record. Please do not hesitate to reach out to us for further clarification.

In 4 emails following this one, I will be including the exhibits to this comment letter. Please include those in the record with this submission.

Thank you,
Andrew

--
Andrew Rehn
Water Resources Engineer, Prairie Rivers Network
1605 South State St, Suite 1, Champaign, IL 61820

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downstream water bodies and would use these waters more frequently were they not affected by pollution from this facility and other sources. Our members are threatened by the proposed degradation of the Big Muddy, Pond Creek and other downstream and adjacent waters. Our members and others rely on clean waters in the Big Muddy watershed for activities including hunting, recreational fishing, commercial fishing, trapping, paddling, boating, birdwatching and other wildlife viewing.

Southern Illinoisans Against Fracturing Our Environment (SAFE) is an organization based in Southernmost Illinois and has members who live adjacent to the Big Muddy River, and who enjoy kayaking, canoeing, and birdwatching along the river. Members living next to the river experience issues with flooding of the Big Muddy with regularly occurring precipitation events as we did last weekend, January 11 when 4-5" pushed flood waters into the back yard of members' homes. Numerous SAFE members were present at the IEPA hearing on December 18, 2019, including Jan Thomas, Cameron Smith, Tabitha Tripp, and Tenney Naumer.

Legal Overview

The hearing and documents obtained through the Illinois Freedom of Information Act (FOIA) disclosed that the permit cannot be legally granted under 35 Ill. Adm. Code 302.102, 302.105, 304.105, 309.141(a) and (d), 309.143(a) and 309.146 because the draft permit as written does not ensure compliance with Illinois water standards or permitting rules and would violate at least the following applicable regulations:

- **35 Ill. Adm. Code 302.105(a)** (Tier 1 antidegradation) by allowing increased discharges of chloride, sulfate, total suspended solids and other pollutants that will adversely affect existing uses of the Big Muddy River and Pond Creek and other creeks in the area. Among the ways in which existing uses will be impacted will be through chemical and biological processes resulting from allowed discharges that will cause increased methyl mercury, increased phosphorus, increased cyanobacteria and decreased dissolved oxygen (DO) in the water column. Damage to existing uses may also occur through damage to creeks not receiving discharges from the mine but that may be affected in quality from reduced stream flow caused by groundwater moving downward to fill areas vacated by groundwater filling the mine.
- **35 Ill. Adm. Code 304.105, and 309.141(d) and 309.143** by increasing the levels of methyl mercury and phosphorus, decreasing DO levels, and causing violations of narrative standards in the Big Muddy. The Big Muddy is already listed as impaired by methyl mercury, low DO and TSS in the receiving segment and numerous downstream segments and as potentially impaired by phosphorus.
- **35 Ill. Adm. Code 302.105(c)** (Tier 2 antidegradation) by allowing new discharges to the Big Muddy River and Pond Creek that are not necessary to accommodate important social or economic development but, on the contrary, will harm social and economic development by further wedding the local economy to an industry without a long term future and a company likely to leave the community with a large environmental hazard

January 17, 2020

Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P. O. Box 19276
Springfield, IL 62794-9276

Sent via email to epa.publichearingcom@illinois.gov

Re: NPDES Permit No. IL0077666, Notice 7516c- Williamson Energy, LLC

Dear Ms. Lieberoff and other Illinois EPA officials;

The proposed permit plainly cannot be legally granted by the Illinois Environmental Protection Agency (IEPA) based on the current record. Further, any attempt to remedy the grossly defective draft permit and permit record with new documents or a revised permit cannot be allowed to result in a new permit being issued without re-noticing the revised permit and allowing a further public hearing based on a properly supported public notice and antidegradation analysis.

As shown at the public hearing held December 18, 2019, and confirmed by the comments and science submitted with this written comment including the attached comments of Dr. Matthew Baker (Ex. A) and Dr. JoAnn Burkholder (Ex. B), the permit would allow substantial harm to the environment and its issuance would violate numerous provisions of law.

Commenting Organizations

This letter includes the post-hearing comments of Prairie Rivers Network, Sierra Club and Southern Illinoisans Against Fracturing Our Environment (SAFE).

Prairie Rivers Network (PRN) works to protect water, heal land, and inspire change and their energy program works to reduce the impact of coal on rivers and groundwater across the state. PRN has 1200 members, including members who live near and use the Big Muddy River watershed and downstream areas for fishing, paddling, birdwatching, and other recreational activities. Amanda Pankau, staff member of Prairie Rivers Network, attended the hearing and gave testimony and asked clarifying questions.

Sierra Club has 100,000 members and supporters across Illinois who seek to restore and protect a clean and healthy environment for all residents of Illinois. Sierra Club members attended the hearing and gave testimony, including Lucia Amorelli, Jean Sellar, Jane Cogie, Connie Schmidt, Barbara McKasson, and Albert Ettinger. Our members are affected by pollutant discharges into Pond Creek, the Pond Creek tributary, the Big Muddy River and

that will have to be cleaned up with public funds. Neighbors of the mine will continue to be harmed by the mining operations. Further, the mining of coal, to the extent it occurs and the coal is burned in China or elsewhere, will harm the local economy (and the world economy) by increasing the emission of greenhouse gases.

- **35 Ill. Adm. Code 302.105(a), 35 Ill. Adm. Code 304.105, and 309.141(d), 309.143, and 309.146** by allowing a mixing zone that (the misrepresentations made in the record by the applicant notwithstanding) will in fact result in violations of applicable water quality standards outside the mixing zone by allowing increased discharges subject to implementation of a complex dilution and monitoring formula by an applicant that has proven itself utterly incapable of complying with the limits and reporting requirements of its current relatively simple permit and by allowing a mixing zone in Pond Creek where no dilution is available.
- **35 Ill. Adm. Code 302.102(a), 302.105(a), 35 Ill. Adm. Code 304.105, and 309.141(d) and 309.143** by failing to protect mussels.
- **35 Ill. Adm. Code 146** by failing to require monitoring adequate to determine compliance with the complex dilution scheme contemplated by the permit.
- **35 Ill. Adm. Code 302.102, 302.105(a), 35 Ill. Adm. Code 304.105, and 309.141(d) and 309.143** because the reasonable potential test on which the public document relies was not properly performed at least with regard to mercury, copper, iron, nickel, and selenium. It appears that cadmium and manganese have also not been tested properly.
- **35 Ill. Adm. Code 302.102, 302.105(a), 35 Ill. Adm. Code 304.105, and 309.141(d) and 309.143** because the testing done for mercury was not done with sufficient sensitivity to determine whether there is a reasonable potential for the discharge to cause or contribute to violations of the applicable 12 ng/L water quality standard (35 Ill.Adm.Code 302.208(f)).[1]

I. Tier 1 Antidegradation - Existing uses are not being Protected in Violation of 35 Ill.Adm.Code 302.105(a).

The discharger purports to be establishing a complex scheme to prevent violations of Illinois water quality standards outside the mixing zone for numerous pollutants, but the scheme for meeting the standard is unlikely to be implemented and the criteria are not protective of existing uses as to numerous pollutants. The segment of the Big Muddy where the proposed discharge will be located is designated as impaired for Aquatic Life, Fish Consumption and Primary Contact Recreation. However, fishing occurs in the Big Muddy and over ten thousand pounds of fish are caught from the river each year, according to IDNR data (Ex. I)

In particular, the permit is not protective of existing uses because the impact of the increased chloride, conductivity, sulfate, total suspended solids (TSS), copper, iron, manganese, and nickel has not been properly considered and the cumulative effect of the increased

[1] 415 ILCS 5/11 and the Illinois Pollution Control Board regulations require that IEPA "ensure" that every NPDES permit prevent discharges of pollutants that have a reasonable potential of violating any Illinois water quality standard. Prairie Rivers Network v. Illinois PCB 2016 IL App (1st) 150971 par. 26.

concentrations of all of these pollutants together has been totally ignored.[2] Further, the background levels of chloride have not been properly stated and the amount of acidity and other pollutants that will enter the waters is not being properly monitored.

The reality is that the permittee intends to continuously discharge at the maximum allowable flow rate in order to get rid of all the saline groundwater pouring into the mine. Their own report admits this.[3] This is also shown through estimating how much discharge could have been received by the Big Muddy based on the historical flow record. The mine estimates that, currently, 2.7 million gallons per day of mine water will need to be pumped out, and this could increase up to 3.5 mgd.[4] Assuming that the chloride concentrations reach levels similar to those seen at Sugar Camp mine, as is anticipated,[5] the load that the Big Muddy could carry without violating the 500 mg/L chloride standard at the edge of the mixing zone would range from 1.8 to 4.7 mgd, based on historical flow records.[6] On the low end of that range (drier years), when the Big Muddy could only take an average daily discharge of 1.8 mgd from the mine, the river would not have been able to assimilate the entire 2.7 mgd of mine waste without violating water quality standards (which, again, could increase to 3.5 mgd in the future). This means that the mine would be discharging at its limit the whole year. Even at the high flow end of this estimate, where the Big Muddy could supposedly assimilate 4.7 mgd, the mine would still be often be pumping near the limit. The flow limitations from the mixing equation, then, are not some theoretical maximum that the mine might hit. The mine will be operating at this limit nearly all the time when the infiltrating groundwater reaches anticipated levels.[7]

Continual discharge at maximum levels would raise the background chloride concentrations of the Big Muddy downstream to higher levels. A crude approximation, assuming the applicant can meet the limit of 500 mg/L Chloride in ¼ of the river for mixing, shows that the chloride levels in the river would increase as follows:

> Background Concentration: 108 mg/L starting level
> Mix with Sugar Camp: 0.25 * 500 mg/L + 0.75 * 108 mg/L = 206 mg/L
> Mix with Pond Creek: 0.25 * 500 mg/L + 0.75 * 206 mg/L = 280 mg/L

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[2] The limits of the testing and the sensitivity of the testing methods is such that increased loading of a number of other pollutants is probable.

[3] Conceptual Diffuser Design: "The controlled low-flow periods have in the past extended for more than a year. The Mine cannot hold water for that long of a period. At the same time, the Mine cannot discharge the full amount of water that it needs to at the low flow condition. The solution is to discharge some water all of the time, increasing the discharge as conditions allow." page 6-1

[4] Anti-degradation Assessment Pond Creek No. 1 Mine ((November 18, 2016) ("Anti-degradation Assessment") pg 16

[5] Conceptual Diffuser Design page vii

[6] Conceptual Diffuser Design page viii

[7] Indeed, the diffuser design document states "The controlled low-flow periods have in the past extended for more than a year. The Mine cannot hold water for that long of a period. At the same time, the Mine cannot discharge the full amount of water that it needs to at the low flow condition. The solution is to discharge some water all of the time, increasing the discharge as conditions allow."

In other words, the entire Big Muddy downstream would be forced to sustain concentrations above the United States Environmental Protection Agency (U.S. EPA) recommended chronic chloride standard of 230 mg/L, which recent science shows is not adequate to protect aquatic life (see infra), and any additional downstream discharge of chloride would push the Big Muddy further beyond the current outdated and insufficiently stringent U.S. EPA recommended criteria.[8]

A. Increased loadings of chloride will harm existing uses.

The applicant purports that it will establish a complex scheme for prevention of violation of the Illinois 500 mg/L acute chloride standard. However, it appears that the permit applicant does not intend to monitor directly for chloride in either the discharge or the Big Muddy River but, rather, will be estimating chloride levels from conductivity data. Problems with the correlation are discussed in Section V below.

Considering just the direct effects of chloride alone, there are at least four fatal problems that preclude granting the permit under 302.105(a) and numerous other provisions of law.

First, the monitoring proposed is not properly spelled out or enforceable and the applicant intends to monitor conductivity rather than chloride directly. The levels of chloride present given a particular level of conductivity varies from place to place and time to time as was admitted by the Agency during the hearing. See also, Comment of Dr. Burkholder (Ex. B, p.6). Thus, the permit applicant has not presented any sound methodology for making a reasonable estimate of chloride levels with the equipment that it plans to use. Moreover, as will be discussed further in Section V below, it is apparent that this discharger, which has committed numerous permit violations as well as violations of reporting requirements, is utterly incapable of implementing the complex monitoring and discharging scheme it pretends that it will utilize.

Second, the available data indicates that for the Antidegradation Assessment the applicant and IEPA are using an estimate of the background level of chloride that is lower than that shown by the available data. The current antidegradation assessment prepared by the mine notes that the 90th percentile background level of Chloride is 30 mg/L,[9] and the report states this number comes from Illinois EPA. An evaluation of available chloride data just upstream of the proposed discharge shows that a proper Antidegradation assessment would include an updated 90th percentile background for chloride. The last five years of water quality data from the Big Muddy at Plumfield (segment N-11) just north of the proposed discharge point show that the 90th percentile chloride concentration is greater than 103 mg/L. See also, Comment of Dr. Baker (Ex. A, p.3).

Further, the entire scheme assumes without evidence that all of the chloride discharged into the Big Muddy will flow downstream without any adverse impact and that no chloride will be stored

[8] The U.S. EPA chronic water quality standard for chloride is contained in Ambient Water Quality Criteria for Chloride - 1988 EPA 440/5-88-001 (February 1988) available on the U.S. EPA website.
[9] Antidegradation Analysis page 12 (pdf 13)

in groundwater, side channels, sediment or biota to re-emerge into the river at a later time when the applicant under its scheme may be discharging chloride at a higher rate than would be allowed. If a portion of the high chloride discharged during high-flow periods is still present in the system when flows decrease, violations of the 500 mg/L acute standard can be expected. See also Comment of Dr. Burkholder on the chemical interactions between the overlying water and stream sediments (Ex. B, p.5).

Still further, it is clear that the Illinois 500 mg/L chloride standard is not protective of existing uses against chronic toxicity especially during warm weather. As was discussed by Professor David Soucek of the University of Illinois in IPCB 18-32, the entire record of which is incorporated by reference in opposition to this permit. A properly protective chronic standard adjusted to account for the water temperature and hardness factors that may be present during the proposed discharges would require prohibiting discharges that would cause chronic levels in the Big Muddy to exceed the levels indicated as safe by Dr. Soucek's studies and the studies on which he relied (Ex. C).

B. Impact of increased and high conductivity has not been assessed.

There is abundant scientific evidence to suggest that total conductivity itself is a parameter that may affect existing uses. See Comment of Dr. Baker (Ex. A, p.3). This was further documented in the Draft Field Based Methods for Developing Aquatic Life Criteria (U.S. EPA 2016) (Ex. D). Neither the applicant nor IEPA have apparently given any thought as to how increased conductivity might affect existing uses in Pond Creek or the Big Muddy River. The available evidence indicates that harm to existing uses will occur.

C. Increased chloride and sulfate will increase toxic mercury levels.

It is well established that the Big Muddy is already impaired by methyl-mercury pollution and that increased chloride in a water body will increase the level of mercury released from the sediments in a water body that will take toxic forms (methyl-mercury and others). See Illinois 303(d) list[10]; Comments of Dr. Burkholder (Ex. B, pp. 1-2); and Hearing Transcript (Barb McKasson at p.110-111). Accordingly, the permit would allow increased impairment of existing uses, harm public health and commercial fishing, as well as violate other provisions of Illinois Law to be discussed below.

Moreover, as discussed in Section III below, potential mercury levels in the discharge have not been tested using sufficiently sensitive methods or using a proper reasonable potential analysis.

[10] Currently available at:
https://www2.illinois.gov/epa/topics/water-quality/watershed-management/tmdls/Pages/303d-list.aspx

D. The effects of increased sulfate, TSS, copper, iron, cadmium, selenium, hydrogen sulfide, acidity, and nickel on existing uses have not been properly determined

No effort has been made to properly estimate the high levels of these pollutants that may occur in the discharge under the USEPA Technical Support Document EPA/505/2-90-001, PB91-127415 (March 1991)[11]. The fact that the applicant has chosen to take very few samples is no excuse for not using the proper multipliers needed to determine the potential levels of those pollutants. See *Illinois EPA v. Illinois PCB*, 386 Ill. App. 3d 375, 387 (Ill. App. 2008).[12]

Further, the potential for the discharge to cause the creation of toxic hydrogen sulfide must be considered given the increase in sulfate that would be allowed in this permit. See Comment of Dr. Burkholder (Ex. B, p. 5). Still further, the increased toxicity in the mixing zone will have the effect of increasing biological oxygen demand and, thus, increasing the existing violation of the DO standard in violation of 302.105(a) and the other cited regulations that prohibit allowing a discharge that will cause or contribute to violations of state water quality standards. See also, 40 CFR 122.44(d) and Comment of Dr. Burkholder (Ex. B, p.4)

Still further, it appears that levels of extreme acidity may be found in the discharge as shown by the discharge monitoring report for Outfall 7 in September 2016, June 2017, December 2017, March 2018 for low pH, and at Outfall 8 in September 2016, June 2017, and December 2017 for low pH (Ex. F). The Big Muddy is already impaired by low pH. Given these problems with low pH discharges, we question why the Agency is permitting outfalls 006, 007 and 008 as acid mine drainage. IEPA cannot grant a permit unless the proposed discharge will not increase the existing pH impairment.

E. The cumulative effects of all the increased pollutants and the effects of existing low dissolved oxygen conditions and other stressors must be considered.

Any proper analysis of the potential effect of the proposed discharge would consider the cumulative effects of all of the pollutants and stresses that it is proposed to increase together and in the context of the fact that the Big Muddy River is already plagued by dissolved oxygen levels that regularly fall below applicable Illinois water quality standards. The proposed discharge is very likely to exacerbate the existing aquatic life impairment. See comment of Dr. Baker (Ex. A, p.3) and comment of Dr. Burkholder (Ex. B, p.6-7).

F. IEPA must consider the effects of the proposed discharges on Pond Creek and on other creeks in the vicinity of the mine.

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[11] Currently available at: https://www3.epa.gov/npdes/pubs/owm0264.pdf

[12] IEPA in 2016 did a reasonable potential analysis of some of the outfalls based in each case on one sample (Ex. E). Reasonable potential was found at one or more outfalls for cadmium, copper, nickel, mercury, and silver. Cadmium was found at levels above the acute standard in numerous outfalls.

IEPA must also determine the potential effect of allowing this discharge on creeks in the area of the mine, the existing uses of which may be affected by drawdowns of groundwater and surface waters that may be connected to the saline aquifer the mine is now draining.

G. The permit makes no assessment of the effect of the discharge on mussels.

The permit and the antidegradation assessment make no attempt to address impacts to mussels or even assess if mussels are present in the area, despite clear direction that Illinois' antidegradation policy calls for the maintenance and protection of existing uses, including the prevention of a shift from pollution-sensitive to more pollution-tolerant community and the loss of species diversity (Section 302.105(a)(1)). Sensitive mussels have been shown to be killed in chloride/sulfate mixtures when sulfate is much lower than what would be allowed in the permit.[13]

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[13] Freshwater mussels are one of the most imperiled groups of organisms. Nearly 70 percent of these species are designated either as threatened, endangered or in decline (Williams, JD, ML Warren, KS Cummings, JL Harris, RJ Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18, 6-22.) Recent studies have shown that for some contaminants, freshwater mussel glochidia and juveniles are more sensitive than standard test organisms, leading to concerns that U.S.EPA chronic criteria, which are 230 mg/L, do not adequately protect freshwater mussels Wang, N., CD Ivey, RA Dorman, CG Ingersoll, J Steevens, EJ Hammer, CR Bauer, and DR Mount. 2018b. Acute toxicity of sodium chloride and potassium chloride to a unionid mussel (Lampsilis siliquoidea) in water exposures. Environmental Toxicology and Chemistry. First published: 19 June 2018, https://doi.org/10.1002/etc.4206. Wang, N., JL Kunz, RA Dorman, CG Ingersoll, JA Steevens, EJ Hammer, and CR Bauer. 2018a. Evaluation of chronic toxicity of sodium chloride or potassium chloride to a unionid mussel (Lampsilis siliquoidea) in water exposures using standard and refined toxicity testing methods. Environmental Toxicology and Chemistry. 21 Aug. 2018, https://doi.org/10.1002/etc.4258,

In Gillis, PL. 2011. Assessing the toxicity of sodium chloride to the glochidia of freshwater mussels: implications for salinization of surface waters. Environmental Pollution 159: 1702-108, it is pointed out that for glochidia, the end point for studies of acute chloride toxicity is not death, but loss of ability to attach to a host species, which is necessary for their survival, and renders them "effectively dead." In their study of acute chloride toxicity of Fatmucket, *Lampsilis siliquoidea*, juveniles and glochidia, Wang et al. (2018b) state that including their more recent mussel data in the toxicity database would "likely lower the [USEPA Water Quality Criteria 230 mg/L] and [Water Quality Standards] for [Chlorides]." Wang et al (2018a) made a similar statement in their study of the chronic chloride toxicity of the Fat Mucket, in which they state "inclusion of the data from the present study and recent publications to update the national chronic water quality criterion or Iowa chronic water quality standard would likely lower the criterion or standard."

A study by the Great Lakes Environmental Center (GLEC) and the Illinois Natural History Survey (INHS) tested the acute toxicity of chloride to four freshwater invertebrate species including a species of fingernail clam, *Sphaerium simile*. GLEC and INHS found that "[f]ingernail clams are approximately 5.6 times more acutely sensitive to chloride at 50 and 200 mg/L total hardness than tubificid worms, and approximately 2.7 to 4.2 times more sensitive than the snail" USEPA. 2008. Final Draft Report. Acute toxicity of chloride to select freshwater invertebrates. Prepared for the USEPA by Great Lakes Environmental Center and Illinois Natural History Survey. 28 Oct. 2008.
(footnote continues on following page)
(footnote 13 continued) In terms of chronic long-term effects on invertebrate assemblages, in Wallace, AM and RG Biastoch. 2016. Detecting changes in the benthic invertebrate community in response to

Also see Comment of Dr. Burkholder (Ex. B, p.7). A 2012 study of mussels in the Big Muddy by the Illinois Natural History Survey (Ex. G) found their presence in nearly all of the nearby tributaries in the Big Muddy, which likely indicates that they are present in the main stem of the river (however, the main stem was too deep for the Survey staff to assess at the time of their study). If mussels are found, harming those mussels would be improper as a forbidden impact on existing uses (35 Ill.Adm.Code 302,105(a)(1)). Worse, this particular permit proposes a flow that will discharge and mix at the bottom of the river first, subjecting any mussel bed there to the highest of chloride concentrations.

The permit cannot be issued if the presence of mussels has not been assessed.

II. Tier 2 Antidegradation - The permit violates 35 Ill. Adm. Code 302.105(c) because the new discharges have not been shown to be necessary to accommodate important social and economic development and the record establishes that the new discharges would be socially and economically destructive.

The Anti-degradation Assessment filed by the applicant relies on a number of patently false statements regarding the need for and future of the coal industry and completely fails to consider anything but the alleged benefits of keeping the mine open. In fact, the benefits are extremely unlikely to be realized while the damage to be done to the environment and the local economy is deadly certain.

A. Workforce analysis ignores the applicant's financial perils.

The applicant's claims regarding future jobs and need for the coal are wildly inaccurate. There is no reason to believe the applicant will continue to operate for long, even if it receives this destructive permit. As explained at the hearing, stock prices of the applicant and related companies such as Foresight Energy have crashed. In 2019, eight major coal mining companies, including Murray Energy, filed for bankruptcy. The January 14, 2020, U.S. Energy Information Administration Short-Term Energy Outlook forecasts that coal production will reach a four-decade low in 2020, stating that coal-fired power plant retirements, electricity from lower coast natural gas and new renewables, and declining exports are expected.[14] Indeed, the whole Southern Illinois coal industry is in a downward spiral. Recent analysis from the Institute for Energy Economics and Financial Analysis reports that "Illinois Basin's coal industry is entering a period of structural decline," and "within the next 20 years, virtually all of the U.S. coal-fired

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increasing chloride in streams in Toronto, Canada. Freshwater Science 35(1): 353-63, it is found that in streams in Toronto, Canada, the macroinvertebrate community demonstrated the most taxa changes (declining frequency and abundance of taxa sensitive to chloride and increasing frequency and abundance of taxa tolerant of chloride) at a threshold of approximately 50 to 90 mg Cl-/L. The authors point out that this is below the Canadian Water Quality Guideline of 120 mg Cl-/L for chronic exposure and suggest that chloride may be having nonlethal effects on the benthic macroinvertebrate communities in the Toronto, Ontario region.

[14] "SHORT-TERM ENERGY OUTLOOK," US Energy Information Administration, accessed on 1/14/20: https://www.eia.gov/outlooks/steo/report/coal.php

plants that currently buy the basin's coal will be either retired or little used, the result of an economic and technologically driven energy transition in the electric power industry that favors lower-cost and cleaner alternatives." (Ex. H)

The insinuation in the Do Not Mine alternative that Illinois power plants are reliant on Illinois coal is false, as few power plants in Illinois actually burn Illinois coal, and most Illinois coal is shipped out of state. The absurd idea that 4.7 million American homes would go dark without this mine is untrue, and ignores the reality that coal is more expensive than other generation sources and that Illinois is a huge exporter of energy - so we have some to spare. What is proposed here, then, is to sacrifice the Illinois environment and economy, produce more toxic coal ash, and pump more CO2 and other co-pollutants into the atmosphere so that foreign countries can buy cheaper coal with which to pollute the atmosphere.

While the claimed benefits are illusory and, to the extent they exist, may continue for only a certain window of time, the probable social and economic results of granting this permit can leave massive public costs and have clearly damaging impacts to the long-term social and economic well-being of the area. These costs have not been taken into account.

Workers will continue to face uncertainty over employment and benefits. The United Mine Workers of America website is following the Murray Energy bankruptcy proceedings and has posted that existing employment agreements can be changed by who owns the mine after bankruptcy proceedings. While Mr. Murray exited his company as CEO, having paid himself $14 million in 2019 before declaring bankruptcy, mine workers face an unknown future regarding their employment, health and retirement benefits. There is every reason to believe miners will be cheated, as were miners at the Blackjewel Mine, where the miners, in an act of protest, had to resort to blockading a train carrying coal,[15] and similar protests have begun in Kentucky against Quest Energy.[16] The miners at Blackjewel eventually got their pay, but only after taking organized action against the company. Regarding health benefits, in November, 2019, Murray Energy owed $155 million to the Black Lung Trust fund, but was offering to pay only $1.1 million.[17]

Williamson Energy LLC, a subsidiary of Foresight Energy GP LLC, has 80% holdings by Murray and 20% from the Cline Group. Foresight stocks are 6 cents a share as of January 15, 2020. Murray Energy announced Chapter 11 Bankruptcy on October 29, 2019, claiming $2.7 billion in

[15] "Blackjewel Coal Miners to Get Millions in Back Pay After Train Blockade" New York Times, 1/17/20, https://www.nytimes.com/2019/10/24/us/blackjewel-coal-miners.html

[16] Kentucky miners block coal train in protest for pay," NBC News, 1/15/20 https://www.nbcnews.com/news/us-news/kentucky-miners-block-coal-train-protest-pay-n1116096

[17] "Black Lung Trust Fund Likely Burdened by Murray Bankruptcy," WFPL, 11/20/19, https://wfpl.org/black-lung-trust-fund-likely-burdened-by-murray-bankruptcy/

debt and more than $8 billion in actual or potential liabilities including worker pensions and health care.[18]

In December, 2019, Congress passed the American Miners Act as part of federal spending legislation approved before year end to avoid a government shut-down. The Act will put pension and healthcare costs for approximately 120,000 union mine workers under federal payment via funds taken out of the Abandoned Mine Lands (AML) reclamation fund. The fund was intended to pay for environmental degradation and hazards left in the 200 years of coal mining across the United States before U.S. laws were established but now will be used in large part to pay for miner pensions and healthcare with the result that the Illinois taxpayer can be expected to pay the clean up cost of the mines.[19]

The trajectory of the coal industry is clear. As of November 2019, 48% of the Fortune 500 and 63% of the Fortune 100 are vowing to cut their greenhouse gases by increasing their use of green energy and improving their energy efficiencies.[20] BlackRock, the world's largest money manager with $7 trillion in assets, announced it will make sustainability and climate risks key tenets of its investing strategy and exit investments in thermal coal, along with other actions"[21]

B. Flooding

The negative economic effects of discharge on flooding in Big Muddy must also be weighed on the scale. While a demonstration has been attempted to show that the increased discharges to be caused by the proposal would not be large, even small increases cannot be discarded as insignificant when there are already flooding problems that will be increased. Obviously, nearly every individual source of floodwater can claim that, considered in isolation, it is insignificant. It is in the very nature of flooding that it is the result of large numbers of small factors that collectively lead to disaster. See Galloway Report on 1993 Flood (Ex. J, p.94). Due to climate change, it is already a given that "extreme weather events will become more frequent and intense,"[22] including the frequency of flooding.[23]

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[18] "Coal Producer Murray Energy Files for Bankruptcy," The Columbus Dispatch, 10/29/19 https://www.dispatch.com/business/20191029/coal-producer-murray-energy-files-for-bankruptcy

[19] See also, Macey, Joshua and Salovaara, Jackson, Bankruptcy as Bailout, Stanford Law Review, Vol 71, p. 879 (April 2019) available at https://review.law.stanford.edu/wp-content/uploads/sites/3/2019/04/Macey-Salovaara-71-Stan.-L.-Rev.-879.pdf

[20] "Bankruptcy of Coal Giant Murray Energy Is a Turning Point for Renewable Power," Forbes, 11/3/19 https://www.forbes.com/sites/kensilverstein/2019/11/03/murray-energys-bankruptcy-dovetails-with-the-rise-of-tesla-and-new-energy/

[21] "BlackRock Makes Climate Change Central to Its Investment Strategy," Washington Post, 1/14/20 https://www.washingtonpost.com/business/2020/01/14/blackrock-letter-climate-change/

[22] United States Global Change Research Program, "Fourth National Climate Assessment Volume I" (2017). *See also* United States Global Change Research Program, "Fourth National Climate Assessment Volume II" (2018).

[23] "Changing climate is likely to increase the frequency of floods in Illinois. Over the last half century, average annual precipitation in most of the Midwest has increased by 5 to 10 percent. But rainfall during

Further, increased salinity and other pollutants in Big Muddy floodwaters will increase damage done by flooding to farm fields, golf courses, and other facilities that are flooded.

C. Climate Change

Mining and burning coal pursuant to the proposed permit would itself be destructive of the environment and economy because coal extracted from this mine will cause increased emissions of climate-warming greenhouse gases. "Transformations in the energy sector—including the displacement of coal by natural gas and increased deployment of renewable energy—along with policy actions at the national, regional, state, and local levels are reducing greenhouse gas emissions in the United States."[24]

We are in a climate change emergency. The earth has warmed by 1°C from 1901, the warmest in modern civilization, and warming is projected to reach 1.5°C between 2030-2050 under all best case scenarios.[25] "[H]uman activities, especially emissions of greenhouse gases, are the dominant cause" of record-breaking, climate-related weather extremes in recent years.[26] Catastrophic climate change will occur if global warming exceeds 1.5°C, yet to stay under 1.5°C warming, greenhouse gas emissions must be reduced 45% from 2010 levels by 2030, and reach net zero by 2050. With current global emissions, earth currently is on track to reach 3°C global warming by 2100.

With most of Illinois at 1°F warming as of 2016,[27] permitting the Pond Creek mine not only would be unconscionable, it would go against Illinois law and policy. The Illinois Constitution provides as a state public policy the duty of each person "to provide and maintain a healthful environment for the benefit of this and future generations."[28] Illinois further provides individual rights to a "healthful environment" and individual enforcement "against any party, governmental or private."[29]

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the four wettest days of the year has increased about 35 percent, and the amount of water flowing in most streams during the worst flood of the year has increased by more than 20 percent. During the next century, spring rainfall and average precipitation are likely to increase, and severe rainstorms are likely to intensify. Each of these factors will tend to further increase the risk of flooding." United States Environmental Protection Agency, "What climate change means for Illinois" (Aug. 2016).

[24] United States Global Change Research Program, "Summary Findings, Fourth National Climate Assessment Volume II" at Section 4 (2018).

[25] Intergovernmental Panel on Climate Change, "Special Report on Global Warming of 1.5 °C" (2018).

[26] United States Global Change Research Program, "Fourth National Climate Assessment Volume I" (2017). *See also* United States Global Change Research Program, "Fourth National Climate Assessment Volume II" (2018).

[27] United States Environmental Protection Agency, What climate change means for Illinois (2016). *See also* Fourth National Climate Assessment Volume II at Chapter 21: Midwest (2018).

[28] Illinois Constitution Article XI.

[29] Illinois Constitution Article XI.

Supporting a stable and sustainable economy requires good stewardship of the environment. Absent unprecedented efforts, climate change will increase losses in infrastructure and property, and slow economic growth.[30] Any temporary economic growth would be outweighed irrevocably by short- and long-term climate change consequences.

D. Economic impacts on neighbors and land of long wall mining at site

The Pond Creek mine is a longwall mine. This is a highly automated and high extraction form of coal mining, taking out nearly the entire coal seam, with room and pillar mining done only for access corridors to the longwall panels. Once the longwall equipment is removed, the ground subsides unevenly, often by the depth of the coal seam that was removed. This has permanent, earthquake-like impacts on the ground surface in the land permitted for mining, referred to as the shadow area. The original Williamson Energy application to IDNR for this mine stated on page 280 that, "High extraction mining in the proposed shadow area can be expected to cause considerable surface subsidence." What were once flat farm fields may become uneven and drainage systems farmers have worked decades to improve often have to be replaced. Local property owners face dewatering of their ponds, private wells, or flooding in areas that previously were not a problem due to the geologic changes from the longwall void underground and surface land subsidence. Surface stream flow can be disrupted. While the mines are to restore what is economically and technologically feasible, it is highly questionable that the full impacts on neighbors and area lands and water resources will ever be returned to pre-mining condition. Homes undermined by the mine have been torn down and while some will be rebuilt, family life is disrupted and property owners face years ahead where the ground can still settle and shift. The emotional and health toll imposed on residents is never factored in. One example of subsidence damage is the destruction of the company's own groundwater wells, as noted in their groundwater monitoring reports.

Local residents have repeatedly tried to appeal to state agencies for enforcement of regulations regarding air quality, water concerns, and noise problems at the Pond Creek Mine. Illinois Pollution Control Board case PCB 2007-145 went on from 2007 to 2014 and the death of one of the petitioners (Ex. K). Concerns in this case are very similar to PCB case 2007-135 in which a local resident details the daily coal dust, noise, loss of right to enjoy one's own property and safety concerns in living next to Pond Creek Mine (Ex. L). Loss of property value and long-term harm from longwall mining are not calculated. Long-wall subsided lands can have prompt surface subsidence but residual movement can continue for years.The original mine permit had longwall indicated for 4,630 acres and Revision 2 to the original IDNR Permit 375 added 7,000 more acres that can be subsided by longwall extraction.

The 229.78 acres under consideration for approval in this draft NPDES will enable the Pond Creek Mine to continue to use the centuries old management method of a surface coal slurry

[30] *See* United States Global Change Research Program, "Summary Findings, Fourth National Climate Assessment Volume II" at Section 2 (2018).

impoundment Refuse Disposal Area (RDA) for waste water from mining including washing coal. Land that was once productive farmland and wetlands has been covered by a monstrous high hazard dam impoundment that will be approximately 190 feet high and over 400 acres in size. The area covered by this slurry refuse disposal cannot be used by future generations for farming or building, and will contain heavy metals and pollutants that can leach into the area watershed for generations to come. Outfalls 009 and 009ES will allow the mine to add more discharges to Pond Creek. The proximity of this expansion to the unnamed Pond Creek tributary at Outfall 009ES shows the eastern wall for the RDA running approximately parallel to the course of this drainage. This mine has a history with IDNR of RDA wall collapse.

The mine has not supplied any explanation for what the extraction of millions of gallons a day of groundwater withdrawn in their mining operations may do to the surrounding area. It is not known if sinkholes or other hazards could occur. Not only is the mine causing this huge disruption in groundwater, it can take advantage of public water resources that at times have been rationed by area communities. Both the Pond Creek Mine and the Sugar Camp Mine have an agreement through a third party for use of Rend Lake water in the "Rend Lake Water Supply Withdrawal Agreement between the State of Illinois, Adena Resources, LLC and Akin Water District, September 21, 2007 and Amendment Number One, August 14, 2009," (Ex. S) with up to 6.5 million gallons total per day allowed. Pond Creek Mine could use up to 2.2 mgd of Rend Lake public water.

E. Inadequate Alternatives Analysis

Finally, there has been a completely inadequate consideration of treatment alternatives - costs are not fully quantified. We are asked to just take the company's word that doing the better thing is too expensive.[31] We are provided with rough estimates of what the applicant thinks more advanced treatment would cost but no idea of the profits that might be made from the mine against which to weigh such costs.

The applicant's summary rejection of better treatment certainly cannot be accepted by IEPA given that other coal mines are actually using wastewater treatment methods that the applicant claims cannot be used, in operating mines in West Virginia and Poland. See "Case history on the reduction of chlorides from mine water" (Ex. T); See also Leatherwood Creek Report (Ex. U) and "Treatment and disposal of saline wastewater from coal mines in Poland" (Ex. V).

III. Mixing Zone Rules - The proposed discharge violates numerous provisions of the rule concerning mixing zone rules 35 Ill. Adm. Code 132.102

[31] A new document regarding consideration of alternatives was apparently given to the Agency only days before the hearing. The public certainly has not had time to analyze this study and its dubious conclusion that nothing can be done to treat the mine's wastewater other than letting most of the solids settle and then piping it to Pond Creek or the Big Muddy.

A mixing zone may not, of course, be allowed when the water quality standard for the constituent in question is already violated in the receiving water (35 Ill.Adm.Code 132.102(b)(9)). Here, it appears that the discharge may cause a violation of that rule in numerous ways:

A. Mercury in the Big Muddy

The testing of mercury in the discharge is not adequate to determine whether the discharge will directly increase the bioavailable toxic form of mercury level due to the insensitive testing method and the failure to allow for variability as required by the U.S. EPA TSD which has been recognized by the Illinois PCB. However, it is clear, as explained above, that the discharge of chloride and sulfate will increase the level of bioavailable methyl mercury and other toxic form of mercury and, thus, violate 35 Ill.Adm.Code 132.102(b)(9) as well as other rules that preclude causing increased violations of water quality standards.

B. Acidity in the Big Muddy

It appears that the permit will allow decreased pH in a water body already listed as impaired by low pH, given inadequate monitoring and violations at Outfall 7 in September 2016, June 2017, December 2017, March 2018 for low pH, and violations at Outfall 8 in September 2016, June 2017, and December 2017 for low pH. See US EPA DMR Report (Ex. F) and Echo Report (Ex. R).

C. Total suspended solids and biochemical oxygen demand in the Big Muddy

As explained above, the permit will allow an increased loading of Total Suspended Solids (TSS), and the discharge would lead to an increase in biological oxygen demand (BOD) with the effect that the existing violations of the TSS and Dissolved Oxygen standards will be exacerbated in further violation of 35 Ill.Adm.Code 132.102(b)(9). See also Comment of Dr. Burkholder.

D. Mussel presence in the Big Muddy

As noted earlier in Section I, if mussel beds are found at the discharge location, the proposed mixing zone would not be allowed (**35 Ill. Adm. Code 302.102(b)(4)**). However, the applicant has made no effort to assess for mussels at the discharge location, while the mixing zone itself would impact the bottom of the river most severely. There is reason to believe mussels may be present at this location in the Big Muddy due to the presence of mussel in the major tributaries (Ex. G).[32]

[32] As explained above, because mussels are not protected by the 500 mg/L standard, they will also be harmed well outside the supposed mixing zone.

E. Iron in the Big Muddy

The proposed permit limit for total Iron (3 mg/L daily average, 6 mg/L daily max) has not been shown to meet the applicable water quality standard of 1 mg/L dissolved iron. The Antidegradation Analysis offers no rationale for why the dissolved portion of the total iron would not be above the water quality standard of 1 mg/L. The Big Muddy is impaired for iron, as noted in the public notice. The permittee should not be granted a mixing zone to meet iron limits when the Big Muddy is already impaired for iron.

F. IEPA may not allow increased chloride or TSS loading to Pond Creek

Pond Creek has no dilution capacity for at least chloride, TSS and low DO. As noted in the public notice, Pond Creek is impaired for chlorides. Further, the mine's own reports indicate that the chloride standard has been frequently violated by their discharge from Outfall 007 into Pond Creek (Ex. F). Direct samples of the creek itself found chloride levels well above 500 mg/L, both in May of 2019 (Ex. M, p.6) and August of 2019 (Ex. P, p.3). Therefore, a mixing zone cannot be permitted as is proposed in Special Condition 14 for Outfall 009 (35 Ill. Adm. Code 302.102(b)(9)). Still further, given that IEPA lists Pond Creek as also impaired by "cause unknown" in its 303(d) report, it should not be allowing any increased discharge of a pollutant into Pond Creek that may be part of the unknown cause of the impairment.

IV. The proposed permit does not ensure compliance with other Illinois water quality standards in violation of 35 Ill. Adm. Code 302.210, 304.105, and 309.141(d) and 309.143

As discussed above, the permit does not ensure that the discharge will not cause or contribute to the violation of Illinois water quality standards because, in addition to violating the regulations regarding antidegradation and mixing zones, the permit fails to ensure that the discharge will not cause or contribute to violations of the standards regarding:

- **Mercury** - because (i) the sensitivity of the testing to determine reasonable assurance of meeting the 12 ng/L human health standard is inadequate and (ii) the effect of chloride and sulfate pollution on levels of methyl mercury and other toxic forms of mercury has not been considered.
- **Chloride** - because (i) the complex scheme to prevent violation of the 500 mg/L acute standard is not described in detail, ignores the danger of chloride and cannot be implemented by this applicant and (ii) Pond Creek has no dilution capacity.
- **Conductivity and TSS** - because the permit allows discharges that may cause or contribute to violations of the other toxic substances criteria (35 Ill.Adm.Code 302.210).
- **Copper, iron and nickel** - because the reasonable potential has not been properly calculated using the U.S. EPA Technical Support Document.
- **Dissolved Oxygen** - because the impact of the discharge in raising Biochemical Oxygen Demand levels in the mixing zone and outside the mixing zone has not been considered.

- **pH** - because of the failure to review the applicants discharging monitoring reports showing the potential for a very acidic discharge. See report from Outfall 7 on discharge of pH of 3.3 on Mar. 31, 2018 (Ex. N) and US EPA DMR report (Ex. F) on discharge from Outfall 7 in September 2016, June 2017, December 2017, March 2018 for low pH, and at Outfall 8 in September 2016, June 2017, and December 2017 for low pH.
- **Cadmium** - It is clear that there are high levels of cadmium coming from the mine (Ex. E). The company reports that it found only low levels of cadmium in its very limited monitoring of what it now dubiously claims will be water representative of the discharge. (Anti-degradation Assessment Table 2-1 Water Holding Cell Data) This conclusion, which is hard to credit given the data earlier considered by the Agency, must be treated with great caution by IEPA and only be accepted after independent verification to assure the discharge will not cause or contribute to a violation of the cadmium standard. Cadmium is limited at Outfalls 001 through 007 but should be limited at all outfalls given the very limited testing, the history of this applicant's non-compliance, and the uncertainties caused by lack of knowledge regarding future operations.

V. The Proposed Permit, in violation of 35 Ill. Adm. Code 309.146, does not require adequate or feasible monitoring to determine compliance.

A. Complex Monitoring Scheme - The permit proposes a complex monitoring scheme for compliance at Outfall 009 and Outfall 011, then requires insufficient monitoring to achieve it.

Monitoring and reporting must be adequate to track compliance with all conditions under 35 Ill.Adm.Code 309.146 but the monitoring proposed in the permit completely fails to do so.

Regarding the chloride monitoring scheme proposed for both Outfall 009 into Pond Creek and Outfall 011 into the Big Muddy, the proposed permit limits the applicant's discharge based on a mixing equation, but fails to identify how all the inputs to that mixing equation will be monitored, how often that monitoring will occur, how they will be reported, and how often reporting will occur. To evaluate the mixing equation, the discharger needs to continuously monitor the flow and concentrations upstream in the Big Muddy as well as the flow and concentration of their effluent. Yet the permit contains no requirements whatsoever for monitoring the flow or concentration of the effluent, and gives no clarity on how the concentration of chloride in the effluent will be measured (correlation or otherwise).

Even if the monitoring scheme was clear, the reporting is insufficient for IEPA or the public to evaluate whether the mixing equation is being met. There is no daily reporting of upstream conductivity, upstream flow, effluent conductivity, or effluent flow. There is a continuous downstream monitor of chloride, but relying on a single sensor downstream does not guarantee

that discharge has not been in violation of limits. The inputs to the mixing equation should all be monitored, and the reporting should be at least daily, if not hourly[33].

The permit specifies the location of the downstream monitor such that it minimizes protections. It requires that the downstream monitor be placed in "a sufficient distance downstream of the associated outfall to ensure that complete mixing has occurred." This seems like an unwarranted gift to the permit applicant, essentially granting them as much mixing as they want. Instead, the permit should require that the downstream monitor be placed as close to the edge of the mixing zone as possible, so we know that Illinois waters are being protected and that the mixing zone is as small as possible (35 Ill.Adm.Code 302.102(b)(12)).

Lastly, the permit allows the permittee to reduce or eliminate monitoring requirements, clear error given that the antidegradation assessment explicitly identifies that the groundwater seeping into the mine is likely to significantly increase in chloride concentration (and associated pollutants). The permit should anticipate an increase in the amount and toxicity of the discharge, never allow an elimination of monitoring, and explicitly require an increase in monitoring.

To make this monitoring scheme more feasible, the permit should, at a minimum:

- Require Williamson Energy to create a Quality Assurance Project Plan for the chloride monitoring scheme and give the public an opportunity to comment on the plan.
- Require Williamson Energy to report enough information to evaluate whether the mixing equation is being met. This means monitoring the effluent flow rate and concentration as well as the upstream flow rate and concentration in real time, and reporting that data back to the public. At a minimum, whenever these values are measured and flow in the pipe should be adjusted, it should be reported, at least daily.
- Make it clear how the chloride in the effluent is being monitored. If that monitoring is to be a correlation to conductivity, the effluent and the receiving waters will need correlations developed based on years of data and allowing for variability because it is clear that wide swings in conductivity occur in the Big Muddy (Ex. O).
- Identify whether the result of the mixing equation or the downstream measurement of chloride, or both, are the regulated constraint for chloride concentrations.
- Require a plan for validating the correlation of conductivity to chloride, and stipulate that the correlation has to be sufficiently developed for use, and reviewed by the public, before the permit is granted or the permittee can begin discharging. Conductivity should always be reported with chloride when using the correlation.
- Specify the location of the downstream monitoring to be as close to the estimated boundary of the mixing zone as possible.
- Require accurate monitoring of all of the constituents of the discharge using methods sufficiently sensitive to detect any violations of numeric or narrative water quality standards.

[33] The reporting would not need to be in real time (ie. the public does not need real time access), but the reported data should be hourly.

- ❑ Clearly identify a maximum discharge limit for the pipe.

B. History of Violations and Failure to Monitor Properly - Because the permit applicant has already shown itself incapable of compliance with its existing relatively simple permit through numerous permit violations and failures to report, detailed independent monitoring is necessary.

"In granting permits, the Agency may impose reasonable conditions specifically related to the applicant's past compliance history with this Act as necessary to correct, detect, or prevent noncompliance." 415 ILCS 5/39(a) Here, there is no reason to believe the permit applicant can comply with the proposed permit and any permit granted by the Agency would have to subject to strict terms necessary to detect or prevent noncompliance.

The Williamson Energy's inability to properly report discharge is demonstrated by an August 2019 Inspection Report memo by Illinois EPA inspector Brian Rodely (Ex. P). The report notes that "DMR's appear to have been submitted with no discharge reported during non-precipitation events despite the daily influent of approximately 2.7 million gallons of underground mine water. The water mass balance of influent water and discharged water does not appear consistent." Further, the inspection notes "Analysis not conducted of discharges, inadequate frequency of sampling, and invalid/ unrepresentative sample as required by permit." Additionally, the Illinois Attorney General took action against the mine in Illinois Pollution Control Board Case PCB 2019-085 (Ex. Q). The case was regarding a 2016 IEPA Emergency Response Unit inspection citing black, tar-like material in an unnamed tributary of Pond Creek. It was settled in June of 2019. Continued concerns are clear from the Inspection Report memo that states a near-by property owner commented the IEPA should take samples on a weekend when dark gob water is released when the mine knows it will not be caught.

While self-monitoring is norm in NPDES permit, it would be irresponsible to rely on self-monitoring in this case, given the mine's history of reporting issues and especially with the complex monitoring scheme proposed in this permit. Were this permit to be granted, a third-party should be used to monitor the chloride in the Big Muddy, such as the United State Geological Survey and independent monitoring should be required at the discharge points to the Big Muddy and Pond Creek.

The permit applicant is a frequent violator of their current NPDES permit. In June 2019, ECHO reports (Ex. R) show that the mine violated its effluent limits for chloride and sulfate at Outfall 002. This also occurred in 2017. In 2018 it violated its chloride and sulfate limits at Outfall 006. It violated its pH limit at Outfalls 007 and 008 in three quarters in 2017 and 2018. The mine received a letter of violation from IEPA in August 2016.

C. Correlation curves must be established and included in the permit rather than waiting to develop them after the permit is issued and the dataset used as the basis, and the supporting statistics, should be provided to the public.

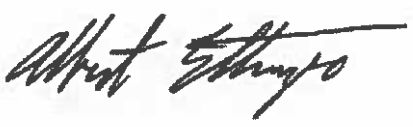
The permit proposes monitoring chloride concentrations by establishing a correlation to conductivity, but offers no guidance on how this correlation is established or whether the Agency needs to approve the correlation. If the permittee begins discharging before the correlation is established, it is impossible for the Agency to evaluate compliance. The correlation needs to be part of the permit. That way both the Agency and the public have the opportunity to review the correlation. This is especially important because chloride is not the only chemical constituent which can change conductivity, and the Big Muddy already has a wide variability in conductivity (Ex. O) so the correlation will never be very accurate and will be tricky to establish.

Conclusion

The permit as proposed is plainly illegal and must be denied.

Moreover, even a vastly improved permit cannot properly be issued without re-noticing the permit and giving the public a fair chance to review the improvements and determine whether they cure the many fatal flaws in the draft. No permit can legally be issued without such fundamental alterations that the changes would necessarily be beyond a logical outgrowth of the totally deficient record on which the draft was based. See, 35 Ill.Adm.Code 309.120. Given that the antidegradation analysis, the reasonable potential analysis, the data collection, and the monitoring have not been set forth in sufficient detail to allow the public a reasonable chance to gauge the effects of the permit; and given the fact that all of the data from this discharger are suspect, a new draft permit should only be issued after the appropriate studies are done by IEPA itself; any data supplied by the permit applicant are shown to have been collected with solid QA/QC; and a revised record is created for public comment.

We look forward to continuing to work with the Agency to protect water quality.



Albert Ettinger
Counsel for Sierra Club



Andrew Rehn
Water Resources Engineer
Prairie Rivers Network

Cynthia Skrukrud, PhD
Clean Water Program Director
Sierra Club, Illinois Chapter

Amanda Pankau
Energy Campaign Coordinator
Prairie Rivers Network

Cameron J. Smith

Cameron J. Smith
Treasurer of SAFE &
Property owner in Murphysboro, IL

Jane Cogie
Chair
Shawnee Group, Sierra Club Illinois

Jan A. Thomas

Jan A. Thomas
Steering Committee of SAFE

Sabrina Hardenbergh
Shawnee Group Sierra Club newsletter editor
SAFE member

Cc: Steve Jann, Region 5 U.S. EPA

Exhibit 389A

From:	Andrew Rehn
To:	EPA.PublicHearingCom; Lieberoff, Barb
Cc:	Albert Ettinger; Cindy Skrukrud; Sabrina Hardenbergh; Jan thomas; Cameron J. Smith; Jane Cogie; Amanda Pankau; Jann.Stephen@epa.gov
Subject:	[External] (Exhibits 1/4) IL0077666 Pond Creek Mine Post-Hearing Comments from PRN, SC, SAFE
Date:	Friday, January 17, 2020 3:58:57 PM
Attachments:	Exhibit_A3-Baker_Materials Reviewed.pdf Exhibit_A Baker_Proposed discharges to BMR and PCr.pdf Exhibit_A2 Baker_CV_Jan20.pdf Exhibit_B Burkholder letter.pdf Exhibit_B2 Burkholder CV - January 2020.pdf Exhibit_C 18-32 Amended Petition TECHNICAL SUPPORT DOCUMENT SUPPLEMENT 2 20 2019.pdf

Please find the Exhibits A-C attached.

On Fri, Jan 17, 2020 at 3:56 PM Andrew Rehn <arehn@prairierivers.org> wrote:

> Dear Ms. Lieberoff and other Illinois EPA officials;
>
> On behalf of Prairie Rivers Network, Sierra Club and Southern Illinoisans Against Fracturing Our Environment, attached are post-hearing comments regarding the proposed NPDES Permit IL0077666 for the Pond Creek mine. As these comments will explain, the proposed permit plainly cannot be legally granted by the Illinois Environmental Protection Agency (IEPA) based on the current record. Please do not hesitate to reach out to us for further clarification.
>
> In 4 emails following this one, I will be including the exhibits to this comment letter. Please include those in the record with this submission.
>
> Thank you,
> Andrew
>
> --
> **Andrew Rehn**
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> 1605 South State St, Suite 1, Champaign, IL 61820
>
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Review of Proposed Discharges to the Big Muddy River and Pond Creek by Williamson Energy: Permit No. IL0077666

January 15, 2020

To Whom it May Concern:

I am a Professor of Environmental Science with more than 20 years of experience in the fields of aquatic ecology and watershed science. I received a PhD in Aquatic Ecology from the University of Michigan, Ann Arbor in 2002 and worked as a Research Associate at the Smithsonian Institution from 2002-2005. I have expertise in analyzing biological community data, characterizing and modeling physical and chemical drivers, and diagnosing causes of biological change in aquatic ecosystems using field observations and quantitative analytical techniques. I have applied these approaches to understand variation in community response to hydrologic, thermal, and chemical gradients in Michigan rivers, to identify land use thresholds in Maryland watersheds, to evaluate biological community response to hydrologic and chemical stressors in Maryland, Ohio, West Virginia, and Massachusetts streams. I have experience in analyzing stream hydrology and geomorphology in basins throughout the Midwest, Chesapeake Bay watershed, and New England, and applied similar techniques to rivers and streams in Argentina and Brazil. I have served as a manuscript reviewer for over 50 peer-reviewed journals and federal agencies including USEPA, USGS, USFS, and NSF. I currently serve as an Associate Editor for the international journal *Freshwater Science*. Over the past 10 years, I have conducted workshops for federal and state agencies and at regional aquatic biology meetings in which I trained attendees about statistical methods for analyzing biological data. I have also held an appointment as a Research Professor with the USGS where I provided advice to agency scientists regarding analysis and interpretation of observational data. More information on my background and qualifications in provided in the attached *Curriculum Vitae.*

At the request of the Sierra Club, I have reviewed certain materials relating to proposed new discharges to the Big Muddy River and Pond Creek from the Pond Creek No. 1 Mine. It is my understanding that Williamson Energy has applied for a revision of its 2005 NPDES permit, in which it proposes to substantially alter its current discharges into Pond Creek and add an additional discharge into the Big Muddy River, some 12 miles away. In deciding whether to approve this permit revision, my understanding is that the Illinois Environmental Protection Agency (IEPA) must act to *protect* and *maintain* water quality standards in Illinois. The list of materials reviewed is provided at the end of this document. From these materials, I have developed the following opinions:

1) The discharges described in the NPDES renewal and the anti-degradation documents exceed levels known to be harmful to aquatic life. Whether it involves the high levels of TDS or Specific Conductivity (SC), high

concentrations of sulfate, chlorides, or various metals, the discharges described here will impact sensitive taxa in any receiving freshwater body (e.g., Pond et al. 2008, Pond 2010, Timpano et al. 2011, Pond 2012, US EPA 2013, Suter and Cormier 2013, Pond et al. 2014, Griffith 2017). Although the region has higher background levels of conductance than regions with more resistant rock types and dilute waters, regional background concentrations are nonetheless similar to what is found discharging from calcareous rocks (Griffith 2014), and in any case the proposed mining discharges dwarf natural concentrations by orders of magnitude. Recent investigations of anthropogenic stressors suggest that such novel environmental gradients are associated with ecological thresholds (Hobbs et al. 2006, King et al. 2011, Bernhardt et al. 2012, Voss et al. 2015).

2) Proposed amendments to NPDES # IL0077666 involving discharges into Pond Creek represent excess chloride for a stream *already listed for chlorides* in the states 303(d) impairment summary. Approving any permit to allow additional discharges of an impairment-listed pollutant represents a clear violation of the intent of the Clean Water Act and Illinois administrative codes [35 Ill. Adm. Code 302.102(b)(9)]. Moreover, previous description of the conditions in Pond Creek characterizes its flow above the outfall as *intermittent*. If this is the case, there will be times during the year when the mining company effluent constitutes the majority, if not all, of the flow in the stream. Under such conditions, there will be very limited potential for mixing. Effluent limitations must be at least as stringent as the water quality standards they seek to meet.

3) There seems to be discrepancy in the water quality standards for various analytes, and under such circumstances EPA limits should be considered. The anti-degradation document lists reporting levels for chloride at 500 mg/l and sulfate at 1182 mg/l, well above the current EPA levels of 230 mg/l for chronic and 860 mg/l for acute chloride impacts to aquatic life (EPA 1988, Wang et al. 2018). Moreover, levels for sulfate toxicity are listed as low as 600-800 mg/l in the literature (Soucek and Kennedy 2005, Elphick et al. 2011, Wang et al. 2016) but much higher here. In the groundwater well documentation I reviewed, there appeared to be an altogether different set of standards (200 mg/l chloride and 400 mg/l sulfate) being applied (and the state reviews appear to be allowing reports from Williamson Energy that are rife with obvious errors, suggesting lax oversight). A single numeric requirement does not account for the difference between for acute and chronic effects or for differences across taxa, and even then the typical WET tests that help drive EPA chronic toxicity levels are of a relatively limited duration. Most testing for such limits are performed on crustaceans, mollusks, fish, or highly tolerant macroinvertebrates due to the challenges in raising sensitive taxa in a controlled environment (Kennedy et al. 2004, Kunz et al. 2013). More recent work has suggested both that sensitive organisms

respond differently than tolerant taxa and that a typical test does not consider the impacts of discharges throughout the life history of the organisms (Clements and Kotalik 2016, Voss and Bernhard 2017).

4) Proposed amendments to NPDES # IL0077666 involving discharges into the Big Muddy River represent toxic additions to the water body. In this case, the mining company has made an effort to mitigate the effects of the discharges through the proposed use of five single-port diffuser system. However, background chloride levels (listed by IEPA as 30.1 mg/l to purportedly represent the 90th percentile of stream observations) are too low. According to IEPA ambient water quality data set. The 30.1 mg/l level provided is not the 90th percentile (which is actually >103 mg/l) but the *50th percentile or the median* of IEPA observations. Secondly, the existing observations represent irregular monthly grab samples that are incapable of accurately representing dynamic levels of concentration extremes apparent in USGS conductivity data form the same reach. Both point to much higher extant levels of chloride and other solutes than assumed in the modeling simulation offered by Williamson Energy and used to guide their proposal. Further, the Big Muddy River is itself already listed as impaired for a number of stressors including mercury, iron, PCBs, and sulfate in 2014, and the proposed discharges would simply be adding to the sulfate load. In that situation, where pollutants already exceed the allowable in-stream concentrations, a mixing zone should not be permitted.

The materials included in the permit application are insufficient to make a reasoned conclusion that impacts of the proposed discharge will not impact aquatic life.

Recent work has suggested that conductivity related to both chlorides and sulfates can produce both acute and chronic toxicity as well as reduced metabolism and lowered abundance of sensitive taxa (Clements and Kotalik 2016, Voss and Bernhard 2017). The fact that the stream is already impaired does not relieve the mining company or IEPA from establishing effluent limits protective of water quality standards, including those meant to protect aquatic life. There is little to no consideration of the addition of more chlorides, sulfates, or other pollutants to these streams or effects on other taxa (e.g., Wang et al. 2007, Timpano et al. 2010, Bier et al. 2012). What consideration that exists is implicitly focused entirely on concentrations and not also on the impact of loads.

Second, cumulative or synergistic effects are likely to occur in a stream where additional stressors and harmful pollutants are present (Omerod et al. 2010). I have observed this myself in mining impacted streams, where conditional analysis showed that impacts of habitat degradation or thermal stress were enhanced by the presence of mining effluent (Baker 2014). Other studies have taken such impacts and interaction into account when investigating the effects of mining discharges (e.g., Gerritson et al. 2010,

Merriam et al. 2011, Cook et al. 2015). Cumulative effects have lately been the focus of study where multiple NPDES permits contribute to downstream impairment (Lindberg et al. 2011, Merriam et al. 2015, Nippgen et al. 2017, McManus et al 2020). IEPA has not taken these cumulative or synergistic effects into account at all in the proposed permit.

In order to developed an informed opinion about the effects of the proposed discharges, the agency should require more information about Pond Creek and the Big Muddy (up and downstream of the confluence) prior to issuance of any permit to better understand the impacts of the mine discharge. In addition, I have the following specific concerns:

1) There does not appear to be a margin of safety in the proposed plans. Given that the design parameters suggest the mining company will be operating near its discharge capacity nearly all of the time to dispose of excess water, there is potential for violation of its limits due to poor calibration of the diffusers with river flow, effluent concentrations, or temporary system failure. Since the limits themselves appear to be at or above concentrations where tests detect aquatic degradation (again, the tests themselves are structured to return a level where one is sure that harm has occurred) their plans are based on a faulty premise, any disruption in their best-case scenario should result in a violation of the standard and a virtual guarantee of aquatic harm. From the documentation provided, it does not appear to include recommended allowances (USEPA Technical Support Document) for permit limits set with limited and variable data.

2) No consideration of cumulative effects. The Anti-degradation document mentions that Sugar Camp mine, owned by the same company as Pond Creek mine, will be discharging into the Big Muddy River upstream of Outfall 11. Assuming they operate effectively with no mishaps and appropriate monitoring (again, this is best-case planning with no safety margin), the mine apparently plans to discharge sufficient chloride to raise a quarter of river flow to 500 mg/l chloride. By the time that water reaches the downstream Pond Creek mine discharge, the entire river will have a chloride concentration of in excess of 140 mg/l from mine inputs alone. If Pond Creek mine is also discharging at or near its maximum, the entire river downstream of Pond Creek mine outfall will be around 240 mg/l chloride from mine discharge alone (i.e., above the EPA chronic standard). This does not account for any other sources of chloride or any other pollutants, from the mine or other sources, nor does it consider how this proposed discharge will mix with Pond Creek itself, below their downstream confluence.

3) No collection of pre-mining data. As I understand this history of these permits, there has been no effort to understand how past discharges from the Pond Creek mine have impacted stressed aquatic communities and to distinguish those effects. Other mining states are discovering to

their regret that large fractions of their freshwater resources, including regional fish populations (Griffith et al. 2012, Hitt and Chambers 2014, Griffith et al. 2018) are now impaired due to mining. Why hasn't there been greater consideration of these impacts?

4) No mention of potential interactions among stressors. For example, one obvious issue is that the Big Muddy River has been listed as impaired for both mercury and sulfate, and there is a robust literature linking the methylation of mercury to the presence of high concentrations of sulfate and sulfate reducing bacteria (e.g., Jeremiason et al. 2006, Olof Regnell et al. 2019, Lazareva et al. 2019). It seems as though the IEPA is willing to consider adjusting chloride standards given the presence of sulfate, but will not consider adjusting sulfate standards (indeed allows a more lax standard than elsewhere) in the presence of high levels of mercury. Given the potentially toxicity of methylmercury and its ability to bioaccumulate in the food web, I am quite surprised to see no mention of this factor in the permit documents.

My impression of the overall picture here is that the mining company is asking the state for permission to further impair public waters. Indeed, the request to discharge into the Big Muddy is an effort to take advantage of its greater assimilatory capacity so that the mine can increase its discharges without so obviously violating its original permit. This is strikingly similar to remedy proposals from Appalachian mining companies that have been found liable for violating their NPDES permits in federal court (S.D. W.Va. 2:13-5006). The fallacy here is that neither the Big Muddy River nor Pond Creek is an unimpaired stream, so regardless of efforts to limit discharges, they mining company will still be adding to impairment and inhibiting further recovery efforts.

The Anti-Degradation document presents several alternatives to the increased level of effluent discharge. It discards each of them as too difficult, too uncertain, or too expensive. The implication is then, that environmental degradation is less expensive because the company does not bear the full cost of disposal. The State is thus asked to approve the sole alternative that would keep the mine in operation. It is not my place to decide for the State of Illinois whether this bargain for economic benefit is worth the environmental cost. Both the cost and the benefit of the mine will depend on its expected lifespan. In the documentation, I found two distinct estimates of the expected life of the mine: >10 years or >20 years. These estimates were made in 2005. Since the mine is already 15 years old, it would appear that 5-10 years from now is an optimistic interpretation of those initial projections.

I am concerned that the proposed permit revision may only solve part of the company's water management problem. The revised proposal variously describes excess water on the order of 2.3-3.5 mgd and indicates expected discharges of between 1.83 and 4.73 mgd at Outfall 11, depending on river

flow conditions. These projections are far too optimistic given the errors in the mixing simulations mentioned above, so the company would be unable to discharge the expected amount. Further it remains unclear how *in situ* concentrations will vary with higher flows. Whereas high flows with dilute concentrations should pose little difficulty for assimilating their pollutant load, what is the plan for handling excess effluent during a drought or when high flows also flush road salts? This remains absent from the planning documents.

The materials that I have reviewed lead to the conclusion that the proposed discharges will cause harm to aquatic life, that there is an surprising amount of unknown risk being taken on by the IEPA. IEPA did not require the necessary documentation or background information to ensure compliance with state water quality standards, and it is clear more work needs to be done.

Submitted Respectfully,



Matthew Baker, PhD
Professor
Department of Geography and Environmental Systems
University of Maryland, Baltimore County
Baltimore, MD 21250

Cases within the last four years in which I been deposed or testified as a witness:

Ohio Valley Environmental Coalition v. Fola Coal, (S.D. W.Va. 2:13-21588) (Leatherwood Liability)

Ohio Valley Environmental Coalition v. Fola Coal, (S.D. W.Va. 2:13-5006) (Stillhouse Remedy)

Ohio Valley Environmental Coalition v. Fola Coal, (S.D. W.Va. 2:13-21588) (Leatherwood Remedy)

Ohio Valley Environmental Coalition v. Fola Coal, (S.D. W.Va. 2:15-1371) (Monoc Liability)

Canaan Christian Church and Burtonsville Crossing, LLC and Burtonsville Associates, LLC and Jennifer M. Sarem and Marion G. Sarem v. Montgomery

County, Maryland and Montgomery County Council and Isiah Leggett, (MD Case No.:16-cv-03698-TDC)

Materials Reviewed:

Anti-Degradation Document.pdf
PondCreekPermit2005.pdf
IEPA_AmbientWQData.xlsx
Comment and Request for Hearing on NPDES Permit No. IL0077666, Notice No. 7516c, Williamson Energy, LLC, Pond Creek Mine.pdf
USGS gauge and water quality records for #05599490 Big Muddy River at RTE 127 at Murphysboro from Jan 2016 to Nov 2019
IEPA water quality records for Segment N-11, NG-05
NACL Proposal 2019.docx
Big Muddy River (N) 2000.pdf
Pond Creek mine outfall.pdf
Detailed Facility Report _ ECHO _ US EPA.pdf
WaterData_Bugs_Fish_BigMuddy_N_PondCr_NG_ToCindySkrukrud_2020_01_10.xlsx
Set of Pond Creek FOIA Documents:
12.12.16AD&QBELPdCrMine_08122019114439.PDF
Application 7-18-18 Ownership&ViolationsPCmine_08122019101005.PDF
Gh2oPCmine_08122019100223.PDF
Gh2oPCmine_08122019100359.PDF
Gh2oPCmine_08122019100529.PDF
GH20pondck_08122019102002.PDF
GH20pondck_08122019102029.PDF
GH20pondck_08122019102230.PDF
OwnershipPdCrMine_08122019111909.PDF
RDA2PdCrMine_08122019113337.PDF
ResptoIEPAonRDA3PdCrMine_08122019113730.PDF
T&ERDA3PdCrMine_08122019114056.PDF

References

Bernhardt, E. S., B. D. Lutz, R. S. King, A. M. Helton, C. A. Carter, J. P. Fay, D. Campagna, J. Amos. 2012. How many mountains can we mine? Assessing the regional degradation of Central Appalachian rivers by surface coalmining. Environmental Science & Technology 46: 8115–8122.

Bier, R. L., Voss, K. A., & Bernhardt, E. S. (2015). Bacterial community responses to a gradient of alkaline mountaintop mine drainage in Central Appalachian streams. *The ISME journal*, *9*(6), 1378.

Cañedo-Argüelles, M., Hawkins, C. P., Kefford, B. J., Schäfer, R. B., Dyack, B. J., Brucet, S., ... & Coring, E. (2016). Saving freshwater from salts. Science, 351(6276), 914-916.

Clements, W. H., & Kotalik, C. (2016). Effects of major ions on natural benthic communities: an experimental assessment of the US Environmental Protection Agency aquatic life benchmark for

conductivity. Freshwater Science, 35(1), 126-138.
Cook, et al, (2015) Habitat and water quality as drivers of ecological system health in Central Appalachia. Ecological Engineering 84:180-189.
Cormier S. and G.W. Suter. 2013a. A method for assessing causation of field exposure- response relationships. Environmental Toxicology and Chemistry 32:272–276.
Cormier S., S. P. Wilkes, and L. Zheng. 2013b. Relationship of land use and elevated ionic strength in Appalachian watersheds. Environmental Toxicology and Chemistry 32:296-303.
Cormier SM, Suter GW, and Zheng L. 2013c. Derivation of a benchmark for freshwater ionic strength. Environmental Toxicology and Chemistry 32:263–271.
Cormier, S. M., Suter, I. I., & Glenn, W. (2013). A method for deriving water- quality benchmarks using field data. Environmental Toxicology and Chemistry 32(2), 255-262.
Dugan, H. A., Bartlett, S. L., Burke, S. M., Doubek, J. P., Krivak-Tetley, F. E., Skaff, N. K., ... & Roberts, D. C. (2017). Salting our freshwater lakes. Proceedings of the National Academy of Sciences, 114(17), 4453-4458.
Elphick, J. R., Davies, M., Gilron, G., Canaria, E. C., Lo, B., & Bailey, H. C. (2011). An aquatic toxicological evaluation of sulfate: The case for considering hardness as a modifying factor in setting water quality guidelines. Environmental Toxicology and Chemistry, 30(1), 247-253.
Gerritsen, J., Zheng, L., Burton, J., Boschen, C., Wilkes, S., Ludwig, J., & Cormier, S. M. (2010). Inferring causes of biological impairment in the Clear Fork Watershed, West Virginia. EPA 600/R-08/146. US Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, Cincinnati, OH, USA.
Griffith, M. B., Norton, S. B., Alexander, L. C., Pollard, A. I., & LeDuc, S. D. (2012). The effects of mountaintop mines and valley fills on the physicochemical quality of stream ecosystems in the central Appalachians: A review. Science of the Total Environment 417, 1
Griffith, M. B. (2014). Natural variation and current reference for specific conductivity and major ions in wadeable streams of the conterminous USA. *Freshwater Science*, *33*(1), 1-17.
Griffith, M. B. (2017). Toxicological perspective on the osmoregulation and ionoregulation physiology of major ions by freshwater animals: teleost fish, Crustacea, aquatic insects, and Mollusca. *Environmental toxicology and chemistry*, *36*(3), 576-600.
Griffith, M. B., Zheng, L., & Cormier, S. M. (2018). Using extirpation to evaluate ionic tolerance of freshwater fish. *Environmental toxicology and chemistry*, *37*(3), 871-883.
Hitt, N. P., & Chambers, D. B. (2014). Temporal changes in taxonomic and functional diversity of fish assemblages downstream from mountaintop mining. Freshwater Science 33(3), 915-926.
Hitt, N. P., & Chambers, D. B. 2014. Temporal changes in taxonomic and

functional diversity of fish assemblages downstream from mountaintop mining. Freshwater Science 33(3), 915-926.
Hobbs, R. J., Arico, S., Aronson, J., Baron, J. S., Bridgewater, P., Cramer, V. A., ... & Zobel, M. (2006). Novel ecosystems: theoretical and management aspects of the new ecological world order. Global ecology and biogeography, 15(1), 1-7.
Jeremiason et al. 2006. Sulfate Addition Increases Methylmercury Production in an Experimental Wetland. Environ. Sci. Technol. 2006, 40, 12, 3800-3806.
Kaushal, S. S., Likens, G. E., Pace, M. L., Utz, R. M., Haq, S., Gorman, J., & Grese, M. (2018). Freshwater salinization syndrome on a continental scale. Proceedings of the National Academy of Sciences, 115(4), E574-E583.
Kennedy, A. J., Cherry, D. S., & Currie, R. J. (2004). Evaluation of ecologically relevant bioassays for a lotic system impacted by a coal-mine effluent, using Isonychia. Environmental Monitoring and Assessment 95(1-3), 37-55.
King, R. S., M. E. Baker, P. F. Kazyak, and D. E. Weller. 2011. How novel is too novel? Stream community thresholds at exceptionally low levels of catchment urbanization. Ecological Applications 21:1659-1678
Kunz, J. L., Conley, J. M., Buchwalter, D. B., Norberg, King, T. J., Kemble, N. E., Wang, N., & Ingersoll, C. G. (2013). Use of reconstituted waters to evaluate effects of elevated major ions associated with mountaintop coal mining on freshwater invertebrates. Environmental Toxicology and Chemistry 32(12): 2826-2835.
Lazareva, Olesya, Donald L. Sparks, Richard Landis, Carol J. Ptacek, and Ma. "Investigation of legacy industrial mercury in floodplain soils: South River, Virginia, USA." Environmental Earth Sciences 78, no. 8 (2019): 246.
Lindberg, T. T., Bernhardt, E. S., Bier, R., Helton, A. M., Merola, R. B., Vengosh, A., & Di Giulio, R. T. (2011). Cumulative impacts of mountaintop mining on an Appalachian watershed. Proceedings of the National Academy of Sciences 108(52): 20929-20934.
Merriam, E. R., Petty, J. T., Strager, M. P., Maxwell, A. E., & Ziemkiewicz, P. F. (2015).Landscape-based cumulative effects models for predicting stream response to mountaintop mining in multistressor Appalachian watersheds. Freshwater Science, 34(3), 1006-1019.
Merriam, E.R., JT Petty, GT Merovich, JB Fulton, and MP Strager. 2011. Additive effects of mining and residential development on stream conditions in a central Appalachian watershed. Journal of the North American Benthological Society, 30:399-418.
Nippgen, F., Ross, M.R.V., Bernhardt, E.S., and McGlynn, B.L. (2017). Creating a more perennial problem? Mountaintop removal coal mining enhances and sustains saline baseflows of Appalachian watersheds. Environmental Science & Technology 51(15): 8324–8334.
Olof Regnell, Carl. J. Watras. Microbial Mercury Methylation in Aquatic Environments: A Critical Review of Published Field and Laboratory

Studies. Environmental Science & Technology 2019, 53 (1) , 4-19. DOI: 10.1021/acs.est.8b02709.
Ormerod, S. J., Dobson, M., Hildrew, A. G., & Townsend, C. (2010). Multiple stressors in freshwater ecosystems. Freshwater Biology, 55, 1-4.
Pond, G. 2010. Patterns of Ephemeroptera taxa loss in Appalachian 3 headwater streams (Kentucky, USA). Hydrobiologia 641:185–201.
Pond, G. J. 2012. Biodiversity loss in Appalachian headwater streams (Kentucky, USA): Plecoptera and Trichoptera communities. Hydrobiologia 679(1):97-117.
Pond, G. J. M.E. Passmore, F.A. Borsuk, L. Reynolds, and C.J. Rose. 2008. Downstream effects of mountaintop coal mining: comparing biological conditions using family- and genus- level macroinvertebrate bioassessment tools. Journal of the North American Benthological Society 27:717-737.
Pond, G. J., Passmore, M. E., Pointon, N. D., Felbinger, J. K., Walker, C. A., Krock, K. J., ... & Nash, W. L. 2014. Long-Term Impacts on Macroinvertebrates Downstream of Reclaimed Mountaintop Mining Valley Fills in Central Appalachia. Environmental Management 1-15.Regnell, O., & Watras, C. J. (2018). Microbial mercury methylation in aquatic environments: a critical review of published field and laboratory studies. Environmental science & technology, 53(1), 4-19.
Soucek, D. J., & Kennedy, A. J. (2005). Effects of hardness, chloride, and acclimation on the acute toxicity of sulfate to freshwater invertebrates. Environmental Toxicology and Chemistry: An International Journal, 24(5), 1204-1210.
Suter, G.W. and S.M. Cormier. 2013. A method for assessing the potential for confounding applied to ionic strength in central Appalachian streams. Environmental Toxicology & Chemistry 32:288-295.
Timpano, A. J., Schoenholtz, S. H., Zipper, C. E., & Soucek, D. J. (2010). Isolating effects of total dissolved solids on aquatic life in central Appalachian coalfield streams. Proceedings America Society of Mining and Reclamation, 1284-1302.
Timpano, A. J., Schoenholtz, S., Zipper, C., & Soucek, D. (2011). Levels of dissolved solids associated with aquatic life effects in headwater streams of Virginia's Central Appalachian coalfield region (Doctoral dissertation, University Libraries, Virginia Polytechnic Institute and State University).
US EPA (Environmental Protection Agency). 2000. Stressor identification guidance document.
US EPA (Environmental Protection Agency). 2000. Stressor identification guidance document.
US EPA (Environmental Protection Agency). 2011. A Field-based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams. Office of Research and Development, National Center for Environmental Assessment, Washington, DC. EPA/600/R-10/023F.
US EPA (Environmental Protection Agency). 2011. A Field-based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams. Office of Research and Development, National Center for Environmental

Assessment, Washington, DC. EPA/600/R-10/023F.
Voss, K. A., King, R. S., & Bernhardt, E. S. 2015. From a line in the sand to a landscape of decisions: a hierarchical diversity decision framework for estimating and communicating biodiversity loss along anthropogenic gradients. Methods in Ecology and Evolution 37(1):130-137.
Voss, K. A., & Bernhardt, E. S. (2017). Effects of mountaintop removal coal mining on the diversity and secondary productivity of Appalachian rivers. *Limnology and Oceanography*, *62*(4), 1754-1770.
Wang, N., Ingersoll, C. G., Greer, I. E., Hardesty, D. K., Ivey, C. D., Kunz, J. L., ... & Kane, C. M. (2007). Chronic toxicity of copper and ammonia to juvenile freshwater mussels (Unionidae). *Environmental Toxicology and Chemistry: An International Journal*, *26*(10), 2048-2056.
Wang, N., Dorman, R. A., Ingersoll, C. G., Hardesty, D. K., Brumbaugh, W. G., Hammer, E. J., ... & Mount, D. R. (2016). Acute and chronic toxicity of sodium sulfate to four freshwater organisms in water only exposures. *Environmental toxicology and chemistry*, *35*(1), 115-127.
Wang, N., Kunz, J. L., Dorman, R. A., Ingersoll, C. G., Steevens, J. A., Hammer, E. J., & Bauer, C. R. (2018). Evaluation of chronic toxicity of sodium chloride or potassium chloride to a unionid mussel (Lampsilis siliquoidea) in water exposures using standard and refined toxicity testing methods. *Environmental toxicology and chemistry*, *37*(12), 3050-3062.

CURRICULUM VITAE

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EDUCATION

Ph.D. 2002 University of Michigan, Ann Arbor, MI (Aquatic Ecology)

M.S. 1996 University of Michigan, Ann Arbor, MI (Terrestrial Ecology)

B.A. 1992 Emory University, Atlanta, GA (English and Ecology)

EXPERIENCE IN HIGHER EDUCATION

2016-present	*Professor*, University of Maryland, Baltimore County, Department of Geography and Environmental Systems
2015-2016	*Interim Chair*, University of Maryland, Baltimore County, Department of Geography and Environmental Systems
2015-present	*Graduate Program Director*, University of Maryland, Baltimore County (Shady Grove Campus), Professional Studies Program in Geographic Information Systems, Department of Geography and Environmental Systems
2011-2016	*Associate Professor*, University of Maryland, Baltimore County, Department of Geography and Environmental Systems
2009-present	*Faculty Fellow*, University of Maryland, Baltimore County, Center for Urban Environmental Research and Education
2008-2011	*Assistant Professor*, University of Maryland, Baltimore County, Department of Geography and Environmental Systems
2008-2013	*Adjunct Assistant Professor*, Utah State University, Department of Watershed Sciences, The Ecology Center
2005-2008	*Assistant Professor*, Utah State University, Department of Watershed Sciences, The Ecology Center, Western Center for Monitoring and Assessment of Freshwater Ecosystems

PROFESSIONAL EXPERIENCE

2018-present	*Expert Witness*, Whiteford, Taylor & Preston L.L.P., Baltimore, Maryland
2014-present	*Expert Witness*, Appalachian Mountain Advocates, Charleston, West Virginia
2014-2015	*Maryland Fellow*, National Center for Socio-Ecological Synthesis (SESYNC)
2014-2015	*Expert Witness*, Internal Revenue Service, Office of Chief Counsel, Baltimore, Maryland
2011-2017	*Research Professor*, U.S. Geological Survey, New England Water Science Center
2002-2005	*Research Associate*, Smithsonian Environmental Research Center, Ecological Modeling and Spatial Analysis Laboratory

HONORS RECEIVED

2015	IRC Summer Faculty Fellowship, College of Humanities, Arts, and Social Sciences, UMBC
2014	Finalist, Boggess Best Paper Award, American Water Resources Association (Weller & Baker 2014)
2014-2015	Faculty Research Fellowship, College of Humanities, Arts, and Social Sciences, UMBC
2011-12	UMBC Faculty Teaching Scholar
2010	Faculty1000 selection for recommended reading (Baker & King 2010)
2009	Summer Faculty Fellowship, UMBC
2007	William B. Gardner Foreign Travel Award
2006	Finalist, New Faculty Advisor of the Year
2005	Faculty1000 selection for recommended reading (King et al. 2005)
2002	US-IALE, Best Student Presentation Award Winner
2002	US-IALE NASA-MSU Award Winner
2000-1	Jeffery Lund Award for outstanding scholarship in Forest Ecology
2000-1	Samuel A. Graham Award for excellence in Forest Biology
1996-8	Merit based scholarships
1995-6	Samuel A. Graham Award for excellence in Forest Biology
1993 Xi	Sigma Pi Forestry Honor Society
1992-5	Merit based scholarships

RESEARCH SUPPORT

2019-2020	Baker M (Principal) "Mapping woodland patches across major urban areas of the Eastern US", USDA Forest Service $15,000

2018-2024	Baker M (Principal) "High-resolution stream mapping across the Chesapeake Bay Watershed" Sponsored by the U.S. Environmental Protection Agency Chesapeake Bay Program, $1,200,000
2018-2020	Baker M (Principal) "Patapsco River Restoration Phase II: Post-Removal Survey" Sponsored by American Rivers/NOAA, $107,380
2018-2019	Baker M (Principal) "Patapsco River Restoration Phase II: Pre-Removal Survey" Sponsored by the American Rivers/NOAA, $93,680
2017-2019	Baker (Principal) "Continuous mapping of channel features for monitoring aquatic habitat and sediment flux in coastal systems" Sponsored by Maryland SeaGrant, $44,974
2017-2019	Baker (Principal) "New measures of aquatic habitat for assessing restoration resilience" Sponsored by Maryland SeaGrant, $43,706
2017-2020	Baker M (Co-PI), Yu M (Principal) "Acquisition of Hybrid CPU/GPU Nodes for the Interdisciplinary UMBC High Performance Computing Facility" Sponsored by the National Science Foundation (NSF-MRI), $550,000
2016-2018	Baker M (Principal) "Scalable applications for mapping stream channels from high resolution terrain data" Sponsored by the Chesapeake Bay Trust, $74,997
2015-2016	Baker M (Co-Principal), Miller A (Co-Principal) "Long term monitoring—physical response to lower Patapsco River dam removals: Patapsco River restoration project" Sponsored by the National Oceanographic and Atmospheric Administration, $170,189
2014-2017	Baker M (Co-Principal), Armstrong D (Principal) "Urbanization and Massachusetts streams: Unpacking the biological effects of impervious cover" Sponsored by Massachusetts Department of Fish & Game, $405,000
2013-2015	Baker (Principal) "Riparian Indicators of Eco-Hydraulic Function for Improved Watershed Management and Monitoring" Sponsored by Maryland SeaGrant, $82,500
2012-2015	Baker M (Sen. Pers.), Gobbert M (Principal) "Acquisition of Hybrid CPU/GPU Nodes for the Interdisciplinary UMBC High Performance Computing Facility" Sponsored by the National Science Foundation (NSF-MRI), $300,000

2011-12 Baker M (Co-Principal), Armstrong D (Principal) "Application of Threshold Indicator Taxa Analysis (TITAN) to assess the effects of land-use, impervious cover, dams, and water withdrawals on fish taxa in Massachusetts" Sponsored by the US Geological Survey and Massachusetts Department of Fish & Game, $34,000

2010-11 Baker M (Principal) "Thresholds in aquatic communities in response to exurbanization and environmental change" Sponsored by Maryland SeaGrant, $58,010

2010-15 Baker M (Co-Principal), Swan C (Principal) "The role of network topology and environmental filtering in shaping the ecology of spatially structured communities" Sponsored by the National Science Foundation, $410,000

2010-11 Baker M (Co-Principal), Armstrong D (Principal) "Coordinated Assessment and Protection of New England's Coldwater Fishery Resources: Development of a multivariate TITAN" Sponsored by US Environmental Protection Agency and Massachusetts Department of Fish & Game, $50,000

2010-2015 Baker M (Collaborator), Vigliano P (Principal) "Habitat template and stream fish assemblages of sub basins of Nahuel Huapi lake, Patagonia Argentina" Sponsored by the Argentinian National Scientific and Technical Research Council (CONICET), $70,000 (approximate)

2010-14 Baker M (Sen. Pers.), Welty C (Principal) "Acquisition of Liquid Water Isotope Analyzer Capability for Advancing Hydrologic Research in Baltimore Ecosystem Study LTER" Sponsored by the National Science Foundation (NSF-MRI), $244,694

2009-14 Baker M (Co-Principal), Vidon P (Principal) "Greenhouse gas emissions form riparian zones across a regional hydrogeomorphic gradient" Sponsored by the US Department of Agriculture, $399,000

2007-09 Baker M (Co-Principal), Ramsey D (Principal), "Assessment of ecosystem condition in Grand Teton National Park" Sponsored by the US Department of Interior National Park Service, $100,000

2007-09 Baker M (Principal) "A pilot study of trout invasions in low productivity environments of Andean Patagonia" Utah State University Community Research Initiative, $19,000

2007 Baker M (Principal) "Remote analysis of watershed attributes using

Shuttle Radar Topography Mission data: Andean Patagonia" Utah State University Water Initiative, $6,000

2007-09 Baker M (Co-Principal), Kasahara T (Principal) "Evaluating the effect of climate and topography on water residence time and hydrologic scaling in semi-arid, alpine catchments" Sponsored by the Inland Northwest Research Alliance Water Research Consortium, $62,500

2007 Baker M (Collaborator), Beard K (Principal), "Spatial distribution of frog invasions on tropical islands" Sponsored by the National Science Foundation-ADVANCE, $7200

2007 Baker M (Principal) Utah State University New Faculty Competitive Research Grant, $15,000

2006-10 Baker M (Principal) "A strategic planning tool for targeted buffer restoration and enhanced coastal stewardship " Sponsored by the National Oceanographic and Atmospheric Administration, $308,968

2005-08 Baker M (Sen. Pers.) Prince S (Principal), "A watershed Classification System for improved Monitoring and Restoration: Indicators of Watershed Impairment" Sponsored by the US Environmental Protection Agency, $800,000

1998-02 Baker M (Graduate Student author) Wiley M (Principal), "Ecosystem Structure and Function at the Land-Water Interface" Sponsored by the Michigan Department of Natural Resources, $250,000

1997 Baker M (Graduate Student Supervisor) Wiley M (Principal), "Aquatic Community Assemblage Structure in Relation to Macro-Habitat Units in Lower Michigan" Sponsored by The Nature Conservancy, $60,000

Ph.D. STUDENTS

Tanushree Biswas, 2009, committee member, USU
John Lowry, 2010, committee member, USU
Daniel Miles, 2011, committee member, UMBC
John Olsen, 2012, committee member, USU
Nicholas Magliocca, 2012, committee member, UMBC
Garth Linder, 2014, committee member, UMBC
Jonathan Dandois, 2014, committee member, UMBC
Anna Johnson, 2015, committee member, UMBC
Molly Van Appledorn, 2016, Chair, UMBC
Maira Bezerra, 2017, committee member, UMCP

Mariya Shcheglovitova, 2020, committee member, UMBC
Peter Chirico, PhD candidate, committee member, UMBC
Dorothy Bowory, PhD candidate, committee member, UMBC
April Sparkman, PhD candidate, committee member, UMBC
Peter Claggett, 3rd year, Chair, UMBC
Alex Rittle, PhD candidate, Chair, UMBC
Adam Dixon, PhD candidate, committee member, UMBC
Gina Lee, PhD candidate, committee member, UMBC
Ohad Paris, 3rd year, committee member, UMBC
Ben Daniels, 2nd year, committee member, UMBC

MASTER'S STUDENTS

Kristi Green, 2008, committee member, USU
S. Kirk Dahle, 2009, committee member, USU
Molly Van Appledorn, 2009, Chair, USU
Andrew Hill, 2010, Co-Chair, USU
Amanda Schulz, 2010, Co-Chair, USU
Jennifer Li, 2011, committee member, UMBC
Mattie Whitmore, 2011, Co-Chair, UMBC
Matthew Panunto, 2012, Chair, UMBC
Christina Simini, 2012, Chair, UMBC
Daniel Jones, 2013, Co-Chair, UMBC
Haley Martin, 2013, Co-Chair, UMBC
Mitchell Donovan, 2014, committee member, UMBC
Christopher Zink, 2014, Chair, UMBC
Janet Fairbank, 2014, Chair, UMBC
Michael Glassman (withdrew 2015), Chair, UMBC
Alex Martin, 2016, committee member, UMBC
Charles Wahl, 2015, committee member, UMBC
Katherine Ralston, 2017, Chair, UMBC
Marina Metes, 2018, committee member, UMBC
Zach Clifton, 2018, Chair, UMBC
Rikke Jepsen, 2018, committee member, UMBC
Daniel Cunningham, 2019, committee member, UMBC
Hayley Oakland, 2020, Chair, UMBC
Beatriz Shobe, 2nd year, committee member, UMBC
Kaitlyn Holtsclaw, 2nd year, Chair, UMBC
Michelle, Katoski, 1st year, Chair, UMBC
Nicati Robidoux, 1st year, Chair, UMBC

UNDERGRADUATE STUDENTS

Santiago Muevar, Research Assistant, 2018, UMBC
Ryan Woolbridge, Research Assistant, 2018, UMBC
Kristian Nelson, Research Assistant, 2018, UMBC
Chiamaka Chuckwuma, Research Assistant, 2018, UMBC
Carly Toulon, Research Assistant, 2018, UMBC
Jessica Whitacre, Research Assistant, 2018, UMBC
Adam Segal, Research Assistant, 2018, UMBC
Juan Camacho, Research Assistant, 2017, UMBC
Michelle Katoski, Research Assistant, 2017-2018, UMBC
Siarah Beall, Research Assistant, 2017, UMBC
Jaelyn Bos, Research Intern 2017, UMBC
Dan Cunningham, Research Intern 2015, UMBC
Alyssa Houde, Research Intern 2015, UMBC
Parker Damm, Research Intern 2015, UMBC
Ellen Woytowitz, Research Intern 2015, UMBC
Jaelyn Bos, Research Intern 2015, UMBC
Meghna Bhatt, Research Assistant 2014-2015 UMBC
Briana Diacopopulous, Research Assistant 2014-2015 UMBC
Zach Clifton, Research Assistant 2014-2015 UMBC
Jaelyn Bos, Research Intern 2014-2015 UMBC
Patrice Matthews, Service Learning Intern, 2013, UMBC
Gabrielle Filippi, Service Learning Intern 2012, UMBC
Matthew Schley, URA advisee, 2012-2013, UMBC
Matthew Schley, Research Intern, Fall 2011, UMBC
Haley Martin, Research Intern, Spring 2010, UMBC
Matthew Schley, Research Fellow, Spring 2010, UMBC
Sean Kain, Research Technician, Spring-Summer 2009, Mentor, UMBC
Doug Call, Research Intern, Summer 2002, mentor, UVA
James Graves, Research Intern, Summer 2002, Mentor, Earlham College
Kristina Herz, Research Intern, Summer 2003, Mentor, PSU
Michael Marshall, Research Intern, Summer 2003, Mentor, Clark University
Medora Hackler, Research Intern, Summer 2004, Mentor, Sweet Briar College

PUBLICATIONS, PRESENTATIONS, and CREATIVE ACHIEVEMENTS

PEER-REVIEWED WORKS

Package TITAN2; Threshold Indicator Taxa Analysis (v2.2), published on the Comprehensive R Analysis Network (CRAN), December 2019: https://cran.r-project.org/web/packages/TITAN2/index.html

*Articles (co-lead in bold, *student author)*

2020

49. Pickett, ST, et al. 2020. Theoretical perspectives of the Baltimore Ecosystem Study: conceptual evolution in a social-ecological research project. Bioscience (*in press*).

2019

48. Baker, ME, ML Schley*, JO Sexton. 2019. Impacts of expanding impervious surface on specific conductance in urbanizing streams. Water Resources Research https://doi.org/10.1029/2019WR025014.
47. Van Appledorn* M, ME Baker, AJ Miller. 2019. Empirical evaluation of 2D unsteady hydraulic models for applications in floodplain forest ecology. Physical Geography https://doi.org/10.1080/02723646.2019.1676186.
46. Phillips* T, M Baker, K Lautar, I Yessalonis, M Pavao-Zuckerman. 2019. The capacity of urban forest patches to infiltrate stormwater is influenced by soil physical properties and soil moisture. Journal of Environmental Management 246: 11-18.
45. Macchi, L, C Levers, M Baumann, M Baker, T Kummerle. 2019. Satellite-based tree and shrub cover reveal thresholds in bird community in the South American dry Chaco. J. Applied Ecology.
44. Van Appledorn* M, ME Baker, AJ Miller.2019. River-valley morphology, basin size, and flow-event magnitude interact to produce wide variation in flooding dynamics. Ecosphere 10(1):e02546.

2017

43. Dandois*, J, M Baker, M Olano, G Parker, E Ellis. 2017. What is the Point? Using Computer Vision Point Clouds to Observe Vegetation Structure and Spectral Properties. Remote Sensing *9*(4), 355; doi:10.3390/rs9040355.
42. Collins, MJ, NP Snyder, G Boardman, WSL Banks, M Andrews, ME Baker, M Conlon, A Gellis, S McClain, A Miller, P Wilcock. 2017. Channel response to sediment release: insights from a paired dam-removal analysis. Earth Surface Processes and Landforms 10.1002/esp.4108.

2016

41. Donovan* M, AJ Miller, ME Baker. 2016. Reassessing the role of milldams in Piedmont floodplain development and remobilization. Geomorphology 268:133-145.
40. Utz, R, K Hopkins , L Beesley, D Booth , R Hawley , ME Baker, M Freeman, and K Jones. 2016. Do specific natural watershed and channel attributes confer ecological resistance to urbanization in streams? Freshwater Science 35(1):380-397.
39. Lallement* M, P Macchi, P Vigliano, S Juarez, M Baker, N Bouwes, T Crowl. 2016. Rising from the ashes: changes in salmonid fish assemblages after 30 months of the Puyehue-Cordon Caulle volcanic eruption. Science of the Total Environment 541:1041-1051.

2015

38. Koch, BJ, CM Febria, RM Cooke, JD Hosen*, ME Baker, MA Palmer. 2015. Suburban watershed nitrogen retention: estimating the effectiveness of stormwater management structures. Elementa 3:63 doi: 10.12952/journal.elementa.000063.

37. Smith, R, PD Venugopal, ME Baker, and WO Lamp. 2015. Regional and local processes structure a stream insect metacommunity in a partially urbanized landscape. Freshwater Biology doi: 10.1111/fwb.12605.
36. Dandois*, JP, D. Nadwodny*, E. Anderson*, A. Bofto*, ME Baker, and EC Ellis. 2015. Forest census and map data for two temperate deciduous forest edge woodlot patches in Baltimore MD, USA. Ecology 96(6):1734-1734.
35. Suding, K, E Higgs, M Palmer, JB Callicott, CB Anderson, ME Baker, JJ Gutrich, KL Hondula, MC LaFevor, BMH Larson, A Randall, JB Ruhl, KZS Schwartz. 2015. Committing to ecological restoration. Science 348(6235):638-640
34. Donovan, M*, AJ Miller, ME Baker, and A Gellis 2015. Long-term sediment erosion from Mid-Atlantic tributaries of Chesapeake Bay. Geomorphology DOI: 10.1016/j.geomorph.2015.01.025.
33. Jacinthe PA, P Vidon, K Fisher, X Liu, ME Baker. 2015. Soil Methane and Carbon Dioxide Fluxes from Cropland and Riparian Buffers in Different Hydrogeomorphic Settings. Journal of Environmental Quality 44(4):1080.

2014

32. Jones, DK*, ME Baker, AJ Miller, T Jarnigan, and DM Hogan. 2014. Tracking geomorphic signatures of watershed suburbanization with multi-temporal LiDAR. Geomorphology 219:42-52.
31. Liu, X*, P Vidon, P Jacinthe, K Fisher*, M Baker. 2014. Seasonal and geomorphic controls on N and P removal in riparian zones of the US Midwest. Biogeochemistry 19(1):245-257
30. Fisher, K*, Jacinthe PA, P Vidon, X Liu*, M Baker. 2014. Nitrous oxide emission from cropland and adjacent riparian buffers in contrasting hydrogeomorphic settings. Journal of Environmental Quality. 43:338-348.
29. Vidon, P, P Jacinthe, X Liu*, K Fisher*, M Baker. 2014. Hydrobiogeochemical controls on riparian nutrient and greenhouse gas dynamics: 10 years post-restoration. Journal of the American Water Resources Association 50(3):639-652.
28. Weller, DE and ME Baker. 2014. Cropland riparian buffers throughout Chesapeake Bay watershed: spatial patterns and effects on nitrate loads delivered to streams. Journal of the American Water Resources Association 50(3):696-710.

2013

27. Vidon, P, Mitchell C.P.J., Jacinthe P.A., Baker M., Liu X.*, and Fisher K.* 2013. Mercury Dynamics in Groundwater across Three Distinct Riparian Zones of the US Midwest. Environmental Science: Process and Impacts 15(11), 2131-2141.
26. Baker, ME and RS King. 2013. Of TITAN and straw men: an appeal for greater understanding of community data. Freshwater Science 32(2):489-506.
25. Sexton, JO, X-P Song*, C Huang, ME Baker, and JR Townshend. 2013. Urban growth of the Washington, D.C – Baltimore, MD metropolitan region from 1984 to 2010 by annual continuous fields of impervious cover. Remote Sensing of the Environment 129:42-53.

2012

24. Ramsey, RD, CM McGinty, JH Lowry*, EI Leydsman-McGinty*, L.A Langs* Stoner, BA Crabb*, WA Adair*, A Hernandez*, ME Baker, JC Schmidt, M Majerova, B

Hudson, and AK Montrone. 2012. Grand Teton National Park and John D. Rockefeller, Jr. Memorial Parkway: Natural resource condition assessment. Natural Resource Report NPS/GRYN/NRR—2012/550. National Park Service, Fort Collins, Colorado.

23. Studds, C, WV Deluca*, ME Baker, RS King, and PP Marra. 2012. Land cover and climatic variation interact to shape waterbird community composition. PLoS ONE 7(4):e35969.
22. Lowry, JH*, DR Ramsey and ME Baker. 2012. Determinants of urban tree canopy in residential neighborhoods: Household characteristics, urban form, and geophysical landscape. Urban Ecosystems doi: 10.1007/s11252-011-0185-4.

2011

21. Tesfa, T*. DG Tarboton, DW Watson, KA Schreuders, ME Baker, RM Wallace. 2011. Parallel evaluation of a class of new topographic variables fro distributed hydrological modeling. Environmental Modeling and Software doi:10.1016/j.envsoft.2011.07.018
20. Budy, P, K Dahle* and ME Baker. 2011. Predicting Fish Growth Potential and Identifying Water Quality Constraints: A Spatially-Explicit Bioenergetics Approach. Environmental Management doi: 10.1007/s00267-011-9717-1.
19. King, RS, ME Baker, PF Kazyak, and DE Weller. 2011. How novel is too novel? Stream community thresholds at exceptionally low levels of watershed urbanization. Ecological Applications doi: 10.1890/10-1357-1.
18. Weller, DE, **ME Baker**, and TE Jordan. 2011. Empirical tests for effects of riparian buffers on watershed nitrate discharges. Ecological Applications doi:10.1890/10-0789-1.
17. King, RS and **ME Baker**. 2011. An alternative view of ecological community thresholds and appropriate analyses for their detection. Comment. Ecological Applications doi:10.1890/10-0882- 1.

2010

16. King, RS and **ME Baker**. 2010. Considerations for identifying and interpreting ecological community thresholds. Journal of the North American Benthological Association 29(3):998-1008.
15. **Baker ME** and RS King. 2010. A new method for identifying and interpreting ecological community thresholds. Methods in Ecology & Evolution 1:25-37.

2009

14. Stanfield, LW, B Kilgour, K Todd, S Holysh, A Piggott, and ME Baker. 2009. Estimating summer low- flow in streams of the Oak Ridges Moraine ecoregion using spatial models. Canadian Water Resources Journal 34(3):269-284.
13. Baker, ME and MJ Wiley. 2009. Multiscale controls of flooding in riparian forests of Lower Michigan. Ecology 90(1):145-159.

2008

12. Baker, ME, MJ Wiley, and PW Seelbach. 2008. Map-based predictions of riparian ecotopes: relating climate and hydrology to streamside forests in Lower Michigan. Michigan Department of Natural Resources, Fisheries Technical Report 2008-2, Ann Arbor.

2007

11. Baker, ME, DE Weller, and TE Jordan. 2007. Effects of stream map resolution on measures of riparian buffer distribution and nutrient retention potential. Landscape Ecology 22:973-992.

2006

10. Baker, ME, DE Weller, and TE Jordan. 2006. Improved methods for quantifying potential nutrient interception by riparian buffers. Landscape Ecology 21(8):1327-1345.
9. Baker, ME, DE Weller, and TE Jordan. 2006. Comparison of automated watershed delineations: effects on land cover areas, percentages, and relationships to nutrient discharges. Photogrammetric Engineering & Remote Sensing 72(2):159-168.

2005

8. King, RS, ME Baker, DF Whigham, DE Weller, TE Jordan, PF Kazyak, and MK Hurd. 2005. Spatial considerations for linking watershed land cover to ecological indicators in streams. Ecological Applications 15(1):137-152.

2004

7. King, RS, J Beaman, DF Whigham, AH Hines, ME Baker, and DE Weller. 2004. Watershed land use is strongly linked to PCBs in white perch from Chesapeake Bay subestuaries. Environmental Science and Technology 38:6546-6552.
6. Baker, ME and MJ Wiley. 2004. Characterization of woody species distribution in riparian forests of Lower Michigan using map-based models. Wetlands 24(3):500-561.

2003

5. Baker, ME, MJ Wiley, PW Seelbach, and ML Carlson. 2003. A GIS-based index of groundwater potential for aquatic resource inventory, assessment, and environmental management. Environmental Management 32:706-719.
4. Baker, ME, MJ Wiley, and PW Seelbach. 2003. Spatially-explicit models of groundwater loading in glaciated landscapes: considerations and development in Lower Michigan. Fisheries Research Report No. 2064, Michigan Department of Natural Resources, Ann Arbor.

Pre-2002

3. Baker, ME, MJ Wiley, and PW Seelbach. 2001. GIS-based hydrologic modeling of riparian areas: implications for stream water quality. Journal of the American Water Resources Association 37(6): 1615-1628.
2. Baker, ME and BV Barnes. 1998. Landscape ecosystem diversity of river floodplains in northwestern Lower Michigan, USA. Canadian Journal of Forest Research 28:1405-1418.
1. Seelbach, PW, MJ Wiley, JC Kotanchik and ME Baker.1997. A landscape-based ecological classification system for river valley segments in Lower Michigan. Fisheries Research Report No. 2036, Michigan Department of Natural Resources, Ann Arbor.

Peer-reviewed Book Chapters

5. King, RS and ME Baker. 2014. Use, misuse, and limitations of Threshold Indicator Taxa Analysis (TITAN) for estimating ecological community thresholds. In: G. Guntenspergen (editor), *Application of Threshold Concepts in Natural Resource Decision Making,* Springer, New York.
4. Tarboton, DG and ME Baker. 2008. Toward an algebra for terrain-based flow analysis. Chapter 12 in N. Mount, G. Harvey, G. Priesthall, and P. Apin. (eds). Representing, Modelling, and Visualizing the Natural Environment. Innovations in GIS series. CRC Press-Taylor & Francis, London.
3. Gregory, S, A Allen, M Baker, K Boyer, T Dillaha, and J Elliott. 2007. Realistic expectations of timing between conservation and restoration actions and ecological responses. In M. Schnepf (ed.), Managing Agricultural Landscapes for Environmental Quality. Soil and Water Conservation Society.
2. Seelbach, PW, MJ Wiley, ME Baker, and KE Wehrly. 2006. Initial Classification of river valley segments across Michigan's Lower Peninsula. Chapter 1 in RM Hughes, L Wang, and PW Seelbach, editors. Influences of landscape on stream habitats and biological assemblages. American Fisheries Society Symposium 48:25-48.
1. Crow, TR, ME Baker, and BV Barnes. 2000. Diversity in riparian landscapes. In ES Verry, JW Hornbeck, and CA Dollloff (eds.) Riparian Management in Forests of the Continental Eastern United States. Lewis Publishers, New York.

Conference Proceedings

2. Tarboton, DG, KAT Schreuders, DW Watson, and ME Baker. 2009. Generalized terrain-based flow analysis of digital elevation models. 18th World IMACS/MODSIM Congress, Cairns, Australia, July 2009.
1. Nielson, BT, C. Bandaraogoda, ME Baker, JS Horsburgh, DK Stevens. 2009. Watershed modeling for water quality trading. Proceedings of the AWRA summer specialty conference, Snowbird, Utah, June 2009.

NON-PEER-REVIEWED WORKS

2. Morzillo, AT, JW Hollister, CA Drew, ME Baker, JM Bossenbroek, ME Rocca, and C Mazzarella. 2008. A young scientist's guide to gainful employment: recent graduates' experiences and successful strategies. Bulletin of the Ecological Society of America 89(2):193-203.
1. Wiley, MJ and ME Baker. 1997. Fish assemblage structure in relation to macro-habitat (valley segment) units in Lower Michigan. The Nature Conservancy, Freshwater Initiative.

WORKS SUBMITTED OR IN PREPARATION

Submitted for Publication:

Bezerra*, M, M Baker, M Palmer, S Filoso. *(in revision)*. Sugarcane agriculture exacerbates gully formation in headwater catchments in Brazil. Physical Geography.

In Preparation

Baker ME, J Bos*, and RS King. (*in prep*). Reconsidering taxon-specific contributions to measures of community change: updates to Threshold Indicator Taxa Analysis. Freshwater Science.

Baker ME, I Yessalonis, K Lautar, and Nancy Sonti. (*in prep*) Mapping the forest for the trees: understanding the socio-ecological significance of urban woodlands. Landscape Ecology

Baker ME and DS Rich (*in prep*) Observations regarding the causal consequences of mountaintop mining. Environmental Science & Technology.

Baker ME, J Bos*, and RS King. (*in prep*). Reconsidering taxon-specific contributions to measures of community change: updates to Threshold Indicator Taxa Analysis. Freshwater Science.

Van Appledorn* M and ME Baker. (*in prep*). Regional correspondence of woody riparian plant functional traits subject to different flood regimes. Freshwater Biology.

Van Appledorn* M and ME Baker. (*in prep*). Regional patterns of flood regime across the conterminous United States. Water Resources Research.

Van Appledorn* M, AJ Miller, and ME Baker. (*in prep*). Differentiation of functional traits along flood regime gradients reveal role of hydraulic signals in structuring floodplain forests. Ecology.

Oakland* H, CM Swan, and ME Baker. (*in prep*). Regional variation in meta-community response to local stream environments. Ecography.

PRESENTATIONS

Presentations and Posters (Non-juried/Refereed)

Baker ME and D Saavedra. 2019. Development and application of automated channel extraction from LiDAR in Chesapeake Bay Watersheds. Society for Freshwater Science, May 2019, Salt Lake City Utah.

Oakland, H, M Baker, and S Kroll. 2019. Assessing aquatic habitat in stream restorations using low altitude remote imagery. Society for Freshwater Science, May 2019, Salt Lake City Utah.

Baker, ME, A Miller, S Van Ryswick, E Boyd, M Cashman, M Collins, M Andrews. Tracing geomorphic change and downstream progress of sediment released by removal of Bloede Dam, Patapsco River, Maryland. American Geophysical Union, December 2018, Washington, DC.

Baker, ME. Assessing causality in stream assessment and restoration: a case study in Appalachian surface mining. Invited speaker, Smithsonian Environmental Research Center, November 2018.

Baker ME and D Saavedra. 2018. Development of automated channel extraction from LiDAR in Chesapeake Bay Watersheds. American Water Resources Association,

November 2018, Baltimore Maryland.

Baker, ME. What We Have Learned About Baltimore's Forests. Oral Presentation for Baltimore's Fantastic Forest Forum, Cylburn Arboretum, November 2017, Baltimore MD.

Rittle, A, M Baker, M Cashman, and A Miller. Workflow Evaluation of Error and Distortion in SfM-Derived Point Clouds in Fluvial Environments. Oral Presentation for the American Geophysical Union. Dec 2017. New Orleans, LA.

Baker, ME, D Jones, E Woytowitz, A Miller. Alternative models of hydrogeomorphic connectivity in urbanizing Piedmont landscaps. Society for Freshwater Science Annual Meeting. May, 2017. Raleigh, NC.

Rittle, A, ME Baker, and AJ Miller. A UAV-SfM Approach fro extracting Channel Bathymetry and Fluvial Features. Oral Presentation for the American Association of Geographers. April 2017. Boston, MA.

Clifton, Z and ME Baker.Assessing the limits of aerial detection of floodplain sediment storage via multi-temporal LiDAR. Oral Presentation for the US- International Association for Landscape Ecology Annual Symposium. April 2017. Baltimore, MD.

Van Appledorn, M and ME Baker. Incorporating 2D hydraulic modeling in floodplain ecosystem investigation. Oral Presentation for the US- International Association for Landscape Ecology Annual Symposium. April 2017. Baltimore, MD.

Van Appledorn, M and ME Baker. Flooding does not always constrain riparian species composition: evidence of environmental filtering and limiting similarity in floodplain forests. Oral Presentation for the US- International Association for Landscape Ecology Annual Symposium. April 2016. Ashville, NC.

Van Appledorn, M and ME Baker. Flooding does not always constrain riparian species composition: evidence of environmental filtering and limiting similarity in floodplain forests. Oral Presentation for the Ecological Society of America Annual Meeting. August 2015. Baltimore, MD.

Baker, ME. Landscape approaches to nutrient and sediment management in streams: past research and future directions . *Invited presentation* Society for Freshwater Science Annual Meeting. May, 2015. Milwaukee, WI.

Van Appledorn, M and ME Baker. Quantifying hydrologic and functional diversity of riparian forest ecosystems in Maryland: towards a more mechanistic understanding of abiotic-biotic interactions for cost-effective restoration. Invited Oral Presentation for the Chesapeake Modeling Symposium. May 28-29, 2014. Annapolis, MD.

Baker, ME. Taxon-specific contributions to community change: updates to Threshold Indicator Taxon Analysis. Oral Presentation for the Joint Aquatic Science Meetings. May, 2014. Portland, OR.

Van Appledorn, M and ME Baker. Regional comparison of flood regimes and functional trait distributions. Oral Presentation for the Joint Aquatic Science Meetings. May, 2014. Portland, OR.

Baker, ME. Impacts of urbanization on stream conductance over 25 years. Oral Presentation for the Society for Urban Stream Ecology. May, 2014. Portland, OR

Van Appledorn, M and ME Baker. A comparison of functional trait distributions among riparian floodplain landforms. Oral Presentation for the Ecological Society of America Annual Meeting. August, 2013. Minneapolis, MN.

Van Appledorn, M and ME Baker. A comparison of functional trait distributions of riparian plant species from floodplain landscapes in Michigan and Maryland. Poster Presentation for the US- International Association for Landscape Ecology Annual Symposium. April, 2013. Austin, TX.

Baker, ME and RS King. Reconciling perspectives of community change: refinements to Threshold Indicator Taxa Analysis. North American Benthological Society (NABS), Louisville, KY, June 2012.

King, RS and ME Baker. Multiple lines of evidence of nonlinear ecological community response to novel environmental gradients. North American Benthological Society (NABS), Louisville, KY, June 2012.

Van Appledorn, M. and M.E. Baker. Evaluating the role of environmental controls on riparian plant communities: relative importance of climate and hydrologic processes varies by riparian plant community type. US-International Association for Landscape Ecology Annual Symposium. April, 2012. Newport, RI.

Baker, ME and JC Schmidt. Some Implications of recent climate change in Grand Teton National Park. 2012 US-IALE Annual Meeting, Newport Rhode Island.

VanAppledorn M and ME Baker. Evaluating the role of environmental controls on riparian plant communities: relative importance of climate and hydrologic processes varies by riparian plant community type. . 2012 US-IALE Annual Meeting, Newport Rhode Island.

Panunto MH and ME Baker. River Network Path-Dependence: effects of valley segment sequencing on floodplain hydroperiods. . 2012 US-IALE Annual Meeting, Newport Rhode Island.

VanAppledorn M and ME Baker. How do longitudinal patterns of in-channel sediment transport relate to floodplain heterogeneity. 2011 US-IALE Annual Meeting Portland, OR.

Panunto MH and ME Baker. Effect of valley segment sequencing on floodplain hydroperiod. 2011 US-IALE Annual Meeting Portland, OR.

Baker, ME, RS King, and PF Kazyak. 2010. Strikingly consistent biodiversity losses to watershed impervious cover across taxonomic groups revealed by Threshold Indicator Taxa Analysis (TITAN). ALSO/NABS Joint Meeting, Santa Fe, NM.

Weller, DE, ME Baker, and TE Jordan. 2010. Nitrate removal by riparian buffers and in-stream processes in Chesapeake Bay Catchments. ALSO/NABS Joint Meeting, Santa Fe, NM.

King, RS and ME Baker. 2010. Considerations for analyzing ecological community thresholds in response to anthropogenic environmental gradients. ALSO/NABS Joint Meeting, Santa Fe, NM.

Baker ME and RS King 2010. A new method for detecting biodiversity and ecological community thresholds. US-IALE Annual Meeting Athens, GA.

VanAppledorn M and ME Baker. New software tools for strategic prioritization of riparian coservation and restoration. 2010 US-IALE Annual Meeting Athens, GA.

Panunto M and ME Baker. Using a hydrogeomorhic typology to understand distributions of riparian buffers in Central Indiana. US-IALE Annual Meeting Athens, GA.

Van Appledorn M and ME Baker 2009 Effects of relative wetness on riparian buffers potential in Maryland. NABS Grand rapids, MI.

Baker, ME, DE Weller, TE Jordan 2009 Effects of riparian buffers on watershed nitrate discharges: new models and m management implications. NABS annual meeting, Grand Rapids, MI.

King RS and ME Baker. 2009. Threshold Indicator Taxa Analysis (TITAN): a new method for detecting biodiversity and ecological community thresholds NABS, Grand Rapids, MI.

Van Appledorn M and ME Baker 2009 Effects of relative wetness on riparian buffers potential in Maryland. IALE Annual meeting, Snowbird, UT.

Weller, DE, ME Baker, and TE Jordan Effects of riparian buffers on watershed nitrate discharges: new models and m management implications. IALE Snowbird, UT.

Baker ME and RS King Threshold Indicator Taxa Analysis (TITAN): a new method for detecting biodiversity and ecological community thresholds IALE ,Snowbird, UT.

Weller, DE, ME Baker, and TE Jordan Effects of riparian buffers on watershed nitrate discharges: new models and m management implications. EBM Baltimore, MD.

Baker, ME, DE Weller, TE Jordan New tools for measuring the effects of riparian buffers. EBM Baltimore, MD.

Baker, ME and DG Tarboton. Generalized models of flow across terrain using digital elevation models. American Geophysical Union, San Francisco, CA December 2008.

Van Appledorn, M and ME Baker. A Comparison of Riparian Restoration Strategies for Water Quality Improvement within and Among Watersheds. AWRA Summer specialty conference Virginia Beach, VA June 2008.

Boomer K, DE Weller, ME Baker, and TE Jordan. Using Fine-Resolution Topography Data to Infer Groundwater Flowpaths and Denitrification Potential in Riparian Wetlands in the Chesapeake Bay Watershed. AWRA Summer specialty conference Virginia Beach, VA June 2008.

Van Appledorn, M and ME Baker. A simulation comparing spatially-explicit riparian restoration strategies for water quality improvement within and among watersheds. International Association of Landscape Ecology (US-IALE), Madison, WI, April 2008.

Baker, ME and DG Tarboton. New approaches for representing uncertainty in watershed connectivity. International Association of Landscape Ecology (US-IALE), Madison, WI, April 2008.

Tarboton, DG, KA Schreuders, ME Baker. New TauDEM tools for deriving hydrologic information from digital elevation models. AWRA 2008 Spring Specialty Conference, San Mateo, CA, March 2008.

Tarboton, DG, ME Baker, KA, Schreuders. Terrain analysis and the modeling of catchment architecture. European Geophysical Union, Vienna, Austria, April 2008.

Baker, ME, MJ Wiley. Using structural equations to explore multi-scale predictions of riparian hydrology. ***Invited***: North American Benthological Society (NABS), Columbia, SC, May 2007.

Baker, ME, MA White, DE Weller, TE Jordan. Using land surface phenology to explore the effects of landscape and riparian features on nutrient discharges in tributary watersheds of Chesapeake Bay. International Association of Landscape Ecology (US-IALE), Tucson, AZ, April 2007.

White, MA, ME Baker, DE Weller, TE Jordan. Land surface phenology in eastern United Stated watersheds: relationships between remote sensing metrics, stream chemistry,

snow cover, and leaf and bird phenology. American Geophysical Union, Sand Francisco, CA.

Baker, ME, DE Weller, TE Jordan. Effects of Stream Map Resolution on Measures of Riparian Buffer Distribution and Nutrient Retention Potential. American Geophysical Union, Baltimore, MD May 2006.

Baker, ME, DE Weller, TE Jordan. Watershed-scale thresholds in the potential effectiveness of riparian buffers. US-IALE, San Diego, CA, March, 2006.

Baker, ME, DE Weller, TE Jordan. Transport-distance effects in regional predictions of nitrate discharge: implications for nitrogen transformation. NABS/AGU Joint Session, New Orleans, LA, June 2005.

Baker, ME, DE Weller, TE Jordan. Improved methods for quantifying patterns of riparian buffers US-IALE, Syracuse, NY, April, 2005.

Baker, ME, DE Weller, TE Jordan. Effect of within-watershed land cover arrangement on nutrient discharge. NABS, Vancouver, BC, June 2004.

Baker, ME, DE Weller, TE Jordan. Landscape-level effects of riparian buffers: considering spatial configuration and hydrologic routing in geographic predictions of nutrient discharge. US-IALE, Las Vegas, NV, April, 2004

Baker, ME, DE Weller, TE Jordan. Landscape-level effects of riparian buffers: considering spatial configuration and hydrologic routing in geographic predictions of nutrient discharge. ***Invited***: Soil Science Society of America, Denver, CO, October, 2003.

Baker, ME, DE Weller, TE Jordan. The effect of distance-weighted source areas in geographic predictions of nutrient discharge from coastal-plain watersheds. NABS, Athens, GA, May, 2003.

Baker, ME, DE Weller, TE Jordan. The effect of distance-weighted source areas in geographic predictions of nutrient discharge. US-IALE, Banff, Alberta, Canada, April, 2003.

Baker, ME, MJ Wiley. Climatic and hydrologic influences on the spatial variation of riparian forests. NABS, Pittsburgh, PA, May 2002.

Baker, ME, MJ Wiley, PW Seelbach. GIS-based modeling of riparian hydrology and stream water quality. US-IALE, Lincoln, NE, April 2002.

Baker, ME, MJ Wiley. Predicting spatial variation in riparian hydrology and forest composition across Lower Michigan. US-IALE, Tempe, AZ, April 2001.

Baker, ME, MJ Wiley. Using GIS-based models to understand riparian function and forest composition. 62nd Midwest Fish and Wildlife Conference, Minneapolis, MN, December 2000.

Baker, ME, MJ Wiley. Predicting the structure and function of riparian ecosystems. AWRA conference on Riparian Ecology and Management, Portland, OR, July 2000.

Baker, ME, MJ Wiley, PW Seelbach. GIS modeling of potential groundwater sources to rivers. IMAGINE GIS conference, Lansing, MI, May 2000.

Baker, ME, MJ Wiley, PW Seelbach. A spatially-explicit groundwater model for river and watershed management. US-IALE, Ft. Lauderdale, FL, April 2000.

Baker, ME, BV Barnes, LE Cablk. Considering the diversity of river valley and wetland ecosystems in both regional and local contexts. ***Invited***: The role of embedded wetlands in an upland matrix. Ecological Society of America, Baltimore, MD, July 1998.

Baker, ME, BV Barnes. Landscape controls on riparian ecosystems. 59th Midwest Fish and Wildlife Conference, Milwaukee, WI, December 1997.

Other Professional Presentations

Baker, ME. 2014. Impacts of development on Ten Mile Creek. Testimony before the Montgomery County Council. Jan-Feb. Rockville, MD

Baker, ME. 2010. Opportunities at the interface of hydrology and ecology. National Research Council's Committee on Challenges and Opportunities in the Hydrologic Sciences. National Academy of Sciences, Washington DC, Invited Speaker, Sept 9th, 2010.

Baker ME and RS King 2009 Threshold Indicator Taxa Analysis (TITAN): a new method for detecting biodiversity and ecological community thresholds. Fall BES meeting, Baltimore, MD.

Baker ME and RS King 2009 Threshold Indicator Taxa Analysis (TITAN): a new method for detecting biodiversity and ecological community thresholds. EPA Regional Stormwater meeting, Edison NJ.

Media Activities

Chicago Tribune. Sept 5th, 2018: http://www.chicagotribune.com/sns-drones-to-track-one-of-the-largest-dam-removals-on-the-eastern-seaboard-100071-20180905-story.html

US News & World Report, Sept 5th, 2018: https://www.usnews.com/news/best-states/articles/2018-09-05/commentary-drones-to-track-one-of-the-largest-dam-removals-on-the-east-coast

The Conversation, Sept 5th, 2018: http://theconversation.com/drones-to-track-one-of-the-largest-dam-removals-on-the-eastern-seaboard-100071

Technical.ly, July 24, 2018: https://technical.ly/baltimore/2018/08/24/a-new-mapping-effort-will-provide-a-closer-look-at-the-streams-that-feed-the-chesapeake-bay/

NPR Here and Now, April 13th 2017: http://www.npr.org/2017/04/13/522607589/in-coal-country-environmental-regulations-are-creating-jobs

Ohio Valley Resource, March 31st, 2017: http://ohiovalleyresource.org/2017/03/31/restoration-scientists-concerns/

Charleston Gazette-Mail, January 4th, 2017: http://www.wvgazettemail.com/news-cops-and-courts/20170104/us-court-upholds-mountaintop-removal-pollution-ruling

Bay Journal, December 2016:

http://www.bayjournal.com/article/baltimore_group_can_see_the_urban_forests_amid_the_trees

Washington Post, February 4th 2014: http://www.washingtonpost.com/local/md-politics/council-members-push-proposal-to-sharply-limit-new-construction-in-ten-mile-creek/2014/02/03/a40c6cd0-8d3b-11e3-98ab-fe5228217bd1_story.html

WYPR Maryland in the Morning with Shelia Kast, February 10, 2010: http://mdmorn.wordpress.com/2010/02/09/210102-measuring-the-biological-effects-of- development/

Environmental Protection online, February 4th, 2010: http://eponline.com/articles/2010/02/04/ecologists-create-a-more-precise-way-to-measure-human- impacts.aspx

Baltimore Sun, B'more Green with Meredith Cohn, February 3rd, 2010: http://weblogs.baltimoresun.com/features/green/2010/02/new_way_found_to_tell_when_spe.html

Science Centric, February 3rd, 2010: http://www.sciencecentric.com/news/10020331-researcher- develops-new-method-detecting-biodiversity-losses.htm

B,more media interview with Walaika Haskins, February 1st, 2010:http://www.bmoremedia.com/innovationnews/umbcecologist020210.aspx

Legal Activities (in which I have been deposed or provided expert testimony)

1. IRS easement assessment (146 Tax Court No. Docket 5445-13, Baltimore, MD)

2. *Ohio Valley Environmental Coalition v. Fola Coal,* (S.D. W.Va. 2:13-21588) Liability

3. *Ohio Valley Environmental Coalition v. Fola Coal,* (S.D. W.Va. 2:13-5006) Remedy

4. *Ohio Valley Environmental Coalition v. Fola Coal*, (S.D. W.Va. 2:13-21588) Remedy

5. *Ohio Valley Environmental Coalition v. Fola Coal*, (S.D. W.Va. 2:15-1371) Liability

6. *Canaan Christian Church and Burtonsville Crossing, LLC and Burtonsville Associates, LLC and Jennifer M. Sarem and Marion G. Sarem v. Montgomery County, Maryland and Montgomery County Council and Isiah Leggett*, (MD Case No.:16-cv-03698-TDC)

Courses Taught

Workshop: Threshold Indicator Taxa Analysis (TITAN) and analysis of biological community data in R. Society for Freshwater Science: Mid-Atlantic Chapter, January 30th, 2015, Philadelphia, PA.

Workshop: Threshold Indicator Taxa Analysis (TITAN) and analysis of biological community data in R. Association of Mid-Atlantic Aquatic Biologists, March 27th-28th, 2014, Berkeley Springs, WV.

Workshop: Statistical Workshop for water resource managers: Analysis of biological community data in R. New England Association of Environmental Biologists, March 25-26th, 2014, Burlington, VT.

Workshop: R statistical computing and training and Threshold Indicator Taxa Analysis (TITAN). New England Association of Environmental Biologists, March 19-20th, 2013, Lake Placid, NY.

Workshop: 2011. R statistical computing and Threshold Indicator Taxa Analysis (TITAN). USGS New England Water Resource Center. Feb.

Workshop: 2010. R statistical computing and Threshold Indicator Taxa Analysis (TITAN). USGS Maryland-Delaware-Virginia Water Resource Center. Oct.

Geography and Environmental Systems (UMBC) 405 Applied Landscape Ecology

Geography and Environmental Systems (UMBC) 110 Physical Geography

Geography and Environmental Systems (UMBC) 404 Forest Ecology

Geography and Environmental Systems (UMBC) 419 Watershed Analysis and Modeling

Geography and Environmental Systems (UMBC) 319 Watershed Science and Management

Geography and Environmental Systems (UMBC) 400 Ecology and Management of Riparian Ecosystems

Geography and Environmental Systems (UMBC) 602 Research Methods

Geography and Environmental Systems (UMBC) 689 Departmental Seminar

Watershed Sciences (USU) 4930/6920 Geographic Information Science.

Watershed Sciences (USU) 6200 Watershed Analysis.

Watershed Sciences (USU) 5640 Riparian Ecology and Management.

Watershed Sciences (USU) 5490 Small Watershed Hydrology, Guest lectured on GIS applications in hydrology and watershed modeling.

Environment and Society (USU) 6200 Bioregional Analysis and Planning, Guest lectured on analysis and assessment of watershed hydrology, four 2-hr class periods.

Natural Resources and Environment (UMich) 511 Introduction to Aquatic Ecosystems, TA responsible for laboratory content delivery, taught 5-hr laboratory sections and led field trips for two semesters.

Natural Resources and Environment (UMich) 435 Forest Ecology, TA and assisted in content delivery, taught field laboratory section.

Natural Resources and Environment (UMich) 337/437 Biology and Identification of

Woody Plants, TA, fully responsible for two 5-hr field laboratory sections, taught 4 semesters.

Environmental Law Program (Vermont Law School) Watershed Management and Protection, TA developed and delivered field laboratory for a capstone course.

Maine Conservation School, Forest Ecology and Limnology, assisted in developing content, fully responsible for instruction to high-school and continuing education students

SERVICE TO THE DEPARTMENT, UNIVERSITY, COMMUNITY, and PROFESSION

SERVICE TO THE DEPARTMENT

2018-19 Human Geography Search Committee, GES, UMBC

2016-17 Chair, GIS/Geovisualizaton Search Committee, GES, UMBC

2015-present Undergraduate Committee, GES, UMBC

2015-2016 Graduate Committee, GES, UMBC

2015-present Graduate Program Director, MPS in GIS program

2011-present GES P&T Committee

2011-2019 Chair, GIS committee, GES, UMBC

2014-15 GIS Search Committee, GES, UMBC

2012-13 Chair, Biogeography Search Committee, GES, UMBC

2012-13 Human Geography Search Committee, GES, UMBC

2012-2013 Writing Across the Geography Curriculum committee, GES, UMBC

2010-2014 Graduate Committee, GES, UMBC

2010-11 Human Geography Search Committee, GES, UMBC

2009-2011 GIS Committee, GES, UMBC

2008-9 Environmental Policy Search Committee, GES, UMBC

2008-present Undergraduate Advisor, GES, UMBC

2008 Watershed Management Faculty Search Committee, WATS, USU

2008 Instructor of record, Graduate Student Seminar, GES, UMBC

2005-8 Undergraduate Advisor, Dept. of Watershed Sciences, USU

2005-8 Graduate Affairs Committee, Dept. of Watershed Sciences, USU

SERVICE TO THE UNIVERSITY

2019 Member, Search Committee, UMBC Athletic Director

2017-present	Faculty Athletic Representative to the NCAA, UMBC
2017-present	Athletic Policy Committee, UMBC
2016-2017	Vice President, Faculty Senate, UMBC
2016-2017	Executive Committee, UMBC
2016-2017	University Steering Committee, UMBC
2016-2017	Academic Programming and Budget Committee, UMBC
2015-present	Co-Chair, Climate Action Steering Committee, UMBC
2015-present	CERA steering committee, UMBC
2014-2018	ILSB Research Technical Advisory Committee, UMBC
2012-2016	Co-Chair, Course Evaluation Implementation Committee, UMBC
2012-2013	Executive Committee, UMBC
2012-2013	Chair, Faculty Affairs Committee, UMBC
2012	Faculty Development Center, Search Committee, UMBC
2011-14	iCubed Faculty Mentor
2011-2013	Faculty Affairs Committee, UMBC
2006-8	Chair, Information Technology Committee, College of Natural Resources, Utah State University
2000-1	Dean Search Committee, School of Natural Resources and Environment, U. of Michigan
1998-2001	Newcomb Tract Caretaker, School of Natural Resources & Environment, U. of Michigan
1997-9	Graduate Student Representative, School of Natural Resources & Environment, U. of Michigan
1997-8	Ecosystem Management Committee, , School of Natural Resources & Environment, U. of Michigan

SERVICE TO THE COMMUNTIY

2016-2018	Advisory Committee, Baltimore Green Network Plan
2014-2017	Technical Review Committee, Anne Arundel County Biological Monitoring and Assessment Program
2012-present	Advisor, Baltimore Greenspace
2001-08	Member, Science Advisory Council, The Nature Conservancy Emiquon Floodplain Restoration Project
2001-05	Member, Board of Directors. The Lake Michigan Federation (Now Alliance

for the Great Lakes)

SERVICE TO THE PROFESSION

2019	Promotion & Tenure Review (University of Connecticut)
2018	Promotion & Tenure Review (Vassar College)
2018-present	Associate Editor, Freshwater Science
2016	Promotion & Tenure review (University of Maryland, College Park)
2016	Promotion & Tenure review (University of Michigan)
2016-2017	Local Host, 2017 Annual Meeting, International Association of Landscape Ecology (IALE), U.S. Chapter
2015-2018	International Association of Landscape Ecology (IALE), U.S. Chapter: Executive Board
2015	Promotion & Tenure review (University of Maryland, Center for Environmental & Estuarine Science)
2014	Convening Co-Chair, Special Session: Modeling and mapping spatiotemporal patterns of stream biodiversity in the Chesapeake Bay watershed. Chesapeake Research Consortium Modeling Symposium, Annapolis, MD
2013	Promotion & Tenure review (Pennsylvania State University)
2010-2016	IALE, U.S. Chapter: Site Selection Committee
2010-2011	National Academy of Sciences, National Research Council, Challenges and Opportunities in the Hydrologic Sciences, Contributor
2009-10	National Science Foundation Doctoral Dissertation Improvement Grant Panel
2008-10	International Association of Landscape Ecology (IALE), U.S. Chapter: Executive Board
2008-10	IALE, U.S. Chapter: Chair-Site Selection Committee
2006	Convening Chair, AGU Special Session: Interactions between Watershed Characteristics, Stream Dynamics, and Water Quality, Baltimore, MD
2005-08	American Geophysical Union, Water Quality Committee
2003-05	IALE, U.S. Chapter: Strategic Planning Review Committee

Ad Hoc Reviewer for:

American Fisheries Society; American Geophysical Union; Aquatic Ecology; Biological

Conservation; Biological Invasions; CALFED Ecosystem Restoration Program; CALFED Science Program; Ecology; Chesapeake Bay Trust; Conservation Biology; Delaware SeaGrant; Ecography; Ecological Applications; Ecological Engineering; Ecological Indicators; Ecological Monographs; Ecological Restoration; Ecology; Ecosphere; Ecosystems; Environmental Management; Environmental Modeling & Software; Environmental Monitoring & Assessment; Environmental Reviews; Environmental Science: Processes & Impacts; Environmental Science & Technology; Fisheries Management & Ecology; Freshwater Biology; Freshwater Science; Geomorphology; Hydrobiologia; Hydrological Processes; International Journal of Applied Earth Observation and Geoinformation; International Journal of the Digital Earth; Journal of the American Water Resources Association; Journal of Applied Ecology; Journal of Applied Geography; Journal of Ecology; Journal of Environmental Management; Journal of Forestry; Journal of Hydrology; Journal of the North American Benthological Society (now Freshwater Science); Journal of Urban Ecology; Journal of Vegetation Science; Landscape Ecology; Limnology and Oceanography; Methods in Ecology & Evolution; Michigan SeaGrant; National Science Foundation; New Phytologist; Photogrammetric Engineering & Remote Sensing; PLoS One; Proceedings of the National Academy of Sciences; Restoration Ecology; Science of the Total Environment; Urban Forestry and Urban Greening; US Geological Survey; Water Research; Water Resources Research; Wetlands

This document contains explanations of the materials reviewed by Dr. Baker in his letter which is attached to our comment letter as Exhibit A:

In the Record/IEPA documents

- **Anti-Degradation Document.pdf** *This is the Nov. 18, 2016 Antidegradation Assessment Report submitted by Williamson Energy to IEPA.*
- **PondCreekPermit2005.pdf** *This is the mine's current permit issued June 28, 2005.*
- **IEPA_AmbientWQData.xlsx** ***IEPA*** *Ambient Water Quality network results for stream segments N-11, N-12, and NH-06, retrieved by FOIA through request on Nov. 14, 2019 and received on Nov. 22, 2019.*
- **Comment and Request for Hearing on NPDES Permit No. IL0077666, Notice No. 7516c, Williamson Energy, LLC, Pond Creek Mine.pdf** *This is the August 12,2019 letter to IEPA from Sierra Club and Prairie Rivers Network.*
- **USGS gauge and water quality records for #05599490 Big Muddy River at RTE 127 at Murphysboro from Jan 2016 to Nov 2019** *These records are available online at USGS and include dissolved oxygen and conductivity data.*
- **IEPA water quality records for Segment N-11, NG-05** *These include data sets we received from IEPA records.*
- **Big Muddy River (N) 2000.pdf** *This is the IEPA report AN INTENSIVE SURVEY OF THE BIG MUDDY RIVER BASIN: Data Summary Summer 2000, June 2003. We received this report from IEPA on Dec. 18, 2019 in response to our FOIA request of Dec. 3, 2019.*
- **Pond Creek mine outfall.pdf** *This is a map prepared by Prairie Rivers Network showing existing and proposed outfalls for the Pond Creek and Sugar Camp mines at their operations and on the Big Muddy River.*
- **WaterData_Bugs_Fish_BigMuddy_N_PondCr_NG_ToCindySkrukrud_2020_01_10.xlsx** *These are data received from IEPA Ambient Water Quality Monitoring Program in response to the FOIA request by Cindy Skrukrud on Dec. 3, 2019 and received on Jan. 10, 2020.*
- **Set of Pond Creek FOIA Documents** *These are all documents that Sierra Club copied in its review of the Pond Creek NPDES file at IEPA offices on August 12, 2019. These materials were made available to us from our July 24, 2019 FOIA:*
    - 12.12.16AD&QBELPdCrMine_08122019114439.PDF
    - Application 7-18-18 Ownership&ViolationsPCmine_08122019101005.PDF
    - Gh2oPCmine_08122019100223.PDF
    - Gh2oPCmine_08122019100359.PDF
    - Gh2oPCmine_08122019100529.PDF
    - GH20pondck_08122019102002.PDF
    - GH20pondck_08122019102029.PDF
    - GH20pondck_08122019102230.PDF
    - OwnershipPdCrMine_08122019111909.PDF
    - RDA2PdCrMine_08122019113337.PDF
    - ResptoIEPAonRDA3PdCrMine_08122019113730.PDF
    - T&ERDA3PdCrMine_08122019114056.PDF
- **Detailed Facility Report _ ECHO _ US EPA.pdf** is Exhibit_R Detailed Facility Report _ ECHO _ US EPA.pdf
- **NACL Proposal 2019.docx** *These are the proposed changes to the Illinois chloride water quality standards that were proposed in* Exhibit_C 18-32 Amended Petition TECHNICAL SUPPORT DOCUMENT SUPPLEMENT 2 20 2019.pdf

901 Glencastle Way
Raleigh, NC 27606
January 15, 2020

Mr. Albert Ettinger
53 W. Jackson #1664
Chicago, Illinois

Dear Mr. Ettinger,

In response to your request made on behalf of the Sierra Club, I am sending these comments about draft NPDES Permit No. IL0077666 for Williamson Energy, LLC's Pond Creek Mine. As background, there were 47 permitted coal mines in the Big Muddy River watershed as of about 15 years ago (IEPA 2004). About 88% of the Upper Big Muddy River watershed has an annual minimum water table depth of 79 centimeters (~31 inches) or less, and in about 20% of the watershed the annual minimum water table depth is only 15 centimeters (~6 inches), with hydric soils (LimnoTech 2018). Thus, coal mining operations in this watershed threaten both surface water and groundwater with contamination from mining wastes.

The permit includes three new alkaline discharges from sediment pond operation and maintenance, the focus of these comments, by the Pond Creek Mine: outfalls 011, 009, and 009ES. Outfall 011 would discharge to stream segment N-11 of the Big Muddy River. That entire stream segment is on the Illinois draft 2016 303(d) list of impaired waters for aquatic life use (low dissolved oxygen [DO], iron, pH, total suspended solids [TSS], sedimentation/siltation); mercury and PCBs (fish consumption); and fecal coliforms (primary contact recreation).

The other two proposed outfalls would drain from a new refuse disposal area with sediment basin. Outfall 009 would discharge to Pond Creek (tributary of Big Muddy River segment N-11). Outfall 009ES would discharge to an unnamed tributary of Pond Creek that already receives discharges from the mine's outfalls 001, 002, 003, 004, 005, 006, 007, and 008. The entire length of Pond Creek is on the state's 2016 draft 303(d) list, including the stream segment (NG-02) that would receive the discharges from outfalls 009 and 009ES. Coal mining and agriculture are the major land uses in the watershed (Carpenter et al. 2018). Both streams are impaired for aquatic life use (alteration in stream-side or littoral vegetative cover, changes in stream depth and velocity patterns, loss of instream cover, chlorides, low DO, and sedimentation/siltation) (IEPA 2019). While mercury contamination is not listed as a cause of impairment to Pond Creek or the unnamed tributary, IEPA (2004) has described mercury contamination via atmospheric deposition as an interstate/international issue affecting many Illinois waters. The Illinois Department of Public Health (2019) has posted fish consumption advisories due to mercury contamination for the "Big Muddy River and Tributaries" in Franklin and Williamson Counties (which include Pond Creek and the unnamed tributary) as well as six other counties in the Big Muddy River watershed. Thus, mercury contamination is affecting Pond Creek and its unnamed tributary, as well as the Big Muddy River. The following comments emphasize Big Muddy River segment N-11, but the issues and the underlying science are also applicable to the Pond Creek and unnamed tributary segments that would be affected by the permitted discharges.

A. *The high chloride and sulfate concentrations added to the water column of the substantial mixing zones would significantly increase mercury release from the sediments and, in turn, increase the potential for mercury contamination and toxicity to fish and other beneficial aquatic life.* These effects would occur because there are strong chemical interactions between the overlying water and the sediments (Wetzel 2001). Mercury contamination is already contributing to the

degradation of this stream segment (IEPA 2016).

Elevated chloride – An abrupt, pronounced increase in mercury release from the sediments of aquatic systems has been reported, as a conservative estimate, when chloride (Cl^-) concentrations reach or exceed 2×10^{-2} M (709 mg/L) (Wang 1991). The dramatic mercury release with increasing chloride has been attributed to the dissolution of adsorbed mercury through its complexation with chloride. The IEPA is considering a permit level of 500 mg chloride/L outside the mixing zones, within the same order of magnitude as the threshold value of 709 mg/L for major mercury release from the sediments. The mining company would be allowed to discharge up to 12,000 mg chloride/L at the point of discharge to the Big Muddy River (maximum volume allowed – 5,000 gallons per minute). More than 90% of the total mercury present in the water and sediments generally is sorbed onto and held in the sediments (Wang 1991 and references therein). As mercury is already contributing to degradation of this segment, appreciable mercury can be expected to have accumulated over time in the sediments. The substantial mixing zone for the Big Muddy River that would be allowed by this permit, encompassing up to $1/4^{th}$ the river volume in the area, and the high chloride concentration discharged, would result in major mercury release from the sediments throughout the mixing zone. Some of that mercury would be moved by currents beyond the mixing zone. Pond Creek segment N-2 and the unnamed tributary, receiving effluents from outfalls 009 and 009ES respectively, would also be permitted at 500 mg chloride/L along with a mixing zone for outfall 009 (IEPA 2019), and would be similarly impacted.

The threshold value for major mercury release from the sediments may be substantially lower: In other work (Farrell et al. 1990), the fraction of total mercury-II (Hg^{+2}) bound in the form of chloro-complexes increased as the chloride concentration of the water increased; and the total toxic activity of the mercury chloro-complexes increased as a near-linear function of the total chloride concentration – but there was no significant increase in the mole fraction until the total chloride concentration was 10^{-3} M (35 mg chloride/L). The data again suggested a threshold for mercury release, at 35 mg chloride/L; this concentration corresponded to the chloride level at which significant decreases, related to mercury toxicity, were observed in growth of the test organisms. The permit level of chloride under consideration by IEPA, 500 mg chloride/L (outside mixing zones) would be more than 10-fold higher than that estimated threshold.

Elevated sulfate – High inputs of sulfate to the overlying water can also stimulate methyl-mercury production and release from anoxic sediments (Gilmour et al. 1992, Benoit et al. 1999, Jeremiason et al. 2006). Bacterial sulfate reduction and mercury methylation in freshwater sediments are strongly related (Gilmour et al. 1992); mercury methylation is dependent on sulfate availability (as an electron acceptor) because sulfate-reducing bacteria mediate the biotic methylation of mercury (Mitchell et al. 2008). There is feedback inhibition, wherein the high pore-water sulfide concentrations that can result from rapid sulfate reduction (see section E below) can inhibit mercury methylation (Gilmour et al. 1992 and references therein). The bacteria involved in mercury methylation under high sulfate conditions also require sufficient organic carbon (Gilmour et al. 1992, Harmon et al. 2004, Mitchell et al. 2008), which would be supplied by the organic carbon in the anoxic sediments and the decomposition of dead and dying aquatic organisms in the mixing zones (outfalls 011, 009).

B. *The mine discharges at outfalls 011, 009, and 009ES will exacerbate the TSS conditions in the receiving streams.* Excessive total suspended solids are already contributing to the degradation of these stream segments.

For all streams and rivers in the Upper Big Muddy River watershed, IEPA has developed a loading reduction strategy target of 32.2 mg/L (IEPA 2016), or 39.3% TSS reduction (LimnoTech

2018). These targets were based on an average of what were described as "validated, real-world data (1999-2013) for the nearby Upper Kaskaskia watershed, which [still] contains several streams that are in full support of aquatic life." Pond Creek segment NG-02 has an even higher loading reduction strategy target of 62.7% TSS reduction (Limnotech 2018). Yet, the effluent standards for TSS in mine drainage are established pursuant to 35 Ill. Adm. Code 406.106 (Illinois Pollution Control Board 2019), which allow 35 mg TSS/L. In the permit IEPA applies the statute as a "30-day average" without indicting the number of samples that will be taken per month (at least three are required; 35 Ill Adm. Code 304.104). This allows for much larger concentrations over a monthly period as long as the average is *35 mg TSS/L*. The daily maximum – outside the mixing zones (also for outfall 009ES) – is double the value in the mine drainage statute, *70 mg TSS/L*, as allowed by statute (35 Ill Adm. Code 304.104). It is noteworthy that the same approach is applied by IEPA to iron and manganese, effectively doubling the concentrations stated as acceptable in statute 35 Ill. Adm. Code 406.106.

Many adverse impacts on stream ecosystems have been documented from excessive suspended sediment loading, including marked effects on fish and macroinvertebrate diversity and abundance (e.g., Newcombe and MacDonald 1991, Wood and Armitage 1997, and references therein). The extent of the impacts on aquatic life strongly depends on the TSS concentration x the duration of exposure (Newcombe and MacDonald 1991). Macroinvertebrates, zooplankton sensitive fish species, and other beneficial organisms can be stressed or killed at ~25-30 mg TSS/L depending on the environmental conditions, and if subjected to such concentrations for hours to days. In allowing a daily concentration of up to 70 mg TSS/L, there is no evidence that IEPA considered the need to protect aquatic biota during critical conditions such as reproductive and recruitment periods (e.g., see Sweeten and McCreedy 2002).

C. *Harmful toxigenic cyanobacteria will have a competitive advantage over other algae in the environmental conditions created by the Pond Creek Mine's alkaline effluent, including high specific conductance, high chloride, and enhanced phosphorus (P) release from the sediments.* Cyanobacteria also generally have high tolerance for limited light and toxic heavy metals relative to other algae.

The Pond Creek Mine alkaline waste effluent discharged at the three proposed new outfalls and existing outfalls would have elevated concentrations of salts with strong bases and carbonates. The resulting elevated chloride/salinity and alkalinity are characteristic of rivers and streams affected by what has come to be called the *freshwater salinization syndrome* (Kaushal et al. 2018). A major cause of this syndrome is alkaline coal mine wastes, and a major symptom is contaminant mobilization (e.g., mercury as noted above).

Pertinent to benthic cyanobacteria, high concentrations of sulfate and chloride have been shown to enhance phosphorus release from the sediments (Caraco et al. 1993, Zak et al. 2006, Jin et al. 2013). Most toxigenic cyanobacteria are "phosphorus loving" (Burkholder 2009 and references therein) – that is, they have high P optima and would be expected to be stimulated by the enhanced sediment P release. The hypoxic conditions that are contributing to the degradation of this stream segment (IEPA 2016) would further enhance sediment P release (Carlton and Wetzel 1988, Stumm and Morgan 1995).

Various toxic cyanobacteria have also been shown to be capable of withstanding major increases in salinity as influx of chloride salts. For example, growth rate and toxin production of freshwater *Microcystis aeruginosa* were unaffected by salinity levels up to nearly 1/3rd strength seawater (salinity 10), and *M. aeruginosa* could withstand short-term salinity shock up to half-strength seawater (salinity 17.5) (Tonk et al. 2007). In other research, *M. aeruginosa* tolerated salinities as high as 14 (Verspagen et al. 2006). Additional studies demonstrated that several tested freshwater

and brackish cyanobacteria taxa were more salinity-tolerant (up to salinities of 15-20) than other co-occurring algae (Moisander et al. 2002). In laboratory experiments with freshwater and brackish cyanobacteria, inorganic nitrogen supplies (nitrate or ammonium) or organic nitrogen as glutamate significantly enhanced salt tolerance (Reddy et al. 1989). These nitrogen substances inhibited sodium influx, thought to be a major mechanism involved in cyanobacteria tolerance of substantial salinities (Reddy et al. 1989).

Cyanobacteria additionally tend to have high tolerance for limited light in comparison to many other algae (Graham et al. 2016 and references therein), as well as high tolerance of toxic heavy metals (Baptista and Vasconcelos 2006, Cassier-Chauvat and Chauvat 2015, Shilpi et al. 2015). They also have effective mechanisms that enable them to avoid washout in river environments, and they can thrive along the river bottom during high-flow conditions (Quiblier et al. 2013, McAllister et al. 2016). These traits collectively give cyanobacteria major advantages over other algae in freshwaters affected by coal mining alkaline effluents (e.g., Valkanas and Trun 2018). The Pond Creek Mine's alkaline effluent will promote their growth over other, beneficial algae.

D. *Fauna that die in the substantial mixing zone of the Big Muddy River*, the smaller mixing zone of Pond Creek, and the outfall area of the unnamed tributary, *will increase biochemical oxygen demand and exacer-bate the low dissolved oxygen conditions* both in this stream segment and in downstream waters. Low-oxygen conditions are already contributing to the degradation of these stream segments.

A wealth of peer-reviewed science publications have documented "devastating effects" on aquatic communities from coal mine waste pollution, whether the effluent is added continuously or episodically (e.g, Maccausland and McTammany 2007, Bier et al. 2015, Giam et al. 2018, and references therein). Many biota (invertebrates, fish, salamanders, etc.) are killed outright in areas affected by the discharged effluent, and their taxonomic richness and abundance are significantly depressed as a long-term outcome (Giam et al. 2018). The resulting biochemical oxygen demand for decomposition of these organisms will exacerbate the low dissolved oxygen conditions that are already contributing to the degradation of these three stream segments, in and downstream from the mixing zones (outfalls 011, 009) and discharge area (outfall 009ES).

E. *The permit mistakenly asserts that the highly toxic coal mine effluent will not cause <u>any</u> long-term impacts. The writing does not account for* (i) *the effects of chloride and sulfate on mercury (see part A, above); and* (ii) *the substantial resuspension/downstream movement of pollutants, which <u>will</u> promote chronic physiological stress, disease, and death of sensitive biota* both within the mixing zones/discharge area and well beyond them.

Intermittent riverine resuspension of pollutants is recognized as such a "common, ubiquitous" reality (Kleeberg et al. 2013) that books have been written about it (e.g., Van Rijn 1993, Westrich and Förstner 2007), and studies have tracked toxic contaminant movement downstream in rivers via resuspension of settled materials (e.g., Theis et al. 1988, Jamieson et al. 2005, Schneider et al. 2007). Despite this wealth of peer-reviewed, published science, the permit section entitled "Fate and Effect of Parameters Proposed for Increased Loading" does not make a science-based assessment of either the fate or the effects of the mining pollutants considered, nor can this information be found elsewhere in the permit. The writing states (pp.15, 17):

> Chloride and sulfates would remain dissolved in the water and would move through the downstream continuum. Manganese, iron, nickel, copper, and total suspended solids will most likely settle and become part of the bed sediment.... Because of the near-real-time continuous monitoring of upstream and down-

> stream conditions in the receiving stream, and the ability of the permittee's diffuser to adjust to flow and background concentration conditions, discharges will always [emphasis added] be into a waterbody that is below water quality standards and in concentrations and flow combinations that will not cause or contribute to an exceedance downstream of the mixing zone. No adverse impacts [emphasis added] to streams would occur as all water quality standards are expected to be met in the receiving water....The proposed activity will result in only short-term, temporary increases in pollutant loading [emphasis added] and will not result in long-term or permanent impacts to existing uses including aquatic life habitat.

Corrective information is provided as follows:

- The permit writing asserts that [all of the] chloride and sulfates will remain dissolved in the water and "move through the downstream continuum" without mention of any ill effects. The well-established reality instead is that there are strong chemical interactions between the overlying water and the stream sediment pore waters. That is, in part, why high chloride and high sulfate promote toxic mercury release from the sediments (section A, above).

  ** Based on a review of chloride fate and transport in watersheds, streams, and lakes, once added to streams, (i) much of the chloride moves from the overlying water into sediment pore water (Kennedy et al. 1984; also see Lerman and Weiler 1970, Effler et al. 1990, Besser et al. 2009); there it undergoes a large suite of competitive equilibrium reactions with ionic mercury species (making toxic mercury more bioavailable; see section A of this letter and supporting references therein) and other metals; and (ii) some of the chloride, still in the overlying water, is moved downstream by currents (Ward et al. 2013). Analogously as for chloride movement through soils in watersheds, initial pore-water concentrations (from the water column) in streams and lakes can be elevated near the sediment surface (Lerman and Weiler 1970, Effler et al. 1990, Lax and Peterson 2008). Within chloride-unsaturated sediments, chloride moves mostly vertically downward through the sediments, driven by diffusion. As high loading to the overlying water continues, the pore water becomes a long-term chloride source to sub-surface groundwater (decades; Lax and Peterson 2008, Kelly et al. 2012 and references therein).

  It should be noted that much of the high sulfate added to the overlying water ***also*** moves into the pore water (e.g., see Ng et al. 2017 and references therein), where it promotes toxic methylmercury production (see Section A of this letter) and toxic hydrogen sulfide production (below), can be directly toxic to biota (Elphick et al. 2011), etc.

  ** *High concentrations of sulfate in the water*, such as those that would be allowed by the permit in all three affected stream segments, *lead to* ***production of hydrogen sulfide*** *in the sediments* (Stumm and Morgan 1995, Bernhardt and Palmer 2011). This occurs because the elevated water-column sulfate concentrations will stimulate microbial sulfate reduction in the sediments: the microbes use sulfate (SO_4^{-2}) instead of oxygen (which is not available in anoxic sediments, or sparse in hypoxic sediments) in their consumption of organic matter. The sulfur (S) in the sulfates is converted to sulfide (HS^-), then to hydrogen sulfide (H_2S). Hydrogen sulfide is toxic to many organisms, from plants and other beneficial aquatic life to humans (Lamers et al. 1998, Bagarinao 1992, Reiffenstein et al. 1992). It has been implicated in mass mortalities of fish and other aquatic life (Bagarinao 1992 and references therein).

  ** In addition to being directly toxic under some conditions (Elphick et al. 2011), *the high*

sulfate will also promote eutrophication through ***phosphorus release*** *from the sediments* of the three streams (Bernhardt and Palmer 2011, and references therein): Sulfide binds strongly with iron in sediments and converts it to pyrite minerals, which is beneficial in reducing bioavailable iron; but much of the phosphorus in freshwaters is bound to iron minerals. In the high-sulfide surficial sediment environment resulting from the high water-column sulfate, the sulfide interferes with the iron-P bonds so that phosphorus is released to the water column (Caraco et al. 1989, 1993). By this mechanism, high sulfate additions to the overlying water is known to promote eutrophication of freshwaters (van der Welle et al. 2008, Myrbo et al. 2017).

- The permit *guestimates* (p.15) that "manganese, iron, nickel, copper, and TSS will most likely settle and become part of the bed sediment in the river." Peer-reviewed science has shown that at least a portion of the toxic heavy metals (e.g., cadmium, manganese, zinc, nickel) and TSS in alkaline mine waste effluent settle out and become embedded within the microbial biofilm matrix at the sediment/water interface (Bier et al. 2015). The permit writing indicates no consideration for resuspension/downstream movement of that "bed sediment" in the three affected streams.

- The permit writing, assuring readers of "near-real-time continuous monitoring upstream and downstream", is *highly misleading because only flow (upstream) and one chemically related parameter (conductivity) will be monitored continuously* upstream and downstream from the three outfalls (IEPA 2019). ***Most parameters will not be monitored adequately for assessment of compliance*** (see, e.g., Robertson and Roerish 1999, Stansfield 2001):

  ** The only information given about continuous (if that is the meaning of the permit writing, "full flow measurement", which is not clear) flow is that, "the upstream flow should be based on the full flow measurement upstream of the proposed outfall 011 that shall be approved by the Agency".

  ** Metals in the discharges at the three outfalls, other than iron, will be monitored ***twice per year and only total concentrations*** will be measured. Regarding the latter point, *dissolved concentrations* are generally much more important for assessment of toxicity to aquatic biota, not total. Thus, it is not possible from the extremely sparse data (2 samples over an entire year) to gain insight about the threat of these metals to beneficial aquatic organisms.

  ** Sulfate and dissolved iron will be monitored from the effluent ***monthly*** when discharging.

  ** *There is no requirement to monitor chloride at any of the three outfalls. Instead, chloride will be* calculated from conductivity data taken by two conductivity meters, one installed upstream, the other downstream from each outfall. The calculated value would be the only requirement in discharge monitoring reports. The conductivity meters are described as continuously monitoring, but no information is given as to the data collection frequency. Furthermore, the permit provides no information about the equation selected to derive calculated chloride values from conductivity data (for example, no information to address the question of how statistically strongly conductivity is correlated with chloride along the concentration gradient). The permit also provides no information science literature in support of the selected equation, or whether a robust background dataset was used to customize it for the Big Muddy River prior to applying the equation.

  ** Upstream from the discharge areas, the three streams will be monitored ***once per year,***

and only for discharge rate, sulfate, chloride, and hardness (exceptions: flow and conductivity as described above).

** Downstream from the discharge area, the river will be monitored ***four times per year***, and only for discharge rate, sulfate, chloride, and hardness (exception – conductivity data as described above). Moreover, the permit provides steps that the mining company could take to request reduction or elimination of any downstream monitoring requirements.

** Other mention of continuous monitoring in the permit writing (p.13) was that during operations of the pipeline, continuous flow monitors would be installed to provide protection against leakage.

** No information was included in the permit about the frequency of monitoring TSS upstream or downstream of discharge locations, or in the effluents. "Monthly averages" must be based on at least three samples over a monthly period (35 Ill Adm. Code 304.104).

- The permit writing provides unrealistic assurances that (i) there will never be any violations of the water quality standards. Moreover, the writing makes mistaken assurances, without basis in science, that there will be no adverse impacts whatsoever, and no long-term impacts to existing uses including aquatic life habitat.

** The Pond Creek Mine has had numerous previous violations of water quality standards (e.g., excessive iron, chloride, and manganese; see https://echo.epa.gov/detailed-facility-report?fid=IL0077666). Why, from now on, should IEPA or readers of the permit believe that the mine operation will be "perfect"?

** As stated, a large body of peer-reviewed science repeatedly has shown that coal mine effluents cause major, long-term impacts to receiving waters in degraded water quality; otherwise-degraded habitats; physiological stress, disease, and death of beneficial aquatic life; and replacement of those organisms with highly tolerant, noxious, usually undesirable taxa (e.g., see Maccausland and McTammany 2007, Giam et al. 2018). Considering the scientific information presented above, there is no question but that the mine's discharged effluent will cause or contribute to further degradation of the Big Muddy River.

F. *Interactive effects of some pollutants, and enhanced bioavailability in low-oxygen conditions characteristic of the three affected stream segments, have not been considered* in the permit.

Coal mine alkaline effluent contains many toxic contaminants other than those considered for regulation in the three streams by this permit, such as antimony, arsenic, barium, cadmium, chromium, cobalt, lead, manganese, nickel, phenols, selenium, silver, and zinc (Watzlaf et al. 2004). Many metals in the above list are essential micronutrients, but become toxic at concentrations higher than needed for normal growth (Nies 1999). Others (e.g., cadmium and lead) have no known beneficial role in biota and are toxic even at extremely low concentrations (Rand and Petrocelli 1995). Toxic metals – including the substantial mercury that will be released from the sediments in and around the mixing zones (above) – and other substances are known to act additively or synergistically (Marking et al. 1977), yet none of these serious impacts were addressed in the permit. The following examples illustrate the high potential for synergistic and additive, adverse effects to beneficial aquatic life in the three stream segments affected by mining waste contamination from outfalls 009, 009ES, and 011:

- *Additive, adverse effect of [chloride + sulfate]* – The acute toxicity of chloride and sulfate ($NaCl + Na_2SO_4$) mixtures to juvenile unionid mussels in hardwaters (within the range

characteristic of the river segment affected by the Pond Creek Mine discharge) significantly increased with sulfate additions at or above 350 mg/L (Wang et al. 2018). The permit allows single values for sulfate as high as 2,120 mg/L (IEPA 2019, p.14). The fatmucket mussel species tests is reported to occur in the Big Muddy River drainage (Shasteen et al. 2012). The lower range of EC50s (median effective concentration, that is, the concentration expected to produce death or other effect in 50% of the test population) for fatmucket glochidia (sensitive larval stage) was reported at 441 mg chloride/L. The permit allows for chloride concentrations outside the mixing zones as high as 500 mg/L (IEPA 2019). These data indicate that permit levels derived individually for chloride or sulfate will not be protective at moderate to high, co-occurring concentrations of the two ions. Additive toxicity of NaCl + Na_2SO_4 mixtures has also been reported from acute toxicity testing with the zooplankter *Ceriodaphnia dubia* (Erickson et al. 2017).

- *Synergistic, adverse effect of [nickel + mercury]* on the fatty acid composition of fish muscle tissues (Senthamilselvan et al. 2016). This impact is germane given that the body burden of mercury in fish already warrants warnings against human consumption and is a cause of degradation for listing the Big Muddy River – segment N-11 on Illinois' 303(d) list. According to IEPA (see https://www2.illinois.gov/epa/topics/water-quality/watershed-management/tmdls/Pages/303d-list.aspx), this river segment has been so listed for the past decade, indicating that substantial mercury contamination has occurred, ongoing.

- *Synergistic, adverse effect of [chromium + mercury]* on the histology and physiology of fish (Dwivedi et al. 2012). This impact is germane as explained above.

Such information helps to explain the recent finding that one coal mine constitutes a regional source of stress to stream fish assemblages: Daniel et al. (2015) tested threshold responses of fish metrics to coal and mineral mine densities. As expected, increased mine densities were associated with declines in multiple fish metrics, and mines had a worse impact on fish communities than other human-related land uses – *and just one mine in a watershed adversely affected fish throughout that watershed.* Synergistic and additive effects of the wide array of toxic pollutants in the effluent discharged to the Big Muddy River, Pond Creek, and the unnamed tributary by the Pond Creek Mine would contribute to this regional effect. That mine is not the only coal mine in the Big Muddy River watershed (e.g., see U.S. Energy Information Administration 2011, 2016). These points underscore the need to have a margin of safety in the permit to account for synergistic and additive impacts of the many pollutants in the mine waste effluents proposed for discharge at outfalls 009, 009ES, and 011 and the existing mine outfalls.

Overall, in view of the issues raised above, it is my opinion that the proposed discharge to Big Muddy River segment N-11, Pond Creek segment NG-02, and the unnamed tributary to Pond Creek by the Pond Creek Mine would increase levels of toxic mercury to the detriment of fish consumption and public health; increase levels of harmful algae to the detriment of swimming and other recreational uses; and cause major harm to aquatic life, long-term.

Sincerely,

JoAnn M. Burkholder

JoAnn M. Burkholder, Ph.D.
William Neal Reynolds Distinguished Professor

References Cited

Bagarinao, T. (1992) Sulfide as an environmental factor and toxicant: tolerance and adaptations in aquatic organisms. *Aquatic Toxicology* 24: 21-62.

Baptista, M.S. and M.T. Vasconcelos (2006) Cyanobacteria metal interactions: requirements, toxicity, and ecological implications. *Critical Reviews in Microbiology* 32: 127-137.

Benoit, J.M., C.C. Gilmour, R.P. Mason, and A. Heyes (1999) Sulfide controls on mercury speciation and bioavailability to methylating bacteria in sediment pore waters. *Environmental Science and Technology* 33: 951-957.

Bernhardt, E.S. and M.A. Palmer (2011) The environmental costs of mountaintop mining valley fill operations for aquatic ecosystems of the Central Appalachians. *Ann. NY Acad. Sci.* 1223: 39-57.

Besser, J.M., B. Brumbaugh, and C. Ingersoll (2009) Ecotoxicology studies with sediment, pore water, and surface water from the Palmerton Zinc site. Columbia Environmental Research Center, USGS, Columbia, MO.

Bier, R.L., K.A. Voss, and E.S. Bernhardt (2015) Bacterial community responses to a gradient of alkaline mountaintop mine drainage in central Appalachian streams. *The International Society for Microbial Ecology (ISME) Journal* 9: 1378-1390.

Burkholder, J.M. (2009) Harmful algal blooms, pp. 264-285. In: *Encyclopedia of Inland Waters, Volume 1*, by G.E. Likens (ed.) Elsevier, Oxford, UK.

Caraco, N.F. (1993) Disturbance of the phosphorus cycle – a case of indirect effects of human activity. *Trends in Ecology and Evolution* 8: 51-54.

Caraco, N.F., J.J. Cole, and G.E. Likens (1993) Sulfate control of phosphorus availability in lakes. *Hydrobiologia* 253: 275-280.

Caraco, N.F., J.J. Cole, and G.E. Likens (1989) Evidence for sulphate-controlled phosphorus release from sediments of aquatic systems. *Nature* 341: 316-318.

Carlton, R.G. and R.G. Wetzel (1988) Phosphorus flux from lake sediments: Effect of epipelic algal oxygen production. *Limnology and Oceanography* 33: 562-571.

Carpenter, T., J. Heilman, and C. Nixon (2018) *Pond Creek Watershed Inventory and Assessment.* Report #GERPDC-2018-1113. Greater Egypt Regional Planning and Development Commission, Marion IL.

Cassier-Chauvat, C. and F. Chauvat (2015) Responses to oxidative and heavy metal stresses in cyanobacteria: recent advances. *International Journal of Molecular Sciences* 16: 871-886.

Daniel, W.M., D.M. Infante, R.M. Hughes, Y.-P. Tsang, P.C. Esselman, D Wieferich, K. Herreman, A.R. Cooper, L. Wang, and W.W. Taylor (2015) Characterizing coal and mineral mines as a regional source of stress to stream fish assemblages. *Ecological Indicators* 50: 50-61.

Dwivedi, S., A. Chezhian, N. Kabilan, and T.S. Kumar (2012) Synergistic effect of mercury and chromium on the histology and physiology of fish, *Tilapia mossambica* (Peters, 1852) and *Lates calcarifer calcarifer* (Bloch, 1790). *Toxicology International* 19: 235-240.

Effler, S.W., S.M. Doerr, C.M. Brooks, and H.C. Rowell (1990) Diffusion and accumulation of chloride and sodium in Lake Ontario sediment. *Water, Air, and Soil Pollution* 51: 315-326.

Elphick, J.R., M. Davies, G. Gilron, E.C. Canaria, B. Lo, and H.C. Bailey (2011) An aquatic toxicological

evaluation of sulfate: The case for considering hardness as a modifying factor in setting water quality guidelines. *Environmental Toxicology and Chemistry*, available at https://doi.org/10.1002/etc.363.

Erickson, R.J., D.R. Mount, T.L. Highland, J.R. Hockett, D.J. Hoff, C.T. Jenson, T.J. Norberg-King, and K.N. Peterson (2017) The acute toxicity of major ion salts to *Ceriodaphnia dubia*. II. Empirical relationships in binary salt mixtures. *Environmental Toxicology and Chemistry* 36: 1525-1537.

Farrell, R.E., J.J. Germida, and P.M. Huang (1990) Biotoxicity of mercury as influenced by mercury (II) speciation. *Applied and Environmental Microbiology* 56: 3006-3016.

Giam, X., J.D. Olden, and D. Simberloff (2018) Impact of coal mining on stream biodiversity in the US and its regulatory implications. *Nature Sustainability* 1: 176-183.

Gilmour, C.C., E.A. Henry, and R. Mitchell (1992) Sulfate stimulation of mercury methylation in fresh-water sediments. *Environmental Science and Technology* 26: 2281-2287.

Graham, L.E., J.M. Graham, L.W. Wilcox, and M.E. Cook (2016) *Algae*, 3rd edition. LJLM Press, LLC, Madison (WI).

Harmon, S.M., J.K. King, J.B. Gladden, G.T. Chandler, and L.A. Newman (2004) Methylmercury formation in a wetland mesocosm amended with sulfate. *Environmental Science and Technology* 38: 650-656.

Jamieson, R.C., D.M. Joy, H. Lee, R. Kostaschuk, and R.J. Gordon (2005) Resuspension of sediment-associated *Escherichia coli* in a natural stream. *Journal of Environmental Quality* 34: 581-589.

Jeremiason, J.J., D.R. Engstrom, E.B. Swain, E.A. Nater, B.M. Johnson, J.M. Almendinger, B.A. Monson, and R.K. Kolka (2006) Sulfate addition increases methylmercury production in an experimental wetland. *Environmental Science and Technology* 40: 3800-3806.

Jin, X., Y. He, B. Zhang, Y. Hassan, and K. George (2013) Impact of sulfate and chloride on sediment phosphorus release in the Yangtze Estuary Reservoir, China. *Water Science and Technology* 67: 1748-1756.

Kelly, V.R., G.M. Lovett, K.C. Weathers, S.G. Findlay, D.L. Strayer, D.J. Burns, and G.E. Likens (2008) Long-term sodium chloride retention in a rural watershed: Legacy effects of road salt on streamwater concentration. *Environmental Science and Technology* 42: 410-415.

Kennedy, V.C., A.P. Jackman, S.M. Zand, G.W. Zellweger, and R.J. Avanzino (1984) Transport and concentration controls for chloride, strontium, potassium and lead in Uvas Creek, a small cobble-bed stream in Santa Clara County, California, USA, 1. Conceptual model. *Journal of Hydrology* 75: 67-110.

Kleeberg, A., M. Hupfer, G. Gust, I. Salka, K. Pohlmann, and H.-P. Grossart (2013) Intermittent riverine resuspension: Effects on phosphorus transformations and heterotrophic bacteria. *Limnology and Oceanography* 58: 635-652.

Illinois Environmental Protection Agency (IEPA) (2004) Big Muddy River TMDL Report. Report #IEPA/BOW/04-015. Bureau of Water, IEPA, Springfield, IL.

Illinois Environmental Protection Agency (IEPA) (2016) *Illinois Integrated Water Quality Report and Section 303(d) List, 2016. Clean Water Act Sections 303(d), 305(b) and 314.* Water Resource Assessment Information and List of Impaired Waters Volume I: Surface Water. Illinois Environmental Protection Agency, Bureau of Water, Springfield, IL.

Illinois Environmental Protection Agency (IEPA) (2019) NPDES Permit No. IL0077666 –

Williamson Energy, LLC – Pond Creek Mine. Bureau of Water, Division of Water Pollution Control – Permit Section, IEPA, Springfield, IL.

Illinois Pollution Control Board (2019) Title 35: Environmental Protection; Subtitle D: Mine Related Water Pollution; Chapter 1: Pollution Control Board; Part 406 Mine Waste Effluent and Water Quality Standards. Available at: http://www.ilga.gov/commission/jcar/admincode/035/035004060A01060R.html.

Illinois Department of Public Health (2019) Big Muddy River and Tributaries, including Beaucoup Creek and Little Muddy River – Franklin, Jackson, Jefferson, Marion, Perry, Union, Washington, and Williamson counties – Species and Meal Frequency. Available at: http://www.dph.illinois.gov/topics-services/environmental-health-protection/toxicology/fish-advisories/map/bigmuddy-river-multicounty.

Kaushal, S.S., G.E. Likens, M.L. Pace, R.M. Utz, S. Haq, J. Gorman, and M. Grese (2018) Freshwater salinization syndrome on a continental scale. *Proceedings of the National Academy of Sciences (USA)*, www.pnas.org/cgi/doi/10.1073/pnas.1711234115 .

Lamers, L.P.M., H.B.M. Tomassen, and J.G.M. Roelofs (1998) Biological implications of sulfide in sediment - A review focusing on sediment toxicity. *Environmental Science and Technology* 32: 199-205.

Lax, S, and E. Peterson (2008) Characterization of chloride transport in the unsaturated zone near salted road. *Environmental Geology* 58: 1041-1049.

Lerman, A. and R.R. Weiler (1970) Diffusion and accumulation of chloride and sodium in Lake Ontario sediment. *Earth and Planetary Science Letters* 10: 150-156.

LimnoTech (2018) *Watershed Implementation Plan to Achieve the TMDLs and Load Reduction Strategy in the Upper Big Muddy River Watershed*. Prepared for Illinois EPA. Draft for Public Comment (Oct. 15). LimnoTech, Ann Arbor, MI.

Ludwikowski, J.J. and E.W. Peterson (2018) Transport and fate of chloride from road salt within a mixed urban and agricultural watershed in Illinois (USA): assessing the influence of chloride application rates. *Hydrogeology Journal* 26: 1123-1135.

Marking, L.L., F.M. Mocyer, and J.L. Hamelink (editors) (1977) Method of assessing additive toxicity of chemical mixtures, pp. 99-108. In: *Aquatic Toxicology and Hazard Evaluation*. American Society for Testing and Materials (ASTM) Special Technical Publication. ASTM Memphis, TN.

Maccausland, A. and M.E. McTammany (2007) The impact of episodic coal mine drainage pollution on benthic macroinvertebrates in streams in the Anthracite region of Pennsylvania. *Environmental Pollution* 149: 216-226.

McAllister, T.G., S.A. Wood, and I. Hawes (2016) The rise of toxic benthic *Phormidium* proliferations: a review of their taxonomy, distribution, toxin content and factors regulating prevalence and increased severity. *Harmful Algae* 55: 282-294.

Mitchell, C.P.J., B.A. Branfireun, and R.K. Kolka (2008) Assessing sulfate and carbon controls on net methylmercury production in peatlands: an in situ mesocosm approach. *Applied Geochemistry* 23: 503-518.

Moisander, P.H., E. McClinton III, and H.W. Paerl (2002) Salinity effects on growth, photosynthetic parameters, and nitrogenase activity in estuarine planktonic cyanobacteria. *Microbial Ecology* 43: 432-442.

Myrbo, A., E.B. Swain, N.W. Johnson, D.R. Engstrom, J. Pastor, B. Dewey, P. Monson, J. Brenner, M.

Dykhuizen Shore, and E.B. Peters (2017) Increase in nutrients, mercury, and methylmercury as a consequence of elevated sulfate reduction to sulfide in experimental wetland mesocosms. *Journal of Geophysical Research: Biogeosciences* 122: 2769-2785.

Newcombe, C.P. and D.D. MacDonald (1991) Effects of suspended sediments on aquatic ecosystems. *North American Journal of Fisheries Management* 11: 72-82.

Nies, D.H. (1999) Microbial heavy metal resistance. *Applied Microbiology and Biotechnology* 51: 730-750.

Ng, G.-H., A.R. Yourdi, N.W. Johnson, and A.E. Myrbo (2017) Modeling hydrologic controls on sulfur processes in sulfate-impacted wetland and stream sediments. *Journal of Geophysical Research: Biogeosciences* 122: 2435-2457.

Quiblier, C., S. Wood, I. Echenique-Subiabre, M. Heath, A. Villeneuve, and J.-F. Humbert (2013) A review of current knowledge on toxic benthic freshwater cyanobacteria–ecology, toxin production and risk management. *Water Research* 47: 5464-5479.

Rand, G.M. and S.R. Petrocelli (eds.) (1995) *Fundamentals of Aquatic Toxicology: Methods and Applications*, 2nd edition. Hemisphere Publishing Group, Washington, DC.

Reddy, B.R., S.K. Apte, and J. Thomas (1989) Enhancement of cyanobacterial salt tolerance by combined nitrogen. *Plant Physiology* 89: 204-210.

Reiffenstein, R.I., W.C. Hulbert, and S.H. Roth (1992) Toxicology of hydrogen sulfide. *Annual Review of Pharmacology and Toxicology*, pp. 109-134.

Robertson, D., and E. Roerish (1999) Influence of various water quality sampling strategies on load estimates for small streams. *Water Resources Research* 35: 3747-3759.

Schneider, A.R., E.T. Porter, and J.E. Baker (2007) PCB release from resuspended Hudson River sediment. *Environmental Science and Technology* 41: 1097-1103.

Senthamilselvan, D., A. Chezhian, and E. Suresh (2016) Synergistic effect of nickel and mercury on fatty acid composition in the muscle of fish *Lates calcarifer*. *Journal of Fisheries and Aquatic Science* 11: 77-84.

Shasteen, D.K., A.L. Price, and S.A. Bales (2012) *Freshwater Mussels of the Big Muddy River*. INHS Technical Report 2012(11). Prepared for the Illinois Department of Natural Resources: Office of Resource Conservation, the U.S. Fish & Wildlife Service, and the Illinois Natural History Survey. Prairie Research Institute, University of Illinois at Urbana-Champaign.

Shilpi, G., S. Shilpi, and S. Sunita (2015) Tolerance against heavy metal toxicity in cyanobacteria: role of antioxidant defense system. *International Journal of Pharmacy and Pharmaceutical Sciences* 7: 9-16.

Stansfield, B. (2001) Effects of sampling frequency and laboratory detection limits on the determination of time series water quality trends. *New Zealand Journal of Marine and Freshwater Research* 35: 1071-1075.

Stumm, W. and J.J. Morgan (1995) *Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters*, 3rd edition. Wiley Inter-Science, New York.

Sweeten, J. and C. McCreedy (2002) *Suspended Stream Sediment: An Environmental Indicator of Warmwater Streams*. 319 Nonpoint Source Pollution Report ARN 98-175. Asherwood Environmental Science Center, Wabash, IN.

Theis, T.L., T.C. Young, and J.V. DePinto (1988) Factors affecting metal partitioning during resuspension of sediments from the Detroit River. *Journal of Great Lakes Research* 14: 216-226.

Tonk, L., K. Bosch, P.M. Visser, and J. Huisman (2007) Salt tolerance of the harmful cyanobacterium *Microcystis aeruginosa*. *Aquatic Microbial Ecology* 46: 117-123.

United States Energy Information Administration (EIA) (2011) Coal plants without scrubbers account for a majority of U.S. SO_2 emissions [map and data summary]. Based on Form EIA-860, EPA Continuous Emissions Monitoring System, Ventyx Energy Velocity, available at: https://www.eia.gov/todayinenergy/detail.php?id=4410.

United States Energy Information Administration (EIA) (2016, Apr 28) Power sector coal demand has fallen in nearly every state since 2007. EIA, available at https://www.eia.gov/todayinenergy/detail.php?id=26012.

Valkanas, M.M. and N.J. Trun (2018) A seasonal study of a passive abandoned coalmine drainage remediation system reveals three distinct zones of contaminant levels and microbial communities. *MicrobiologyOpen* 2018;7:e585, https://doi.org/10.1002/mbo3.585, 13 pp.

van der Welle, M.E.W., J.G.M. Roelofs, and L.P.M. Lamers (2008) Sulfate-induced entrophication and phytotoxicity in freshwater wetlands. *Science of the Total Environment* 406: 426-429.

Van Rijn, L.C. (1993) *Principles of Sediment Transport in Rivers, Estuaries and Coastal Seas*. Aqua Publications, Blokzijl, The Netherlands.

Verspagen, J.M.H., J. Passarge, K.D. Jöhnk, P.M. Visser, L. Peperzak, P. Boers, H.J. Laanbroek, and J. Huisman (2006) Water management strategies against toxic *Microcystis* blooms in the Dutch delta. *Ecological Applications* 16: 313-327.

Wang, J.S., P.M. Huang, W.K. Liaw, and U.T. Hammer (1991) Kinetics of the desorption of mercury from selected freshwater sediments as influenced by chloride. *Water, Air, and Soil Pollution* 56: 533-542.

Wang, N., C.D. Ivey, R.A. Dorman, C.G. Ingersoll, J. Steevans, E.J. Hammer, C.R. Bauer, and D.R. Mount (2018) Acute toxicity of sodium chloride and potassium chloride to a unionid mussel (*Lampsilis siliquoidea*) in water exposures. *Environmental Toxicology and Chemistry* 9999: 1-9.

Ward, A.S., M.N. Gooseff, T.J. Voltz, M. Fitzgerald, K. Singha, and J.P. Zarnetske (2013) How does rapidly changing discharge during storm events affect transient storage and channel water balance in a headwater mountain stream? *Water Resources Research* 49: 5473-5486.

Watzlaf, G.R., K.T. Schroeder, R.L.P. Kleinmann, C.L. Kairies, and R.W. Nairn (2004) *The Passive Treatment of Coal Mine Drainage*. Report #DOE/NETL-2004/1202. National Energy Technology Laboratory, U.S. Department of Energy, Pittsburgh, PA.

Westrich, B. and U. Förstner (eds.) (2007) *Sediment Dynamics and Pollutant Mobility in Rivers: An Interdisciplinary Approach*. Springer.

Wetzel, R.G. (2001) *Limnology*, 3rd edition. Academic Press, New York, NY.

Wood, P.J. and P.D. Armitage (1997) Biological effects of fine sediment in the lotic environment. *Environmental Management* 21: 203-217.

Zak, D., A. Kleeberg, and M. Hupfer (2006) Sulphate-mediated phosphorus mobilization in riverine sediments at increasing sulphate concentration, River Spree, NE Germany. *Biogeochemistry* 80: 109-119.

Curriculum Vitae

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Education

Undergraduate:	Iowa State University	Zoology	B.Sc., 1975
Graduate:	University of Rhode Island	Aquatic Botany	M.Sc., 1981
	Michigan State University	Botanical Limnology	Ph.D., 1986

Research Interests

Algal nutritional physiology and ecology, spanning the salinity gradient from freshwater to estuarine and marine species; and chronic effects of eutrophication (nutrient over-enrichment and associated pollutants) on aquatic ecosystems

Professional Experience

2013 - present	Director, CAAE, Department of Applied Ecology, NCSU
2013 - present	Professor, Department of Applied Ecology; jointly appointed to the Department of Plant & Microbial Biology (formerly the Department of Plant Biology), NCSU
1999 - 2012	Director, CAAE, Department of Plant Biology, NCSU
1998 - 2012	Professor, Department of Plant Biology (formerly the Department of Botany), NCSU
1993 - 1997	Associate Professor, Department of Botany, NCSU
1993 - 2012	Affiliate Professor, Department of Marine, Earth and Atmospheric Sciences (MEAS), NCSU
1986 - 1992	Assistant Professor, Department of Botany, NCSU
1982 - 1986	Graduate Research Assistant, Michigan State University (W.K. Kellogg Biological Station), Hickory Corners, MI
1981 (fall)	Instructor, *Introductory Chemistry* (for science majors), Quinebaug Valley Community College, Danielson, CT
1979 - 1980	Instructor of *Marine Botany,* summers, St. Georges College Prep. School, Newport, RI
1978 - 1981	Graduate Research Assistant and Graduate Teaching Assistant, Department of Botany, University of Rhode Island, Kingston, RI
1976 - 1977	Environmental Scientist, EcolSciences, Inc., Rockaway, NJ
1974 - 1975	Undergraduate Research Assistant, Limnology Laboratory, Department of Zoology, Iowa State University, Ames, IA

Awards and Distinctions

2016	Women of Achievement Award, General Federation of Women's Clubs of North Carolina
2015	Fred A. Harris Fisheries Conservation Award, American Fisheries Society - North Carolina Chapter (recognizes non-Chapter members who have distinguished themselves by service or

commitment to the fisheries resources of North Carolina)

2009 Borlaug Joint Award for Service to the Environment and Society, College of Agriculture and Life Sciences/ College of Natural Resources, NCSU

2008 William Neal Reynolds Distinguished Professor, College of Agriculture and Life Sciences, NCSU, for excellence in research

2008 J. Compton River Achievement Award, River Network, lifetime achievement for leadership in research to advance water quality protection

2007 Darbaker Prize, Botanical Society of America, for excellence in research

2004 Fellow, American Association for the Advancement of Science (AAAS)

2003 Honorary Doctorate, Knox College, Galesburg, IL

2003 Provasoli Award, best paper of 2002, *Journal of Phycology*

2001 Honorary Doctorate, Southampton College - Long Island University

2000 Fellow, Aldo Leopold Leadership Program, Ecological Society of America

1999 Hutner Award, Society of Protozoologists, for excellence in microalgal research

1998 Scientific Freedom and Responsibility Award, AAAS

1998 Distinguished Service in Environmental Education Award, Environmental Educators of North Carolina

1998 Distinguished Scholarly Achievement Award, NCSU Honors Convocation

1998 Conservationist of the Year Award, National Wildlife Federation

1998 Conservationist of the Year Award, Governor of North Carolina and the North Carolina Wildlife Federation

1998 Jack Bayless Award – outstanding presentation of the year, South Carolina Fishery Workers Association, and the North and South Carolina chapters of the American Fisheries Society

1997 Admiral of the Chesapeake Award, Federal and State Leadership Summit, Washington, DC

1997 Outstanding Achievement Award, Society of Business and Professional Women of North Carolina

1997-2000 Pew Fellow in Marine Conservation, the Pew Foundation

1994 Outstanding Research Award, NCSU Alumni Association

Honors to the NCSU CAAE

2013 The CAAE was recognized as the reason why NCSU placed 31st among the top 50 "Colleges Saving the World" (http://www.onlinecollegesdatabase.org/50-colleges-saving-the-planet).

2012 The CAAE received the highest evaluation possible (Excellent) by an outside Peer Review Panel that reviewed in detail the Center's performance over its entire span of operation. The panel was organized by the NCSU College of Agriculture and Life Sciences as required by the UNC Board of Governors.

Other Honors

2013 Invited presentation on Harmful Algae - Capital Hill Briefing, representing the Coastal and Estuarine Research Federation

2007 Theodore L. Jahn and Eugene C. Bovee Award, International Society of Protozoologists, for best graduate student research paper, to doctoral candidate Hayley Skelton (coauthors of the paper, Burkholder and Parrow)

2001 Elected member, Alumni Hall of Fame, Rock Valley College, Rockford, Illinois

2001 Convocation speaker, Appalachian State University

2001 Convocation speaker, Southampton College - Long Island University

1998 Special recognition for excellence in research, Phi Kappa Phi

1998 Invited testimony, Congressional Hearing on the Value of Estuaries, US Senate, Senate

	Environment and Public Works Committee
1998	Invited testimony, Congressional Hearing on Harmful Algal Blooms, US Senate, Committee on Commerce, Science and Transportation
1997	Invited testimony, Congressional Hearing on Fisheries Conservation, Wildlife and Oceans, US House of Representatives – Committee on Resources
1997	Invited testimony, Congressional Hearing on Harmful Algae and Human Health, US House of Representatives – Committee on Government Reform and Oversight
1997-1999	Science Advisor, Governor's Commission on *Pfiesteria*, Maryland
1993-1994	Member, North Carolina Coastal Futures Committee (governor-appointed)
1993-1995	Member, Board of Directors, Partnership for the Sounds (directive, environmental education for eastern North Carolina)
1992-1997	Member-at-large, North Carolina Marine Fisheries Commission (governor-appointed)
1985	Elected member, Phi Kappa Phi, Michigan State University
1984-1986	Graduate fellow, Department of Botany and Plant Pathology, Michigan State University

Selected Research Accomplishments

(with thanks to my graduate students, postdoctoral research associates and other research associates, and collaborators)

Freshwater Ecosystems

- First to maintain automated platform stations with depth profiling capability for advanced research and monitoring of North Carolina reservoirs; the real-time data from these stations is also helping to safeguard drinking water supplies depended upon by ~750,000 people.
- Experimentally quantified interactions between nutrient and sediment loadings in controlling noxious algal blooms in turbid reservoirs.
- First to document widespread occurrence, at low levels, of cyanotoxins in major potable water supplies in North Carolina.
- Documented novel nutritional and physical adaptations of a cryptic group of dinoflagellates in reservoirs affected by episodic suspended sediment loading.

Estuarine and Marine Ecosystems

- Discovered that water-column nitrate enrichment from sewage and other sources inhibits *Zostera marina*, the dominant seagrass of north temperate U.S. waters, as a direct physiological effect.
- Co-discovered the toxic dinoflagellates, *Pfiesteria piscicida* and *Pfiesteria shumwayae*, as causative agents of major estuarine fish kills; this research also led to colleagues' discovery of a group of *Pfiesteria* toxins new to science.
- First to design and maintain a series of automated platform stations for advanced research and monitoring of a North Carolina estuary; coauthor of a patent for an automated depth profiler.
- First to show that shallow lagoonal estuarine ecosystems are resilient to the adverse effects of hurricanes, recovering within 4-5 years.
- Helped to develop a model for water mass transport to the Neuse Estuary; used the model and a detailed dataset for improved quantification of nutrient loads, including decadal trend analysis.

Grants (past ~decade)

My research routinely involves analyzing the species composition and abundance of phytoplankton in samples from lakes, reservoirs, rivers, estuaries, and marine coastal environments. For example, my research associate, Ms. Elle Allen, and I recently analyzed 1,000 phytoplankton samples from lakes across the nation as part of a major contract to Dr. Beaver from the U.S. Environmental Protection Agency.

Support for my research and education outreach has been obtained from the National Science Foundation,

National Park Service, U.S. Environmental Protection Agency, National Oceanic and Atmospheric Administration, U.S. Department of Defense, the Burroughs Wellcome Fund, the Park Foundation, the Z. Smith Reynolds Foundation, the NCSU Research and Innovation Seed Funding Program, and the North Carolina Clean Water Management Trust Fund.

Professional Consulting

1989	Phytoplankton Analyst - Duke Power and Light Company, Charlotte, NC (samples from local reservoirs: species identifications, quantification of cell numbers and biovolumes)
1990-1992	Phytoplankton Analyst - consulting firm of Dr. J. Beaver (samples from central Florida lakes with major cyanobacteria blooms: species identifications, quantification of cell numbers and biovolumes)
2004	Expert Witness - requested by several concerned citizens groups to review impacts of Georgia Pacific, Inc. on marine coastal ecosystems on the west Florida shelf
2005	External Reviewer (1 of 2) – contracted by the higher administration at Miami University of Ohio to review the academic and research programs of the Department of Botany. Our review resulted in new positions, a strengthened Bioinformatics Facility, and other significant support for the department.
2005	External Reviewer – contracted by the Harris Chain of Lakes Restoration Council in Florida to review the sampling protocols and two annual environmental reports from a commercial laboratory/consulting firm on water quality and cyanobacteria blooms in the Harris Lake Chain. Included a presentation at a public Council meeting.
2006-2010	Panelist on a review team of the *South Florida Environmental Report* (*SFER*) for the South Florida Water Management District. Formally critique the annual draft report (selected chapters, ~1,200 pages), emphasizing water quality sampling/ compliance and water quality programs/ restoration in the Kissimmee River basin, Lake Okeechobee, the Everglades, and eight estuarine ecosystems; and environmental education outreach programs
2006	Coauthor of the report, *Indicators for Restoration*, for the South Florida Ecosystem Restoration Task Force
2009	Panel Representative who presented key findings of review of the draft 2010 *SFER* to the the Board of Governors of the South Florida Water Management District, Key Largo, FL
2009 - 2018	Consultant on eutrophication issues in lakes and streams for PEER (Public Employees for Environmental Responsibility - Mississippi River Collaborative), the Minnesota Center for Environmental Advocacy, Earthjustice, and the Natural Resources Defense Council
2010 - 2011	Consultant on U.S. Environmental Protection Agency's Science Advisory Board - Ecological Process and Effects Committee Augmented for the Ballast Water Advisory
2019	Consultant on nitrate toxicity in drinking water and surface freshwaters, and on a coal Mining permit, for the Sierra Club

Publications (Peer-reviewed, in scientific journals, books and symposia volumes)

1) Burkholder JM, Bachmann RW (1979) Potential phytoplankton productivity in three Iowa streams. *Proceedings of the Iowa Academy of Sciences* 86: 22-25.

2) Sheath RG, Burkholder JM (1983) Morphometry of *Batrachospermum* populations intermediate

between *B. boryanum* and *B. ectocarpum* (Rhodophyta). *Journal of Phycology* 19: 324-331.

3) Burkholder JM, Sheath RG (1984) The seasonal distribution, abundance and diversity of desmids (Chlorophyta) in a softwater, north temperate stream. *Journal of Phycology* 20: 159-172.

4) Sheath RG, Burkholder JM (1985) Characteristics of softwater streams in Rhode Island. II. Composition and seasonal dynamics of macroalgal communities. *Hydrobiologia* 128: 109-118.

5) Burkholder JM, Sheath RG (1985) Characteristics of softwater streams in Rhode Island, U.S.A. I. A comparative analysis of physical and chemical features. *Hydrobiologia* 128: 97-108.

6) Bachmann MD, Carlton RG, Burkholder JM, Wetzel RG (1986) Symbiosis between salamander eggs and green algae: Microelectrode measurements inside eggs demonstrate effects of photosynthesis on oxygen concentrations. *Canadian Journal of Zoology* 64: 1586-1588.

7) Sheath RG, Burkholder JM, Hambrook JA, Hogeland A, Hoy E, Kane ME, Morison MO, Steinman AD, Van Alstyne KL (1986) Characteristics of softwater streams in Rhode Island. III. Distribution of macrophytic vegetation in a small drainage basin. *Hydrobiologia* 140: 183-191.

8) Sheath RG, Burkholder JM, Morison MO, Steinman AD, Van Alstyne KL (1986) Effect of tree canopy removal by gypsy moth larvae on the macroalgae of a Rhode Island headwater stream. *Journal of Phycology* 22: 567-570.

9) Moeller RE, Burkholder JM, Wetzel, RG (1988) Significance of sedimentary phosphorus to a rooted submersed macrophyte (*Najas flexilis*) and its algal epiphytes. *Aquatic Botany* 32: 261-281.

10) Sheath RG, Burkholder JM (1988) Stream macroalgae, pp. 53-59. In: *Freshwater and Marine Plants of Rhode Island*, by Sheath RG and Harlin MM (eds.). Kendall/Hunt Publishers, Dubuque (IA), 149 pp.

11) Burkholder JM, Wetzel RG (1989) Microbial colonization on natural and artificial macrophytes in a phosphorus-limited hardwater lake. *Journal of Phycology* 25: 55-65.

12) Burkholder JM, Wetzel RG (1989) Epiphytic microalgae on natural substrata in a hardwater lake: Seasonal dynamics of community structure, biomass, and ATP content. *Archives für Hydrobiologie/ Supplement* 83: 1-56.

13) Burkholder, J.M. and R.G. Wetzel (1990) Epiphytic alkaline phosphatase on natural and artificial plants in an oligotrophic lake: Re-evaluation of the role of macrophytes as a phosphorus source for epiphytes. *Limnology and Oceanography* 35: 736-747.

14) Burkholder JM, Wetzel RG, Klomparens KL (1990) Direct comparison of phosphate uptake by adnate and loosely attached microalgae within an intact biofilm matrix. *Applied and Environmental Microbiology* 56: 2882-2890.

15) Cuker BE, Gama P, Burkholder JM (1990) Type of suspended clay influences lake productivity and phytoplankton community response to phosphorus loading. *Limnology and Oceanography* 35: 830-839.

16) Burkholder JM, Cuker BE (1991) Response of periphyton communities to clay and phosphate loading in a shallow reservoir. *Journal of Phycology* 27: 373-384.

17) Everitt DT, Burkholder JM (1991) Seasonal dynamics of macrophyte communities from a stream flowing over granite flatrock in North Carolina, U.S.A. *Hydrobiologia* 222: 159-172.

18) Burkholder JM (1992) Phytoplankton and episodic suspended sediment loading: Phosphate partitioning and mechanisms for survival. *Limnology and Oceanography* 37: 974-988.

19) Burkholder JM, Mason KM, Glasgow HB (1992) Water-column nitrate enrichment promotes decline of eelgrass (*Zostera marina* L.): Evidence from seasonal mesocosm experiments. *Marine Ecology Progress Series* 81: 163-178.

20) Burkholder JM, Noga EJ, Hobbs CW, Glasgow HB, Smith SA (1992) New "phantom" dinoflagellate is the causative agent of major estuarine fish kills. *Nature* 358: 407-410, *Nature* 360: 768.

21) Mallin MA, Burkholder JM, Sullivan MJ (1992) Benthic microalgal contributions to coastal fishery yield. *Transactions of the American Fisheries Society* 121: 691-695.

22) Martin TH, Crowder LB, Dumas CF, Burkholder JM (1992) Indirect effects of fish on macrophytes in Bays Mountain Lake: Evidence for a littoral trophic cascade. *Oecologia* 89: 476-481.

23) Noga EJ, Smith SA, Burkholder JM, Hobbs CW, Bullis RW (1993) A new ichthyotoxic dinoflagellate: Cause of acute mortality in aquarium fishes. *Veterinary Record* 133: 48-49.

24) Burkholder JM, Glasgow HB, Cooke JE (1994) Comparative effects of water-column nitrate enrichment on eelgrass *Zostera marina*, shoalgrass *Halodule wrightii*, and widgeongrass *Ruppia maritima*. *Marine Ecology Progress Series* 105: 121-138.

25) Coleman VL, Burkholder JM (1994) Community structure and productivity of epiphytic microalgae on eelgrass (*Zostera marina* L.) under water-column nitrate enrichment. *Journal of Experimental Marine Biology and Ecology* 179: 29-48.

26) Burkholder JM, Glasgow HB (1995) Interactions of a toxic estuarine dinoflagellate with microbial predators and prey. *Archiv für Protistenkunde* 145: 177-188.

27) Burkholder JM, Glasgow HB, Hobbs CW (1995) Distribution and environmental conditions for fish kills linked to a toxic ambush-predator dinoflagellate. *Marine Ecology Progress Series* 124: 43-61.

28) Burkholder JM, Glasgow HB, Steidinger KA (1995) Stage transformations in the complex life cycle of an ichthyotoxic "ambush-predator" dinoflagellate, pp. 567-572. In: *Harmful Marine Algal Blooms*, by Lassus P, Arzul G, Erard E, Gentien P, Marcaillou C (eds.). Lavoiser, Intercept Ltd., Paris.

29) Coleman VL, Burkholder JM (1995) Response of microalgal epiphyte communities to nitrate enrichment in an eelgrass (*Zostera marina* L.) meadow. *Journal of Phycology* 31: 36-43.

30) Glasgow HB, Burkholder JM, Schmechel DE, Fester PA, Rublee PA (1995) Insidious effects of a toxic dinoflagellate on fish survival and human health. *Journal of Toxicology and Environmental Health* 46: 501-522.

31) Lewitus AJ, Jesien RV, Kana TM, Burkholder JM, Glasgow HB, May E (1995) Discovery of the "phantom" dinoflagellate in Chesapeake Bay. *Estuaries* 18: 373-378.

32) Mallin MA, Burkholder JM, Larsen LM, Glasgow HB (1995) Response of two zooplankton grazers to an ichthyotoxic estuarine dinoflagellate. *Journal of Plankton Research* 17: 351-363.

33) Steidinger KA, Truby EW, Garrett JK, Burkholder JM (1995) The morphology and cytology of a newly discovered toxic dinoflagellate, pp. 83-88. In: *Harmful Marine Algal Blooms*, by Lassus P, Arzul G, Erard E, Gentien P, Marcaillou C (eds.). Lavosier, Intercept Ltd., Paris, France.

34) Burkholder JM (1996) Interactions of benthic algae with their substrata, pp. 253-297. In: *Benthic Algae in Freshwater Ecosystems*, by Stevenson RJ, Bothwell M, Lowe RL (eds.). Academic Press, New York.

35) Noga EJ, Khoo L, Stevens JB, Fan Z, Burkholder JM (1996) Novel toxic dinoflagellate causes epidemic disease in estuarine fish. *Marine Pollution Bulletin* 32: 219-224.

36) Steidinger KA, Burkholder JM, Glasgow HB, Hobbs CW, Truby E, Garrett J, Noga EJ, Smith SA (1996) *Pfiesteria piscicida* gen. et sp. nov. (Pfiesteriaceae, fam. nov.), a new toxic dinoflagellate with a complex life cycle and behavior. *Journal of Phycology* 32: 157-164.

37) Burkholder JM, Glasgow HB (1997) *Pfiesteria piscicida* and other toxic *Pfiesteria*-like dinoflagellates: Behavior, impacts, and environmental controls. *Limnology and Oceanography* 42: 1052-1075.

38) Burkholder JM, Glasgow HB (1997) Trophic controls on stage transformations of a toxic ambush-predator dinoflagellate. *Journal of Eukaryotic Microbiology* 44: 200-205.

39) Burkholder JM, Mallin MA, Glasgow HB, Larsen LM, McIver MR, Shank GC, Deamer-Melia N, Briley DS, Springer J, Touchette BW, Hannon EK (1997) Impacts to a coastal river and estuary from rupture of a large swine waste holding lagoon. *Journal of Environmental Quality* 26: 1451-1466.

40) Levin ED, Schmechel DE, Burkholder JM, Glasgow HB, Deamer-Melia N, Moser VC, Harry GJ (1997) Persistent learning deficits in rats after exposure to *Pfiesteria piscicida*. *Environmental Health Perspectives* 105: 1320-1325.

41) Mallin MA, Burkholder JM, Shank GC, McIver MR, Glasgow HB, Springer J, Touchette BW (1997) Comparative effects of poultry and swine waste lagoon spills on the quality of receiving stream waters. *Journal of Environmental Quality* 26: 1622-1631.

42) Burkholder JM (1998) Implications of harmful marine microalgae and heterotrophic dinoflagellates in management of sustainable marine fisheries. *Ecological Applications* 8: S37-S62.

43) Burkholder JM, Glasgow HB, Lewitus AJ (1998) Physiological ecology of *Pfiesteria piscicida* with general comments on "ambush-predator" dinoflagellates, pp. 175-191. In: *Physiological Ecology of Harmful Algae,* by Anderson DM, Cembella A, Hallegraeff GM (eds.). NATO ASI Series G: Ecological Sciences, Vol. 41. Springer-Verlag, Berlin, Germany.

44) Burkholder JM, Larsen LM, Glasgow HB, Mason KM, Gama P, Parsons JE (1998) Influence of sediment and phosphorus loading on phytoplankton communities in an urban piedmont reservoir. *Lake and Reservoir Management* 14: 110-121.

45) Glasgow HB, Lewitus AJ, Burkholder JM (1998) Feeding behavior of the ichthyotoxic estuarine dinoflagellate, *Pfiesteria piscicida*, on amino acids, algal prey, and fish vs. mammalian erythrocytes, pp. 394-397. In: *Harmful Microalgae – Proceedings, VIIth International Conference on Harmful Algal Blooms* by Reguera B, Blanco J, Fernandez ML, Wyatt T (eds.). Xunta de Galicia and IOC of UNESCO, Paris, France.

46) Burkholder JM, Glasgow HB (1999) Science ethics and its role in early suppression of the *Pfiesteria* issue. *Human Organization* 58: 443-455.

47) Burkholder JM, Mallin MA, Glasgow HB (1999) Fish kills, bottom-water hypoxia, and the toxic *Pfiesteria* complex in the Neuse River and Estuary. *Marine Ecology Progress Series* 179: 301-310.

48) Burkholder JM, Springer JJ (1999) Signaling in dinoflagellates, pp. 335-359. In: *Microbial Signaling and Communication,* by England RR, Hobbs G, Bainton NJ, Roberts DMcL (eds.). Fifty-Seventh Symposium of the Society for General Microbiology. Cambridge University Press, Oxford, United Kingdom.

49) Fairey ER, Edmunds JS, Deamer-Melia NJ, Glasgow HB, Johnson FM, Moeller PR, Burkholder JM, Ramsdell JS (1999) Reporter gene assay for fish killing activity produced by *Pfiesteria piscicida*. *Environmental Health Perspectives* 107: 711-714.

50) Harvell CD, Kim K, Burkholder JM, Colwell RR, Epstein PR, Grimes J, Hofmann EE, Lipp E, Osterhaus ADME, Overstreet R., Porter JW, Smith GW, Vasta G (1999) Emerging marine diseases: Climate links and anthropogenic factors. *Science* 285: 1505-1510.

51) Levin ED, Simon BB, Schmechel DE, Glasgow HB, Deamer-Melia NJ, Burkholder JM, Moser VC, Jensen K, Harry GJ (1999) *Pfiesteria* toxin and learning performance. *Neurotoxicology and Teratology* 21: 215-221.

52) Lewitus AJ, Glasgow HB, Burkholder JM (1999) Kleptoplastidy in the toxic dinoflagellate, *Pfiesteria piscicida*. *Journal of Phycology* 35:303-312.

53) Lewitus AJ, Willis BM, Hayes KC, Burkholder JM, Glasgow HB, Glibert PM, Burke MK (1999) Mixotrophy and nitrogen uptake by *Pfiesteria piscicida* (Dinophyceae). *Journal of Phycology* 35: 1430-1437.

54) Rublee PA, Kempton J, Schaefer E, Burkholder JM, Glasgow HB, Oldach D (1999) PCR and FISH detection extends the range of *Pfiesteria piscicida* in estuarine waters. *Virginia Journal of Science* 50: 325-336.

55) Burkholder JM (2000) Critical needs in harmful algal bloom research, pp. 126-149. In: *Opportunities for Environmental Applications of Marine Biotechnology.* National Academy of Sciences – National Research Council, Washington, DC.

56) Burkholder JM (2000) Chronic impacts from toxic microalgae on finfish, shellfish and human health. In: *Proceedings of the Symposium on Conservation Medicine*, by Barakatt C (ed.). School of Veterinary Medicine, Tufts University. Academic Press, New York.

57) Bowers HA, Tengs T, Glasgow HB, Burkholder JM, Rublee PA, Oldach DW (2000) Development of real-time PCR assays for rapid detection of *Pfiesteria piscicida* and related dinoflagellates. *Applied and Environmental Microbiology* 66: 4641-4648.

58) Glasgow HB, Burkholder JM (2000) Water quality trends and management implications from a five-year study of a eutrophic estuary. *Ecological Applications* 10: 1024-1046.

59) Levin ED, Rezvani AH, Christopher NC, Glasgow HB, Deamer-Melia NJ, Burkholder JM, Moser VC, Jensen K (2000) Rapid neurobehavioral analysis of *Pfiesteria piscicida* effects in juvenile and adult rats. *Neurotoxicology and Teratology* 22: 533-540.

60) Levin ED, Schmechel DE, Glasgow HB, Deamer-Melia NJ, Burkholder JM (2000) *Pfiesteria* toxin, pp. 975-976. In: *Experimental and Clinical Neurotoxicology* (2nd edition), by Spencer PS, Shaumberg HS, Ludolph AC (eds.). Oxford University Press, New York.

61) Mallin MA, Burkholder JM, Cahoon LB, Posey MH (2000) The North and South Carolina Coasts. In: *The Seas at the Millennium,* by Shepherd C (ed.). Academic Press, New York. Also among several contributions selected from this multi-volume set, for publication in *Marine Pollution Bulletin* (vol. 41, pp. 56-75).

62) Oldach DW, Delwiche, Jakobsen KS, Tengs T, Brown EG, Kempton JW, Schaefer EF, Bowers H, Glasgow HB, Burkholder JM, Steidinger KA, Rublee PA (2000) Heteroduplex mobility assay guided sequence discovery: elucidation of the small subunit (18S) rDNA sequence of *Pfiesteria piscicida* and related dinoflagellates from complex algal culture and environmental sample DNA pools. *Proceedings of the National Academy of Sciences (USA)* 97: 4303-4308.

63) Touchette BW, Burkholder JM (2000) Overview of the physiological ecology of carbon metabolism in seagrasses. *Journal of Experimental Marine Biology and Ecology* 250: 169-205.

64) Touchette BW, Burkholder JM (2000) Review of nitrogen and phosphorus metabolism in seagrasses. *Journal of Experimental Marine Biology and Ecology* 250: 133-167.

65) Burkholder JM (2001) Chronic impacts from toxic microalgae on finfish, shellfish and human health, pp. 103-126. In: *Waters in Peril*, by Bendell-Young L, Gallaugher P (eds.). Kluwer Academic Publishers, Dordrecht, the Netherlands.

66) Burkholder JM (2001) Eutrophication and oligotrophication, pp. 649-670. In: *Encyclopedia of Biodiversity*, Vol. 2, by Levin S (ed.). Academic Press, New York.

67) Burkholder JM, Glasgow HB (2001) History of toxic *Pfiesteria* in North Carolina estuaries from 1991 to the present. *BioScience* 51: 827-841.

68) Burkholder JM, Glasgow HB, Deamer-Melia NJ (2001) Overview and present status of the toxic *Pfiesteria* complex. *Phycologia* 40: 186-214.

69) Burkholder JM, Glasgow HB, Deamer-Melia NJ, Springer J, Parrow MW, Zhang C, Cancellieri P (2001) Species of the toxic *Pfiesteria* complex, and the importance of functional type in data interpretations. *Environmental Health Perspectives* 109: 667-679.

70) Burkholder JM, Marshall HG, Glasgow HB, Seaborn DW, Deamer-Melia N.J. (2001) The standardized fish bioassay procedure for detecting and culturing actively toxic *Pfiesteria,* used by two reference laboratories for Atlantic and Gulf Coast states. *Environmental Health Perspectives* 109: 745-756.

71) Cancellieri PJ, Burkholder JM, Deamer-Melia NJ, Glasgow HB (2001) Chemosensory attraction of zoospores of the estuarine dinoflagellates, *Pfiesteria piscicida* and *P. shumwayae*, to finfish mucus and excreta. *Journal of Experimental Marine Biology and Ecology* 264: 29-45.

72) Glasgow HB, Burkholder JM, Mallin MA, Deamer-Melia NJ, Reed RE (2001) Field ecology of toxic *Pfiesteria* complex species, and a conservative analysis of their role in estuarine fish kills. *Environmental Health Perspectives* 109: 715-730.

73) Glasgow HB, Burkholder JM, Morton SL, Springer J (2001) A second species of ichthyotoxic *Pfiesteria* (Dinamoebales, Pyrrhophyta). *Phycologia* 40: 234-245.

74) Glasgow HB, Burkholder JM, Morton SL, Springer J, Parrow MW (2001) The fish-killing activity and nutrient stimulation of a second toxic *Pfiesteria* species, pp. 97-100. In: *Harmful Algal Blooms 2000*, by Hallegraeff GM, Blackburn SI, Bolch CJ, Lewis RJ (eds.). IOC of UNESCO, Paris, France.

75) Kimm-Brinson KL, Moeller PDR, Barbier M, Glasgow HB, Burkholder JM, Ramsdell JS (2001) Identification of a $P2X_7$ receptor in GH4C1 rat pituitary cells: A potential target for a bioactive substance produced by *Pfiesteria piscicida*. *Environmental Health Perspectives* 109: 457-462.

76) Melo AC, Moeller PDR, Glasgow HB, Burkholder JM, Ramsdell JS (2001) Microfluorimetric analysis of a purinergic receptor ($P2X_7$) in GH_4C_1 rat pituitary cells: effects of a bioactive substance produced by *Pfiesteria piscicida*. *Environmental Health Perspectives* 109: 731-738.

77) Moeller PDR, Morton SL, Mitchell BA, Sivertsen SK, Fairey ER, Mikulski TM, Glasgow HB, Deamer-Melia NJ, Burkholder JM, Ramsdell JS (2001) Current progress in isolation and characterization of toxins isolated from *Pfiesteria* spp. *Environmental Health Perspectives* 109: 739-743.

78) Parrow MW, Glasgow HB, Burkholder JM, Zhang C (2001) Comparative response to algal prey by *Pfiesteria piscicida*, *Pfiesteria shumwayae* sp. nov., and a co-occurring 'lookalike' species, pp. 101-104. In: *Harmful Algal Blooms 2000*, by Hallegraeff GM, Blackburn SI, Bolch CJ, Lewis RJ (eds.). IOC of UNESCO, Paris.

79) Rublee PA, Kempton JW, Schaefer EF, Allen C, Burkholder JM, Glasgow HB, Oldach DW (2001) Distribution of *Pfiesteria* sp. and an associated dinoflagellate along the U.S. East Coast during the active season in 1998 and 1999, pp. 89-91. In: *Harmful Algal Blooms 2000*, by Hallegraeff GM, Blackburn SI, Bolch CJ, Lewis RJ (eds.). IOC of UNESCO, Paris.

80) Rublee PA, Kempton JW, Schaefer EF, Allen C, Harris J, Oldach DW, Bowers H, Tengs T, Burkholder JM, Glasgow HB (2001) Use of molecular probes to assess geographic distribution of *Pfiesteria* species. *Environmental Health Perspectives* 109: 765-767.

81) Touchette BW, Burkholder JM (2001) Nitrate reductase activity in a submersed marine angiosperm: Controlling influences of environmental and physiological factors. *Plant Physiology and Biochemistry* 39: 583-593.

82) Anderson DM, Glibert PM, Burkholder JM (2002) Harmful algal blooms and eutrophication: nutrient

sources, composition, and consequences. *Estuaries* 25: 704-726.

83) Brownie C, Glasgow HB, Burkholder JM, Reed RE, Tang Y (2002) Re-evaluation of the relationship between *Pfiesteria* and estuarine fish kills. *Ecosystems* 6: 1-10.

84) Burkholder JM (2002) Cyanobacteria, pp. 952-982. In: *Encyclopedia of Environmental Microbiology*, by Bitton G (ed.). Wiley Publishers, New York.

85) Burkholder JM (2002) *Pfiesteria:* the toxic *Pfiesteria* complex, pp. 2431-2447. In: *Encyclopedia of Environmental Microbiology*, by Bitton G (ed.). Wiley Publishers, New York.

86) Burkholder JM, Glasgow HB (2002) The life cycle and toxicity of *Pfiesteria piscicida*, revisited. *Journal of Phycology* 38: 1261-1267.

87) Jakobsen KS, Tengs T, Vatne A, Bowers HA, Oldach DW, Burkholder JM, Glasgow HB, Rublee PA, Klaveness D (2002) Discovery of the toxic dinoflagellate, *Pfiesteria*, from northern European waters. *Proceedings of the Royal Society of London (B)* 269: 211-214.

88) Lewitus AJ, Hayes KC, Willis BM, Burkholder JM, Glasgow HB, Holland AF, Maier P, Rublee PA, Magnien R (2002) Low abundance of the dinoflagellates, *Pfiesteria piscicida*, *P. shumwayae*, and cryptoperidiniopsoid species in South Carolina tidal creeks and open estuaries. *Estuaries* 25: 586-597.

89) Lewitus AJ, Hayes KC, Willis BM, Burkholder JM, Holland AF, Rublee PA, Magnien R (2002) Low abundance of the dinoflagellates, *Pfiesteria piscicida*, *P. shumwayae*, and cryptoperidiniopsoid spp. in South Carolina estuaries: Relevance as reference sites to areas impacted by *Pfiesteria* toxic events, pp. 211-214. In: *Proceedings of the Ninth International Conference on Harmful Ninth International Conference on Harmful Algal Blooms,* by Hallegraeff GM, Blackburn SI, Bolch CJ, Lewis RJ (eds.). IOC of UNESCO, Paris, France.

90) Parrow MW, Burkholder JM (2002) Flow cytometric determination of zoospore DNA content and population DNA distribution in cultured *Pfiesteria* spp. (Pyrrhophyta). *Journal of Experimental Marine Biology and Ecology* 267: 35-51.

91) Parrow MW, Burkholder JM, Deamer NJ, Zhang C (2002) Vegetative and sexual reproduction in *Pfiesteria* spp. (Dinophyceae) cultured with algal prey, and inferences for their classification. *Harmful Algae* 1: 5-33.

92) Rhodes LL, Burkholder JM, Glasgow HB, Rublee PA, Allen C, Adamson JE (2002) *Pfiesteria shumwayae* (Pfiesteriaceae) in New Zealand. *New Zealand Journal of Marine and Freshwater Research* 36: 621-630.

93) Springer J, Shumway SE, Burkholder JM, Glasgow HB (2002) Interactions between the toxic estuarine dinoflagellate, *Pfiesteria piscicida* and two species of bivalve molluscs. *Marine Ecology Progress Series* 245: 1-10.

94) Stoecker DK, Parrow MW, Burkholder JM, Glasgow HB Glasgow (2002) Grazing by microzoo-plankton of *Pfiesteria piscicida* cultures with different histories of toxicity. *Aquatic Microbial Ecology* 28: 79-85.

95) Touchette BW, Burkholder JM (2002) Seasonal variations in carbon and nitrogen constituents in eelgrass (*Zostera marina* L.) as influenced by increased temperature and water-column nitrate. *Botanica Marina* 45: 23-34.

96) Fan C, Glibert PM, Burkholder JM (2003) Characterization of the affinity for nitrogen, uptake kinetics, and environmental relationships for *Prorocentrum minimum* in natural blooms and laboratory cultures. *Harmful Algae* 2: 283-299.

97) Levin ED, Blackwelder WP, Glasgow HB, Burkholder JM, Moeller PDR, Ramsdell JS (2003)

Learning impairment caused by *Pfiesteria* toxin infusion into the hippocampus of rats. *Neurotoxicology and Teratology* 25: 419-426.

98) Parrow MW, Burkholder JM (2003) Reproduction and sexuality in *Pfiesteria shumwayae* (Dinophyceae). *Journal of Phycology* 39: 697-711.

99) Parrow MW, Burkholder JM (2003) Estuarine heterotrophic cryptoperidiniopsoids (Dinophyceae): Life cycle and culture studies. *Journal of Phycology* 39: 678-696.

100) Tengs T, Bowers HA, Glasgow HB, Burkholder JM, Oldach DW (2003) Identical ribosomal DNA sequence data from *Pfiesteria piscicida* (Dinophyceae) isolates with different toxicity phenotypes. *Environmental Research* 93: 88-91.

101) Touchette BW, Burkholder JM, Glasgow HB (2003) Growth and developmental responses of eelgrass (*Zostera marina* L.) under increased temperature and water-column nitrate. *Estuaries* 26: 142-155.

102) Burkholder J, Eggleston D, Glasgow H, Brownie C, Reed R, Melia G, Kinder C, Janowitz G, Corbett R, Posey M, Alphin T, Toms D, Deamer N, Springer J (2004) Comparative impacts of two major hurricane seasons on the Neuse River and western Pamlico Sound. *Proceedings of the National Academy of Sciences (USA)* 101: 9291-9296.

103) Burkholder JM, Ramsdell JS, Moeller PDR, Gordon AS, Lewitus AJ, Glasgow HB, Marshall HG, Morton SL (2004) Status of *Pfiesteria* science, including tests of *Pfiesteria shumwayae* strain CCMP 2089 for ichthyotoxicity and toxin, pp. 50-52. In: *Harmful Algae 2002 - Proceedings of the Xth International Conference on Harmful Algae*, by Steidinger KA, Landsberg JA, Tomas CR, Vargo GA (eds.). Florida Fish and Wildlife Conservation Commission, Florida Institute of Oceanography, and the IOC of UNESCO, St. Petersburg, FL.

104) Coyne KJ, Burkholder JM, Feldman RA, Hutchins DA, Cary SC (2004) Modified serial analysis of gene expression method for construction of gene expression profiles of microbial eukaryotic species. *Applied and Environmental Microbiology* 70: 5298-5304.

105) Glasgow HB, Burkholder JM, Reed RE, Lewitus AJ (2004) Real-time remote monitoring of water quality: a review of current applications, and advancements in sensor, telemetry, and computing technologies. *Journal of Experimental Marine Biology and Ecology* 300: 409-448.

106) Mallin MA, Ensign SH, Parsons DC, Johnson VL, Burkholder JM, Rublee PA (2004) Relationship of *Pfiesteria* spp. and pfiesteria-like organisms to environmental factors in tidal creeks draining urbanized watersheds, pp. 68-70. In: *Harmful Algae 2002 - Proceedings of the Xth International Conference on Harmful Algae*, by Steidinger KA, Landsberg JA, Tomas CR, Vargo GA (eds.). Florida Fish and Wildlife Conservation Commission, Florida Institute of Oceanography, and the IOC of UNESCO, St. Petersburg, FL.

107) Parrow MW, Burkholder JM (2004) The sexual life cycles of *Pfiesteria piscicida* and cryptoperidiniopsoids (Dinophyceae). *Journal of Phycology* 40: 664-673.

108) Parrow MW, Deamer NJ, Alexander JL, Burkholder JM (2004) A cell cycle synchronization and purification technique for heterotrophic *Pfiesteria* and cryptoperidiniopsoid dinoflagellates analyzed by flow cytometry, pp. 420-422. In: *Harmful Algae 2002 - Proceedings of the Xth International Conference on Harmful Algae*, by Steidinger KA, Landsberg JA, Tomas CR, Vargo GA (eds.). Florida Fish and Wildlife Conservation Commission, Florida Institute of Oceanography, and the IOC of UNESCO, St. Petersburg, FL.

109) Reed RE, Glasgow HB, Burkholder JM, Brownie C (2004) Seasonal halocline structure, nutrient distributions, and acoustic Doppler current profiler flow patterns over multiple years in a shallow,

stratified estuary. *Estuarine and Coastal Shelf Science* 60: 549-566.

110) Rublee PA, Allen C, Schaefer E, Rhodes L, Adamson J, Lapworth C, Burkholder J, Glasgow H (2004) Global distribution of toxic *Pfiesteria* complex species, pp. 320-322. In: *Harmful Algae 2002 – Proceedings of the Xth International Conference on Harmful Algae*, by Steidinger KA, Landsberg JA, Tomas CR, Vargo GA (eds.). Florida Fish and Wildlife Conservation Commission, Florida Institute of Oceanography, and the IOC of UNESCO, St. Petersburg, FL.

111) Springer J, Glasgow HB, Burkholder JM (2004) Characterization of lectin binding profiles for *Pfiesteria* spp. and other dinoflagellates, pp. 255-257. In: *Harmful Algae 2002 - Proceedings of the Xth International Conference on Harmful Algae*, by Steidinger KA, Landsberg JA, Tomas CR, Vargo GA (eds.). Florida Fish and Wildlife Conservation Commission, Florida Institute of Oceano graphy, and the Intergovernmental Oceanographic Commission of UNESCO, St. Petersburg, FL.

112) Zhang C, Allen EH, Glasgow HB, Moeller PDR, Burkholder JM, Lewitus AJ, Melia GM, Morton SL (2004) Evaluation of toxicity in nine raphidophyte strains isolated from different geographic regions, pp. 198-200. In: *Harmful Algae 2002 - Proceedings of the Xth International Conference on Harmful Algae*, by Steidinger KA, Landsberg JA, Tomas CR, Vargo GA (eds.). Florida Fish and Wildlife Conservation Commission, Florida Institute of Oceanography, and the IOC of UNESCO, St. Petersburg, FL.

113) Burkholder JM, Gordon AS, Moeller PD, Law JM, Coyne KJ, Lewitus AJ, Ramsdell JS, Marshall HG, Deamer NJ, Cary SC, Kempton JW, Morton SL, Rublee PA (2005) Demonstration of toxicity to fish and to mammalian cells by *Pfiesteria* species: Comparison of assay methods and multiple strains. *Proceedings of the National Academy of Sciences (USA)* 102: 3471-3476.

114) Glibert PM, Seitzinger S, Heil CA, Burkholder JM, Parrow MW, Codispoti LA, Kelly V (2005) Eutrophication – new perspectives on its role in the global proliferation of harmful algal blooms. *Oceanography* 18: 198-209.

115) Parrow MW, Burkholder JM, Deamer NJ, Ramsdell JS (2005) Contaminant-free cultivation of *Pfiesteria shumwayae* (Dinophyceae) on a fish cell line. *Aquatic Microbial Ecology* 39: 97-105.

116) Springer JJ, Burkholder JM, Glibert PM, Reed RE (2005) Use of a real-time remote monitoring network and shipborne sampling to characterize a dinoflagellate bloom in the Neuse Estuary, North Carolina, U.S.A. *Harmful Algae* 4: 533-551.

117) Burkholder JM, Azanza RV, Sako Y (2006) The ecology of harmful dinoflagellates, pp. 53-66. In: *The Ecology of Harmful Algae*, by Granéli E, Turner J (eds.). Springer-Verlag, New York.

118) Burkholder JM, Dickey DA, Kinder C, Reed RE, Mallin MA, Melia G, McIver MR, Cahoon LB, Brownie C, Deamer N, Springer J, Glasgow H, Toms D, Smith J (2006) Comprehensive trend analysis of nutrients and related variables in a large eutrophic estuary: A decadal study of anthropogenic and climatic influences. *Limnology and Oceanography* 51: 463-487.

119) Burkholder JM, Glibert PM (2006) Intraspecific variability: An important consideration in forming generalizations about toxigenic algal species. *African Journal of Marine Science* 28: 177-180.

120) Glibert PM, Burkholder JM (2006) The complex relationships between increasing fertilization of the Earth, coastal eutrophication, and HAB proliferation, pp. 341-354. In: *The Ecology of Harmful Algae*, by Granéli E, Turner J (eds.). Springer-Verlag, New York.

121) Marshall HG, Hargraves PE, Burkholder JM, Parrow MW, Elbrächter M, Allen EH, Knowlton VM, Rublee PA, Hynes WL, Egerton TA, Remington DL, Wyatt KB, Lewitus AJ, Henrich VC (2006) Taxonomy of *Pfiesteria* (Dinophyceae). *Harmful Algae* 5: 481-496.

122) Parrow MW, Elbrächter M, Krause MK, Burkholder JM, Deamer NJ, Hyte N, Allen EH (2006) The taxonomy and growth of a *Crypthecodinium* species (Dinophyceae) isolated from a brackish water fish aquarium. *African Journal of Marine Science* 28: 185-191.

123) Shumway SE, Burkholder JM, Springer J (2006) Effects of the estuarine dinoflagellate *Pfiesteria shumwayae* (Dinophyceae) on survival and grazing activity of several shellfish species. *Harmful Algae* 5: 442-458.

124) Skelton HM, Parrow MW, Burkholder JM (2006) Phosphatase activity in the heterotrophic dinoflagellate, *Pfiesteria shumwayae* (Dinophyceae). *Harmful Algae* 5: 395-406.

125) Glibert PM, Burkholder JM, Parrow MW, Lewitus AJ, Gustafson DE (2006) Direct uptake of nitrogen by *Pfiesteria piscicida* and *Pfiesteria shumwayae*, and nitrogen nutritional preferences. *Harmful Algae* 5: 380-394.

126) Lewitus AJ, Wetz MS, Wills BM, Burkholder JM, Parrow MW, Glasgow HB (2006) Grazing activity of *Pfiesteria piscicida* (Dinophyceae) and susceptibility to ciliate predation vary with toxicity status. *Harmful Algae* 5: 427-434.

127) Rublee PA, Nuzzi R, Waters R, Schaefer ER, Burkholder JM (2006) *Pfiesteria piscicida* and *Pfiesteria shumwayae* in coastal waters of Long Island, New York, USA. *Harmful Algae* 5: 374-379.

128) Zimba PV, Camus A, Gregg K, Allen EH, Burkholder JM (2006) Co-occurrence of white shrimp, *Penaeus vannamei*, mortalities and microcystin toxin in a southeastern USA shrimp facility. *Aquaculture* 261: 1048-1055.

129) Burkholder JM, Libra B, Weyer P, Heathcote S, Kolpin D, Thorne PS, Wichman M (2007) Impacts of waste from concentrated animal feeding operations on water quality. *Environmental Health Perspectives* 115: 308-312.

130) Burkholder JM, Hallegraeff GM, Melia G, Cohen A, Bowers HA, Oldach DW, Parrow MW, Sullivan MJ, Zimba PV, Allen EH, Mallin MA (2007) Phytoplankton and bacterial assemblages in ballast water of U.S. military ships as a function of port of origin, voyage time and ocean exchange practices. *Harmful Algae* 6: 486-518.

131) Burkholder JM, Tomasko D, Touchette BW (2007) Seagrasses and eutrophication. *Journal of Experimental Marine Biology and Ecology* 350: 46-72.

132) Touchette BW, Burkholder JM (2007) Partitioning of cellular phosphomonoesterase activity between carbon source and sink tissues in *Zostera marina* L. *Journal of Experimental Marine Biology and Ecology* 342: 313-324.

133) Touchette BW, Burkholder JM (2007) Carbon and nitrogen metabolism in the seagrass, *Zostera marina* L.: Environmental control of enzymes involved in carbon allocation and nitrogen assimilation. *Journal of Experimental Marine Biology and Ecology* 350: 216-233.

134) Touchette BW, Burkholder JM, Allen EH, Alexander JL, Kinder CA, James J, Britton CH (2007) Eutrophication and cyanobacteria blooms in run-of-river impoundments in North Carolina, U.S.A. *Lake and Reservoir Management* 23: 179-192.

135) Anderson DM, Burkholder JM, Cochlan WP, Glibert PM, Gobler CJ, Heil CA, Kudela R, Parsons ML, Rensel JE, Townsend DW, Trainer VL, Vargo GA (2008) Harmful algal blooms and eutrophication: Examining linkages in selected U.S. coastal regions. *Harmful Algae* 8: 39-53.

136) Burkholder JM, Glibert PM, Skelton HM (2008) Mixotrophy, a major mode of nutrition for harmful algal species in eutrophic waters. *Harmful Algae* 8: 77-93.

137) Glibert P, Azanza R, Burford M, Furuya K, Abal E, Al-Azri A, Al-Yamani F, Andersen P, Anderson DM, Beardall J, Berg GM, Brand L, Bronk D, Brookes J, Burkholder JM, Cembella A, Cochlan WP, Collier J, Collos Y, Diaz R, Doblin M, Drennen T, Dyhrman S, Fukuyo Y, Furnas M, Galloway J, Granéli E, Ha DV, Hallegraeff G, Harrison J, Harrison PJ, Heil CA, Heimann K, Howarth R, Jauzein C, Kana AA, Kana TM, Kim H, Kudela R, Legrand C, Mallin M, Mulholland M, Murray S, O'Neill J, Pitcher G, Qi Y, Rabalais N, Raine R, Seitzinger S, Salomon P, Solomon C, Stoecker DK, Usup G, Wilson J, Yin K, Zhou M, Zhu M (2008) Ocean urea fertilization for carbon credits poses high ecological risks. *Marine Pollution Bulletin* 56: 1049-1056.

138) Hégaret H, Shumway SE, Wikfors GH, Pate S, Burkholder JM (2008) Potential transport of harmful algae via relocation of bivalve molluscs. *Marine Ecology Progress Series* 361: 169-179.

139) Heisler J, Glibert P, Burkholder J, Anderson D, Cochlan W, Dennison W, Gobler C, Dortch Q, Heil C, Humphries E, Lewitus A, Magnien R, Marshall H, Stockwell D, Suddleson M. (2008) Eutrophication and harmful algal blooms: A scientific consensus. *Harmful Algae* 8: 3-13.

140) Holm ER, Stamper DM, Brizzolar RA, Barnes L, Deamer N, Burkholder JM (2008) Sonication of bacteria, phytoplankton and zooplankton: Application to treatment of ballast water. *Marine Pollution Bulletin* 56: 1201-1208.

141) Skelton HM, Burkholder JM, Parrow MW (2008) Axenic cultivation of the heterotrophic dinoflagellate *Pfiesteria shumwayae* and observations of feeding behavior. *Journal of Phycology* 44: 1614-1624.

142) Reed RE, Dickey DA, Burkholder JM, Kinder CA, Brownie C (2008) Water level variations in the Neuse and Pamlico Estuaries, North Carolina, due to local and non-local forcing. *Estuarine, Coastal and Shelf Science* 76: 431-446.

143) Burkholder JM (2009) Harmful algal blooms, pp. 264-285. In: *Encyclopedia of Inland Waters, Volume 1*, by Likens GE (ed.) Elsevier, Oxford, UK.

144) Glibert PM, Burkholder JM, Kana TM, Alexander J, Skelton H, Shillings C (2009) Grazing by *Karenia brevis* on *Synechococcus* enhances growth and may help to sustain blooms. *Aquatic Microbial Ecology* 55: 17-30.

145) Skelton HM, Burkholder JM, Parrow MW (2009) Axenic cultivation of the heterotrophic dinoflagellate *Pfiesteria shumwayae* in a semi-defined medium. *Journal of Eukaryotic Microbiology* 56: 73-82.

146) Rothenberger M, Burkholder JM, Wentworth T (2009) Multivariate analysis of phytoplankton and environmental factors in a eutrophic estuary. *Limnology and Oceanography* 54: 2107-2127.

147) Rothenberger M, Burkholder JM, Brownie C (2009) Long-term effects of changing land use practices on surface water quality in a coastal river and lagoonal estuary. *Environmental Management* 44: 505-523.

148) Pate SE, Burkholder JM, Shumway SE, Hégaret H, Wikfors GH, Frank D (2010) Effects of the toxic dinoflagellate *Alexandrium monilatum* on survival, grazing and behavioral response of three ecologically important bivalve molluscs. *Harmful Algae* 9: 281-293.

149) Burkholder JM, Frazier W, Rothenberger MB (2010) Source water assessment and treatment strategies for harmful and noxious algae, pp. 299-328. In: *Algae Manual*, AWWA Manual 57, by the American Water Works Association, Denver, CO.

150) Reed RE, Burkholder JM, Allen EH (2010) Current online monitoring technology for surveillance of algal blooms, potential toxicity, and physical/chemical structure in rivers, reservoirs, and lakes, pp. 3-24. In: *Algae Manual*, AWWA Manual 57, by the American Water Works Association, Denver, CO.

151) Burkholder JM, Shumway SE (2011) Bivalve shellfish aquaculture and eutrophication, pp. 155-215. In:

Shellfish and the Environment, by Shumway SE (ed.). Wiley, New York, NY.

152) Glibert PM, Burkholder JM (2011) Harmful algal blooms and eutrophication: Strategies for nutrient uptake and growth outside the Redfield comfort zone. *Chinese Journal of Oceanography* 29: 724-738.

153) Glibert PM, Fullerton D, Burkholder JM, Cornwell JC, Kana TM (2011) Ecological stoichiometry, biogeochemical cycling, invasive species and aquatic food webs: San Francisco Estuary and comparative systems. *Reviews in Fisheries Science* 19: 358-417.

154) Null KA, Corbett DR, DeMaster DJ, Burkholder JM, Thomas CJ, Reed RE (2011) ^{222}Rn-based advection of ammonium into the Neuse River Estuary, North Carolina, USA. *Estuarine, Coastal and Shelf Science* 95: 314-325.

155) Burkholder JM, Marshall HG (2012) Toxigenic *Pfiesteria* species - updates on biology, ecology, toxins, and impacts. *Harmful Algae* 14: 196-230.

156) Flynn, KJ, Mitra A, Stoecker DK, Raven JA, Granéli E, Glibert PM, Hansen PJ, Burkholder JM G. (2012) An ocean of mixotrophs – a new paradigm for marine ecology. *Journal of Plankton Research* 35: 3-11.

157) Glibert PM, Burkholder JM, Kana TM (2012) Recent insights about relationships between nutrient availability, forms, and stoichiometry, and the distribution, ecophysiology, and food web effects of pelagic and benthic *Prorocentrum* species. *Harmful Algae* 14: 231-259.

158) Hathaway JM, Moore TLC, Burkholder JM, Hunt WF (2012)Temporal analysis of stormwater SCM effluent based on harmful algal bloom (HAB) sensitivity in surface waters: Are annual nutrient EMCs appropriate during HAB-sensitive seasons? *Ecological Engineering* 49: 41-47.

159) Burkholder JM, Glibert PM (2013) Eutrophication and oligotrophication, pp. 347-371. In: *Encyclopedia of Biodiversity*, 2nd edition, Volume 3, by Levin S (ed.). Academic Press, Waltham, MA.

160) Wang W-C, Allen E, Campos AA, Cade RK, Dean L, Dvora M, Immer JG, Mixson S, Srirangan S, Sauer M-L, Schreck S, Sun K, Thapaliya N, Wilson C, Burkholder J, Grunden AM, Lamb HH, Sederoff H, Stikeleather LF, Roberts WL (2013) ASI: *Dunaliella* marine microalgae to drop-in replacement liquid transportation fuel. *Environmental Progress* (November): DOI:10.1002/ep.11855.

161) Mitra A, Flynn KJ, Burkholder JM, Berge T, Calbet A, Raven JA, Granéli E, Glibert PM, Hansen PJ, Stoecker DK, Thingstad F, Tillmann U, Våge S, Wilken S, Zubkov M (2013) The role of mixotrophic protists in the biological carbon pump. *Biogeosciences Discussion* 10: 13535-13562.

162) Mixson SM, Stikeleather LF, Simmons OD III, Wilson CW, Burkholder JM. (2014) Auto-flocculation, electro-flocculation, and hollow-fiber filtration techniques for harvesting the saltwater microalga *Dunaliella*. *Journal of Applied Phycology* DOI 10.1007/s10811-013-0232-z.

163) Byrd SM, Burkholder JM, Zimba PV (2016) Environmental stressors and lipid production by *Dunaliella* spp. I. Salinity. *Journal of Experimental Marine Biology and Ecology* 487: 18-32.

164) Byrd SM, Burkholder JM (2016) Environmental stressors and lipid production by *Dunaliella* spp. II. Nutrients, pH, and light under optimal or low salinity. *Journal of Experimental Marine Biology and Ecology* 487: 33-44.

165) Glibert PM, Wilkerson FP, Dugdale RC, Raven JA, Dupont C, Leavitt PR, Parker AE, Burkholder JM, Kana TM (2016) Pluses and minuses of ammonium and nitrate uptake and assimilation by phytoplankton and implications for productivity and community composition, with emphasis on nitrogen-enriched conditions. *Limnology and Oceanography* 61: 165-197.

166) Gobler CJ, Burkholder JM, Davis TW, Harke MJ, Johengen T, Stow C, Van de Waal DB (2016) The dual role of nitrogen supply in controlling the growth and toxicity of cyanobacterial blooms. *Harmful Algae* 54: 87-97.

167) Mitra A, Flynn KJ, Tillmann U, Raven JA, Caron D, Stoecker DK, Not F, Hansen PJ, Hallegraeff G, Sanders R, Wilken S, McManus G, Johnson M, Pitt P, Våge S., Berge T, Calbet A, Thingstad F, Jeong HJ, Burkholder JM, Glibert PM, Granéli E, Lundgren V (2016) Defining planktonic protist functional groups on mechanisms for energy and nutrient acquisition: Incorporation of diverse mixotrophic strategies. *Protist* 167: 106-120.

168) Burkholder JM, Gobler CJ, O'Neill JM (2018) Cyanobacteria, pp. 591-595. In: *Harmful Algal Blooms and Their Management: A Compendium Desk Reference*, by Shumway SE, Burkholder JM, Morton SL (eds.). John Wiley & Sons Ltd., Hoboken, NJ.

169) Burkholder JM, Marshall HG (2018) *Pfiesteria piscicida* and *Pfiesteria shumwayae*, pp. 621-624. In: *Harmful Algal Blooms and Their Management: A Compendium Desk Reference*, by Shumway SE, Burkholder JM, Morton SL (eds.). John Wiley & Sons Ltd., Hoboken, NJ.

170) Glibert PM, Burkholder JM (2018) *Prorocentrum*, pp. 625-628. In: *Harmful Algal Blooms and Their Management: A Compendium Desk Reference*, by Shumway SE, Burkholder JM, Morton SL (eds.). John Wiley & Sons Ltd., Hoboken, NJ.

171) Glibert PM, Burkholder, JM (2018) Causes of blooms, pp. 1-38. In: *Harmful Algal Blooms and Their Management: A Compendium Desk Reference*, by Shumway SE, Burkholder JM, Morton SL (eds.). John Wiley & Sons Ltd., Hoboken, NJ.

172) Burkholder JM, Shumway SE, Glibert PM (2018) Food web and ecosystem impacts of harmful algae, pp. 243-336. In: *Harmful Algal Blooms and Their Management: A Compendium Desk Reference*, by Shumway SE, Burkholder JM, Morton SL (eds.). John Wiley & Sons Ltd., Hoboken, NJ.

173) Lapointe BE, Burkholder JM, Van Alstyne KL (2018) Harmful macroalgal blooms in a changing world: Causes, impacts, and management, pp. 515-560. In: *Harmful Algal Blooms and Their Management: A Compendium Desk Reference*, by Shumway SE, Burkholder JM, Morton SL (eds.). John Wiley & Sons Ltd., Hoboken, NJ.

174) Flood SL, Burkholder JM, Cope GW (2018) Assessment of atrazine toxicity to the benign estuarine phytoplankter, *Dunaliella tertiolecta* (Chlorophyta) under varying nutrient conditions. *Environmental Science and Pollution Research* 25: 11409-11423.

175) Flood SL, Burkholder JM (2018) Imbalanced nutrient regimes increase *Prymnesium parvum* resilience to herbicide exposure. *Harmful Algae* 75: 57-74.

176) Flood SL, Burkholder JM (2018) *Chattonella subsalsa* (Raphidophyceae) growth and hemolytic activity in response to agriculturally-derived estuarine contaminants. *Harmful Algae* 76: 66-79.

177) Mallin MA, Burkholder JM, Cahoon LB, Grogan AE, Sanger DR, Smith E (2019) An environmental assessment of the North and South Carolina Coasts, pp. 405-426. In: Sheppard CRC (ed.), *World Seas: An Environmental Evaluation*, 2nd edition. Vol. 1 – Europe, the Americas and West Africa. Academic Press, Cambridge, MA.

178) Leles SG, Mitra A, Flynn KJ, Tillmann U, Stoecker D, Jeong HJ, Burkholder J, Hansen PJ, Caron DA, Glibert PM, Hallegraeff G, Raven J, Sanders RW, Zubkov M (2019) Sampling bias misrepresents the biogeographical significance of constitutive mixotrophs across global oceans. *Global Ecology and Biogeography* – https://doi.org/10.1111/geb.12853.

179) Shalygin S, Huang I-S, Allen E, Burkholder J, Zimba PV (2019) *Odorella benthonica* gen & sp. nov. (Pleurocapsales, Cyanobacteria): an odor and prolific toxin producer isolated from a California aqueduct. *Journal of Phycology* 55: 509-520.

Technical Reports (peer-reviewed)

Burkholder JM, Parsons JE (1993) *Sediment and Phosphorus Loading: Predicting Water Quality in Urban Piedmont Reservoirs.* Report No. 274. UNC Water Resources Research Institute, Raleigh, NC, 194 pp.

Burkholder JM, Glasgow HB, Fensin E (1996) *Neuse Estuary Biomonitoring Study – May 1993 – December 1995.* Report of the first three years of a five-year study, to the U.S. Marine Air Station – Cherry Point, Cherry Point, NC. Aquatic Botany Laboratory, NCSU, Raleigh, 86 pp.

Burkholder JM (1998) *The Toxic* Pfiesteria *Complex: A Scientific Discussion of its History, Ethology, and Impacts on Human Health.* Office, Assistant Secretary of the Army - Installations, Logistics and Environment. Pentagon, Washington, DC.

Burkholder JM, Glasgow HB, Deamer-Melia N (1998) *Neuse Estuary Biomonitoring Study – Physical, Chemical, and Biological Characteristics of Water Samples Collected from the Neuse Estuary in the Vicinity of Cherry Point, North Carolina, May 1993 - April 1998.* Final Report of a five-year study, to the U.S. Marine Air Station, Cherry Point, NC. Aquatic Botany Laboratory, NCSU, Raleigh, 110 pp.

Burkholder JM (1999) *The Role of Toxic* Dinoflagellates *in Fish Lesions.* Issue paper prepared for the U.S. Army. Office, Assistant Secretary of the Army - Installations, Logistics and Environment. Pentagon, Washington, DC.

Burkholder JM, Glasgow HB (1999) *Neuse Estuary Biomonitoring Study, with Additional Information on Overall Nutrient Loading to the Mesohaline Estuary.* Final Report to the U.S. Marine Air Station – Cherry Point. Department of Botany, NCSU, Raleigh, 134 pp.

Burkholder JM, Glasgow HB, Rublee PA, Shumway SE (2001) *The Toxic Dinoflagellate,* Pfiesteria, *as a Potential Biosensor of Estuarine Stress.* Final Report to the U.S. EPA, Washington, DC, 108 pp.

Touchette BW, Burkholder JM, Glasgow HB (2001) *Distribution of American Water Willow (*Justicia americana *L.) in the Narrows Reservoir.* Final Report to Alcoa Power Generating Inc., Badin, NC, 51 pp.

van der Schalie WH, Shedd T, Widder M, Kane AS, Reimschussel R, Sarabun J, Burkholder J, Glasgow H (2001) *Real-Time Monitoring for Toxicity Caused by Harmful Algal Blooms and Other Water Quality Perturbations.* Report EPA/600/R-01/103, U.S. EPA, Washington, DC.

Burkholder J, Glasgow H, Deamer N, Melia G, Litzenberger T (2003) *Response of* Pfiesteria piscicida, *Microbial Predators and Prey, and Fish to Common Dithiocarbamate Fungicides and Heavy Metals.* Final Report to the U.S. EPA, Research Triangle Park, NC, 26 pp. + appendix.

Burkholder JM (2010) *Assessment of Water Resources and Watershed Conditions in the Kennesaw Mountain National Battlefield Park, Georgia.* Draft Report to the Southeast Coast Inventory and Monitoring Network of the National Park Service, Southeast Regional Office, Atlanta, GA, 71 pp.

Burkholder JM, Allen EH, Kinder CA (2010) *Assessment of Water Resources and Watershed Conditions in Ocmulgee National Monument, Georgia.* Natural Resource Report NPS/SECN/NRR—2010/276. National Park Service, Fort Collins, CO, 81 pp.

Burkholder JM, Allen EH, Kinder CA, Morris E (2010) *Assessment of Water Resources and Watershed Conditions in the Chattahoochee River National Recreation Area, Georgia.* Draft Natural Resource Report NPS/SECN.NRR-2010/274. National Park Service, Fort Collins, CO, 202 pp.

Burkholder JM, Rothenberger MB (2010) *Assessment of Water Resources and Watershed Conditions in Horseshoe Bend National Military Park, Alabama.* Natural Resource Report NPS/SECN.NRR-2010/268. National Park Service, Fort Collins, CO, 51 pp.

United States Department of Environmental Protection (U.S. EPA) (2011) *Efficacy of Ballast Water Treatment Systems: A Report by the EPA Science Advisory Board (SAB)*. U.S. EPA SAB Ecological Processes and Effects Committee Augmented for the Ballast Water Advisory. Report #EPA-SAB-11-009. U.S. EPA, Washington, DC, ~150 pp. Burkholder was an Augmented Panel Member and a coauthor of this report.

Burkholder JM, Allen EH, Flood S, Kinder CA (2015) *Natural Resource Condition Assessment - Horseshoe Bend National Military Park*. Natural Resource Report NPS/SECN/NRTR—2015/981. National Park Service, Fort Collins, CO, 270 pp.

Burkholder JM, Allen EH, Flood S, Kinder CA (2017) *Natural Resource Condition Assessment - Ocmulgee National Monument, Georgia*. Natural Resource Report NPS/SECN/NRTR—2017/1521. National Park Service, Fort Collins, CO, 179 pp.

Burkholder JM, Allen EH, Flood S, Kinder CA (2017) *National Resource Condition Assessment - Cape Lookout National Seashore, North Carolina*. Natural Resource Report NPS/SECN/NRTR—2017/xxx. National Park Service, Fort Collins, CO, 248 pp.

Burkholder JM, Allen EH, Flood S, Kinder CA (2018) *National Resource Condition Assessment - Moores Creek National Battlefield, North Carolina*. Natural Resource Report NPS/SECN/NRTR—2018/xxx. National Park Service, Fort Collins, CO, 202 pp.

Burkholder JM, Allen EH, Flood S, Kinder CA (2018) *National Resource Condition Assessment - Congaree National Park, South Carolina*. Natural Resource Report NPS/SECN/NRTR—2018/xxx. National Park Service, Fort Collins, CO, 324 pp.

Non-Referred and Popular Press Articles and Reports

Burkholder, J.M. (2019) *Nitrate in Drinking Water and Surface Freshwaters: Occurrence, Impacts, and Recommendations for Protection of Human Health and Aquatic Life*. Report prepared for the Sierra Club. Department of Applied Aquatic Ecology, North Carolina State University, Raleigh, NC.

Burkholder, J.M. (2018) *A Synopsis on Developing Numeric Nutrient Criteria for Freshwaters*. Report prepared for the Mississippi River Consortium.

Burkholder JM (2006) A major potable water supply reservoir poised for increased cyanobacteria blooms. *LakeLine* (summer), pp. 49-51.

Burkholder JM (2003) Science and the press. On-line modules (editor, N. Kriesberg), NCSU, Raleigh.

Schmechel DE, Burkholder JM, Attix DK, Glasgow HB (2002) Toxic *Pfiesteria*. Microbiology No. MB 02-5 (MB-036). *Check Sample, American Society for Clinical Pathology* 45:65-88.

Burkholder JM (2000) Brushstrokes from Floyd, pp. 72-79. In: *Eye of the Storm – Essays in the Aftermath*, by E.W. Rickert (ed.). Coastal Carolina Press, Wilmington.

President's Committee of Advisors on Science and Technology (PCAST) (1998) *Teaming with Life: Investing in Science to Understand and Use America's Living Capital.* Section I: Make Use of Current Knowledge in Managing Biodiversity and Ecosystems of the U.S., p.27. PCAST Panel on Biodiversity and Ecosystems, Washington, DC.

Burkholder JM (1997) *Pfiesteria* and Nutrient Pollution. Requested by Maryland's Governor Glendening

for a summit meeting of five governors of states in the Chesapeake Bay watershed, Annapolis, pp. 1-5.

Burkholder JM (1995) Fish kills' message: Get serious about reducing nutrient over-enrichment to our estuaries, pp.1-3. In: *WaterWise*, by Doll B (Ed.). Vol. 1, 2nd Quarter. NC Sea Grant News Letter, Raleigh.

Coastal Futures Committee (1994) *Charting a Course for our Coast - A Report to the Governor of North Carolina.* L.R. Preyer, Chair. NC Department of Environment, Health and Natural Resources, Raleigh, 106 pp. [As the only scientist on the 15-member committee, I contributed substantially to all sections related to water quality, habitat, and fisheries in the document, and to the executive summary of prioritized recommendations.]

Burkholder JM (1993) Vital grasses need clean water to grow. In: *Currents*, News Letter of the Pamlico-Tar River Foundation, Vol. 13, Fall, p.7, Washington (NC).

Burkholder JM (1993) A newly discovered toxic alga and its relationship to fish kills, pp.48-58. In: *Proceedings from the Second North Carolina Marine Recreational Fishing Forum.* NC Sea Grant Report UNC-SG-93-06. UNC Sea Grant, NCSU, Raleigh, 61 pp.

Burkholder JM (1993) Golf course runoff: View from below the water surface, pp. 18-23. In: *Is Golfing Green? The Impact of Golf Courses on the Coastal Environment*. Symposium Proceedings (sponsored by the NC Coastal Federation and the NCSU Cooperative Extension Service through the NC Sea Grant College Program), Wilmington.

Patent

U.S. Patent #7,040,157. "Variable depth automated dynamic water profiler", Reed, Glasgow, Burkholder, Toms, May 2006 (NCSU; patent sold to YSI, Inc.).

Professional Activities (examples)

Co-Editor of Book: (2017) *Harmful Algal Blooms and Their Management: A Compendium Desk Reference*, by Shumway SE, Burkholder JM, Morton SL (eds.). Elsevier, New York.

Editorial

Guest Co-Editor, special issue, *Harmful Algae* (Intraspecific Variation, 2009)
Guest Co-Editor, special issue, *Harmful Algae* (Harmful Algae and Eutrophication), 2007
Guest Co-Editor, special issue, *Harmful Algae* (Ecology of *Pfiesteria*), 2006
Editorial Board, *Journal of Experimental Marine Biology and Ecology*, 2005 - 2016
Editorial Board, *Harmful Algae,* 2002 - 2019
Editorial Board, *Journal of Eukaryotic Microbiology*, 1996-1999
Editorial Board, *Journal of Phycology*, 1995-1997

Other Society Service

Member, Organizing Committee, International Symposium on Harmful Algae, 2009-2010
Member, Organizing Committee, National Symposium on Harmful Algae, 2000, 2002, 2003
Member, Ethics Committee, American Society of Limnology and Oceanography, 1996-1997
Member, Harmful Algae Technical Advisory Committee, Maryland Department of Natural Resources, 1998-2001
Session Chair, Ecology of Aquatic Protozoa session, XIth Meeting, International Congress of Protozoology, 2001
Session Chair, New Harmful Algae, 10th International Conference on Harmful Algal Blooms, 2000
Session Chair, *Pfiesteria* in the Southeast, 1st National Symposium on Harmful Algae, 2000
Session Chair, Harmful Algae, 15th Biennial International Conference of the Estuarine Research Federation,

1999
Session Co-Chair, Harmful Algal Blooms, Annual Summer Meeting, American Society of Limnology and Oceanography, 1998
Session Co-Chair, Harmful Algal Blooms, Joint Meeting - American Society of Limnology and Oceanography and American Geophysical Union, 1997
Chair, Hutchinson Award Committee, American Society of Limnology and Oceanography, 1996
Board of Directors, American Society of Limnology and Oceanography, 1994-1997
Session Chair, Ecology of Freshwater Algae, Joint Meeting - International Phycological Congress and Phycological Society of America, 1991
Session Chair, Phytoplankton, Annual Meeting, American Society of Limnology and Oceanography, 1988

External Panels and Reviews

Member, panel review of the annual South Florida Environmental Report for the South Florida Water Management District, 2006-2011
Examiner ("Opponent") of doctoral candidate Johannes Hagström, Kalmar University, 2006
Member, review team for the Department of Botany, Miami University of Ohio, 2005
Member, review team for the Marine Sciences Programs, Institut für Meereskunde, Salzau, Germany, 1998
National Science Foundation, Biological Oceanography Panel, 1995
UNC Water Resources Research Institute Panel, 1991-1993
Member, review team, Lake Okeechobee Ecosystem Project, South Florida Water Management District, 1991

Workshops (Invited Participant)

Aquatic Plant Biology, Ecology and Identification – participant and invited speaker at a NCSU – Extension conference, Raleigh, NC, 2018
The Importance of Algal Mixotrophy in Trophic Models of the Oceans – participant and invited speaker at an international workshop sponsored by the Leverhume Foundation, University of Maryland - Horn Point, Cambridge, MD, 2013
Taxonomy and Ecology of Algae in the Southeast – co-organizer of a workshop for members of the North Carolina Lake Management Society (NALMS – Southeast Chapter), sponsored by NALMS, 2009, 2010, 2011, 2012
Falls Lake Symposium: Christian Creation Stewardship – keynote speaker of a workshop attended by scientists and theologians, to encourage church memberships to become involved in environmental stewardship of the Falls Lake potable water supply, sponsored by the concerned citizens group, Wake Up Wake County, and organized by Drs. Bob George (editor, Theoecology Journal, online) and Bruce Little (Center for Faith and Culture, Southeastern Theological Seminary), 2012
Algae Affecting Potable Water Supplies – AWWA, Savannah, GA, 2010
Identifying Harmful Cyanobacteria in North Carolina Potable Water Supplies – Organizer; two workshops for potable water treatment plant operators, sponsored by the NC Department of Health and Human Services, 2006
Occurrence of Toxigenic Cyanobacteria in the USA, International Symposium on Harmful Cyanobacterial Blooms, US Environmental Protection Agency (EPA), 2005
National Plan for Harmful Algal Research, Ecological Society of America and the National Oceanic and Atmospheric Administration (NOAA), 2004
Social and Environmental Impacts of Concentrated Animal Feed Operations, The University of Iowa and the National Institute of Environmental Health Sciences (NIEHS), 2004
Conflicted Science / Integrity in Science Conference and Workshop, Center for Science in the Public Interest, Washington, DC, 2003
Estuarine Fish Disease, Delaware Department of Natural Resources & Environmental Control, 2000

Harmful Algae Technical Advisory Committee Workshop, Maryland Department of Natural Resources (MD DNR) and Maryland Department of Environment (MD DE), 2000, 2001, 2002
Re-evaluation of Microbial Water Quality: Powerful New Tools for Detection and Risk Assessment, American Academy of Microbiology, 2000
Conservation Medicine Workshop, Center for Conservation Medicine of Tufts University, 1999
Harmful Algal Blooms: Research and Monitoring Programs, US EPA - Region IV, 1998
Pfiesteria Workshops - Sampling and Identification (organizer), NCSU, 1998
Pfiesteria Sampling and Identification Protocols, Centers for Disease Control & Prevention, 1998
European Harmful Algal Blooms (EUROHAB) Science Initiative, Marine Science and Technology Programme of the European Commission, 1998
Pfiesteria and Water Quality Monitoring Standards Workshop, NOAA, 1998
Pfiesteria and Human Health Workshop, Maryland Department of Health and Mental Hygiene and the Maryland Medical Team, University of Maryland and Johns Hopkins, 1998
State/Federal *Pfiesteria* Working Group - Monitoring Protocols, U.S EPA and NOAA, 1998
Maryland Technical Advisory Committee Workshop on *Pfiesteria*, Fish Kills and Water Quality Monitoring, MD DNR, Baltimore, MD, 1998
Pfiesteria Workshop, 14th Biennial International Conference of the Estuarine Research Federation, Providence, RI, 1997
The Cambridge *Pfiesteria*/Nutrients Workshop, convened by Governor Glendening of Maryland, 1997. The final report, *The Cambridge Consensus*, was used by the governor and the Maryland legislature to change policy about non-point water pollution control in tributaries to Chesapeake Bay and led to passage of the Maryland Water Quality Act of 1998.
Impacts of Toxic *Pfiesteria*/*Pfiesteria*-like Dinoflagellates on Fisheries and Human Health, US EPA (Philadelphia, PA; Washington, DC; Pensacola, FL), 1997; Delaware Department of Environment and Water Resources, 1997
Harmful Algal Blooms and Human Health, NIEHS, 1997
Pocomoke River Fish Disease, MD DNR, 1997
Climate Variability and Human Health, American Society of Microbiology, 1997
Developing an Environmental Education Video on Water Resource Issues in North Carolina, Z. Smith Reynolds Foundation, 1997
Control of Blue-Green Algae in Rainbow Springs, Florida, Department of Fisheries and Aquaculture, University of Florida, 1996
Sustainable Marine Fisheries, National Academy of Sciences Ocean Studies Board, 1996
Disease Events and Meteorology along the US Atlantic Coast, Harvard Medical School, 1995
National Nutrient Assessment Workshop – Estuaries, US EPA, Washington, DC, 1995
Harmful Algal Blooms - Research Initiative Development, NSF / NOAA, 1994
Seagrasses and Eutrophication Impacts, US EPA / Sarasota Bay National Estuary Program, 1993
Techniques in Sampling and Identification of *Pfiesteria* – NOAA, 1992; Florida Department of Environmental Protection - Florida Marine Research Institute, 1992; MD DNR, 1993; MD DE, 1993; Delaware Division of Water Quality, 1993
Target Issues: Development of RFP guidelines for a New NOAA Coastal Ocean Program Initiative on Harmful Algal Blooms, NOAA, 1992
Phytoplankton of the Southeastern United States, North Carolina Department of Environment, Health and Natural Resources (NC DEHNR) and Duke Power Company, 1992
Target Issues for Funding Support of Research on Toxic Phytoplankton, NOAA, 1992
Improved Data Base and Optimal Approaches for Modeling Water Quality in the Albemarle-Pamlico Estuarine System, US EPA and NC DEHNR, 1992
Water Quality Regulations for Protection of Seagrass Habitat on the Gulf Coast, US EPA, 1992
Improved Standards for Protecting Water Quality in the Albemarle-Pamlico Estuarine System, US EPA, 1991
Teaching Aquatic Botany to High School Students (organizer), NCSU, 1987, 1988

Light Microscope-Autoradiography of Microalgae (organizer), Bowling Green State University, Bowling Green, OH, 1987

Research Presentations

Water Quality (Eutrophication, Seagrasses, etc.)

2019

Lindor NL, Burkholder JM. Nutrient profiles, phytoplankton biomass, and algal assemblages in Falls Lake, North Carolina. UNC Water Resources Research Institute, Raleigh (with published abstract).

Buczek SB, Cope WG, Shehdan M, Bishop WM, Richardson RJ, Burkholder JM, Kwak TJ, Jessup J, Black TR. In situ Evaluation of Freshwater Mussel Sensitivity to Prescribed Algaecide Applications in a North Carolina Piedmont Reservoir. North Carolina Chapter of the American Fisheries Society, Morganton, NC (with published abstract).

2018

Burkholder JM, Kinder CA, Reed RE, James J, Mackenzie L, Allen EH. Changing Water Quality in Falls Lake, the Triangle's Major Potable Source Water. UNC Water Resources Research Institute, Raleigh, NC (with published abstract).

Lindor N, Burkholder JM. Eutrophication, nutrient stoichiometry, and phytoplankton blooms in a southeastern U.S. reservoir. Fall meeting of the North Carolina chapter of NALMS, Raleigh (with published abstract).

2016

NC Water Resources Research Institute, Raleigh, NC (Inventory and Assessment of the Present Status of Water Resources at Cape Hatteras and Cape Lookout National Seashores – Burkholder, Allen, Flood, and Kinder). Annual conference of the NC Water Resources Research Institute, Raleigh, NC.

2015

Decadal Analysis of Water Quality in Falls Lake, the Triangle's Major Potable Water Source (Burkholder et al., presentation and published abstract). Annual conference, NC Water Resources Research Institute, Raleigh, NC.

2014

Long-Term Data Show Continued Water Quality Degradation in the Neuse Estuary, and Inadequate Protection by the Total Nitrogen TMDL (Burkholder et al., presentation and published abstract). Annual conference, NC Water Resources Research Institute, Raleigh, NC.

Why Bother? - Who Needs Models for Mixotrophs in Coastal Ecosystems? (invited presentation, Burkholder) Leverhulme Trust Phytoplankton Mixotrophy Workshop, Swansea, United Kingdom.

Unprecedented Toxin-Producing Cyanobacterial Blooms in the Cape Fear River (Mallin et al., presentation and published abstract), Summer Meeting, Sciences of Limnology and Oceanography, San Diego, CA.

2013

Outside Peer Review of the Marine Programs of the UNC System for the UNC Board of Governors, Morehead City, NC - The NCSU CAAE was later given an excellent evaluation by the Panel in its final report.

Coastal and Estuarine Research Federation, San Diego, CA - Onset of unprecedented toxin-producing cyanobacteria blooms in the Cape Fear River system, North Carolina - Mallin MA., Burkholder JM, McIver MR, Metheny JD, Strangman WK, Zimba PV, Wright JL (presentation, with published abstract).

Coastal and Estuarine Research Federation, San Diego, CA - Comparative ecotoxicology of an agricultural herbicide on benign and toxigenic estuarine phytoplankton - Flood S, Burkholder J, Cope G (poster with published abstract).

2012

NC Water Resources Research Institute, Raleigh, NC – The NCSU Center for Applied Aquatic Ecology Falls Lake Monitoring and Research Program - Burkholder J, Reed R, Kinder C, Allen E, James J, Mackenzie L (poster with published abstract)

Falls Lake Creation Care Symposium, Wake Forest, NC - Status of Water Quality in Falls Lake - J. Burkholder. The goal of this national symposium was for scientists to inform theologians about citizens' potential roles, including church congregations, in assisting with natural resource stewardship issues (keynote presentation, with published abstract)

2011

NC Water Resources Research Institute, Raleigh, NC (excessive ammonium concentrations throughout the Falls Lake water column, and implications for the Falls Lake Rules; with published abstract)

American Water Works Association National Webinar, online technology used to monitor algae and associated environmental conditions (invited, with published abstract)

LOICZ Open Science Conference 2011 – Coastal Systems, Global Change and Sustainability, Yantai, China (Shumway SE, Burkholder JM: mitigating coastal eutrophication – are filter-feeding shellfish the answer?) (plenary, with published abstract)

2010

NC Water Resources Research Institute, Raleigh, NC (status of water quality in the most important potable water supply in North Carolina; with published abstract)

2009

National Shellfisheries Association, Savannah, GA (bivalve shellfish aquaculture and eutrophication; with published abstract)

North Carolina Academy of Science, Warren Wilson College, Swannanoa, NC (documenting microbial changes in reservoirs using metagenomics – coauthor; with published abstract)

Department of Civil and Environmental Engineering, Northwestern University, Chicago, IL (decadal analysis of land use, water quality, and phytoplankton assemblages in a coastal watershed)

20th Biennial Conference of the Coastal and Estuarine Research Federation (increasing ammonium in eutrophic estuaries, and its potential importance in governing phytoplankton assemblages; with published abstract)

2008

Department of Occupational and Environmental Health, U IA (water quality and algal blooms in watersheds influenced by industrialized agriculture)

NOAA National Symposium on Shellfish and the Environment, Warwick, RI (chronic effects of eutrophication on shellfish)

American Society of Limnology and Oceanography, St. Johns, Newfoundland, Canada (microdynamics of physical/chemical structure in a lagoonal estuary - lead, R. Reed; with published abstract)

North Carolina Water Quality Monitoring Forum, Charlotte (recent advances in technology for tracking algal blooms and related environmental conditions; with published abstract)

2007

Horn Point Environmental Laboratory, U MD (chronic eutrophication of the Neuse Estuary)

NC Water Resources Research Institute, Raleigh (CAAE's Falls Lake Monitoring and Research Program; with published abstract)

NC Water Resources Research Institute, Raleigh (groundwater and benthic nitrogen flux in the Neuse Estuary - lead, K. Null; poster with published abstract)

NC Water Resources Research Institute, Raleigh (long-term impacts of changing land use practices on water quality and phytoplankton assemblages in the Neuse River ecosystem - lead, M. Rothenberger; poster

with published abstract)
Annual Conference of the North Carolina Academy of Science, Greenville (inorganic nitrogen flux across the sediment-water interface in the Neuse Estuary - lead, K. Null; poster with published abstract).
Conference, Water Initiatives: What's on the Horizon for Lake Users and Managers, Greensboro.
19th Biennial Conference of the Estuarine Research Federation, Norfolk, VA (temporal and spatial variability in high-resolution, cross-estuarine physical/chemical structure in the Neuse Estuary – lead, R. Reed; poster with published abstract).
19th Biennial Conference of the Estuarine Research Federation, Norfolk, VA (multivariate analysis of phytoplankton and environmental factors in a eutrophic estuary - lead, M. Rothenberger; poster with published abstract).

2006
Department of Biology, Cornell University (water quality trends in the Neuse Estuary)
Department of Marine Sciences, U CONN (water quality trends in the Neuse Estuary)

2005
Department of Biology, UNC Greensboro (water quality trends in the Neuse Estuary)
Wilkes Community College, Wilkesboro, NC (honors seminar series - water quality issues)

2003
Center for Science in the Public Interest: Conflicted Science Conference, Washington, DC (water quality and confined animal feed operations [CAFOs]; with published abstract)
Yale University - Conference, The Chicken (environmental impacts of CAFOs; with published abstract)

2002
Medical School, Harvard University (marine diseases, anthropogenic influences)
Wilkes Community College, Wilkesboro (honors seminar series - water quality issues)

2001
Washington College (Chesterton, MD; environmental impacts of CAFOs)
Veterinary, Wildlife and Ecological Toxicology Department, Veterinary Biosciences College of Veterinary Medicine, U IL (national water quality issues)
School of Design, NCSU (environmental effects of CAFOs)
Wilkes Community College (honors seminar series - water quality issues)
American Society of Agronomy and the Soil Science Society of America (Northeast Branch) – annual meeting, URI (environmental effects of CAFOs; with published abstract)

2000
American Fisheries Society - annual meeting, St. Louis, MO (environmental effects of CAFOs; with published abstract).
American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America - joint meeting, Minneapolis, MN (nutrient management on CAFOs, and effects on surface water resources; with published abstract)
Association of Southeastern Biologists, Chattanooga, TN: Plenary Speaker (national water quality issues; with published abstract)
Rock Valley College - Natural Resources and Community Action Series, Rockford, IL: Plenary Speaker (national water quality issues)
U MASS, Amherst - Environmental Policy Seminar Series (invited; national water quality issues)
Yale University, School of Forestry (national and state water quality issues)
Department of Zoology, U WA - Seattle (national water quality issues)
American Fisheries Society (NC chapter), New Hill, NC (impacts of Hurricane Floyd on water quality in the Neuse River and Estuary, and Pamlico Sound; with published abstract)

1999
US Department of Agriculture - National Resources Conservation Service, Washington, DC (state water quality issues)
Simon Fraser University - Oceans Limited Conference, Vancouver, British Columbia, Canada (chronic effects of eutrophication; with published abstract)
Department of Biology, University of Louisville, Louisville, KY (chronic effects of eutrophication)

1998
Society of Environmental Toxicology and Chemistry - annual meeting, Charlotte, NC: Keynote Speaker (effects of chronic eutrophication; with published abstract)

1997
Conference, Nutrients in the Neuse River: Working Toward Solutions (sponsor, UNC Water Resources Research Institute [WRRI]), NCSU (effects of chronic eutrophication; with published abstract)

1996
National Association of Biology Teachers - annual meeting, Charlotte, NC (effects of chronic eutrophication; with published abstract)
Texas A&M University, Corpus Christi (effects of pulsed nutrient enrichment on seagrass physiology)
Department of Zoology, Oregon State University (OSU), Corvallis (seagrasses and eutrophication)

1995
Statewide Nutrient Summit (sponsors, NC Sea Grant, NC DEHNR), NCSU (effects of chronic eutrophication; with published abstract)
Water Quality Research and Extension Overview, College of Agriculture and Life Sciences (CALS), NCSU (surface water quality research in CALS; with published abstract)

1994
NC Academy of Sciences - annual meeting, Manteo - Keynote Speaker (state water quality issues; with published abstract)

1993
NC WRRI Seminar Series, Keynote Accomplishments in Research on Water Resources in NC, Raleigh (seagrasses and water-column nitrate enrichment; with published abstract)
Horn Point Environmental Laboratory, U MD (seagrasses and water-column nitrate enrichment)

1992
NC WRRI Seminar Series, Keynote Accomplishments in Research on Water Resources in NC (sediment and phosphorus loading: predicting reservoir water quality; with published abstract)
American Society of Limnology and Oceanography - annual meeting, Edmonton, Alberta, Canada (seagrasses and eutrophication; with published abstract)

1990
Department of Zoology, U WI - Madison (algal phototrophy *vs.* heterotrophy in turbid reservoirs)

1987
Department of Biology, Bowling Green State University, Bowling Green, OH (biological interactions that structure stream plant communities)

1986 (nutrient interactions - macrophytes, epiphytes)
Department of Botany, NCSU
Department of Biology, Fordham University, Bronx, NY
Savannah River Ecology Laboratory, Aiken, SC

University of Michigan Biological Station, University of Michigan, Pellston, MI

1985

Department of Biology, West Virginia University, Morgantown, WV - importance of benthic microalgae in stream ecosystems

Massachusetts Audubon Society, Lincoln, MA - effects of acid deposition on aquatic ecosystems

Harmful Algal Research

2019

Glibert PM, Wilkerson FP, Dugdale RC, Raven JA, Dupont CL, Leavitt PR, Parker AE, Burkholder JM, Kana TM. Pluses and minuses of ammonium and nitrate uptake and assimilation by phytoplankton and implications for productivity and community composition, with emphasis on nitrogen-enriched conditions. ASLO – Puerto Rico (with published abstract).

2018

Buczek SB, Cope WG, Shehdan M, Bishop WM, Richardson RJ, Rice JA, Burkholder JM, Kwak TJ. Evaluation of Freshwater Mussel Sensitivity to Algaecides Used in Attempts to Control Giant *Lyngbya*. North Carolina Chapter of the American Fisheries Society, Morganton, NC (with published abstract).

Burkholder JM, Allen EH. Potable Source-Water Reservoirs in the Southeast: Forecast for Cyanobacteria Blooms. Southeast Chapter of the North American Lake Management Society, Asheville, NC (with published abstract).

2017

Droughts, Internal and External Nutrient Supplies, and Toxic Cyanobacteria Outbreaks in Potable Source Waters of the Southeast (Burkholder and Allen, presentation and published abstract). Society for Freshwater Science, Raleigh, NC.

Ecotoxicology of Herbicide Exposure on Harmful Estuarine Phytoplankton under Varying Nutrient Conditions (Flood, Burkholder and Cope, poster presentation and published abstract. Microbial Toxicology conference, New York.

2013

Leverhume Foundation International Workshop, U MD - Horn Point, Cambridge, MD (algal mixotrophy and water-column nutrients)

2010

North American Lake Management Society (NALMS), Winston-Salem, NC (climate change and harmful algal blooms in the Southeast; with published abstract)

Webinar Lecture Series, Northwestern University, given at the University of British Columbia, Vancouver, BC, Canada (overview on harmful algae)

2008

Burdick Lecture, Department of Biology, Alfred University, Alfred, NY (*Pfiesteria*, other harmful dinoflagellates - toxicity, impacts)

Annual Toxicology and Risk Assessment Conference, Cincinnati, OH (the toxins of inland algae; with published abstract)

2007

Joint meeting of the Phycological Society of America and the International Society of Protozoologists (cyanobacteria in eutrophic turbid impoundments of the North Carolina Piedmont - lead, J. Burkholder; poster with published abstract)

Joint meeting of the Phycological Society of America and the International Society of Protozoologists

(axenic cultivation of a heterotrophic dinoflagellate - lead, H. Skelton; with published abstract)
4th National Symposium on Harmful Algae, Woods Hole, MA (axenic cultivation of *Pfiesteria shumwayae* on a semi-defined medium; poster with published abstract)

2006
Kalmar University, Kalmar, Sweden (*Pfiesteria*, other harmful dinoflagellates - toxicity, impacts)
American Society of Limnology and Oceanography - annual summer meeting: Plenary Speaker, Victoria, British Columbia, Canada (stimulation of harmful algae by eutrophication; with published abstract)

2005
North American Lake Management Society (NALMS) - National Meeting, U WI - Madison – Keynote Speaker (cyanobacteria in potable water supplies - with published abstract)
GEOHAB (Global Ecology and Oceanography of Harmful Algal Blooms) Symposium, Nutritional Ecology of Harmful Algae, Baltimore, MD (importance of intraspecific variation – with published abstract)
Medical School, Harvard University (harmful algae and seafood safety)
NALMS Southeast Chapter Meeting, Asheville, NC (cyanobacteria in potable water supplies - with published abstract)
American Water Works Association - Source Water Protection Symposium, West Palm Beach, FL (cyanobacteria in potable water supplies - with published abstract)

2004
XIth International Conference on Harmful Algae, Cape Town, South Africa: Plenary Speaker (intraspecific variation in toxicity, behavior and nutrition; with published abstract)
St. Johns Water Management District, Orlando, FL (effects of harmful algae on fish and mammalian health)
International EnviroVet Program, Harbor Branch Oceanographic Institute, Fort Pierce, FL (marine diseases)
Department of Oceanography, U WA - Seattle (science, policy)
Shannon Point Marine Laboratory, Western Washington University (science, policy)
NSF Undergraduate Education Honors Program, NCSU (science, policy)

2003
Elon University - Voices of Discovery Seminar Series: Keynote Speaker (*Pfiesteria*)
International EnviroVet Program, Harbor Branch Oceanographic Institute (toxic dinoflagellates)
Florida Institute of Technology (toxic dinoflagellates)
Conference on Emerging Waterborne Pathogens, NC Department of Health and Human Services (DHHS), Wilmington, NC: Two presentations - toxic dinoflagellates; toxic cyanobacteria)

2002
Hopkins Marine Laboratory, Stanford University, Monterey, CA (*Pfiesteria*, other toxic dinoflagellates - science, policy, science ethics)
National Ocean Service, NOAA, Charleston, SC (progress in *Pfiesteria* research)
Symposium, Climate Change and Fisheries in the Gulf of Maine (sponsor, NOAA), College of the Atlantic, Bar Harbor, ME (harmful algae and climate change)
Department of Biology, UNH, Durham (toxic dinoflagellates).
Department of Biology, Williams College, Williamston, MA (toxic dinoflagellates)
Department of Biology, Miami University of Ohio, Athens (toxic dinoflagellates)

2001
XIth International Congress of Protozoology, Salzburg, Austria (dinoflagellates - complex life histories and feeding behaviors; with published abstract)
George Clark Lecture Series, Wetlands Institute, Cape May, NJ (*Pfiesteria*, other dinoflagellates)
Society for Risk Analysis, Research Triangle Park (biomarkers for species and toxins)
Environmental Lecture Series, Ashland University, Ashland, OH (harmful algae and eutrophication)

Marine Conservation Biology Series, Wheaton College, Springfield, MA (chronic effects of harmful algae on fish and mammalian health)

2000

IXth International Conference on Harmful Algal Blooms, Hobart, Tasmania, Australia: Plenary Speaker (toxic *Pfiesteria*; with published abstract)

Elliott-Nowell-White Symposium, Delta State University, Delta State, MS: Keynote Speaker (chronic and sublethal impacts of harmful algae on mammalian health)

Society of Toxicology of Canada - annual meeting, Montreal, Quebec, Canada (toxic dinoflagellates; with published abstract)

Department of Biology, State University of NY - Syracuse (toxic dinoflagellates)

Brookhaven National Laboratory, Brookhaven, NY (toxic dinoflagellates)

State University of New York - Stony Brook (toxic dinoflagellates)

XIIIth World Congress of the International Society of Toxinology, Paris, France (toxic *Pfiesteria*)

Centers for Disease Control & Prevention, Atlanta - conference, *Pfiesteria*: From Biology to Public Health (ecology and conservative analysis of role in fish kills; with published abstract)

National Association of Biology Teachers - Biotechnology Conference. VPI, Blacksburg (harmful algal research)

University of Mississippi, Oxford - Conference, Sustainability of Wetlands and Water Resources (toxic dinoflagellates)

Department of Biology, University of Memphis (toxic dinoflagellates)

Society of Microbiology - Northeast Chapter, Sturbridge, MA (toxic dinoflagellates)

Society of Toxicology - annual meeting (sponsor, US EPA), Philadelphia (toxic dinoflagellates; with published abstract)

Southeastern Estuarine Research Society - annual meeting in conjunction with the 29th Benthic Ecology Meeting and the annual meeting of the Atlantic Estuarine Research Society, Wilmington, NC (toxic dinoflagellates; with published abstract)

1999

National Academy of Sciences - Workshop on Critical Research Needs, Washington, DC (research needs to advance understanding about harmful algae)

Lake Biwa Research Institute, Forum on Water Quality, Kyoto, Japan: Keynote Speaker (*Pfiesteria*, other toxic dinoflagellates)

Woods Hole Oceanographic Institute, Falmouth, MA (toxic dinoflagellates)

Veterinary School, Tufts University, Grifton, MA (toxic dinoflagellates)

Department of Biology, Yale University (improved mitigation of harmful algal blooms)

Georgetown Conference on Policy and *Pfiesteria*, Georgetown University, Washington, DC: Keynote Speaker (science, policy of *Pfiesteria*; with published abstract)

American Association for the Advancement of Science (AAAS) - annual meeting, Anaheim, CA, session, "Human Health Risks in the Ocean" (chronic and sublethal impacts; with published abstract)

AAAS - annual meeting, Anaheim, CA, session "Harmful Algal Blooms" (toxic *Pfiesteria*; with published abstract)

Department of Geology, University of Oslo (Oslo, Norway) (toxic *Pfiesteria*)

Society of Protozoologists - annual meeting, Raleigh: Keynote Speaker (toxic *Pfiesteria*; with published abstract)

Department of Ecology Evolution and Behavior, U MN - Minneapolis (toxic dinoflagellates; with published abstract)

Phi Beta Kappa Seminar Series, Elon University (toxic *Pfiesteria*)

Honors Seminar Series, Southampton College, Southampton, NY (toxic dinoflagellates)

Department of Biology, Barton College, Wilson (toxic dinoflagellates)

Department of Biology, Davidson College, Davidson (toxic dinoflagellates)

Wilkes Community College, Wilkesboro (toxic dinoflagellates)
Department of Biology, NC A&T University, Greensboro (toxic dinoflagellates)
Department of Pathology, UNC Chapel Hill (toxic dinoflagellates)
Department of Biology, UNC Greensboro (toxic dinoflagellates)
Department of Biology, University of Louisville (toxic dinoflagellates)
Sigma Xi - NC Chapter meeting, Appalachian State University, Boone, NC (toxic *Pfiesteria*)

1998

AAAS - annual meeting, Philadelphia, session, "Management of Harmful Marine Microbes: When Science and Politics Don't Mix" (harmful algae; with published abstract)
Medical School, Harvard University (harmful algae)
Shallow Water Conference (sponsor, US EPA), Atlantic City, NJ: Keynote Speaker (effects of toxic *Pfiesteria* on fish and mammals; with published abstract)
Gordon Conference - annual meeting, Ventura, CA (acute/chronic effects of toxic dinoflagellates; with published abstract)
Department of Biology, Rutgers University (chronic effects of toxic dinoflagellates)
Department of Biology, URI (toxic dinoflagellates)
Department of Pharmacology, U GA - Athens (toxic dinoflagellates)
American Biological Safety Association - 41st Annual Biological Safety Conference, Lake Buena Vista, FL: Eagleston Lecture (*Pfiesteria*, other toxic dinoflagellates; with published abstract)
Wildlife Disease Association - 47th Annual Conference, U WI - Madison (toxic *Pfiesteria*; with published abstract)
Department of Biology, Purdue University (toxic dinoflagellates)
American Institute of Biological Sciences - 49th annual meeting (toxic dinoflagellates; with published abstract)
Microbiology Society of NC - annual meeting, Research Triangle Park: Keynote Speaker (*Pfiesteria*, other toxic dinoflagellates)
NC Water Resources Association - Conference on Water Pollution Issues in NC, Asheville: Keynote Speaker (*Pfiesteria*, other toxic dinoflagellates; with published abstract)
Northeast Algal Symposium - annual meeting, Plymouth, MA – Keynote Speaker (toxic *Pfiesteria*; with published abstract)
American Society of Limnology and Oceanography - joint summer meeting with the Ecological Society of America, Symposium Session Honoring Minority Students: Keynote Speaker (*Pfiesteria*, other harmful algae; with published abstract)
Stanford University, Institute of Ecosystem Ecology (toxic *Pfiesteria*)
NASA, Goddard Space Center, Baltimore, MD (*Pfiesteria*, other toxic dinoflagellates)
Keynote Seminar Series in Marine Sciences, Wilmington, DE (sponsors, U DE, DE Sea Grant): Presentation (*Pfiesteria*)
Friends of the Library, NCSU (*Pfiesteria*, other toxic dinoflagellates)
Department of Biology, Auburn University (toxic dinoflagellates)
Department of Environmental Sciences, Drexel University, Philadelphia (toxic *Pfiesteria*)
Department of Biology, Hampden Sydney College, Hampden-Sydney, VA (toxic dinoflagellates)
Department of Biology, UNC Charlotte (*Pfiesteria*, other toxic dinoflagellates)
Headquarters, US EPA, Washington, DC (toxic *Pfiesteria*)
Distinguished Lecturer Series, Old Dominion University, Norfolk, VA (*Pfiesteria*)

1997

Society for Conservation Biology - annual meeting, Victoria, British Columbia, Canada (harmful algae and eutrophication; with published abstract)
Department of Biology, University at Buffalo, Buffalo, NY (*Pfiesteria*, other toxic dinoflagellates)
Departments of Zoology and Oceanography, OSU (toxic algae)

3rd Annual Conference on Population-Level Effects of Marine and Estuarine Contamination, Charleston, SC (science, policy; with published abstract)
Wagner College, Staten Island, NY (special college-wide seminar, toxic *Pfiesteria*)
Department of Biological Science, Florida State University, Tallahassee (toxic dinoflagellates)
Department of Botany, Duke University (*Pfiesteria*, other toxic dinoflagellates)
Conference on Fisheries, Habitat and Pollution (sponsors, SC Sea Grant, TerrAqua Environmental Science and Policy Institute), Charleston, SC (chronic and sublethal effects of harmful algae; with published abstract)
Institute of Ecosystem Studies, Millbrook, NY (chronic and sublethal effects)
American Fisheries Society, NC Chapter - annual meeting, Lake Wylie, SC (*Pfiesteria*; with published abstract)

1996
AAAS - annual meeting, session Global Change and Emerging Infectious Diseases (effects of harmful algae on fish and mammalian health; with published abstract)
NATO Workshop, Physiological Ecology of Harmful Marine Phytoplankton, Bermuda Biological Station for Research (raptorial dinoflagellates; with published abstract)
Sigma Xi - UNC Greensboro and NCCU Chapters: Keynote Speaker (toxic *Pfiesteria*)
Department of Biology, Southampton College, Long Island University, Southampton, NY (toxic dinoflagellates)
Department of Biology, University of Cincinnati, Cincinnati (toxic dinoflagellates)
NIEHS, Research Triangle Park (toxic *Pfiesteria*)
Whitney Laboratory, U FL - St. Augustine (toxic dinoflagellates)
Department of Biology, Wake Forest University, Winston-Salem (toxic dinoflagellates)
Association of Women in Science, UNC Chapel Hill (*Pfiesteria*, other toxic dinoflagellates)
Texas A & M University, Corpus Christi, TX (*Pfiesteria*, other toxic dinoflagellates)

1995
Society of Protozoologists - annual meeting, U AL, Tuscaloosa, AL: Keynote Speaker (toxic *Pfiesteria* and its microbial, macroinvertebrate and vertebrate prey; with published abstract)
5th Pan American Symposium on Animal, Plant and Microbial Toxins, Baltimore, MD (*Pfiesteria*; with published abstract)
Department of Toxicology, NCSU (toxic dinoflagellates)
Department of Biology, U MD, Baltimore, MD (toxic *Pfiesteria*)

1994
First International Conference on Ecosystem Health and Medicine, Ottawa, Ontario, Canada (effects on human health; with published abstract)
E-MAP Monitoring Program, US EPA, Research Triangle Park (emerging toxic algae - effects on fisheries and public health)
Department of Biology, University of Richmond (emerging toxic algae)
Department of Environmental Health, Boston University (toxic dinoflagellates)
Department of Biology, SUNY - Stony Brook (toxic dinoflagellates)
International Society for Evolutionary Protistology - Biennial Meeting, Halifax, Nova Scotia, Canada: Keynote Speaker (*Pfiesteria* and its prey; with published abstract)
Institute of Ecology, U GA - Athens (harmful heterotrophic dinoflagellates)
Department of Fisheries and Aquaculture, U FL - Gainesville (toxic dinoflagellates)

1993
Fifth International Conference on Modern and Fossil Dinoflagellates (Zeist, the Netherlands): Keynote Speaker (toxic *Pfiesteria*; with published abstract)
Beta Beta Beta Biological Honors Society, Elon University: Keynote Speaker (effects of toxic *Pfiesteria* on estuarine food webs)
Chesapeake Biological Laboratory, Solomons, MD (toxic dinoflagellates)

Southeastern Fisheries Society, Reidsville, NC (toxic dinoflagellates and fish health)
Dauphin Island Marine Laboratory, Dauphin Island, AL (toxic dinoflagellates)
Department of MEAS, NCSU (*Pfiesteria*)

1992

Vth International Symposium on Toxic Algae, Newport, RI (toxic *Pfiesteria*; with published abstract)
Southeast Regional Directors of the Sea Grant College Program - annual meeting: Keynote Speaker (*Pfiesteria*)
Department of Zoology, NCSU (toxic *Pfiesteria*)
US Geological Survey, Raleigh (toxic *Pfiesteria*)
NC Statewide Phytoplankton Meeting, Duke Power Company (Huntersville, NC: Keynote Speaker)
Department of Biology, UNC Wilmington (*Pfiesteria*, other toxic dinoflagellates)
Department of Biology, Appalachian State University, Boone, NC (toxic dinoflagellates)
Department of Biology, UNC Greensboro (toxic dinoflagellates)
US EPA, Narragansett, RI (*Pfiesteria*, other toxic dinoflagellates)
Department of Biology - Marine Sciences Group, UNC Chapel Hill (toxic dinoflagellates)
Bodega Marine Laboratory, U CA - Davis, Bodega Bay (toxic dinoflagellates)

Other Algae

2012

Phycological Society of America, Charleston, SC (Mixson, S. and J. Burkholder - enhancing lipid production in the marine microalga *Dunaliella* through environmental stressors; with published abstract)

2010

Webinar, Northwestern University special summer course for graduate students, given at the University of British Columbia, Vancouver, BC (the ecology of periphyton)

2007

Society of International Limnologists (SIL) - 30th Congress of the International Association of Theoretical and Applied Limnology, Montreal, Quebec, Canada (importance of benthic microalgae across freshwater, estuarine and marine ecosystems; with published abstract)

1999

Society for General Microbiology - Symposium, Microbial Signaling and Communication, University of Edinburgh, Edinburgh, Scotland (signaling in dinoflagellates; with published abstract)

1991

Department of Biology, VPI, Blacksburg, VA (phytoplankton survival of pulsed suspended sediment loading)

1990

Center for Reservoir Research, Hancock Biological Station, Murray State University, Paducah, KY (phytoplankton and periphyton dynamics in turbid, eutrophic reservoirs)
Department of Zoology, NCSU - Aquatic Ecology Seminar Series (mutualistic symbioses involving algae)
Department of MEAS, NCSU (role of benthic microalgae in eutrophication of freshwater and coastal marine habitats)

1989

Experimental Lakes Area (ELA), University of Manitoba, Winnepeg, Manitoba, Canada (relative importance of the water column and macrophytes as nutrient sources for epiphytes)
Hampton University, Hampton, VA (biotechnology in aquatic ecology)
Department of Biology, University of Louisville, Louisville, KY (use of autoradiography to examine nutrient dynamics of microalgal biofilms)
Duke Marine Laboratory, Beaufort (nutrients and epiphytes – unifying trends in freshwater and marine ecosystems)

1988
Department of Biology, UNC Chapel Hill - Marine Macroalgae Seminar Series (epiphytes)
Department of Biology, East Carolina University (phosphorus sources for epiphytic microalgae)
Department of Botany, Duke University (nutrient sources for epiphytic microalgae)
Environmental Section, Carolina Power and Light Company, New Hill, NC (epiphytic microalgae - role in nutrient cycling of lakes)

Science Ethics and Environmental Issues

2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015
Park Scholars Program, NCSU (role of science ethics in environmental issues)

2005
Department of Epidemiology, UNC Chapel Hill, Forum "Funding, Academic Freedom, and Public Responsibility" (industry and water quality)
2004
Department of Biology, Cornell University (toxic algae)
Department of Civil Engineering, NCSU (water quality)
Department of Biology, UNC Asheville (water quality)

2003
New York Metropolitan Association of College and University Biologists – 36th Annual Conference, Wagner College, Staten Island: Keynote address (role of science ethics in natural resource issues)
NSF Environmental Education Program, NCSU (toxic algae, water quality)

1999
Department of Geology, University of Oslo, Oslo, Norway (toxic algae, water quality)
Park Foundation Lecture Series, College of Journalism, UNC Chapel Hill (critical role of journalists in environmental science education and ethics)

1998
Metcalf Institute for Marine and Environmental Journalism - annual board meeting, URI: Keynote Speaker (how environmental journalists can help to strengthen science ethics)

Academic Contributions

Courses Taught

- PB 595A, *Aquatic Plant Ecology* (4 credits; 1987 - present, fall alternate years; updated each time)
- PB 595W / AEC 495/592, *Environmental Issues in Aquatic Ecology* (3 credits, 1990 - present, usually fall alternate years) - special topics/current events graduate course, updated each time
- PB/MB 774, *Phycology* (3 credits including laboratories; 1987 - present, spring alternate years, updated each time)
- BO 595E, *Ecology, Evolution and Diversity* – (2003; course coordinator, Jon Stuckey); mini-course: designed and taught one of eight modules on aquatic vascular plants as bioinvaders
- PB 824C, *Plant Biology Colloquium* (1 credit) – co-taught with Nina Allen (spring 2002, 2004, 2006) or Bill Thompson (spring 2009, 2011, 2013); graduate students receive training to give presentations, write grant proposals, and critique grant proposals)
- HON 398, *Honors Seminar on Aquatic Ecology* (1 credit, spring 2008) – seminar/discussion course for undergraduate honors students on aquatic natural resource issues in North Carolina

- EMS 496/622/822 or TDE 490/610 – STEM Education Seminar Course, *Environmental Issues in Estuarine Ecology and Pedagogical Applications* (1 credit, spring 2010), co-taught with P. Simmons and A. Clark.
- AEC 495/592, *The Biology, Ecology and Diversity of Algae* (3 credits including laboratories; spring 2019.)

Major or Co-major Advisor of Graduate Students

Nicole Lindor, Ph.D. (Plant and Microbial Biology, in progress, 2014-)
Received a WRRI grant ($10,000, 2018)

Stacie Flood, Ph.D. (Plant and Microbial Biology, 2017)
Thesis: Ecotoxicology of estuarine phytoplankton growth and toxicity in response to atrazine exposures.
Post-Graduate Position: Postdoctoral research associate, U.S. EPA, Research Triangle Park, NC (2017).

Stephanie Mixson, Ph.D. (Plant and Microbial Biology [department name change from Plant Biology] - 2013)
Thesis: *Dunaliella* spp. under environmental stress: Enhancing lipid production and optimizing harvest
Honor: Secured a grant to help support her dissertation research, from the Charles A. and Anne Morrow Lindbergh Foundation (2010)
Post-Graduate Position: Analytical Development Specialist, Medicago USA, Research Triangle Park (2013)

Eva Ngulo, M.A. (Plant Biology, 2011)
Final paper: Influence of clay treatment on noxious planktonic cyanobacteria

Kimberly Null, Ph.D. (MEAS; co-advisor with Dr. Dave DeMaster), 2010
Thesis: Ammonium dynamics in a shallow lagoonal estuary
Honors: Secured two grants to help support her dissertation research, from the NC Academy of Science (2006) and the Geological Society of America (2006)
Post-Graduate Positions: Post-Doctoral Research Associate, University of California - Santa Cruz, then Post-Doctoral Research Associate, East Carolina University - Greenville, NC (research in Antarctica)

Hayley Skelton, Ph.D. (MEAS; co-advisor, Dr. Dan Kamykowski), 2008
Thesis: Nutritional features and feeding behavior of the heterotrophic dinoflagellate, *Pfiesteria shumwayae*
Honor: Won the Theodore L. Jahn and Eugene C. Bovee Award for best graduate student research paper, annual meeting of the International Society of Protozoologists, Providence, RI (2007)
Post-Graduate Positions: Post-Doctoral Fellow, National Research Council, NOAA / University of Connecticut (2008), then Supervisor of Algal Culturing, Algenol Biofuels, Fort Myers, FL (2009)

Meghan Rothenberger, Ph.D. (Plant Biology), 2007
Thesis: Long-term impacts of changing land use practices on water quality and phytoplankton assemblages in the Neuse Estuary ecosystem, North Carolina
Honors: Won best graduate research presentation, Graduate Student Forum, Department of Plant Biology (2007)
Won best Ph.D. dissertation of the year (2007) at NCSU, from the NCSU Graduate School (2008)
Post-Graduate Positions: Post-Doctoral Associate, CAAE (Visiting Professor, UNC Greensboro; then assistant professor at Lafayette College, Easton, PA)

Susan Pate, M.Sc. (Botany), 2006
Thesis: Impacts of the toxic dinoflagellate *Alexandrium monilatum* on three ecologically important shellfish species
Post-Graduate Position: Laboratory Administrator (Biotechnology), Duke University

Matthew Parrow, Ph.D. (Botany), 2003
Thesis: Feeding, reproduction, and sexuality in *Pfiesteria* spp. and cryptoperidiniopsoid estuarine heterotrophic dinoflagellates
Honor: Won the Kellar Award for outstanding dissertation research (NCSU), 2004
Post-Graduate Positions: Post-Doctoral Associate, CAAE (now Assistant Professor, UNC Charlotte)

Paul Cancellieri, M.Sc. (Botany), 2001
Thesis: Chemosensory attraction of *Pfiesteria* spp. to fish secreta
Post-Graduate Position: Teacher, Durant Middle School, Raleigh

Howard Glasgow, Ph.D. (MEAS; co-advisor; main advisor, Dr. Dan Kamykowski), 2000
Thesis: Biology and impacts of toxic *Pfiesteria* complex species
Post-Graduate Position: Researcher, CAAE (permanently disabled by a neurological illness)

Jeffrey Springer, M.Sc. (MEAS; co-advisor, Dr. Dave Eggleston), 2000
Thesis: Interactions between two commercially important species of bivalve molluscs and the toxic estuarine dinoflagellate, *Pfiesteria piscicida*
Honor: Won the Best Student Presentation Award at the Annual Meeting of the National Shellfish Association, Seattle, WA, 2002
Post-Graduate Position: Research Associate, CAAE

Naomi Tsurumi, M.A. (Botany), 2000 Thesis: Influence of Industrialized Swine Agriculture on Air Quality
Post-Graduate Position: Environmental Policy M.A. program, Duke University

Brant Touchette, Ph.D. (Botany), 1999
Thesis: Physiological and developmental responses of eelgrass (*Zostera marina* L.) to increases in water-column nitrate and temperature
Post-Graduate Position: Assistant Professor, Elon University (now associate professor)

Elizabeth Fensin, M.Sc. (Botany), 1997
Thesis: Population dynamics of *Pfiesteria*-like dinoflagellates, and environmental controls in the mesohaline Neuse Estuary, North Carolina, USA
Post-Graduate Position: Research Assistant, North Carolina Department of Environment and Natural Resources (then called the NC Department of Environment, Health, and Natural Resources)

L. Michael Larsen, Ph.D. (Zoology; co-advisor with Dr. Sam Mosley), 1995
Thesis: Responses of *Diaphanosoma brachyurum* (Cladocera: Suicide) and other zooplankton to clay loading and algal food quality in a turbid southeastern reservoir.
Post-Graduate Position: Assistant Professor, Campbell University, Fayetteville, NC (now Professor and Department Chair, Biology)

Leslie (Taylor) Taggett, M.Sc. (Botany), 1995
Thesis: Nitrate reductase activity of two intertidal macroalgae across gradients of temperature, salinity and desiccation
Post-Graduate Position: Research Assistant – Analytical Chemistry Laboratory, NC DEHNR

Virginia Coleman, M.Sc. (Botany), 1993
Thesis: Community structure and productivity of epiphytic microalgae on eelgrass (*Zostera marina* L.) under water-column nitrate enrichment
Post-Graduate Position: Research Associate – Algal Laboratory, NC Department of Environment and Natural Resources

Phumelele Gama, M.S. (Botany), 1992
Thesis: Phytoplankton response to a sediment loading gradient in a mesotrophic reservoir
Post-Graduate Position: Lecturer of Botany, University of Zululand, South Africa

Deborah Everitt (Tan), M.S. (Botany), 1992
Thesis: Seasonal dynamics of macrophyte communities from a stream flowing over granite flatrock in North Carolina, USA
Post-Graduate Position: Stream Scientist, MD Department of Natural Resources

Other Graduate Student Committee Memberships

Ph.D.
Stephanie Archer, Applied Ecology
Yini Shangguan, U MD (Center for Environmental Science)
Brett Hartis, Fisheries, Wildlife and Conservation Biology
Geoff Sinclair, MEAS
Diane Whitaker, Science Education
Katherine Galucci, Science Education
Daniel Dickerson, Science Education
Nancy White, Forestry
Louis Elsing, Forestry
Dennis Hazel, Forestry
Gary Kirkpatrick, Zoology
Francois Bergand, Biological and Agricultural Engineering
Leslie Dorworth, MEAS
Thomas Shahady, Zoology
Randall Jackson, Zoology
Elise Irwin, Zoology
Kimberly Jones, Chemistry (UNC Wilmington)
George Hess, Biomathematics
Ann Darrien, Zoology
Elizabeth Marschall, Zoology

M.Sc.
Katherine Culatta, Plant and Microbial Biology
Emily Vulgamore, Crop Science
Susan Randolph, Science Education
John Grady, Plant Biology
Carolyn Foley, Botany
Chad Coley, Soil Science
Angela Poovey, Crop and Soil Science
Scott Thomas, Biological and Agricultural Engineering
Kristin Toffer, Biology, UNC Greensboro
Beth Buffington, Crop and Soil Science
Edward Walycz, MEAS
Lisa Hartley, Botany
Robert Clark, Zoology
Beth Walker, Zoology
Rose Ragnacci, MEAS
Karen Kracko, Zoology

Postdoctoral Associate Advisor

Meghan Rothenberger, 2007: Present position, Assistant Professor, Lafayette College

Matthew Parrow, 2004-2006: Present position, Assistant Professor, UNC Charlotte
Brant Touchette, 2000-2002: Present position, Associate Professor, Elon University
Cheng Zhang, 1999-2003: Present position, Research Scientist, North Carolina Department of Environment and Natural Resources

Visiting Fulbright Scholar

Allasanne Ouattara, Ivory Coast, 2008-2009: Professor from the University of Abobo-Adjamé

Activities in Other Academic Programs

Kenan Fellows Program (for gifted K-12 teachers)

Mentor to Amanda Warren (2009-2010)
Mentor to Susan Randolph (2009-2010)
Mentor to Diane Whittaker (2007-2008)
Secondary mentor to Gayle Powell (2007-2008)
Panelist on selection committee for Kenan Fellows (2007-2009)

Other NC State Service

Chair, Tenure Promotion Evaluation Committee (for Dr. A. Krings; departmental – Plant and Microbial Biology, 2016-2017)
Member, Focus Group guiding the Office of the Executive Vice Chancellor and Provost in creating a Strategic Communications Plan for the Provost's office (University, 2016)
Member, CALS Innovation and Efficiency Committee (college, 2015)
Member, Big Ideas Committee (college, 2014-2015)
Member, Post-Tenure Review Committee (departmental – Applied Ecology, 2014-)
Member, William Neal Reynolds Distinguished Professor Selection Committee (college, 2014)
Member, College of Agriculture and Life Sciences Research Committee (college, 2011-2016)
Member, Executive Committee, Applied Ecology (departmental, 2013-)
Member, Advisory Committee for the NCSU publication, *Results: Research and Innovation at North Carolina State University* (university, 2013-)
Member, Advisory Committee, Plant Biology (departmental, 2011-2013)
Chair, Plant Biology Post-Tenure Evaluation Committee (departmental – Plant and Microbial Biology, 2012)
Member, Selection Committee for Evolutionary Ecologist Position (departmental – Plant and Microbial Biology, 2007)
Member, Larry A. Whitford Botany Scholarship/Fellowship Award Committee (departmental, Plant and Microbial Biology, 2004-2007)
Member, Plant Biology Mentoring Committee for Alexander Krings (departmental, 2007-2009)
Member, Plant Biology Mentoring Committee for Bill Hoffmann (departmental, 2004-2006)
Member, Plant Biology Undergraduate Curriculum Committee (departmental, 2007-2010)
Member, Search Committee, Plant Biology - Evolutionary Ecologist (departmental, 2006)
Member, Water Quality Committee (university, 2004-)
Member, Water Resources Curriculum Committee (university, 2003-)
Member, Ad Hoc Committee on Marine Science (university, 2003-)

Education Outreach (examples, past five years)

K-12 Students and Teachers

The CAAE's *Falls Lake Water Quality Forensics Program* (2019-): Is providing hands-on education about freshwater science, water quality assessment, influential characteristics of watersheds, the direct connection between water quality and human health, and the importance of citizen stewardship in protecting potable source-waters. Thus far, about 2,400 students have participated (8th/rising 9th graders; also 1st-2nd graders).

The CAAE's *Floating Classroom Program* aboard the research/education ship, *RV Humphries*: Provided hands-on education in aquatic science (1/2-day cruise on the Neuse Estuary for 282 8th graders and their teachers (2016), 278 8th graders and their teachers (2015), 345 9th graders and their teachers (2014), 360 9th graders and their teachers (2013), and 480 9th graders and their teachers (2012) from Wayne County schools in economically depressed areas.

General Citizenry

Neuse River Documentary (led by Mr. Bill Leslie, WRAL Television Station; panel participant in public forums in Raleigh and New Bern, NC about the documentary, 2019)

Randleman High School, Randleman, NC – senior science classes, invited presentation on harmful algae (2018)

League of Women Voters, Chapel Hill, NC – invited presentation on water quality issues in NC (2018)

Environmental Seminar Series - Water, High Point University (invited presentation on North Carolina's environmental report card, 2017)

Women's Club of Raleigh, Raleigh, NC, (invited presentation on the safety of the area's drinking water, 2016)

Other Service - Member, City of Raleigh Stormwater Commission, 2015-2016

Society Memberships – American Association for the Advancement of Science (AAAS), Association for the Sciences of Limnology and Oceanography (ASLO), Coastal and Estuarine Research Federation (CERF), North American Lake Management Society (NALMS), Phi Kappa Phi, Phycological Society of America, Sigma Xi

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BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:		
PROPOSED AMENDMENTS TO:	)	
35 Ill. Adm. Code 302.102 and 302.208(g)	)	R18-32
WATER QUALITY STANDARDS	)	
FOR CHLORIDES	)	

NOTICE OF FILING

TO: Don Brown
Clerk of the Board
Illinois Pollution Control Board
100 West Randolph Street, Suite 11-500
Chicago, Illinois 60601
(Via Electronic Mail)

(See Persons on Attached Service List)

PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Illinois Pollution Control Board the attached **AMENDED PETITION TO AMEND 35 ILL. ADM. CODE 302.102 and 302.208(g) WATER QUALITY STANDARDS FOR CHLORIDES, INCLUDING PROPOSED RULE LANGUAGE,** copies of which are herewith served upon you.

Respectfully submitted,

Huff & Huff, Inc.

By: James E. Huff
Senior Consultant

Dated: March 14, 2019

James E. Huff, P.E.
HUFF & HUFF, INC.
915 Harger Road, Suite 330
Oak Brook, IL 60523
James.huff@gza.com
630-684-4444

Electronic Filing: Received, Clerk's Office 3/14/2019

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:		
PROPOSED AMENDMENTS TO:	)	
35 Ill. Adm. Code 302.102 and 302.208(g)	)	R18-32
WATER QUALITY STANDARDS	)	
FOR CHLORIDES	)	

INTRODUCTION

Based on the hearing in this matter held January 23, 2019, this Amended Petition is intended to present a revised water quality standard for chlorides based upon stream temperature at the time of sampling. Recent literature regarding chloride toxicity has been incorporated herein. The proposed language has been modified with respect to winter temperatures, and the toxicity data used to derive the standards have been updated with additional recent literature. The toxicity data have been normalized based on hardness and sulfate. In addition, a temperature relationship was derived based upon a recent article by Jackson and Funk (2019)[1] coupled with the temperature data generated as part of this project. The result is a single year-round water quality standard based upon the stream temperature, hardness, and sulfate at the time of sampling for chlorides.

STATEMENT OF REASONS

The Illinois Pollution Control Board (Board), in R08-9 (Subdocket D) adopted water quality standards on the Chicago Area Waterways (CAWS) and the Lower DesPlaines River (LDPR), including for chlorides. With the exception of the Chicago Sanitary & Ship Canal (CSSC), the Board adopted a chloride water quality standard of 500 mg/L from May 1st through November 30th, and the same standard for the remainder of the year, effective three years after the effective date of those rules. The intent of the three-year delay was "to allow time for the work group to develop a proposal to address chloride and a water body wide variance." (Final Notice Opinion and Order of the Board, R80-9, p 32.)

The focus of the various work groups has been on developing and implementing Best Management Practices (BMPs) to reduce the application of highway de-icing salts, the principal cause of elevated chlorides during the winter (and spring) months in the receiving streams. Elevated chlorides are not unique to the CAWS and LDPR during the winter months; elevated chloride concentrations occur on all urban streams in Illinois. The General Use Water Quality Standard for chlorides, as found in 302.208(g), is 500 mg/L, identical to what the Board has adopted for the CAWS and LDPR, excluding the CSSC.

[1] Jackson, J.K. and Funk, D.H. Temperature affects acute mayfly responses to elevated salinity implication for toxicity of road de-icing salts. *Phil. Trans. R. Soc. B 374: 20180081.*

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More efficient application of sodium chloride for highway de-icing is being implemented. However, as the 500 mg/L standard is a *not-to-exceed* standard, the question is: can BMPs achieve the necessary reduction under the worst storm events? For example, on the North Branch of the Chicago River, data from 2004 to 2014 reveal a maximum chloride concentration of 1,134 mg/L, necessitating a reduction of 55 percent in salt application during the worst events. (Huff, October 2015.[2]) It is appropriate to question whether simply implementing BMPs can consistently achieve this type of reduction. For smaller streams, the required reductions can be even greater. For example, Hickory Creek at Vine Street reached 1,476 mg/L in 2014, necessitating a reduction of 66 percent in salt application during the worst storm events to achieve 500 mg/L. (Huff, Feb 2015.[3]) Despite these elevated winter concentrations some of the impacted waterways still host aquatic communities who score at the upper end of the moderately impaired category of the state aquatic life scale. This observation supports the position that elevated winter concentrations are less destructive to aquatic communities than elevated warm weather concentrations.

While focusing on efficient utilization of de-icing salts is appropriate, there are concerns that implemented alone, BMPs will not achieve the target of 500 mg/L for these worst storm events. These concerns were the basis behind assembling a group of municipalities and sanitary districts, industries, The Salt Institute, a watershed group, and the Illinois Tollway to fund additional research on cold-temperature toxicity of chlorides. The results from these additional toxicity tests form the basis behind this Rulemaking request, as the findings show chlorides are less toxic at colder temperatures, thereby justifying a relaxed chloride standard during the colder months. Illinois already utilizes a similar approach for ammonia for which there are less stringent winter standards, so there is precedent for such an approach. In addition, the Board adopted higher winter chloride standards for the CSSC in R08-9 (Subdocket D).

Given the current water quality violations, chlorides are or should be identified as a cause of impairment for nearly all urban streams in Illinois. The ones not identified as impaired due to chlorides are likely due to the lack of sufficient monitoring. The impact of chlorides being identified as a cause of impairment is a serious impediment to future growth of any kind in the urban areas of Illinois. If increased pavement, housing, or parking lots are planned, then the required de-icing salts will need to be more than offset within the watershed. Finding these offsets is becoming more difficult. BMPs are being implemented as part of the watershed variances currently before the Board, and these same BMPs cannot be used as offsets for new growth. Alternatives to chloride de-icing are not technically feasible on a region-wide basis, when considering safety and mobility. This has been demonstrated by the Connecticut Department of

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[2] Huff, J.E., The Science Behind the Chloride Water Quality Standard, Presentation at the Chicago Area Waterways Chloride Workshop, MWRDGC Stickney Plant, October 29, 2015.

[3] Huff, J.E., Chloride Regulatory Update, Presentation at the Hickory Creek Watershed Planning Group, New Lenox, IL February, 19, 2015.

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Transportation, that for a seven-year period used a mixture of sand-salt (7:2) and compared the accidents to a seven-year period with just salt and found a 19 percent increase in nonfatal injuries and a 33 percent increase in accidents with the sand-salt mixture compared to just salt.[4] So while a reduction in salt usage is an achievable goal, it is technically infeasible to reduce its use for de-icing practices sufficiently to consistently meet the 500 mg/L water quality standard.

Another consideration would simply shut down the highway system during snow events where there would be a potential to exceed the water quality standard. From the information generated in the Technical Support Document, this would vary from an average one storm per year to over five storm events, and the duration of each shut down would last for multiple days. Nationwide, a one-day shutdown of the snowbelt states would yield a loss of $2.6 billion per day, and a loss of retail of $870 million per day.[5] Not only would this be economically unreasonable, the social impacts would not be acceptable to the citizens of Illinois.

I. History and background to the present proceeding

The 500 mg/L Illinois general use water quality standard for chloride was adopted by the Board in 1972 in R71-14, based on the testimony of a "recognized expert in fish biology," that 500 mg/L would be a safe limit. (Opinion of the Board, March 7, 1972.) This Illinois General Use Water Quality Standard has remained in effect for the past 45 years.

U.S. EPA in 1988 published the *Ambient Water Quality Criteria for Chloride-1988* (EPA 440/5-88-001, February 1988) that recommended a four-day limit of 230 mg/L and a one-hour average limit of 860 mg/L that should not be exceeded more than once every three years on the average.

In January 2009, C. Stephan of the USEPA issued a draft update deriving chloride toxicity, factoring in hardness and sulfate concentrations, and utilizing a normalized hardness of 300 mg/L and normalized sulfate concentration of 65 mg/L. Temperature was not a factor in the Stephan document, with data generated at the USEPA guideline temperatures, 25°C for most species. Much of the more recent literature on chloride toxicity relates to the impact of sulfate and hardness concentration on the toxicity.

As nearly all of the toxicity data derived for chlorides have been generated at summer-type temperatures, the results do not accurately reflect the toxicity of chlorides at winter temperatures. This proposal sets forth the findings of both a literature search and toxicity testing with the four sensitive aquatic species (Fingernail clams, mayflies, Amphipod, and *C. dubia*) at 10°C and 25°C. Due to limited funding, hardness and sulfate were not varied as part of the testing, just temperature.

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[4] Mahoney, JU. D.S. Larsen, and E. Jackson. Reduction in nonfatal injury crashes after implementation of anti-icing technology. Transportation Research Record: *Journal of the Transportation Research Board,* No. 2613. Transportation Research Board of the National Academies, Washington, D.C., 2017, pp. 77-86. See Attachment 4

[5] Benefit-Cost of Various Winter Maintenance Strategies, Project 99006/CR13-03, Western Transportation Institute, September 2015. See Attachment 5.

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The original Petition called for a winter chloride standard during the months of December through April. It was clear from the first hearing that a standard based upon actual stream temperature at the time of sampling was a preferred approach, and this Amended Petition has made this change. Factoring in sulfate and hardness in the derivation of chloride water quality standards was suggested during the hearing as well. The proposed language incorporates this request, assuming the same relationship for hardness and sulfate that was derived at temperature at 25°C applies at 10°C. This also seems like a reasonable approach until such time as further research is completed, so in a sense, the proposed standard herein can be viewed as interim water quality standard. Given that the hardness and sulfate relationship for aquatic species was based on one species, utilizing the temperature data from Jackson and Funk, combined with our data to establish a temperature relationship, is appropriate.

A. Purpose and Effect of Regulatory Proposal

The Board's existing 500 mg/L General Use Standard for chlorides is exceeded in all urban streams during snow melt periods in Illinois. For the CAWS and LDPR, the winter 500 mg/L water quality limit goes into effect on December 1, 2019. Most of the urban watersheds in Illinois are working on seeking watershed variances from the 500 mg/L standard. As noted in the introduction, the compliance plans are centered around BMPs for de-icing practices. This is a sound and necessary approach that will reduce chloride concentrations in our waterways. However, it is not likely to consistently achieve the not-to-exceed 500 mg/L standard in many of the urban streams.

This work was undertaken to improve the understanding of chloride toxicity under winter temperatures. The results show that chlorides are less toxic at colder temperatures, and therefore higher water quality standards can be derived for the winter months. The recent publication referenced earlier by Jackson and Funk (2019) demonstrated that the temperature effect on chloride toxicity is a linear relationship, which allowed us to use our data derived at two different temperatures to develop a mathematical relationship, combined with the Jackson and Funk data. If the proposed chloride water quality standards are adopted, it is expected that many smaller streams will be able to achieve the water quality standards through the implementation of BMPs. On larger streams, due to the duration of the chloride spikes, achieving the proposed chronic standard during snow melt periods will prove difficult.

Specifically, the proposed standard consists of the following amendments.

1. **Remove Chloride from Section 302.208(g), Numeric Standards for Chemical Constituents, Single-Value Standards:** Based on the difference in chloride toxicity at colder temperatures, it is appropriate to draft a new section to include chloride standards.

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g) Single-value standards apply at the following concentrations for these substances:

Constituent	Unit	Standard
~~Chloride (total)~~	~~mg/L~~	~~500~~

2. Add Section 302.214 Chlorides

a. Acute chloride standard (Cl_{AC}):

$Cl_{AC} = (1+(0.045)(25-T))* NFAV*(Hardness/300)^{0.205797} *(Sulfate/65)^{-0.07452}$

Where NFAV is the Normalized Acute Value of 518 mg/L.
Hardness (as $CaCO_3$ in mg/L), Sulfate (as SO_4 in mg/L), and Temperature (°C) are the stream results at the time the sample was collected.

b. Chronic chloride standard (Cl_{CV}):

$Cl_{CV} = (1+(0.045)(25-T))* CCC*(Hardness/300)^{0.205797} *(Sulfate/65)^{-0.07452}$

Where CCC is the Normalized Criteria Continuous Concentration of 300 mg/L.
Hardness (as $CaCO_3$ in mg/L), Sulfate (as SO_4 in mg/L), and Temperature (°C) are the stream results at the time the sample was collected.

To calculate the attainment status of chronic standards, the concentration of the chloride result is divided by the calculated water quality standard for the sample to determine a quotient. The water quality standard is attained if the mean of the sample quotient is less than or equal to one for the duration of the averaging period.

The Cl_{CV} shall not be exceeded more than once every three years by the arithmetic average of at least four consecutive samples collected over any period of four days.

3. Amend Section 302.407 Chemical Constituents as follows:

g. Numeric Water Quality Standards for Other Constituents

2) ~~From July 1, 2015 until July 1, 2018, the following concentrations for Chloride and Total dissolved solids shall not be exceeded except in waters for which mixing is allowed pursuant to Section 302.102 of this Part.~~

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~~Constituent~~	~~Unit~~	~~Standard~~
~~Chloride during the period of May 1 through November 30~~	~~mg/L~~	~~500~~
~~Total Dissolved Solids during the period of December 1 through April 30~~	~~mg/L~~	~~1,500~~

~~3) Beginning July 1, 2018, the Chloride and Total Dissolved Solids standards in subsection (g)(2) of the Section are repealed and the following concentration for Chloride shall not be exceeded except in waters for which mixing is allowed pursuant to Section 302.102 of this Part:~~

~~Constituent~~	~~Unit~~	~~Standard~~
~~Chloride~~	~~mg/L~~	~~500~~

~~Where:~~

~~mg/L = milligram per liter~~

Add Section 407(g)(2) Chlorides

a. Acute chloride standard (Cl_{AC}):

$$Cl_{AC} = (1+(0.045)(25-T))^{*} NFAV^{*}(Hardness/300)^{0.205797} {}^{*}(Sulfate/65)^{-0.07452}$$

Where NFAV is the Normalized Acute Value of 518 mg/L.
Hardness (as $CaCO_3$ in mg/L), Sulfate (as SO_4 in mg/L), and Temperature (°C) are the stream results at the time the sample was collected.

b. a chronic chloride standard:

$$Cl_{CV} = (1+(0.045)(25-T))^{*} CCC^{*}(Hardness/300)^{0.205797} {}^{*}(Sulfate/65)^{-0.07452}$$

Where CCC is the Normalized Criteria Continuous Concentration of 300 mg/L.
Hardness (as $CaCO_3$ in mg/L), Sulfate (as SO_4 in mg/L), and Temperature (°C) are the stream results at the time the sample was collected.

To calculate the attainment status of chronic standards, the concentration of the chloride result is divided by the calculated water

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quality standard for the sample to determine a quotient. The water quality standard is attained if the mean of the sample quotient is less than or equal to one for the duration of the averaging period.

The Cl_{CV} shall not be exceeded more than once every three years by the arithmetic average of at least four consecutive samples collected over any period of four days.

II. Technical Feasibility and Economic Justification

A. The Board and the Agency have always supported science-based standards, and this proposed regulatory rule change is consistent with this approach. New research, financially supported by the consortium that was assembled to examine the chloride standards, forms the basis for the proposed changes. This work was undertaken because the current chloride water quality standard is neither technically feasible to achieve nor ecologically or economically justified. The Agency has promoted a pathway forward of watershed variances, relying on Best Management Practices to achieve a 500 mg/L, while at the same time USEPA is promoting even more restrictive water quality standards. However, there was no testimony in the CAWS proceedings that achieving the 500 mg/L winter chloride standard was technically feasible, economically reasonable, or ecologically justified. Proceeding with the Agency's watershed approach will require the regulated community to continue striving to achieve an unachievable standard until someone comes up with an alternative approach, which is exactly what this proposal is intended to do.

B. The temperatures in the waters in Illinois are colder in the winter months. Yet, nearly all of the aquatic toxicity testing conducted prior to the testing contained in this Petition is at temperatures experienced during the summer months, with the majority of studies being conducted at what would be considered near maximum temperatures experienced in Illinois streams (25°C).

C. In summary, the expectation is that if the proposed winter water quality standards are adopted, the watershed approach based on implementing BMPs will become technically feasible and economically reasonable for many urban streams in Illinois, as supported by the stream data presented in the Technical Support Document (Attachment 2).

III. Facts in Support

The original Petition included several Attachments in support of the proposed changes and are not resubmitted herein. A supplement to the Technical Support Document has been prepared with additional supporting information regarding the proposed water quality standards proposed herein.

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IV. Conclusion

The current general use chloride water quality standard is unattainable in many urban streams in Illinois during the winter months. Cold temperature toxicity testing of chlorides developed in support of this Petition has demonstrated that at colder temperatures chlorides are less toxic to aquatic organisms. The recent work by Jackson and Funk has established that a linear relationship exists between temperature and chloride toxicity, that has been used with the research we conducted to develop mathematically derived water quality standards based on temperature. Based on these findings, a new chloride standard is proposed for General Use waters, derived using the USEPA protocol for developing water quality standards.

This Amended Petition, along with the original Petition, satisfies the requirements of Section 102.202 of the Board's rules because the Petition:

- Details the language of the proposed rule change;
- Presents the facts that support the proposal including the environmental, technical, and economic justification;
- Includes a statement of the purpose and effect of the proposal;
- Includes a synopsis of the expected testimony;
- Describes the results of the current knowledge on cold temperature toxicity of chlorides and the findings of the research associated with the request;
- Demonstrated the proposed rule change is consistent with federal law.

WHEREFORE, Petitioner, Huff & Huff, Inc. respectfully requests that the Illinois Pollution Control Board adopt revised chloride water quality standards for the winter months, as proposed herein.

HUFF & HUFF, INC.

Dated: March 14, 2019

By: James E. Huff, P.E.

James E. Huff, P.E.
Huff & Huff, Inc., a Subsidiary of GZA, Inc.
915 Harger Road
Oak Brook, IL 60523
James.Huff@gza.com

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CERTIFICATE OF SERVICE

I, James E. Huff, the undersigned, on oath state the following:

That I have served the attached **PETITION TO AMEND 35 ILL. ADM. CODE 302.102 and 302.208(g) WATER QUALITY STANDARDS FOR CHLORIDES,** via electronic mail upon:

Don Brown Clerk of the Board Illinois Pollution Control Board 100 W. Randolph Street, Suite 11-500 Chicago, Illinois 60601 Don.Brown@illinois.gov	Division Chief of Environmental Enforcement Office of the Attorney General 100 West Randolph Street, Suite 1200 Chicago, Illinois 60601 enviro@atg.state.il.us
Sara Terranova Division of Legal Counsel Illinois Environmental Protection Agency 1021 North Grand Avenue East P.O. Box 19276 Springfield, Illinois 62794-9276 Sara.Terranova@illinois.gov	Office of Legal Services Illinois Department of Natural Resources One Natural Resources Way Springfield, Illinois 62702-1271 Eric.Lohrenz@illinois.gov
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That my email address is James.Huff@gza.com.

That the number of pages in the email transmission is 327 pages .

That the email transmission took place before 5:00 p.m. on the date of March 14, 2019

HUFF & HUFF, INC.

Dated: March 14, 2019

By: James E. Huff, P.E.

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AFFIDAVIT OF E-MAIL SERVICE

I, the undersigned, on oath [or affirmation] state the following:

That I have served the attached **Petition to Amend 35 Ill. Adm. Code 302.102 and 302.208(g) Water Quality Standards for Chlorides, including Proposed Rule Language, and 200 Signatures in Support of this Petition** by email upon Mr. Don Brown, Clerk of the Board, at Don.Brown@illinois.gov.

That my e-mail address is James.Huff@gza.com

That the number of pages in the e-mail transmission is 327 pages .

That the e-mail transmission took place before 5:00 p.m. on the date of March 14, 2019.

James E Huff

SUBSCRIBED AND SWORN TO BEFORE ME this 14th day of March, 2019.

Maureen T Wunderlich

Notary Public

[Notary Seal]

MAUREEN T WUNDERLICH
Official Seal
Notary Public - State of Illinois
My Commission Expires Oct 2, 2020

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TECHNICAL SUPPORT DOCUMENT SUPPLEMENT FOR A WINTER WATER QUALITY STANDARD

March 2019

By

James E. Huff, P.E.

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1. INTRODUCTION

The Illinois Pollution Control Board's General Use Water Quality Standard for chlorides has been 500 mg/L since the early 1970s. Since the adoption of this water quality standard, sales of de-icing salts in the United States have doubled, with a similar increase in chloride concentrations in the receiving streams (Kelly et al., 2012). In Docket R8-09 (Subdocket D), the Board expanded the 500 mg/L chloride water quality standard to include the Chicago Area Waterways (CAWS) and Lower DesPlaines River, excluding the Chicago Sanitary & Ship Canal (CSSC), where site-specific standards were adopted. However, the Board provided three years before the chloride water quality standard would apply during the winter months to the CAWS and Lower DesPlaines River, in recognition of the current water quality exceedances of this 500 mg/L level. Chloride concentrations above the 500 mg/L level are not unique to these two waterways but occur during snow melt periods in nearly all urban streams within Illinois.

The current focus in Illinois to address these chloride exceedances is in pursuing variances from the Board, with a commitment to developing and implementing Best Management Practices (BMPs) to reduce the application of highway de-icing salt. While implementing BMPs is a worthwhile activity, the potential to achieve a *not-to-exceed* limit of 500 mg/L in urban streams under the worst storm conditions is not realistic. As USEPA has also proposed a more restrictive chloride water quality criterion, the 500 mg/L standard has a potential to be significantly reduced at some future date.

Toxicity testing for chlorides has consistently demonstrated the need for restrictive water quality standards. However, this laboratory testing has been conducted at water temperatures between 23 and 25°C, basically near peak summer temperatures. Winter temperature toxicity studies on chlorides are limited. We know that growth and reproduction for most aquatic organisms are limited at colder water temperatures, which raises the question of the appropriateness of the many chronic concerns during the winter months.

In addition, some species are absent from the water column during the winter months. As part of the justification for the site-specific water quality standards in R8-09, Citgo presented data on its collection of Cladocera (water fleas, including *Ceriodaphnia*) from the CSSC. Cladocera population peaked in the summer and steadily declined as the water temperatures cooled. By October 29th, no Cladocera were collected within the CSSC. This finding is not surprising when one considers the life cycle of zooplankton.

Based on the work funded by Citgo as part of R8-09, questions were raised about the impact temperature has on the toxicity of chlorides. Huff & Huff, Inc. solicited funding from a cross section of salt users to fund additional research on cold temperature toxicity of chlorides. The actual toxicity testing for three species (the amphipod *Hyalella azteca,* the fingernail clam *Sphaerium simile,* and mayfly *Neocloeon triangulifer)* was conducted by Dr. David Soucek and Amy Dickinson at the Illinois Natural History Survey (INHS), and the daphnia test (*Ceriodaphnia dubia*) was conducted by the New England Bioassay (NEB) Laboratory in Manchester, Connecticut. The INHS is recognized as the leading research laboratory on aquatic toxicity of chlorides and sulfates.

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Presented herein are the findings from this research, which include more recent literature and cold temperature toxicity testing on four of the most sensitive species to chlorides. Also included herein is an analysis of the duration of exposure to elevated chlorides and derivation of suggested winter water quality standards for chlorides. The proposed water quality standards are then derived, incorporating temperature into the equation.

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2. SUMMARY OF MORE RECENT LITERATURE

The literature survey on the toxicity of chlorides was completed in late 2017, with a focus on temperature effects on this toxicity. There has been minimal research on the effect of temperature on the toxicity of chlorides. Chloride toxicity in general has focused on some of the most sensitive aquatic species, including *C. dubia, N. triangulifer, H. azteca and S. simile,* the same organisms that were studied under the current work. Since completion, there have been additional studies published that are relevant to these proceedings.

Jackson and Funk (2019) of the Stroud Water Research Center presented salinity toxicity data on four species of mayflies representing three different families tested at winter and summer temperatures, using sodium chloride during 96-hour static tests at temperatures ranging from 5 to 25°C. The four mayflies were *Neocloeon triangulifer, Leptophlebia cupida, Maccafertium modesum*, and *Procloeon fragile*. The mayflies were tolerant of high chloride values at low temperature and were less tolerant as temperature increased. For the four species of mayflies, the LC_{50} for chlorides increased with decreasing temperatures, at rates ranging from 201 to 305 mg/L chlorides for every degree C drop in temperature. Taking the least temperature sensitive mayfly species, when the stream temperature declines from 20°C to 10°C, the LC_{50} increases by over 2,000 mg/L as chlorides. The correlation the authors found extended from 5 to 25°C.

Hardness and sulfates have both been recognized as having an impact on the toxicity of chlorides, with the following equation generally recognized today as reflecting this relationship:

$$Acute\ Water\ Quality\ Std = Normalized\ Acute\ Value*(Hardness/300)^{0.205797}\ (Sulfates/65)^{-07452}$$

This relationship was based on the two studies of one species (*C. dubia*), as explained by Stephan (2009). Stephan further explained that any covariance analysis would yield similar exponents. This equation was utilized by Stephan (2009) in his derivation of chloride water quality standards, as well as Pennsylvania and Iowa.

Jackson and Funk (2018) found a linear inverse relationship between temperature and chloride acute toxicity. They utilized actual stream water from White Clay Creek, with a mean hardness of 97 mg/L and sulfate of 17.3 mg/L. Without any adjustments to a *normalized* hardness and sulfate, they evaluated four species of Mayflies the LC_{50} for chlorides increased with decreasing temperatures, at rates ranging from 201 to 305 mg/L chlorides for every degree C drop in temperature. The relationship held for temperatures ranging from 5 to 25°C. An additional key finding from Jackson and Funk is the linear relationship between temperature and toxicity.

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3. DERIVATION OF A TEMPERATURE RELATIONSHIP

Based on the Jackson and Funk study, a linear relationship exists between temperature and chloride toxicity. This is a key finding, as our study evaluated two different temperatures (10°C and 25°C) from which a linear relationship can be derived. Our research found the following changes:

Species	Change in Acute Toxicity
C. dubia	-68.8 mg/L/degree C
S. simile	-83.1 mg/L/degree C
N. triangulifer	-31.2 mg/L/degree C
H. azteca	-30.1 mg/L/degree C

Combining our data with the Jackson and Funk (2018) data yields the following:

Species (Common Name)	Change in Acute Toxicity, mg/L Cl/°C
C. dubia (Cladoceran)	-68.6
S. Simile (Fingernail clam)	-83.1
N. triangulifer (Mayfly)	-31.2
H. azteca (Amphipod)	-30.1
N. triangulifer (Mayfly)	-305.2
P. fragile (Mayfly)	-237.4
L. cupida (Mayfly)	-243.7
M. Modestum (Mayfly)	-201.1

Normalizing the change in toxicity based on the LC_{50} results yields a change of 4.5 percent per degree C decrease in temperature. Note that Jackson and Funk found a five-fold greater impact from temperature, which may be attributable at least to the use of actual stream water, as compared to the use of laboratory synthetic dilution water. Also, Jackson and Funk cultured its mayflies at 20°C, versus Soucek's culturing temperature of 25°C, and this may have impacted the sensitivity to temperatures.

This leads to the following equation for the acute water quality standard:

Acute Water Quality Std =

$$[NFAV+1.045NFAV(25-T)]*(Hardness/300)^{0.205797}\ (Sulfates/65)^{-07452}$$

Chronic Water Quality Std=

$$[1+(0.045)(25-T)]*[CCC*(Hardness/300)^{0.205797}\ (Sulfates/65)^{-07452}]$$

Where NFAV is the Normalized Final Acute Value and CCC is the Criterion Continuous Concentration at 300 mg/L hardness, 65 mg/L sulfate and 25°C.

These equations would be valid for all seasons, based upon the temperature, hardness, and sulfate in the stream at the time of sampling for chlorides.

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4. DURATION OF ELEVATED CHLORIDES IN RECEIVING STREAMS

Elevated chlorides in Illinois streams are episodic events. The levels reached and the duration are functions of the amount of salt applied in response to a storm event, the subsequent temperatures, the base flow in the receiving streams, and antecedent period from the previous snow event (which determines the background chloride concentration before the storm runoff). The smaller the drainage area, the flashier the chloride response will be, typically with spikes of chlorides above 500 mg/L lasting one-to-two days. As the stream size increases, the duration where the chlorides will remain above 500 mg/L can last a week or more. However, these longer durations typically have a return interval longer than three years on most urban streams.

Three data sources for spikes in chlorides or surrogate measurements (conductivity or Total Dissolved Solids or TDS) were used to look at the duration of snow melt events. First, the Citgo Lemont Refinery has measured the chlorides concentration on the CSSC for over a decade. Second, the Metropolitan Water Reclamation District of Greater Chicago (MWRD) has monitored conductivity on many Chicago Area Waterways, each with an individually-derived chloride concentration. The third data source is from the DuPage River/Salt Creek Workgroup (DRSCW), which also has monitored conductivity, with correlation to chlorides. Each of these three datasets provides information on the duration to chlorides spikes on a variety of stream sizes. Each of the three is discussed below.

4.1 Lemont Refinery Chloride Monitoring on the Chicago Sanitary & Ship Canal

Presented in the original Technical Support Document, Appendix C, is the Lemont Refinery's chloride data table for the winter months. The average concentration each winter ranged from a low of 128 mg/L (based on limited data in 2012) to 393 mg/L in 2014. More relevant to our analysis is the duration of elevated chlorides when such events occur. The CSSC represents the largest stream segment, especially associated with urban runoff, so the durations of elevated chlorides would be expected to be longer on this waterbody than all others in Illinois. The chronic water quality standard on the CSSC is 620 mg/L, so using this value, the following table was constructed:

CSSC at Romeoville

Event	# of days 4-day running average above 620 mg/L Chlorides, days	Maximum Chloride Concentration Recorded, mg/L
2017	0	568
2016	0	660
2015	0	904
2014	5	720
2013	2	711
2012	0	145
2011	4	1,099
2010	1	870
2009	1	881

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CSSC at Romeoville

Event	# of days 4-day running average above 620 mg/L Chlorides, days	Maximum Chloride Concentration Recorded, mg/L
2008	7	896
2007	4	998
2006	0	454
2005	1	835

*Note the duration in days is an extrapolation; typically, samples were collected two days per week.

There were 25 events over the 12-year period, with exceedances of the four-day 620 mg/L chronic standard, or an average of two events per year. The average duration of these exceedances was approximately 5 days. Three events had durations greater than 7 days, or a frequency of occurring once per 3.6 winter seasons. The acute standard on the CSSC is 990 mg/L, and documented exceedances occurred twice over the 11-year period, a recurrence frequency of once every 5.5 years.

4.2 MWRD Conductivity Monitoring on the Chicago Area Waterways

The MWRD has a series of conductivity probes throughout the CAWS, and data from 2007 through April 2017 were available for analysis. Using the MWRD conversion from conductivity to chlorides allows for more accurate estimates of duration. The results for the CSSC at Cicero, just above the discharge from the Stickney treatment plant, are summarized below:

CSSC at Cicero

Event	# of days 4-day running average above 620 mg/L Chlorides, days	Maximum Chloride Concentration Recorded, mg/L
Thru April 30, 2017	0	500
2016	0	465
2/15/2015	8	812
1/14/2014	9	916
3/6/2013	7	918
2/12/2013	3	822
2/19/2011	2	719
2010	0	612
12/26/2009	0	634
3/3/2008	0	690
2/12/2008	9	1,241
12/17/2007	11	860
3/1/2007	6	1,008

Over the eleven years on the CSSC at Cicero Avenue, the number of four-day periods when the existing chronic standard of 620 mg/L was exceeded was 55 days, or an average of five days per year. The acute standard (990 mg/L) was exceeded twice over this period, or a recurrence interval of approximately every five years. Durations above the chronic standard longer than seven days

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occurred four times over the period of record, or a recurrence interval of once every 2.7 years. These results are similar to the Lemont Refinery's data presented above.

On the North Branch of the Chicago River, Kinzie Street is just above the confluence with the Main Stem Chicago River. This station has been monitored by the MWRD from 2007 to 2013. Using 640 mg/L for the chronic winter threshold from the original proposal, and 1,010 mg/L for the acute threshold, also from the original proposal, yields the following on the North Branch of the Chicago River.

North Branch at Kinzie Street

Event	# of days 4-day running average above 640 mg/L Chlorides, days	Maximum Chloride Concentration Recorded, mg/L
3/8/2013	1	876
3/1/2013	4	1,075
2012	0	644
2011	0	718
2010	0	699
2009	0	690
2/9/2008	11	1,160
12/13/2007	3	914
2/27/2007	8	1,092

Over the seven years, the number of days when the chronic winter level of 640 mg/L was exceeded was 27 days, or an average of four days per year. An acute value of 1,010 mg/L was exceeded in three events over this seven-year period, or a recurrence interval of approximately every 2.3 years. Durations above the chronic standard longer than seven days occurred twice over the period of record, or a recurrence interval of once every 3.5 years.

For the Cal-Sag Channel, the MWRD has robust records at Cicero Avenue, from 2007 to 2017 for conductivity. Like the North Branch, this station is downstream of one of the major water reclamation facilities.

Cal-Sag at Cicero

Event	# of days 4-day running average above 640 mg/L Chlorides, days	Maximum Chloride Concentration Recorded, mg/L
2017	0	341
2016	0	454
2015	0	646
2014	0	387
2011	0	551
2/25/2010	2	723
2009	0	568
2008	0	668
2007	0	622

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Over the nine years, the number of days when the chronic winter level of 640 mg/L was exceeded was 2 days, or an average of once every 4.5 years. An acute value of 1,010 mg/L has not been exceeded on the Cal-Sag at Cicero over the nine-year period of record, with a maximum estimated chloride of 723 mg/L that occurred on February 25, 2010.

A summary of the MWRD data on the Chicago Area Waterways indicates that most elevated chloride periods last less than seven days, with the peak duration above some chronic level of 11 days.

4.3 DuPage River and Salt Creek Conductivity Data

The DuPage River/Salt Creek Workgroup (DRSCW) has monitored conductivity and chlorides on its waterways since 2007, and their data provide an excellent picture of intermediate-sized streams in urban areas. Salt Creek at Wolf River reflects closer to the downstream end, and below the Fullersburg Woods Dam, so the chloride spikes are dampened to a minor degree at this location. This stream also receives considerable wastewater effluents from the municipalities along the waterway. The following table summarizes the winter days above 640 mg/L and the maximum estimated chlorides.

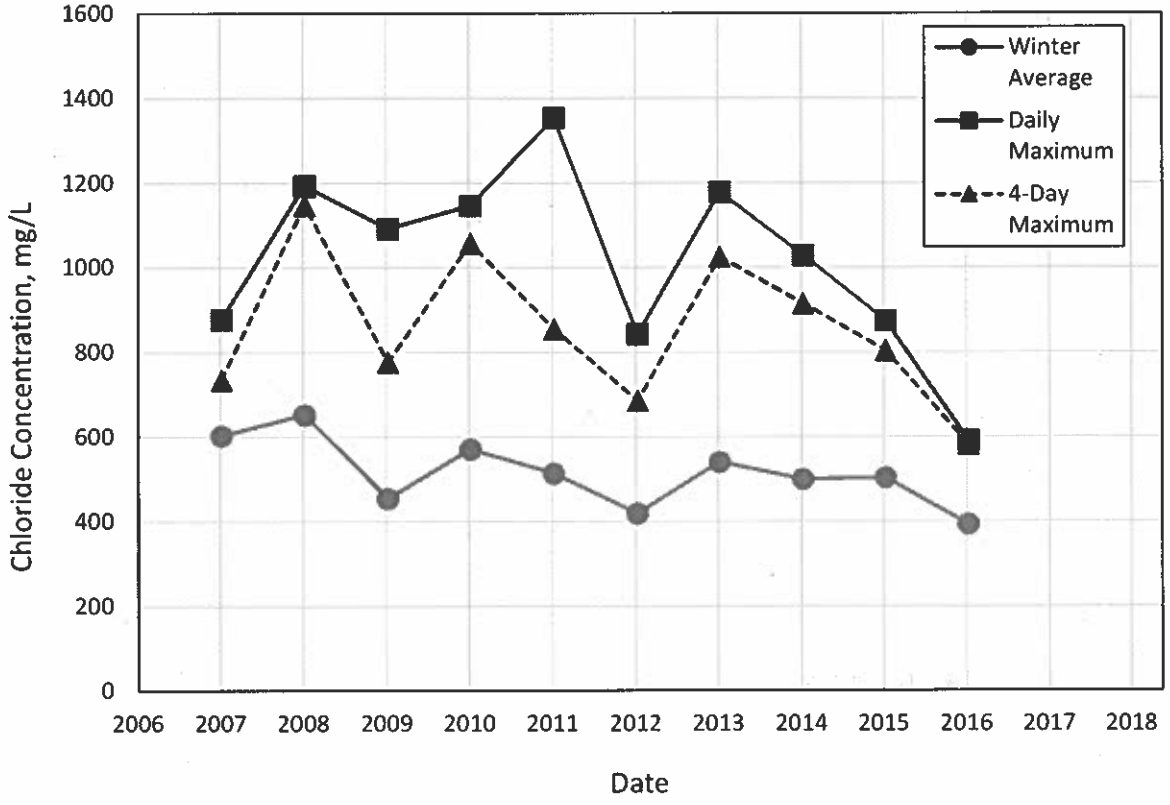
Salt Creek at Wolf Road

Event	Estimated Duration above 640 mg/L Chlorides, days	Maximum Chloride Concentration Recorded, mg/L
2016	0	591
3/25/2015	5	771
3/12/2015	13	861
2/9/2015	9	874
3/13/2014	10	1,028
1/11/2014	5+	931
12/21/2013	2	742
3/7/2013	14	1,178
2/13/2013	1	645
2/8/2013	5	811
2/27/2011	6	815
2/16/2011	4+	990
1/19/2011	1+	**1,353**
2/23/2010	21	1,146
2/11/2010	7	894
2/10/2009	2	670
3/1/2008	11	984
2/9/2008	26	1,193
2/12/2007	4	877

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The durations at this station are longer than at the other stations tabulated, and this may be due to the dam immediately upstream, retarding the flushing of the chlorides. However, the dam would also dampen the peak chloride concentrations. Overall, there appears to be a declining trend in both peak chlorides and in the durations. However, some of this recent improvement may be attributed to the milder winters over the last two years. Figure 1 clearly depicts this trend, including in the winter average chloride concentrations.

Figure 1: ANNUAL CHLORIDE CONCENTRATION - WINTER MONTHS (2007-2016)
SALT CREEK AT WOLF ROAD



DRSCW also monitored the East Branch of the DuPage River at Hobson Road (HR) in Woodridge and Unincorporated DuPage County, Illinois from 2008 to 2015. The results are presented in the following table.

East Branch DuPage River at Hobson Road

Event	Estimated 4-Day Duration above 640 mg/L Chlorides, days	Maximum Chloride Concentration Recorded, mg/L
2/9/2015	4	819
3/22/2014	8	859
2/20/2014	2	987

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2/20/2013	6	1,097
2012	0	788
1/19/2011	3	980
2/23/2010	8	1,172
2/11/2010	3	782
2009	0	513
2/5/2008	17	1,017

The peak recorded chloride was 1,172 mg/L at Hobson Road, and the longest duration above 640 mg/L was 17 consecutive days, back in 2008. Since 2008, eight consecutive days is the longest duration above 640 mg/L.

On the West Branch of the DuPage River, the DRSCW has monitored at Arlington Drive (AD) in Hanover Park, DuPage County, Illinois from 2007 to 2015, with the following chloride winter spikes.

West Branch DuPage River at Arlington Drive		
Event	Estimated 4-Day Duration above 640 mg/L Chlorides, days	Maximum Chloride Concentration Recorded, mg/L
2015	0	589
3/8/2014	1	696
2/19/2014	2	812
3/8/2013	3	758
2012	0	612
1/29/2011	3	731
2010	0	719
2009	0	750
2/9/2008	6	826
2007	0	599

The West Branch is the furthest west, and the least urbanized compared to the East Branch and Salt Creek. The peak chloride over the nine years was 826 mg/L, so no exceedances of the proposed acute standard of 1,010 mg/L. Five events exceeded 640 mg/L for a 4-day period, or less than one event annually.

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5. DERIVATION OF WATER QUALITY STANDARDS

Under federal regulation, 40CFR131.5(c), one of the minimum requirements for water quality standards is that the criteria be sufficient to protect the designated uses. In 1985, the United States Environmental Protection Agency (USEPA) published *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (Stephan, et al., 1985). This document outlines the methodology for deriving water quality criteria, and notes for the chronic criteria, that a four-day averaging period is appropriate, and that a 20 to 30-day period is unacceptable. The four-day period was intended to "prevent increased adverse effects on sensitive life stages by limiting the durations and magnitudes of exceedances of the CCC." (CCC is the Criterion Continuous Concentration, or chronic criteria.) (pg. 5.)

Stephan, et al., goes on to note that, "most bodies of water could tolerate exceedances once every three years on the average. In situations in which exceedances are grouped, several exceedances might occur in one or two years, but then there will be, for example, 10 to 20 years during which no exceedances will occur." (pg 6). This is consistent with the data presented in the previous section, where there are years with no exceedances and other years when exceedances are more frequent. This USEPA document notes that, "Whenever adequately justified, a national criterion may be replaced by a site-specific criterion," (pg 6).

Stephan (2009) updated the chloride database and derived a Criterion Maximum Concentration (CMC) of 602.4 mg/L. Since that time, there have been additional toxicity tests. Adding to Stephan's (2009) database, Table 1 was prepared. The data in Table 1 are limited to studies where hardness and sulfate data are presented. In the case of Jackson and Funk (2019), the LC_{50} results for all temperature tests were *normalized* to 25°C using the slopes presented for each species in the paper, and a geometric mean was utilized for the normalized LC_{50}.

Table 1 presents the data utilized with the normalized acute values (NAV), the species mean acute values (SMAV), and genus mean acute values (GMAV), again starting with Stephan's (2009) list and adding to it the more recent results, including our results (INHS 2018 and NEB 2018).

Table 2 presents the USEPA protocol for deriving acute standards, by ranking the GMAVs, and utilizing the four most sensitive species to compute the normalized CMC. The CMC is computed to be **518.3 mg/L** at 25°C, 300 mg/L hardness, and 65 mg/L sulfate.

Table 3 presents the acute water quality standard at various temperatures, hardness, and sulfate levels, based upon the normalized CMC, the linear relationship with temperature normalized to 4.5 percent per degree decline from 25°C, and the accepted hardness and sulfate correlations. This is provided just as an example of the typical water quality standards.

Table 4 presents the derivation of the Acute:Chronic Ratio (ACR) for both invertebrates and vertebrates, and includes the results from Dr. Soucek's work, as well as the New England Bioassay work. A separate ACR is then applied to the vertebrates and invertebrates based on the data where both test results are reported. A Final ACR (FACR) of 3.45 is calculated as the geometric mean of the available Species Mean ACRs (SMACR) for invertebrates and an FACR of 7.33 is calculated for vertebrates as the geometric mean of the two available SMACRs. The chronic values are then

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derived following the USEPA *Guidelines* and Stephan's 2009 "Derivation of Alternative Chronic Value" method from "*Calculation of Aquatic Life Criteria for Chloride*" and placed in the second part of Table 4 in ascending order of sensitivity. The four most sensitive species are presented, and the Criterion Continuous Concentration (CCC) of **300.5 mg/L** is computed based on the normalized values of 25°C, 300 mg/L hardness, and 65 mg/L sulfate. Three mayflies and the fingernail clam are the most sensitive species based on Table 4, with the mayfly data dominated by the Stroud 2015 study.

Table 5 presents examples of the chronic water quality standard based on varying temperature, hardness, and sulfate levels, again simply for illustrative purposes.

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6. COMPARISON OF PROPOSED WINTER STANDARDS TO RESEARCH RESULTS

Four species were selected for chloride toxicity evaluation at winter temperature, and the results were presented in Section 5 of the original Technical Support Document.

As described in Section 5, extended exposure tests were conducted. The *C. dubia* test, where the organisms were exposed to elevated chlorides for 35 days, yielded a No Observable Effects Concentration (NOEC) of 782 mg/L chlorides at 10°C, above the range of computed chronic water quality standards presented in Table 5. The laboratory testing of *C. dubia* demonstrates that this sensitive species would readily be protected if the proposed criterion was adopted.

For the Fingernail clam toxicity testing, run for 28 days of exposure to various chloride concentrations, no chronic effects were detected with concentrations of 1,000 mg/L chlorides at 10°C. This result also demonstrates that a chronic water quality standard illustrated in Table 5 would be protective of this sensitive species.

The third sensitive species, the Mayfly *Neocloeon triangulifer,* showed no chronic effects found in chloride concentrations up to 750 mg/L. At the highest dose of exposure, 1,500 mg/L chlorides, no chronic effects were observed, but survival declined to 55 percent (compared to 0 percent survival at 25°C). Again, the chronic standards illustrated in Table 5 would be protective of this sensitive species.

The final species evaluated, the amphipod *Hyalella azteca* (Burlington strain) did not survive well at 10°C, with only about a 50% survival rate at 7 to 10 days, independent of the chloride concentration. However, based on the acute testing at the two temperatures, at 25°C the 96-hour LC_{50} was 1,733 mg/L versus 2,185 mg/L at 10°C, or a ratio of 1.26. Applying this same ratio to the 28-day chronic test at 25°C result of 516 mg/L yields an estimated chronic value at 10°C of 650 mg/L from 28 days of exposure to chlorides. Again, this sensitive species will be protected with a 4-day chronic water quality standard illustrated in Table 5.

In summary, using the acute-to-chronic ratio, as described in the previous section, results in a conservative chronic water quality criterion, which will be protective of the most sensitive species.

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7. REFERENCES

Commonwealth of Pennsylvania Department of Environmental Protection. (2016) Triennial Review of Water Quality Standards, Rationale for the Development of Ambient Water Quality Criteria for Chloride Protection of Aquatic Life.

Eldridge, W., Arscott, D.B., and Jackson, J.K. (2012) Review of the 2012 Proposed Water Quality Criteria for Chloride for the Protection of Aquatic Life in Pennsylvania. *Stroud Water Research Center,* Report #2012007.

Elphick, J.R.F.; Bergh, K.D.; and Baile, H.C. (2011) Chronic Toxicity of Chloride to Freshwater Species: Effects of Hardness and Implications for Water Quality Guidelines. *Nautilus Environmental and Rescan Environmental Services.* Environmental Toxicology and Chemistry, Vol. 30, No. 1, pp. 239-246.

Gillis, P.L. (2011) Assessing the Toxicity of Sodium Chloride to the Glochidia of Freshwater Mussels: Implications for Salinization of Surface Waters. *National Water Research Institute, Environment Canada.* Environmental Pollution Vol. 159 (2011), pp. 1702-1708.

Jackson, J.K. and Funk, D.H. (2018) Temperature Affects Acute Mayfly Responses to Elevated Salinity: Implications for Toxicity of Road De-Icing Salts. *Stroud Water Research Center.* Phil. Trans. R. Soc. B 374: 20180081.

Mount, D.R., et al. (2016) The Acute Toxicity of Major Ion Salts to *Ceriodaphnia dubia*: I. Influence of Background Water Chemistry. US Environmental Protection Agency, EMR. Environmental Toxicology and Chemistry, Vo. 35, No. 12, pp. 3039-3057.

Soucek, D.J. and Dickinson, A. (2015) Full-Life Chronic Toxicity of Sodium Salts to the Mayfly *Neocloeon Triangulifer* in Tests With Laboratory Cultured Food. *Illinois Natural History Survey.* Environmental Toxicology and Chemistry, Vol. 34, No. 9, pp. 2126-2137.

Soucek, D.J.; Mount, D.R.; Dickinson, A.; and Hockett, J.R. (2018) Influence of Dilution Water Ionic Composition on Acute Major Ion Toxicity to the Mayfly *Neocloeon triangulifer. Illinois Natural History Survey,* US Environmental Protection Agency. Environmental Toxicology and Chemistry, Vol. 37, No. 5, pp. 1330-1339.

Soucek, D.J. Progress Update 12/04/17: Fingernail clams and Amphipods. Illinois Natural History Survey.

Stephan C.E., Mount D.I., Hansen D.J., Gentile J.R., Chapman G.A., Brungs W.A. (1985) Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses. United States Environmental Protection Agency, 1-54.

Electronic Filing: Received, Clerk's Office 3/14/2019

Stephan, C. (2009a) Draft Summary of Data Concerning the Acute Toxicity of Sodium Chloride to Aquatic Animals. Duluth, MN: US Environmental Protection Agency.

Stephan, C. (2009b) description of the Review of Results of Toxicity Tests on Chloride. Duluth, MN: US Environmental Protection Agency.

Stephan, C. (2009c) Draft Multiple Regression Equation for Chloride. Duluth, MN: US Environmental Protection Agency.

Stephan, C. (2009d) Draft Summary of Data Concerning the Chronic Toxicity of Sodium Chloride to Aquatic Animals. Duluth, MN: US Environmental Protection Agency.

Stephan, C. (2009e) Draft Calculation of Aquatic Life Criteria for Chloride. Duluth, MN: US Environmental Protection Agency.

Wang, N., et al. (2018) Acute Toxicity of Sodium Chloride and Potassium Chloride to A Unionid Mussel (*Lampsilis siliquoidea*) In Water Exposures. US Geological Survey, US Environmental Protection Agency. Environmental Toxicology and Chemistry, Vol. 9999, No. 9999, pp. 1-9.

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TABLES

Table 1
SMAV and GMAV in mg/L Chloride for Updated and Complete Literature Values for Chloride Criteria (Aquatic Life)
SMAVs and GMAVs are normalized to hardness of 300 mg/L, sulfate of 65 mg/L, and temperature of 25 °C

Genus	Species	Common Name	Temperature of Toxicity Testing, °C	Reference	Hardness, mg/L	Sulfate, mg/L	Acute Value (LC50)	Normalized to 25 °C Hardness = 300 mg/L Sulfate = 65 mg/L: Normalized Acute Value	SMAV	GMAV
Anguilla	rostrata	American eel	22 a/	Hinton, Eversole 1978	42.7	40.7	11,880	17,343.4	17,343.4	17,343
Cambarus	sp.	Crayfish	25	Clemens, Jones 1954	22	15	10,557	16,203.2	16,203.2	16,203
Fundulus	kansae	Plains killiefish	25	Clemens, Jones 1954	22	15	9,706	14,897.1	14,897.1	14,897
Libellulidae	spp.	Dragonfly	25	Clemens, Jones 1954	22	15	9,671	14,843.4	14,843.4	14,843
Gasterosteus	aculeatus	Threespine stickleback	25	Garibay, Hall 2004	84.8	81.4	10,200	13,452.6	13,452.6	13,453
Gambusia	affinis	Mosquitofish	25	Clemens, Jones 1954	22	15	6,472	9,933.4	9,933.4	9,933
Lepomis	cyanellus	Green sunfish	25	Clemens, Jones 1954	22	15	6,499	9,974.9	9,974.9	9,157
Lepomis	macrochirus	Bluegill	25	Birge et al. 1985; et al. 1954-1968	---	---	---	---	8,406.5	---
Lepomis	macrochirus	Bluegill	25	Birge et al. 1985	84.8	81.4	5,840	7,702.3	---	---
Lepomis	macrochirus	Bluegill	25	Acad of Nat Sci 1960; Patrick 1968; Trama 1954	44.3	15.5	7,853	10,461.6	---	---
Notropis	lutrensis	Red shiner	25	Clemens, Jones 1954	---	---	---	---	8971.12	8,971
Notropis	lutrensis	Red shiner	25	Clemens, Jones 1954	22	15	5,771	8,857.5	---	---
Notropis	lutrensis	Red shiner	25	Clemens, Jones 1954	22	15	5,920	9,086.2	---	---
Oncorhynchus	*mykiss*	*Rainbow trout*	*25*	*Spehar 1986-1986; Elphick et al. 2011*	*40*	*58.5*	---	---	*8,921.0*	*8,921*
Oncorhynchus	*mykiss*	*Rainbow trout*	*12* a/	*Spehar 1986-1987*	*46*	*3.9*	*6,743*	*8,786.8*	---	---
Oncorhynchus	***mykiss***	***Rainbow trout***	***25***	***Elphick et al. 2011***	***40***	***58.5***	***6,030***	***9,057.2***	---	---
Ameiurus	melas	Black bullhead	25	Clemens, Jones 1954	22	15	4,849	7,442.4	7,442.4	7,442
Pimephales	*promelas*	*Fathead minnow*	*25*	*USEPA 1991, Birge 1985, Elphick 2011*	---	---	---	---	*4,994.5*	*4,995*
Pimephales	*promelas*	*Fathead minnow*	*25*	*USEPA 1991*	*39.2*	*39.2*	*2,790*	*3,481.7*	---	---
Pimephales	*promelas*	*Fathead minnow*	*25*	*USEPA 1991*	*39.2*	*39.2*	*2,123*	*2,649.3*	---	---
Pimephales	*promelas*	*Fathead minnow*	*25*	*USEPA 1991*	*339.0*	*325.4*	*2,244*	*2,467.3*	---	---
Pimephales	*promelas*	*Fathead minnow*	*25*	*Birge et al. 1985*	*84.8*	*81.4*	*6,570*	*8,665.1*	---	---
Pimephales	*promelas*	*Fathead minnow*	*25*	*Clemens, Jones 1954*	*22*	*15*	*5,288*	*8,116.2*	---	---
Pimephales	*promelas*	*Fathead minnow*	*25*	*Clemens, Jones 1954*	*22*	*15*	*5,431*	*8,335.7*	---	---
Pimephales	*promelas*	*Fathead minnow*	*25*	*Mount et al. 1997*	*84.8*	*81.4*	*3,876*	*5,112.0*	---	---
Pimephales	*promelas*	*Fathead minnow*	*25*	*WISLOH 2007*	*84.8*	*81.4*	*4,167*	*5,495.8*	---	---
Pimephales	*promelas*	*Fathead minnow*	*25*	*WISLOH 2007*	*169.5*	*162.7*	*4,127*	*4,970.0*	---	---
Pimephales	***promelas***	***Fathead minnow***	***25***	***Elphick et al. 2011***	***90***	***58.5***	***4,079***	***5,185.0***	---	---
Tubifex	*tubifex*	*Tubificid worm*	*25*	*GLEC, INHS 2007; Elphick 2011*	---	---	---	---	*6,523.7*	*6,524*
Tubifex	*tubifex*	*Tubificid worm*	*25*	*GLEC, INHS 2008*	*52*	*57.9*	*4,278*	*6,083.2*	---	---
Tubifex	*tubifex*	*Tubificid worm*	*25*	*GLEC, INHS 2008*	*220*	*58.9*	*6,008*	*6,357.1*	---	---
Tubifex	***tubifex***	***Tubificid worm***	***25***	***Elphick et al. 2011***	***90***	***58.5***	***5,648***	***7,179.5***	---	---
Hyalella	*azteca*	*Amphipod*	*25*	*INHS and Lasier et al (1997)*	*96.36*	*69.57*	---	---	*2,684.7*	*2,685*
Hyalella	*azteca*	*Amphipod*	*25*	*Lasier et al. 1997*	*102.5*	*98.4*	*3,947*	*5,077.7*	---	---
Hyalella	***azteca***	***Amphipod***	***25***	***Elphick et al. 2011***	***90***	***58.5***	***1,382***	***1,756.7***	---	---
Hyalella	***azteca***	***Amphipod***	***25***	***IHNS 2017***	***97***	***58.5***	***1,733***	***2,169.2***	---	---

Table 1
SMAV and GMAV in mg/L Chloride for Updated and Complete Literature Values for Chloride Criteria (Aquatic Life)
SMAVs and GMAVs are normalized to hardness of 300 mg/L, sulfate of 65 mg/L, and temperature of 25 °C

Genus	Species	Common Name	Temperature of Toxicity Testing, °C	Reference	Hardness, mg/L	Sulfate, mg/L	Acute Value (LC50)	Normalized to 25 °C Hardness = 300 mg/L Sulfate = 65 mg/L: Normalized Acute Value	SMAV	GMAV
Pseudacris	sp.	Chorus frog	25	Garibay, Hall 2004	84.8	81.4	3,553	4,686.0	4,686.0	4,686
Diaptomus	clavipes	Copepod	25	Clemens, Jones 1954	22	15	2,571	3,946.1	3,946.1	3,946
Lirceus	fontinalis	Isopod	25	Birge et al. 1985	84.8	81.4	2,950	3,890.7	3,890.7	3,891
Gyraulus	parvus	Snail	25	GLEC, INHS 2008	---	---	---	---	3,727.7	3,728
Gyraulus	parvus	Snail	25	GLEC, INHS 2008	56	60.9	3,078	4,326.9	---	---
Gyraulus	parvus	Snail	25	GLEC, INHS 2008	212	59.7	3,009	3,211.4	---	---
Physa	gyrina	Snail	25	Birge et al. 1985	84.8	81.4	2,540	3,350.0	3,350.0	3,350
Villosa	delumbis	Mussel	25	Bringolf et al. 2007	169.5	162.7	3,173	3,821.1	3,821.1	3,086
Villosa	iris	Mussel	25	Wang 2007	169.5	162.7	2,069	2,491.6	2,491.6	...
Lampsilis	*fasciola*	*Mussel*	*25*	*Bringolf et al. 2007; Gillis 2011*	---	---	---	---	*874.3*	*1,419*
Lampsilis	*fasciola*	*Mussel*	*25*	*Bringolf et al. 2007*	*169.5*	*162.7*	*2,414*	*2,907.1*	---	---
Lampsilis	***fasciola***	***Mussel***	***21***	***Gillis 2011***	***95***	***58.5***	***113***	***383.4***	---	---
Lampsilis	***fasciola***	***Mussel***	***21***	***Gillis 2011***	***95***	***58.5***	***285***	***599.6***	---	---
Lampsilis	*siliquoidea*	*Mussel*	*25*	*Wang et al. 2018; Bringolf et al. 2007*	---	---	---	---	*2,302.3*	---
Lampsilis	*siliquoidea*	*Mussel*	*25*	*Bringolf et al. 2007*	*169.5*	*162.7*	*1,905*	*2,294.1*	---	---
Lampsilis	*siliquoidea*	*Mussel*	*25*	*Wang 2007*	*169.5*	*162.7*	*2,766*	*3,331.0*	---	---
Lampsilis	***siliquoidea***	***Mussel***	***25***	***Wang et al. 2018***	***299***	***67***	***1,597***	***1,597.0***	---	---
Daphnia	ambigua	Cladoceran	25	Harmon et al. 2003	67.1	64.4	1,213	1,649.7	1,649.7	2,327
Daphnia	*magna*	*Cladoceran*	*25*	*USEPA, Wisloh, Davies, Seymour, Elphick et al.*	---	---	---	---	*3,779.7*	---
Daphnia	*magna*	*Cladoceran*	*25*	*Hoke et al. 1992*	*39.2*	*4.6*	*3,038*	*3,791.1*	---	---
Daphnia	*magna*	*Cladoceran*	*25*	*Hoke et al. 1992*	*39.2*	*4.6*	*2,726*	*3,401.8*	---	---
Daphnia	*magna*	*Cladoceran*	*25*	*Hoke et al. 1992*	*39.2*	*4.6*	*2,053*	*2,561.9*	---	---
Daphnia	*magna*	*Cladoceran*	*25*	*Dowden & Bennett 1965*	*41.5*	*31.2*	*3,563*	*5,068.2*	---	---
Daphnia	*magna*	*Cladoceran*	*25*	*Seymour et al. 1997*	*169.5*	*162.7*	---	*3,906.7*	---	---
Daphnia	*magna*	*Cladoceran*	*25*	*USEPA 1991*	*46*	*3.9*	*1,880*	*2,242.3*	---	---
Daphnia	*magna*	*Cladoceran*	*25*	*WISLOH 2007*	*169.5*	*162.7*	*3,944*	*4,749.6*	---	---
Daphnia	*magna*	*Cladoceran*	*25*	*Valenti et al. 2007*	*84.8*	*81.4*	*3,009*	*3,968.5*	---	---
Daphnia	*magna*	*Cladoceran*	*25*	*Davies & Hall 2007*	*106*	*102*	*3,136*	*4,017.4*	---	---
Daphnia	*magna*	*Cladoceran*	*25*	*Davies & Hall 2007*	*106*	*102*	*3,222*	*4,127.5*	---	---
Daphnia	*magna*	*Cladoceran*	*25*	*Davies & Hall 2007*	*106*	*102*	*3,137*	*4,018.6*	---	---
Daphnia	***magna***	***Cladoceran***	***25***	***Elphick et al. 2011***	***90***	***58.5***	***3,630***	***4,614.3***	---	---
Daphnia	pulex	Cladoceran	25	Birge et al. 1985, Palmer et al. 2004	---	---	---	---	2,020.5	---
Daphnia	pulex	Cladoceran	25	Birge et al. 1985	84.8	81.4	1,470	1,938.8	---	---
Daphnia	pulex	Cladoceran	25	Palmer et al. 2004	84.8	81.4	1,159	1,528.6	---	---
Daphnia	pulex	Cladoceran	25	Palmer et al. 2004	84.8	81.4	1,775	2,341.0	---	---
Daphnia	pulex	Cladoceran	25	Palmer et al. 2004	84.8	81.4	1,805	2,380.6	---	---
Daphnia	pulex	Cladoceran	25	Palmer et al. 2004	84.8	81.4	2,242	2,956.9	---	---

Table 1
SMAV and GMAV in mg/L Chloride for Updated and Complete Literature Values for Chloride Criteria (Aquatic Life)
SMAVs and GMAVs are normalized to hardness of 300 mg/L, sulfate of 65 mg/L, and temperature of 25 °C

Genus	Species	Common Name	Temperature of Toxicity Testing, °C	Reference	Hardness, mg/L	Sulfate, mg/L	Acute Value (LC50)	Normalized to 25 °C Hardness = 300 mg/L Sulfate = 65 mg/L: Normalized Acute Value	SMAV	GMAV
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC, INHS 2008; NEB 2018; Elphick 2011	---	---	---	---	1,567.9	1,568
Ceriodaphnia	*dubia*	*Cladoceran*	25	Mount et al. 1997	84.8	81.4	1,189	1,568.2	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	Mount et al. 1997	84.8	81.4	1,042	1,374.3	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	USEPA 1991	39.2	4.6	1,395	1,740.8	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	USEPA 1991	39.2	4.6	1,638	2,044.1	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	USEPA 1991	39.2	4.6	1,274	1,589.8	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	USEPA 1991	39.2	4.6	1,395	1,740.8	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	USEPA 1991	339	325.4	1,698	1,867.0	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	WISLOH 2007	84.8	81.4	1,677	2,211.8	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	WISLOH 2007	169.5	162.7	1,499	1,805.2	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	Valenti et al. 2007	84.8	81.4	1,413	1,863.6	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	Harmon et al. 2003	67.1	64.4	964	1,311.1	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	30	78.7	947	1,542.9	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	44	75.9	955	1,434.1	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	96	73.7	1,130	1,442.1	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	180	67.7	1,609	1,792.8	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	400	78.7	1,491	1,425.5	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	570	76.2	1,907	1,690.9	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	800	75.5	1,764	1,457.7	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	25	69.9	1,007	1,688.4	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	49	67.8	767	1,117.1	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	95	70.3	1,369	1,744.7	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	194	69.9	1,195	1,314.3	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	375	68.9	1,687	1,618.3	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	560	68.3	1,652	1,458.2	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	792	70.9	1,909	1,573.5	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	280	28.1	1,400	1,334.0	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	280	59.6	1,720	1,733.4	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	280	117	1,394	1,477.2	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	280	239	1,500	1,676.5	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	280	482	1,109	1,306.0	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	280	729	1,206	1,464.7	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	279	22.9	1,311	1,231.2	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	276	49.7	1,258	1,254.4	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	283	107	1,240	1,302.5	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	281	229	1,214	1,351.5	---	---
Ceriodaphnia	*dubia*	*Cladoceran*	25	GLEC & INHS 2008	290	461	1,199	1,397.2	---	---

Table 1
SMAV and GMAV in mg/L Chloride for Updated and Complete Literature Values for Chloride Criteria (Aquatic Life)
SMAVs and GMAVs are normalized to hardness of 300 mg/L, sulfate of 65 mg/L, and temperature of 25 °C

Genus	Species	Common Name	Temperature of Toxicity Testing, °C	Reference	Hardness, mg/L	Sulfate, mg/L	Acute Value (LC50)	Normalized to 25 °C Hardness = 300 mg/L Sulfate = 65 mg/L: Normalized Acute Value	SMAV	GMAV
Ceriodaphnia	*dubia*	*Cladoceran*	*25*	*GLEC & INHS 2008*	*278*	*694*	*1,179*	*1,428.8*	---	---
Ceriodaphnia	***dubia***	***Cladoceran***	***25***	***Elphick et al. 2011***	***90***	***58.5***	***1,068***	***1,357.6***	---	---
Ceriodaphnia	***dubia***	***Cladoceran***	***25***	***Mount et al. 2016***	***84.4***	***81***	***2,004***	***2,644.7***	---	---
Ceriodaphnia	***dubia***	***Cladoceran***	***25***	***NEB 2018***	***90***	***58.5***	***1,920***	***2,440.6***	---	---
Sphaerium	*simile*	*Fingernail clam*	*25*	*GLEC, INHS 2009*	---	---	---	---	*1,386.3*	*1,386*
Sphaerium	*simile*	*Fingernail clam*	*25*	*GLEC, INHS 2009*	*51*	*59.9*	*740*	*1,059.2*	---	---
Sphaerium	*simile*	*Fingernail clam*	*25*	*GLEC, INHS 2009*	*192*	*61.7*	*1,100*	*1,201.1*	---	---
Sphaerium	***simile***	***Fingernail clam***	***25***	***INHS 2017***	***97***	***58.5***	***1,673***	***2,094.1***	---	---
Procloeon	**fragile**	**Mayfly**	**25**	**Jackson and Funk 2018**	**97**	**17.3**	**763**	**872.2**	**872.2**	**872**
Leptophlebia	**cupida**	**Mayfly**	**25**	***Jackson and Funk 2018***	**97**	**17.3**	**1,949**	**2,227.8**	**2,227.8**	**2,228**
Maccaffertium	**modesum**	**Mayfly**	**25**	***Jackson and Funk 2018***	**97**	**17.3**	**1,004**	**1,147.6**	**1,147.6**	**1,148**
Cyprinella	**leedsi**	**Bannerfin shiner**	**25**	***Environ 2009; CCME 2011***	**296**	**---**	**6,070**	**6,111.0**	**6,111.0**	**6,111**
Rana	**catesbeiana**	**Bullfrog (tadpole)**	**25**	***Environ 2009; CCME 2011***	**300**	**---**	**5,846**	**5,897.0**	**5,897.0**	**5,897**
Nephelopsis	**obscura**	**Leech**	**25**	***Environ 2009; CCME 2011***	**290**	**---**	**4,310**	**4,369.0**	**4,369.0**	**4,369**
Lumbriculus	**variegatus**	**Blackworm**	**25**	***Elphick et al. 2011***	**90**	**58.5**	**3,100**	**3,940.6**	**3,940.6**	**3,941**
Chironomus	**dilutus**	**Midge**	**25**	***Elphick et al. 2011***	**90**	**58.5**	**5,867**	**7,457.8**	**7,457.8**	**7,458**
Brachionus	**calyciflorus**	**Planktonic rotifer**	**25**	***Elphick et al. 2011***	**90**	**58.5**	**1,645**	**2,091.0**	**2,091.0**	**2,091**
Neocloeon	***triangulifer***	***Mayfly***	***25***	***INHS (2015 & 2017); Jackson/Funk 2018***					***1,293.7***	***1,294***
Neocloeon	***triangulifer***	***Mayfly***	***25***	***INHS 2017***	**97**	**58.5**	**1,359**	**1,701.1**		
Neocloeon	***triangulifer***	***Mayfly***	***25***	***Soucek, Mount, Dickinson, Hockett 2017***	**90**	**58.5**	**837**	**1,064.0**		
Neocloeon	***triangulifer***	***Mayfly***	***25***	***Soucek, Mount, Dickinson, Hockett 2017***	**205**	**58.5**	**1,116**	**1,197.5**		
Neocloeon	***triangulifer***	***Mayfly***	***25***	***INHS 2015***	**93**	**58.5**	**910**	**1,149.0**		
Neocloeon	***triangulifer***	***Mayfly***	***25***	***INHS 2015***	**93**	**58.5**	**1,140**	**1,439.4**		
Neocloeon	***triangulifer***	***Mayfly***	***25***	***INHS 2015***	**93**	**58.5**	**1,153**	**1,455.8**		
Neocloeon	***triangulifer***	***Mayfly***	***25***	***Jackson and Funk 2018***	**97**	**17.3**	**1,017**	**1,162.5**		

[4] SMAV was recalculated for the temperature adjustment to 25 °C, using the following equation: [AV + (25 - T)*48]*[(300/Hardness)$^{0.305797}$]*[(65/Sulfate)$^{0.074521}$].

*New SMAVs were calculated as the geometric mean of the Normalized Acute Values (NAV) for the *italicized* genus/species using NAVs taken from "*Summary of Data Concerning the Acute Toxicity of Sodium Chloride To Aquatic Animals* " (Stephan, 2009).
Bold cells signify data added from additional studies to accompany Stephan 2009 data.

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Table 2
Ranked GMAV in mg Cl/L
Calculation of Final Acute Value (FAV) and Criterion Maximum Concentration (CMC)
SMAVs and GMAVs are normalized to hardness of 300 mg/L, sulfate of 65 mg/L, and temperature of 25 °C

Rank	GMAV	Genus	Species	Common Name	SMAV	Cumulative Probability, P
33	17,343	Anguilla	rostrata	American eel	17,343.43	0.971
32	16,203	Cambarus	sp.	Crayfish	16,203.20	0.941
31	14,897	Fundulus	kansae	Plains killiefish	14,897.10	0.912
30	14,843	Libellulidae	spp.	Dragonfly	14,843.40	0.882
29	13,453	Gasterosteus	aculeatus	Threespine stickleback	13,452.60	0.853
28	9,933	Gambusia	affinis	Mosquitofish	9,933.40	0.824
27	9,157	Lepomis	cyanellus	Green sunfish	9,974.90	0.794
---	---	Lepomis	macrochirus	Bluegill	8,406.50	---
26	8,971	Notropis	lutrensis	Red shiner	8,971.12	0.765
25	8,921	Oncorhynchus	mykiss	Rainbow trout	8,920.97	0.735
24	7,458	Chironomus	dilutus	Midge	7,457.84	0.706
23	7,442	Ameiurus	melas	Black bullhead	7,442.40	0.676
22	6,524	Tubifex	tubifex	Tubificid worm	6,523.70	0.647
21	6,111	Cyprinella	leedsi	Bannerfin shiner	6,111.00	0.618
20	5,897	Rana	catesbeiana	Bullfrong (tadpole)	5,897.00	0.588
19	4,995	Pimephales	promelas	Fathead minnow	4,994.52	0.559
18	4,686	Pseudacris	sp.	Chorus frog	4,686.00	0.529
17	4,369	Nephelopsis	obscura	Leech	4,369.00	0.500
16	3,946	Diaptomus	clavipes	Copepod	3,946.10	0.471
15	3,941	Lumbriculus	variegatus	Blackworm	3,940.57	0.441
14	3,891	Lirceus	fontinalis	Isopod	3,890.70	0.412
13	3,728	Gyraulus	parvus	Snail	3,727.65	0.382
12	3,350	Physa	gyrina	Snail	3,350.00	0.353
11	3,086	Villosa	delumbis	Mussel	3,821.10	0.324
---	---	Villosa	iris	Mussel	2,491.60	---
10	2,685	Hyalella	azteca	Amphipod	2,684.67	0.294
9	2,327	Daphnia	ambigua	Cladoceran	1,649.70	0.265
---	---	Daphnia	magna	Cladoceran	3,779.70	---
---	---	Daphnia	pulex	Cladoceran	2,020.50	---
8	2,228	Leptophlebia	cupida	Mayfly	2,227.85	0.235
7	2,091	Brachionus	calyciflorus	Planktonic rotifer	2,091.04	0.206
6	1,568	Ceriodaphnia	dubia	Cladoceran	1,567.92	0.176
5	1,419	Lampsilis	fasciola	Mussel	874.32	0.147
---	---	Lampsilis	siliquoidea	Mussel	2,302.31	---
4	1,386	Sphaerium	simile	Fingernail clam	1,386.28	0.118
3	1,294	Neocloeon	triangulifer	Mayfly	1,293.73	0.088
2	1,148	Maccaffertium	modesum	Mayfly	1,147.64	0.059
1	872	Procloeon	fragile	Mayfly	872.16	0.029

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Table 2
Ranked GMAV in mg Cl/L
Calculation of Final Acute Value (FAV) and Criterion Maximum Concentration (CMC)
SMAVs and GMAVs are normalized to hardness of 300 mg/L, sulfate of 65 mg/L, and temperature of 25 °C

Rank	GMAV	Type, *Genus species* (Common Name)	Cumulative Probability, P	$Ln(GMAV)^2$	Ln(GMAV)	$p^{1/2}$
4	1,386	*Sphaerium simile* (Fingernail clam)	0.118	52.34	7.234	0.343
3	1,294	*Neocloeon triangulifer* (Mayfly)	0.088	51.34	7.165	0.297
2	1,148	*Maccaffertium modesum* (Mayfly)	0.059	49.64	7.045	0.243
1	872	*Procloeon fragile* (Mayfly)	0.029	45.85	6.771	0.171
			Σ P	**Σ ($ln(GMAV)^2$)**	**Σ ln(GMAV)**	**Σ $p^{1/2}$**
			0.294	**199.16**	**28.216**	**1.054**
					$(\Sigma ln(GMAV))^2/4$	**$(\Sigma p^{1/2})^2/4$**
					199.037	**0.278**

$S^2 = [\Sigma (ln(GMAV)^2) - (\Sigma ln(GMAV))^2/4] / [\Sigma P - (\Sigma p^{1/2})^2/4]$
$S^2 =$ [199.162 - 199.037] / [0.294 - 0.278]
$S^2 =$ 7.652
S = 2.766

$L = [\Sigma ln(GMAV) - S*(\Sigma p^{1/2})] / 4$
L = [28.216 - 2.766*1.054] / 4
L = 6.325

$A = S*(0.05)^{1/2} + L$
A = 2.766*0.05^(1/2) + 6.325
A = 6.944

$FAV = e^A = exp(A)$
FAV = exp(6.944)
FAV = 1,037

Criterion Max Concentration (CMC) = FAV/2= 518.3 mg/L

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Table 3
Calculation of Acute Water Quality Standard for Chloride at Varying Water Temperature, Hardness, and Sulfate

Equation: Acute Water Quality Standard (WQS) for Chloride:

Acute WQS = $[CMC + 1.045*CMC*(25 - T)]*(Hardness/300)^{0.205797} * (Sulfate/65)^{-0.07452}$

From Table 2, the Criterion Max Concentration (CMC) = 518.3 mg/L

which simplifies to:

Acute WQS = $[1+(0.045)(25-T)]*[518.3*(Hardness/300)^{0.205797} * (Sulfate/65)^{-0.07452}]$

where Acute WQS is in mg Cl/L, T is in °C, Hardness is in mg/L as $CaCO_3$, and Sulfate is in mg SO_4^{2-}/L

Temperature °C	Hardness mg/L	Sulfate mg/L	Acute WQS mg/L
25	300	65	518
25	287	65	514
25	250	65	499
25	200	65	477
25	150	65	449
20	300	65	635
20	287	65	629
20	250	65	612
20	200	65	584
20	150	65	551
15	300	65	752
15	287	65	745
15	250	65	724
15	200	65	691
15	150	65	652
10	300	65	868
10	287	65	860
10	250	65	836
10	200	65	799
10	150	65	753
5	300	65	985
5	287	65	976
5	250	65	949
5	200	65	906
5	150	65	854

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Table 3 (continued)
Calculation of Acute Water Quality Standard for Chloride at Varying Water Temperature, Hardness, and Sulfate

Equation: Acute Water Quality Standard (WQS) for Chloride:

Acute WQS = [CMC + 1.045*CMC*(25 - T)]*(Hardness/300)$^{0.205797}$ * (Sulfate/65)$^{-0.07452}$
From Table 2, the Criterion Max Concentration (CMC) = 518.3 mg/L
which simplifies to:
Acute WQS = [1+(0.045)(25-T)]*[518.3*(Hardness/300)$^{0.205797}$ * (Sulfate/65)$^{-0.07452}$]
where Acute WQS is in mg Cl/L, T is in °C, Hardness is in mg/L as $CaCO_3$, and Sulfate is in mg SO_4^{2-}/L

Temperature °C	Hardness mg/L	Sulfate mg/L	Acute WQS mg/L
25	300	86.8	507
25	287	86.8	503
25	250	86.8	489
25	200	86.8	467
25	150	86.8	440
20	300	86.8	621
20	287	86.8	616
20	250	86.8	598
20	200	86.8	572
20	150	86.8	539
15	300	86.8	736
15	287	86.8	729
15	250	86.8	708
15	200	86.8	677
15	150	86.8	638
10	300	86.8	850
10	287	86.8	842
10	250	86.8	818
10	200	86.8	782
10	150	86.8	737
5	300	86.8	964
5	287	86.8	955
5	250	86.8	928
5	200	86.8	887
5	150	86.8	836

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Table 4
Ranked Predicted Genus Mean Chronic Values (pGMCV) in mg Cl/L
Calculation of Final Acute Chronic Ratio (FACR) and Final Chronic Value (FCV), or Criterion Continuous Concentration (CCC)

Using Stephan 2009 "Derivation of Alternative Chronic Value" method from "*Calculation of Aquatic Life Criteria for Chloride*", Soucek/Dickinson (INHS, 2015), and the sources listed, the available ACRs are:

Genus	Species	Common Name	Type	SMACR	Source
Oncorhynchus	mykiss	Rainbow trout	Vertebrate	6.99	Stephan 2007 & 2009; Elphick 2011
Pimephales	promelas	Fathead minnow	Vertebrate	7.69	Birge et al 1985; Elphick 2011
Daphnia	ambigua	Cladoceran	Invertebrate	4.73	Stephan 2009; Harmon 2003
Daphnia	magna	Cladoceran	Invertebrate	4.12	Stephan 2009; Elphick 2011
Daphnia	pulex	Cladoceran	Invertebrate	3.95	Stephan 2009
Ceriodaphnia	dubia	Cladoceran	Invertebrate	2.40	Stephan 2007; NEB 2018; Elphick 2011
Neocloeon	triangulifer	Mayfly	Invertebrate	4.79	Soucek/Dickinson 2015 & Stroud 2015
Anafroptilum	semirufum	Mayfly	Invertebrate	8.30	Stroud 2015
Procloeon	fragile	Mayfly	Invertebrate	6.10	Stroud 2015
Lumbriculus	variegatus	Blackworm	Invertebrate	3.76	Elphick et al. 2011
Tubifex	tubifex	Tubificid worm	Invertebrate	9.31	Elphick et al. 2011
Chironomus	dilutus	Midge	Invertebrate	2.27	Elphick et al. 2011
Hyalella	azteca	amphipod	Invertebrate	2.07	Soucek 2018; Elphick 2011
Brachionus	calyciflorus	Planktonic rotifer	Invertebrate	1.09	Elphick et al. 2011
Sphaerium	simile	fingernail clam	Invertebrate	1.22	Soucek 2018

	FACR
Vertebrate	**7.33**
Invertebrate	**3.45**

NOTES:

1 The SMACR for N. triangulifer is the geometric mean from (Soucek, Dickinson / INHS; 2015) and (Stroud 2015), which represents four ACRs between the lower and upper chronic limits for the chloride testing from INHS and one ACR from Stroud (8.4).

2 The SMACR for Oncorhynchus mykiss is the geometric mean from (Stephan 2007 and 2009) and (Elphick 2011), which represents three ACRs for the species (7.308, 9.1, and 5.14).

3 The SMACR for Pimephales promelas is the geometric mean from (Birge et al 1985) and (Elphick 2011), which represents two ACRs for the species (10.2 and 5.80).

4 The SMACR for Daphnia amigua is the geometric mean from (Stephan2009) and (Harmon et al 2003), which represents two ACRs for the species (4.148 and 5.4).

5 The SMACR for Daphnia magna is the geometric mean from (Stephan2009) and (Elphick 2011), which represents two ACRs for the species (1.97 and 8.62).

6 The SMACR for Hyalella azteca is the geometric mean from (Soucek 2018) and (Elphick 2011), which represents two ACRs for the species (3.65 and 1.17).

7 The FACR for Invertebrates is the geometric mean of the SMACRs for invertebrates. Per the *"Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses"*, the SMACRs for invertebrates do not vary more than a factor of ten and therefore the FACR calculated as the geometric mean of the SMACRs is appropriate.

8 The calculated FACRs for vertebrates and invertebrates are used to calculate the pGMCVs in the below table, as: pGMCV = GMAV/FACR.

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Table 4
Ranked Predicted Genus Mean Chronic Values (pGMCV) in mg Cl/L
Calculation of Final Acute Chronic Ratio (FACR) and Final Chronic Value (FCV), or Criterion Continuous Concentration (CCC)

Rank	pGMCV	GMAV	Genus	Species	Common Name	Type	Cumulative Probability, P
33	5,028.06	17,343	Anguilla	rostrata	American eel	invertebrate	0.971
32	4,697.43	16,203	Cambarus	sp.	Crayfish	invertebrate	0.941
31	4,303.15	14,843	Libellulidae	spp.	Dragonfly	invertebrate	0.912
30	2,162.11	7,458	Chironomus	dilutus	Midge	invertebrate	0.882
29	2,031.38	14,897	Fundulus	kansae	Plains killefish	vertebrate	0.853
28	1,891.30	6,524	Tubifex	tubifex	Tubificid worm	invertebrate	0.824
27	1,834.47	13,453	Gasterosteus	aculeatus	Threespine stickleback	vertebrate	0.794
26	1,354.48	9,933	Gambusia	affinis	Mosquitofish	vertebrate	0.765
25	1,266.62	4,369	Nephelopsis	obscura	Leech	invertebrate	0.735
24	1,248.69	9,157	Lepomis	cyanellus	Green sunfish	vertebrate	0.706
---	---	---	Lepomis	macrochirus	Bluegill	vertebrate	---
23	1,223.32	8,971	Notropis	lutrensis	Red shiner	vertebrate	0.676
22	1,216.48	8,921	Oncorhynchus	mykiss	Rainbow trout	vertebrate	0.647
21	1,143.99	3,946	Diaptomus	clavipes	Copepod	invertebrate	0.618
20	1,142.42	3,941	Lumbriculus	variegatus	Blackworm	invertebrate	0.588
19	1,128.04	3,891	Lirceus	fontinalis	Isopod	invertebrate	0.559
18	1,080.69	3,728	Gyraulus	parvus	Snail	invertebrate	0.529
17	1,014.80	7,442	Ameiurus	melas	Black bullhead	vertebrate	0.500
16	971.20	3,350	Physa	gyrina	Snail	invertebrate	0.471
15	894.54	3,086	Villosa	delumbis	Mussel	invertebrate	0.441
---	---	---	Villosa	iris	Mussel	invertebrate	---
14	833.31	6,111	Cyprinella	leedsi	Bannerfin shiner	vertebrate	0.412
13	804.13	5,897	Rana	catesbeiana	Bullfrong (tadpole)	vertebrate	0.382
12	778.32	2,685	Hyalella	azteca	Amphipod	invertebrate	0.353
11	681.06	4,995	Pimephales	promelas	Fathead minnow	vertebrate	0.324
10	674.59	2,327	Daphnia	ambigua	Cladoceran	invertebrate	0.294
---	---	---	Daphnia	magna	Cladoceran	invertebrate	---
---	---	---	Daphnia	pulex	Cladoceran	invertebrate	---
9	645.88	2,228	Leptophlebia	cupida	Mayfly	invertebrate	0.265
8	638.99	4,686	Pseudacris	sp.	Chorus frog	vertebrate	0.235
7	606.22	2,091	Brachionus	calyciflorus	Planktonic rotifer	invertebrate	0.206
6	454.56	1,568	Ceriodaphnia	dubia	Cladoceran	invertebrate	0.176
5	411.32	1,419	Lampsilis	fasciola	Mussel	invertebrate	0.147
---	---	---	Lampsilis	siliquoidea	Mussel	invertebrate	---
4	401.90	1,386	Sphaerium	simile	Fingernail clam	invertebrate	0.118
3	375.07	1,294	Neocloeon	triangulifer	Mayfly	invertebrate	0.088
2	332.71	1,148	Maccaffertium	modesum	Mayfly	invertebrate	0.059
1	252.85	872	Procloeon	fragile	Mayfly	invertebrate	0.029

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Table 4
Ranked Predicted Genus Mean Chronic Values (pGMCV) in mg Cl/L
Calculation of Final Acute Chronic Ratio (FACR) and Final Chronic Value (FCV), or Criterion Continuous Concentration (CCC)

Rank	GMCV	Type, *Genus species* (Common Name)	Cumulative Probability, P	$Ln(GMCV)^2$	Ln(GMCV)	$P^{1/2}$
4	402	*Sphaerium simile* (Fingernail clam)	0.118	35.95	5.996	0.343
3	375	*Neocloeon triangulifer* (Mayfly)	0.088	35.13	5.927	0.297
2	333	*Maccaffertium modesum* (Mayfly)	0.059	33.72	5.807	0.243
1	253	*Procloeon fragile* (Mayfly)	0.029	30.61	5.533	0.171
			ΣP	**$\Sigma (\ln(GMCV)^2)$**	**$\Sigma \ln(GMCV)$**	**$\Sigma P^{1/2}$**
			0.294	**135.42**	**23.263**	**1.054**
					$(\Sigma \ln(GMCV))^2/4$	**$(\Sigma P^{1/2})^2/4$**
					135.296	**0.278**

$S^2 = [\ \Sigma (\ln(GMCV)^2) - (\Sigma \ln(GMCV))^2/4\ ] / [\ \Sigma P - (\Sigma P^{1/2})^2/4\ ]$
$S^2 =$ [135.421 - 135.296] / [0.294 - 0.278]
$S^2 =$ 7.652
S = 2.766

$L = [\ \Sigma \ln(GMCV) - S*(\Sigma P^{1/2})\ ] / 4$
L = [23.263 - 2.766*1.054] / 4
L = 5.087

$A = S*(0.05)^{1/2} + L$
A = 2.766*0.05^(1/2) + 5.087
A = 5.705

$FCV = e^A = \exp(A)$
FCV = exp(5.705)
FCV = 300

Criterion Continuous Concentration (CCC) = FCV = 300.5 mg/L

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Table 5
Calculation of Chronic Water Quality Standard for Chloride at Varying Water Temperature, Hardness, and Sulfate

Equation: Chronic Water Quality Standard (WQS) for Chloride:

Chronic WQS =[1+(0.045)(25-T)]*[CCC*(Hardness/300)$^{0.205797}$ * (Sulfate/65)$^{-0.07452}$]
From Table 4, the Criterion Continuous Concentration (CCC) = 300.5 mg/L
which simplifies to:
Chronic WQS = [1+(0.045)(25-T)]*[300.5*(Hardness/300)$^{0.205797}$ * (Sulfate/65)$^{-0.07452}$]
where Chronic WQS is in mg Cl/L, T is in °C, Hardness is in mg/L as $CaCO_3$, and Sulfate is in mg SO_4^{2-}/L

Temperature °C	Hardness mg/L	Sulfate mg/L	Chronic WQS mg/L
25	300	65	301
25	287	65	298
25	250	65	289
25	200	65	276
25	150	65	261
20	300	65	368
20	287	65	365
20	250	65	355
20	200	65	339
20	150	65	319
15	300	65	436
15	287	65	432
15	250	65	420
15	200	65	401
15	150	65	378
10	300	65	503
10	287	65	499
10	250	65	485
10	200	65	463
10	150	65	436
5	300	65	571
5	287	65	566
5	250	65	550
5	200	65	525
5	150	65	495

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Table 5 (continued)
Calculation of Chronic Water Quality Standard for Chloride at Varying Water Temperature, Hardness, and Sulfate

Equation: Chronic Water Quality Standard (WQS) for Chloride:

Chronic WQS $=[1+(0.045)(25-T)]*[CCC*(Hardness/300)^{0.205797} * (Sulfate/65)^{-0.07452}]$

From Table 4, the Criterion Continuous Concentration (CCC) = 300.5 mg/L

which simplifies to:

Chronic WQS $= [1+(0.045)(25-T)]*[300.5*(Hardness/300)^{0.205797} * (Sulfate/65)^{-0.07452}]$

where Chronic WQS is in mg Cl/L, T is in °C, Hardness is in mg/L as $CaCO_3$, and Sulfate is in mg SO_4^{2}/L

Temperature °C	Hardness mg/L	Sulfate mg/L	Chronic WQS mg/L
25	300	86.8	294
25	287	86.8	291
25	250	86.8	283
25	200	86.8	271
25	150	86.8	255
20	300	86.8	360
20	287	86.8	357
20	250	86.8	347
20	200	86.8	331
20	150	86.8	312
15	300	86.8	426
15	287	86.8	423
15	250	86.8	411
15	200	86.8	392
15	150	86.8	370
10	300	86.8	493
10	287	86.8	488
10	250	86.8	474
10	200	86.8	453
10	150	86.8	427
5	300	86.8	559
5	287	86.8	554
5	250	86.8	538
5	200	86.8	514
5	150	86.8	484

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ATTACHMENT 1

LITERATURE

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Soucek Progress Report 2017

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Progress update 12/04/17

Fingernail clams:

-Collected ~300 adult clams in April 2017 from Spring Creek, near Loda, IL, Iroquois County.

-Juvenile clams released in laboratory were acclimated to reconstituted water and appropriate test temperature (25 and 10 °C).

-For each temperature, the test system provided for two water volume additions per day for the duration of the test to ensure sufficient dissolved oxygen and minimized ammonia.

-Because of limited juveniles for testing, acute and chronic tests were conducted concurrently with mortality data from day 4 used to estimate median lethal concentrations (LC50s).

-Overall average % measured Cl/nominal Cl for both tests combined was 96.5 (min = 90.6; max = 101.4)

-25 °C test:

Fingernail clam (*Sphaerium simile*) sodium chloride acute and chronic data (25 C)							
nominal Cl	measured Cl acute	measured Cl chronic	% surv. acute	% surv. chron.	dry weight chron. (mg)	96-h LC50 (mg Cl/L)	28-d LC50 (mg Cl/L)
27.56	27	26	100	100	10.048	1673	1672
100	98	98	100	100	9.928	(unreliable)	(unreliable)
300	292	290	100	100	9.480		
600	573	581	100	100	8.700		
1000	989	988	100	100	8.692		
3000	2831	2831	0	0			

-For the chronic dry weight data, ANOVA detected a significant difference among treatments, but post-hoc pair-wise comparisons failed to detected significant differences from the control. In addition weight did not decrease relative to controls sufficiently in Cl treatments to permit calculation of a 20% effect concentration (EC20).

-10 °C test:

Fingernail clam (*Sphaerium simile*) sodium chloride acute and chronic data (10 C)							
nominal Cl	measured Cl acute	measured Cl chronic	% surv. acute	% surv. chron.	dry weight chron. (mg)	96-h LC50 (mg Cl/L)	28-d LC50 (mg Cl/L)
27.56	27	26	100	100	9.240	>2920	1664
100	99	97	100	100	9.160		(unreliable)
300	289	290	100	100	8.476		
600	568	572	100	100	9.656		
1000	978	970	100	100	9.488		
3000	2920	2855	100	0			

-Controls grew less at 10 °C than at 25 °C, and no dose dependent response was observed for weight.

-While temperature appeared to affect the acute response of *S. simile* to NaCl, we were unable to detect an influence of temperature on chronic response.

Mayflies:

-Conducted acute and chronic (14-d) tests at both temperatures (25 and 10 °C).

- For acute tests, overall average % measured Cl/nominal Cl for both tests combined was 99.65 (min = 92.2; max = 104.2)

-- For chronic tests, overall average % measured Cl/nominal Cl for both tests combined was 99.0 (min = 94.2; max = 110.6)

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-Acute data:

Mayfly (*Neocloeon triangulifer*) sodium chloride acute data (25 C)				
nominal Cl	measured Cl acute	# dead (of 20)	96-h LC50 (mg Cl/L)	95% C.L.
27.6	27.7	0	1359	1249 - 1478
560	543	0		
750	783	0		
1053	1063	2		
1492	1503	14		
2120	2140	20		

Mayfly (*Neocloeon triangulifer*) sodium chloride acute data (10 C)				
nominal Cl	measured Cl acute	# dead (of 20)	96-h LC50 (mg Cl/L)	95% C.L.
27.6	25.8	1	1960	1640 - 2343
276	268	0		
524	533	1		
1021	1029	1		
2014	2003	9		
4000	4071	20		

Chronic data:

Mayfly (*Neocloeon triangulifer*) sodium chloride chronic data (25 C)					
nominal Cl	measured Cl acute	% survival	dry weight/ind (mg)	weight std. dev	14-d LC50 (mg Cl/L)
27.6	27	95	0.069	0.037	998
100	100	100	0.09	0.034	(905 - 1101)
200	202	100	0.095	0.039	weight EC20 (mg Cl/L)
400	395	95	0.049	0.022	326
750	732	95	0.03	0.017	(201 - 529)
1500	1484	0	na		

Mayfly (*Neocloeon triangulifer*) sodium chloride chronic data (10 C)					
nominal Cl	measured Cl acute	% survival	dry weight/ind (mg)	weight std. dev	14-d LC50 (mg Cl/L)
27.6	27	100	0.004	nc	>1466
100	99	89	0.006	nc	
200	198	75	0.080	nc	weight EC20 (mg Cl/L)
400	391	95	0.010	nc	nc
750	723	90	0.010	nc	
1500	1466	55	0.046		

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Amphipods:

-We culture two genetically distinct "strains" of *Hyalella azteca*. Most ecotox labs culture and test "US Lab" strain. This is a southern species, and it did not do well at 10 °C in initial experiments. A couple of labs in Canada culture and test with the "Burlington" strain. This is a northern species.

-We conducted control tests with Burlington strain at 10 °C and they survived well (but see below). Acute and chronic testing were/will be conducted with the Burlington strain for this project.

-We used 23 °C as the upper temperature for *Hyalella* because that is the typical acute test temperature for this species.

-Both acute tests have been completed (data below).

- For acute tests, overall average % measured Cl/nominal Cl for both tests combined was 102.3 (min = 96.9; max = 113.1)

-Acute data:

Amphipod (*Hyalella azteca* (Burlington strain)) sodium chloride acute data (23 C)				
nominal Cl	measured Cl acute	# dead (of 20)	96-h LC50 (mg Cl/L)	95% C.L.
27.6	29.0	1	1733	1592 - 1887
741	785	1		
1047	1098	0		
1484	1550	5		
2108	2173	18		
3000	3084	20		

Amphipod (*Hyalella azteca* (Burlington strain)) sodium chloride acute data (10 C)				
nominal Cl	measured Cl acute	# dead (of 20)	96-h LC50 (mg Cl/L)	95% C.L.
27.6	27.0	0	2185	2013 - 2372
741	745	0		
1047	1055	0		
1484	1492	1		
2108	2100	7		
3000	3008	20		

-Chronic data:

-We have conducted a 28-d chronic at 23 °C.

-For the chronic tests at 23°C, overall average % measured Cl/nominal Cl was 96.5% (min = 91.7; max = 109.2)

-Data for 23 °C test are below.

-We have been having difficulty with control survival for *Hyalella* at 10 °C. Two tests we have started have had ~50% survival within 7-10 days. Therefore we will attempt to use older organisms (~14-d) to start a test to allow young amphipods to grow stronger prior to acclimation to cold temperature and testing.

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Amphipod (Hyalella azteca) sodium chloride chronic data (23 C)				
nominal Cl	measured Cl	% survival	dry weight/ind (mg)	28-d LC50 (mg Cl/L)
27.56	26	82	0.204	949 (829 - 1087)
187	177	76	0.167	28-d EC20 (survival; mg Cl/L)
375	364	82	0.185	744 (617 - 897)
750	745	63	0.079	28-d EC20 weight mg Cl/L)
1500	1480	6	0.038	516 (357 - 745)
2000	1956	0	na	

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Elridge et. al. 2010

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Review of the 2012 proposed water quality criteria for chloride for the protection of aquatic life in Pennsylvania

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1. Introduction

The Environmental Quality Board of Pennsylvania on July 7, 2012 proposed amending 25 Pennsylvania Code Chapter 93.7 relating to the water quality standard for chloride. The Board proposed adopting the Iowa equation-based aquatic life criteria for chloride based on the best available sound science (PA Bulletin 12-1292). This review is in response to the proposed standard for chloride in surface waters and builds on a previous report (Stroud Water Research Center 2010) that evaluated the water quality standard for chloride proposed by the EQB in 2010.

Chloride criteria for aquatic organisms are needed in Pennsylvania to protect aquatic life in our surface waters. Chloride can enter surface water via road salt runoff (e.g., following brine application for dust suppression, or following deicer application or storage), or through wastewater or other industrial discharge. In 2010, the EQB of Pennsylvania proposed adopting the recommended criteria from the US EPA (EPA 1988) for Aquatic Life Uses for Cold Water Fishes (CWF), Warm Water Fishes (WWF), Migratory Fishes (MF), and Trout Stocking (TSF). Those criteria were an acute criterion of 860 mg chloride/L and a chronic criterion of 230 mg chloride/L.

We found a number of faults with the criteria proposed in 2010 and the conclusions of the previous report are attached as **Appendix 1** at the end of this document. The changes proposed in 2010 were not adopted by the EQB, in part because they did not incorporate the latest available science. Some of the concerns identified by us in 2010 have been addressed by the proposed Iowa equation based criteria. However, the Iowa equation based criteria do not adequately address some critical scientific gaps which we feel will leave some species at risk of harm. In this comment, we suggest some options that the EQB may consider. Due to the large amount of uncertainty that remains, one option that may be rapidly incorporated would be to re-derive the chronic criterion and apply a safety factor to provide an enhanced level of protection.

The acute and chronic criteria equations proposed by the EQB of Pennsylvania are based on reports by Stephan (2009 a,b,c,d,e,f,g,h). We will use these reports as the basis of our review and critique.

2. Strengths of the proposed standard

2.1. EPA has not officially adopted new national criteria since 1988 (EPA 1988). The derivation of the 2009 Iowa criteria incorporated data from recent chloride toxicity studies.

2.2. The most significant development with the 2009 Iowa Criteria is an acknowledgement that the toxicity of chloride to aquatic organisms varies depending upon the other ions present. Specifically, the criteria use equations to account for changes in toxicity due to water hardness (i.e., cation content [primarily calcium and magnesium, but could also include iron and manganese] of water) and sulfate concentrations.

2.3. The 2009 Iowa criteria also clarified rules of data inclusion or exclusion. The 2009 criteria included static tests that were excluded in 1988 (Stephan 2009a). The approach was to include a test unless there was an obvious reason to exclude it (Stephan 2009a).

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3. Weaknesses and concerns resulting from implementing the proposed standard

3.1. These proposed criteria are based on toxicity studies of dissolved chloride that has dissociated from sodium chloride (NaCl), although chlorides dissociated from calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), or potassium chloride (KCl) may be present in surface water and can be more toxic to aquatic organisms (e.g., Mount et al. 1997).

3.1.1. In 1988, the EPA noted that "the chlorides of potassium, calcium, and magnesium are generally more toxic to freshwater species than sodium chloride" (EPA 1988 p. 7), but there was insufficient data on the toxicity of the chlorides of calcium, magnesium, or potassium to derive criteria.

3.1.2. The relationship between the toxicity of the chloride of sodium and the toxicity of the chlorides of potassium, calcium and magnesium has held over time. Below are the ***ratios*** of the LC_{50} concentrations for the chloride of calcium (Ca), magnesium (Mg), or potassium (K) to the LC_{50} concentration for the chloride of sodium (Na) for the same species and test water (Stephan 2009a p. 10):

- Ca/Na (n=5): 0.57-0.98
- Mg/Na (n=3): 0.34-0.55
- K/Na (n=5): 0.11-0.25

Note: a ratio <1 indicates that the chlorides dissociated from calcium, magnesium, or potassium caused mortality at a lower concentration.

3.1.3. The chlorides of calcium, magnesium, or potassium may be present in the environment in such a way that they threaten surface waters.

- Potassium, magnesium, or calcium chlorides are used as deicers (Salt Institute 2004, Chang 2009).
- Potassium chloride can be present in the effluent from hydraulic fracturing for natural gas extraction (URS Corporation 2011), and is also commonly used as a water softener.
- Use of liquid brine salts as dust suppressants on roadways and at construction sites (Piechota et al. 2002)

3.2. The proposed chronic criteria may be above the level that causes adverse impacts to aquatic organisms in Pennsylvania.

3.2.1. The proposed criteria are based solely on studies of animals and do not consider toxicity to aquatic plants. Stephan (2009a, 2009b, 2009c, 2009d, 2009g) did not indicate why plants were not considered in the derivation of the Iowa Criteria. In 1988, the EPA noted that the alga *Spirogyra setiformis* was extremely sensitive to the effects of chloride (71 mg/L; growth, chlorophyll, C^{14} fixation; 10d; Shitole and Joshi 1984) as was the desmid *Netrium*

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digitus (200 mg/L; growth inhibition; 21d; Hosiaisluoma 1976). However, the 1988 criteria did not include plant species in the derivation because "a Final Plant Value, as defined in the Guidelines, cannot be obtained because no test in which the concentrations of chloride were measured and the endpoint was biologically important has been conducted with an important aquatic plant species" (EPA 1988). These concentrations for plants are below the SMCV observed for vertebrate and invertebrate animals (Table 1) suggesting that plants may be more sensitive to chloride than are animals.

3.2.2. Recent research with freshwater mussels suggests that the glochidia of some species may be more sensitive to chloride than the current suite of aquatic organisms for which data is available (Gillis 2011, Pandolfo et al. 2012). Stephan included data from juvenile freshwater mussels or freshwater mussels that do not have a glochidia stage (i.e., *Villosa delumbis* and *Lampsilis fsciola*, Bringolf et al. 2007; *Villosa iris* and *Lampsilis siliquoid*, Wang 2007; *Sphaerium simile*, GLEC and INHS 2008), but Stephan excluded all studies with glochidia because of their unique life-history which requires that they attach to a fish host in order to survive (Stephan 2009a p. 7[d]). The unique life history of most freshwater mussel species makes it difficult to design toxicology studies with them. However, freshwater mussels are among the most imperiled organisms in Pennsylvania (PNHP 2012), therefore it is important that water quality criteria be protective of them. One "very important question is 'What species-specific toxicity-test duration is ecologically relevant for glochidia?'" (Stephan 2009a p. 7[d]).

3.3. The proposed chronic criterion is not robust.

3.3.1. The genus mean chronic values (GMCV) should not have been calculated directly from the species mean chronic values (SMCV) without first correcting for hardness and sulfate.

3.3.1.1. The SMCV from different experiments were not normalized for hardness and sulfate (Stephan 2009c). As a result, the SMCV are not directly comparable because the toxicity of chloride varies depending upon the chemical composition of the water in which the test was done (e.g., Mount et al. 1997, Soucek 2007, Elphick et al. 2011). Therefore, calculating the GMCV as the geometric mean of the SMCV for a given species is not appropriate. It should be noted that the species mean acute values (SMAV) were corrected for hardness and sulfate before calculating the GMAV (Stephan 2009g).

3.3.2. There is inconsistency in the meaning of the species mean chronic value (SMCV). The SMCV determined by Stephen (2009c) refer to different levels of impairment for different species.

3.3.2.1. Stephen (2009c) used the geometric mean of the no observed effect concentration (NOEC) and lowest observed effect concentration (LOEC) to determine the SMCV. The NOEC and LOEC refer to test concentrations used in the experiments, but the amount of impairment at the NOEC and LOEC varied among experiments (Table 1). Therefore the SMCV determined by Stephen (2009c) refer to different levels of impairment for different species.

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3.3.3. Different researchers analyzing the same data have arrived at different results and different conclusions.

3.3.3.1. The guidelines that different researchers have used to determine which studies should be included and the interpretation of the EPA 1985 guidelines differ between researchers (e.g., EPA 1988, Stephan 2009a). As a result the rules to determine the appropriate studies and data to use to derive chloride criteria are not interpreted in a consistent manner and researchers have differed in the tests they included or excluded. For example, Stephan (2009c, 2009e) excluded an acute and chronic study of *Rana sylvatica* by Sanzo and Hecnar (2006) because they used technical grade sodium chloride, but Elphick et al. (2011) included this study when deriving a chronic criterion.

3.4. The proposed chronic criterion does not account for uncertainty in data and methods.

3.4.1. The proposed chronic criterion equation may allow for chloride concentrations in surface waters of Pennsylvania above the concentration shown to cause harm to aquatic organisms during laboratory experiments. For example, the SMCV for some species in Table 1 are near or exceed the normalized chronic criterion of 389 mg chloride/L which Iowa adopted for surface waters where sulfate and hardness are not known. The SMCV in Table 1 would need to be corrected for hardness and sulfate to confirm that the chronic criterion would exceed the SMCV. In 1988, the EPA affirmed that the proposed chronic criterion was below the three SMCV available at that time (EPA 1988). Stephan in 2009 did not affirm that the proposed chronic equation was below the level shown in laboratory experiments to impair aquatic organisms.

3.4.2. The proposed chronic criterion equation includes a correction for hardness and sulfate although the exponents for hardness and sulfate are based on studies in two labs (GLEC and INHS 2008, p29 & 36) of only one species (*C. dubia*) under acute conditions (Stephan 2009f). Stephan (2009f) presents evidence that "supports the concept" that "the sulfate exponent might be more negative than indicated by the GLEC and INHS (2008) data" (Stephan 2009f p. 4). A negative exponent for sulfate means that a higher sulfate concentration lowers the LC_{50} for chloride. Thus, reliance on the 2009 Iowa equations may not offer the intended level of protection to aquatic organisms in Pennsylvania.

3.4.3. The endpoints of chronic tests conducted under laboratory conditions (e.g., survival, reproduction) may not reflect the most sensitive response in nature. In nature, a stress response may occur at lower concentrations than what are observed under controlled laboratory settings. A similar pattern is seen with behavioral responses such as avoidance, coughing or rapid breathing by fish, or increased activity (Atchison et al. 1987, Scott and Sloman 2004, Hellou 2011). Behavioral responses have been poorly documented or not measured in most laboratory experiments of chloride toxicity, therefore it is unknown how the behavior of aquatic organisms in nature would be affected by elevated chloride.

3.4.4. There has been no attempt to account for the fact that the available data represents only a small percentage of the species found in Pennsylvania. Including studies conducted since the 2009 Iowa criteria were derived results in a different acute-to-chronic ratio (ACR) and

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acute and chronic criteria (e.g., Elphick et al. 2011). It is to be expected that additional data may change the criteria, such as occurred between the derivation of the 1988 criteria and the 2009 criteria (e.g., ACR= 7.594, EPA 1988; ACR = 3.187, Stephan 2009h; ACR = 3.50, Elphick et al. 2011). Focusing on species found in Pennsylvania may also alter the criteria.

3.4.5. Different methods to derive the chronic criterion may result in different criterion. Stephan (2009c, 2009h) used the ACR whereas Elphick et al. (2011) derived a chronic criterion directly from chronic studies. (chronic criterion = 307 mg/L, Elphick et al. 2011; chronic criterion = 428 mg/L, Stephan 2009h). It should also be noted that other factors, such as if how hardness and sulfate were accounted for, could also account for differences in the criterion.

3.4.6. The lack of robustness in the derivation of the chronic criterion is further evidence of uncertainty.

Table 1: Data used to derive the species mean chronic values (SMCV) by Stephan (2009c). The SMCV is the geometric mean of the NOEC and the LOEC. A subset of this data was used to calculate the genus mean chronic values and the acute-to-chronic ratio, which was used to derive the proposed chronic criterion.

Category	Species	Endpoint	NOEC (mg/L)	LOEC (mg/L)	SMCV(mg/L)	Reference
Fish – non-salmonid	Fathead minnow	33d; survival	352 (9% reduction)	533 (15% reduction)	433.1	(Birge et al. 1985)
Fish - salmonid	Rainbow trout	Early life stage; survival	643 (4% reduction)	1324 (46% reduction)	922.7	Spehar 1987[1]
Cladoceran	*Ceriodaphnia dubia*	7-9d; Reproduction	?[2]	? (EC50)	925	(Cowgill and Milazzo 1990)
Cladoceran	*Ceriodaphnia dubia*	7 d; ?	?	?	235	(Diamond et al. 1992)
Cladoceran	*Ceriodaphnia dubia*	6-7d; Reproduction	N/A[3]	442.2[4] (IC25)	<442.2	WISLOH 2007 (mod. Hard water)
Cladoceran	*Ceriodaphnia dubia*	6-7d; Reproduction	N/A	385.2 (IC25)	<385.2	WISLOH 2007 (Hard water)
Cladoceran	*Ceriodaphnia dubia*	7d; Reproduction	N/A	340 (IC25)	<340	Lasier et al. 2004[5]
Cladoceran	*Ceriodaphnia dubia*	7d; Reproduction (12 studies)	<152-303	346-685 (IC50)	<322	(Aragão and Pereira 2003)
Cladoceran	*Ceriodaphnia dubia*	7d; Survival	1092	1456	N/C[6]	(Cooney et al. 1992)
		7d; Reproduction	<455-819	455-1092	<629	
Cladoceran	*Ceriodaphnia dubia*	7d; Reproduction	N/A	370.6 (EC20)	370.6	(Harmon et al. 2003)
Cladoceran	*Daphnia ambigua*	10d; Reproduction	N/A	292.4 (EC20)	292.4	(Harmon et al. 2003)
Cladoceran	*Daphnia magna*	10d; Reproduction	2184	2597 (EC50)	2382	(Cowgill and Milazzo 1990)
Cladoceran	*Daphnia pulex*	21d; Reproduction	314 (0% reduction)	441 (27% reduction)	372	(Birge et al. 1985)
Frog	*Rana sylvatica*	90d; Survival	N/A	625 (62% reduction)	<625	(Sanzo and Hecnar 2006)

[1] Unpublished memorandum sent directly to C. Stephan from R. L. Spehar on June 24, 1987. Data is not available on-line (scholar.google.com, search "chloride author:Spehar", Aug. 3, 2012).

[2] Data not presented in Stephan (2009c) and document not available for download (Aug. 3, 2012)

[3] Stephan (2009c) did not use the NOEC to calculate the SMCV.

[4] WISLOH 2007 refers to an unpublished study that could not be found on the Wisconsin State Laboratory of Hygiene webpage (http://www.slh.wisc.edu/, search "chloride", Aug. 3, 2012). IDNR (2007) presents results from the WISLOH lab covering the period 2000-2007, however the results in that report (Table 4: *C. Dubia* chronic toxicity 703 mg Cl/L; Table 7: *C. dubia* chronic toxicity: 427 mg Cl/L) do not match those presented by Stephan (2009c). Corsi et al. (2010) present results from the WISLOH lab over the same time period, but the studies do not appear to be the same as the ones reviewed by Stephan (2009c) because the Corsi study focused on surface waters receiving road run-off.

[5] Data was presented in a poster at the SETAC meeting and is not available on-line (Aug. 3, 2012)

[6] The geometric mean for *C. dubia* survival in the study by Cooney et al. (1992) was not calculated by Stephan (2009c) because reproduction was more sensitive.

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4. Point of Clarification

4.1. As written in PA Bulletin 12-1292 it appears that Pennsylvania will adopt the Iowa criteria *in toto*, including Iowa's criteria for waterbodies where sulfate and hardness are not known. Iowa defined normalized acute and chronic criteria to be applied to waterbodies where sulfate and hardness are not known that were based on the statewide background values for hardness (200 mg/L) and sulfate (63 mg/L). Average hardness and sulfate concentrations may be different in PA and therefore the normalized acute and chronic criteria for Iowa may not be appropriate for PA.

5. Summary and Recommendations

5.1. The chloride criteria proposed by the EQB on July 7, 2012 are an improvement over the criteria that were proposed in 2010. Specifically, the proposed criteria incorporate characteristics of the receiving waters that affect chloride toxicity. However, as was highlighted in our previous review, the newly proposed criteria based on the Iowa standard may not be protective of aquatic life in Commonwealth streams, rivers, and lakes. Examples of uncertainty are:

5.1.1. The proposed chronic criterion may allow for ambient chloride concentrations in surface waters in Pennsylvania above the concentrations shown to cause harm to aquatic organisms in laboratory experiments.
5.1.2. The criteria are based only on the chloride of sodium although the chlorides of calcium, magnesium or potassium may enter surface waters of Pennsylvania and are more toxic to aquatic organisms.
5.1.3. The proposed criteria are derived from only a few species found in Pennsylvania.
5.1.4. There are only seven species (6 after excluding the frog, *Rana sylvatica* which Stephan [2009g] excluded because the sodium chloride used in the experiment was technical grade) for which there are acceptable chronic data (Table 1).
5.1.5. Glochidia and plants were not included in the derivation of the acute or chronic criteria.
5.1.6. The proposed criteria may not be protective of our more sensitive stream dwelling invertebrate species, particularly early life history stages (e.g., glochidia of mussels or early life stages of other invertebrates).
5.1.7. Exponents for hardness and sulfate in the acute and chronic criteria equations may be under-protective.
5.1.8. The species mean chronic values (SMCV's) were not corrected for hardness and sulfate concentrations.
5.1.9. The SMCV refer to different levels of impairment for the different experiments and species.
5.1.10. The SMCV are not corrected for hardness or sulfate.
5.1.11. The endpoints of laboratory toxicity studies do not include behavioral responses. Behavior may be affected at lower chloride concentrations than are survival, reproduction or growth.

5.2. Following are some recommendations on how the EQB may address uncertainty.

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5.2.1. Include a safety factor in the derivation of the chronic criterion. At a minimum, that safety factor should be sufficient to ensure that the chronic criterion is below the SMCV or GMCV. Following are some reasons that a safety factor should be used:

5.2.1.1. "Safety factors are used to provide an extra margin of safety beyond the known or estimated sensitivities of aquatic organisms" (EPA 1985 p 36).

5.2.1.2. The acute criterion incorporates a safety factor (i.e., 2) but the chronic criterion does not. The 1985 EPA guidelines indicate that a safety factor of 2 is always to be used when calculating the acute criterion (called the criterion maximum concentration in EPA 1985, p 54, item XI.B.) but does not give a rationale for this using this safety factor. Although the EPA did not include a safety factor when deriving the chronic criterion in 1988, the chronic value was below the level shown to cause harm to the three species for which data were available at that time (EPA 1988). It is unclear if the proposed chronic criterion is below the level shown to cause harm because the SMCV in Table 1 have not been corrected for hardness or sulfate.

5.2.1.3. The acute and chronic criteria are based solely on studies using the chloride of sodium, but the chlorides of potassium, magnesium or calcium may be present in surface waters of Pennsylvania and are more toxic to aquatic organisms than is the chloride of sodium.

5.2.1.4. Environmental impacts (including avoidance) may occur at lower concentrations then those that affect growth or survival.

5.2.1.5. British Columbia (Nagpal et al. 2003) used a safety factor of 5 in the derivation of the chronic guideline. Their justification for this safety factor was as follows:

- Chronic data available from the literature were scant;
- In a recent study, Diamond et al. (1992) found a LOEC/NOEC ratio for reproduction of 3.75 in *C. dubia* exposed to NaCl for 7 days. Also, LC_{50}/LC_0 of 3 and LC_{100}/LC_0 of 4 were obtained by Hughes (1973), whereas the DeGreave et al. (1991) data yielded LC_{50}/NOEC ratios that ranged from about 1.0 to 6.9;
- Additional protection may be required for those species that are more sensitive but have not yet been tested in the literature.

5.2.2. A new review of chloride toxicity studies should be conducted to generate a more complete and up-to-date list of species and genus mean acute and chronic values. The references sited at the end of this comment include a few studies that have been published since 2009. A new review should:

5.2.2.1. Resolve the controversy regarding aquatic plants and glochidia.

5.2.2.2. Clearly define rules to include or exclude a study and document the rationale for studies that are excluded;

5.2.2.3. The species mean acute values and species mean chronic values should be calculated using a consistent and biologically meaningful endpoint. For example,

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Elphick et al. (2011) used probit regression to determine an endpoint that was consistent among species (e.g., the IC10).

5.2.2.4. Derive species mean chronic values normalized for hardness and sulfate;

5.2.2.5. Explore the possibility of deriving chronic criterion directly from the data rather than using the ACR (e.g., Elphick et al. 2011);

5.2.2.6. Include in the review toxicity studies with the chlorides of potassium, magnesium or calcium. Although conducting additional experiments with species found in Pennsylvania is the preferred approach, it may be appropriate to use the ratios cited above (3.1.2) to derive the SMAV or SMCV. For example, the chloride of potassium appears to be 4-10x more toxic to aquatic organisms than is the chloride of sodium.

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6. Literature Cited

Allert, A., Cole-Neal, C., and Fairchild, J. 2012. Toxicity of chloride under winter low-flow conditions in an urban watershed in central Missouri, USA. Bulletin of Environmental Contamination and Toxicology **89**: 296–301. doi: 10.1007/s00128-012-0673-0.

Aragão, M.A., and Pereira, E.V. 2003. Sensitivity of *Ceriodaphnia dubia* of different ages to sodium chloride. Bulletin of Environmental Contamination and Toxicology **70**: 1247–1250. doi: 10.1007/s00128-003-0116-z.

Atchison, G.J., Henry, M.G., and Sandheinrich, M.B. 1987. Effects of metals on fish behavior: a review. Environmental Biology of Fishes **18**: 11–25. doi: 10.1007/BF00002324.

Birge, W.J., Black, J.A., Westerman, A.G., Short, T.M., Taylor, S.B., Bruser, D.M., and Wallingford, E.D. 1985. Recommendations on numerical values for regulating iron and chloride concentrations for the purpose of protecting warm water species of aquatic life in the Commonwealth of Kentucky. Memorandum of Agreement No. 5429, Kentucky Natural Resources and Environmental Protection Cabinet, School of Biological Sciences and Graduate Center for Toxicology, University of Kentucky, Lexington. Available from web.as.uky.edu/Biology/faculty/birge/lab/RecomNumValuesFeClConcProtec.pdf [accessed 3 August 2012].

Cooney, J. d., Lenoble, B. j., Pollock, T. l., Smith, G. j., Degraeve, G. m., and Moore, E. l. 1992. Effects of environmental and experimental design factors on culturing and toxicity testing of *Ceriodaphnia dubia*. Environmental Toxicology and Chemistry **11**: 839–850. doi: 10.1002/etc.5620110612.

Corsi, S.R., Graczyk, D.J., Geis, S.W., Booth, N.L., and Richards, K.D. 2010. A fresh look at road salt: Aquatic toxicity and water-quality impacts on local, regional, and national scales. Environ. Sci. Technol. **44**: 7376–7382. doi: 10.1021/es101333u.

Cowgill, U.M., and Milazzo, D.P. 1990. The sensitivity of two cladocerans to water quality variables : salinity and hardness. Archiv für Hydrobiologie **120**: 185–196. [accessed 3 August 2012].

Diamond, J.M., Winchester, E.L., Mackler, D.G., and Gruber, D. 1992. Use of the mayfly *Stenonema modestum* (Heptageniidae) in subacute toxicity assessments. Environmental Toxicology and Chemistry **11**: 415–425. doi: 10.1002/etc.5620110316.

Elphick, J.R.F., Bergh, K.D., and Bailey, H.C. 2011. Chronic toxicity of chloride to freshwater species: Effects of hardness and implications for water quality guidelines. Environmental Toxicology and Chemistry **30**: 239–246. doi: 10.1002/etc.365.

EPA. 1985. Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses. By C. E. Stephan, D. I. Mount, D. J. Hansen, J. H. Gentile, G. A. Chapman, and W. A. Brungs. PB85-227049. Environmental Protection Agency, Office of Research and Development; Duluth, MN, Naragansett, RI, Corvallis, OR.

EPA. 1988. Ambient Water Quality Criteria for Chloride - 1988. EPA 440/5-88-001, U.S. Environmental Protection Agency, Office of Water, Washington, DC USA.

Gardner, K.M., and Royer, T.V. 2010. Effect of road salt application on seasonal chloride concentrations and toxicity in south-central Indiana streams. Journal of Environmental Quality **39**: 1036–1042. doi: 10.2134/jeq2009.0402.

Gillis, P.L. 2011. Assessing the toxicity of sodium chloride to the glochidia of freshwater mussels: Implications for salinization of surface waters. Environmental Pollution **159**: 1702–1708. doi: 10.1016/j.envpol.2011.02.032.

Harmon, S.M., Specht, W.L., and Chandler, G.T. 2003. A Comparison of the Daphnids <i>Ceriodaphnia dubia</i> and <i>Daphnia ambigua</i> for Their

Electronic Filing: Received, Clerk's Office 3/14/2019

Utilization in Routine Toxicity Testing in the Southeastern United States. Archives of Environmental Contamination and Toxicology **45**: 79–85. doi: 10.1007/s00244-002-0116-8.

Hellou, J. 2011. Behavioural ecotoxicology, an "early warning" signal to assess environmental quality. Environmental Science and Pollution Research **18**: 1–11. doi: 10.1007/s11356-010-0367-2.

IDNR. 2007. DRAFT: Ambient Aquatic Life Criteria for Chloride. Iowa Department of Natural Resources. Available from www.iowadnr.gov/portals/idnr/uploads/water/standards/files/k_chloride.pdf [accessed 3 August 2012].

Lasier, P.J., and Hardin, I.R. 2010. Observed and predicted reproduction of *Ceriodaphnia dubia* exposed to chloride, sulfate, and bicarbonate. Environmental Toxicology and Chemistry **29**: 347–358. doi: 10.1002/etc.29.

Meriano, M., Eyles, N., and Howard, K.W.F. 2009. Hydrogeological impacts of road salt from Canada's busiest highway on a Lake Ontario watershed (Frenchman's Bay) and lagoon, City of Pickering. Journal of Contaminant Hydrology **107**: 66–81. doi: 10.1016/j.jconhyd.2009.04.002.

Mount, D.R., Gulley, D.D., Hockett, J.R., Garrison, T.D. and Evans, J.M. 1997. Statistical models to predict the toxicity of major ions to *Ceriodaphnia dubia*, *Daphnia magna* and *Pimephales promelas* (fathead minnows). Environmental Toxicology and Chemistry **16**: 2009-2019.

Nagpal, N.K., Levy, D.A., and MacDonald, D.D. 2003. Ambient water quality guidelines for chloride. [http://www.env.gov.bc.ca/wat/wq/BCguidelines/chloride/chloride.html, accessed on 31 July 2012].

Novotny, E., and Stefan, H. 2010. Projections of chloride concentrations in urban lakes receiving road de-icing salt. Water, Air, & Soil Pollution **211**: 261–271. doi: DOI: 10.1007/s11270-009-0297-0.

Pandolfo, T.J., Cope, W.G., Young, G.B., Jones, J.W., Hua, D. and Lingenfelser, S.F. 2012. Acute effects of road salts and associated cyanide compounds on the early life stages of the unionid mussel *Villosa iris*. Environmental Toxicology and Chemistry 31:1801-1806.

Piechota, T., van Ee, J. , Batista, J., Stave, K., and James, D. 2004. Potential environmental impact of dust suppressants: "avoiding another times beach". An Expert Panel Summary. Las Vegas, Nevada. May 30-31, 2002. EPA Document EPA/600/R-04-031. March 2004.

PNHP. 2012. Pennsylvania Natural Heritage Program. Available from http://www.naturalheritage.state.pa.us/ [accessed 2 August 2012].

Salt Institute. 2004. Highway salt and our environment. Salt Institue, Alexandria, VA.

Sanzo, D., and Hecnar, S.J. 2006. Effects of road de-icing salt (NaCl) on larval wood frogs (Rana sylvatica). Environmental Pollution **140**: 247–256. doi: 10.1016/j.envpol.2005.07.013.

Scott, G.R., and Sloman, K.A. 2004. The effects of environmental pollutants on complex fish behaviour: integrating behavioural and physiological indicators of toxicity. Aquatic Toxicology **68**: 369–392. doi: 10.1016/j.aquatox.2004.03.016.

Soucek, D.J. 2007. Comparison of hardness- and chloride-regulated acute effects of sodium sulfate on two freshwater crustaceans. Environmental Toxicology and Chemistry **26**: 773–779. doi: 10.1897/06-229R.1.

Stephan, C. 2009a. DRAFT: Description of the Review of Results of Toxicity Tests on Chloride. (09JanChlorideRev.wpd), U.S. Environmental Protection Agency, Duluth.

Stephan, C. 2009b. DRAFT: Summary of Data Concerning the Acute Toxicity of Sodium Chloride to Aquatic Animals. (09JanChlorideAcute.wpd), U.S. Environmental Protection Agency, Duluth.

Stephan, C. 2009c. DRAFT: Summary of Data Concerning the Chronic Toxicity of Sodium Chloride to Aquatic Animals. (09JanChlorideCronic.wpd), U.S. Environmental Protection Agency, Duluth.

Stephan, C. 2009d. DRAFT: Calculation of Aquatic Life Criteria for Chloride. (09JanChlorideCriteria.wpd), U.S. Environmental Protection Agency, Duluth.

Electronic Filing: Received, Clerk's Office 3/14/2019

Stephan, C. 2009e. DRAFT: Results of Literature Search concerning the Toxicity of Chloride to Aquatic Animals. (09JanChlorideRefs.wpd), U.S. Environmental Protection Agency, Duluth.

Stephan, C. 2009f. DRAFT: Multiple Regression Equation for Chloride. (09JanChlorideEq.wpd), U.S. Environmental Protection Agency, Duluth.

Stephan, C. 2009g. DRAFT: Summary of Data Concerning the Acute Toxicity of Sodium Chloride to Aquatic Animals. (09FebChlorideAcute.wpd), U.S. Environmental Protection Agency, Duluth. Available from www.iowadnr.gov/portals/idnr/uploads/water/standards/09mar_proposed.pdf [accessed 1 August 2012].

Stephan, C. 2009h. DRAFT: Calculation of Aquatic Life Criteria for Chloride. (09FebChlorideCriteria.wpd), U.S. Environmental Protection Agency, Duluth. Available from www.iowadnr.gov/portals/idnr/uploads/water/standards/09mar_proposed.pdf [accessed 1 August 2012].

URS Corporation. 2011. Water-related issues associated with gas production in the Marcellus Shale. Fort Washington, PA. Report prepared for the NY State Energy Research and Development Authority (NYSERDA).

Electronic Filing: Received, Clerk's Office 3/14/2019

Appendix 1: from Stroud Water Research Center 2010. Rulemaking by the Pennsylvania Environmental Quality Board [25 PA. CODE CH. 93] for Ambient Water Quality Criterion; Chloride (Ch) [40 Pa.B. 2264] [Saturday, May 1 2010]. Stroud Contribution No. 2010004.

Conclusions

After reviewing four different approaches for deriving water quality chloride criteria to protect aquatic life (Stephan et al. 1985, Evans and Frick 2001, Nagpal et al. 2003, Iowa DNR 2009) and the data underpinning PA's proposed criteria (EPA 1988) and the Iowa criteria (Stephan 2009a,b,c), it is clear that:

1) All approaches set chloride criteria that are at least several times greater than natural baseline chloride concentrations, and therefore represent a measurable and significant change in the chemical composition of freshwater ecosystems in the NE United States. The question that the current evidence is unable to answer is: will these criteria result in significant biological change? There is limited evidence of the biological impact of previous elevated chloride levels in aquatic ecosystems in the U.S. or Canada. Past monitoring efforts (see introduction) suggest that some streams regularly reach the acute criterion, but there has not been a noted change in biota following these pulses, largely because of a dearth of biological data following these episodic events. One study has demonstrated that macroinvertebrate drift increases in response to pulsed chloride input (Blasius and Merritt 2002). Another study has demonstrated losses of species in stream fish communities with small changes in chloride levels across a regional-scale analysis (Meador and Carlisle 2007), and the composition of algal species has been observed to change when chloride concentrations increase (Evans and Frick 2001). Nonetheless, there are limited data on biological changes accompanying changing chloride concentrations in the natural environment. We could not find any studies evaluating the influence of chloride on vital stream functions such as primary production, stream metabolism, or nutrient uptake or processing, all of which are important indicators of water quality for aquatic ecosystems.

2) All of these criteria are based on data for invertebrate and fish species that are not a random subset of stream invertebrate and fish species. Rather, most of the species with chloride data are known to be not especially sensitive to changes in environmental condition, which is one reason they survived well in the laboratory and became standards in laboratory bioassay protocols. The most recent iteration of the taxa that qualify based on EPA standards (in Stephan 2009a,b,c) doesn't include any classically sensitive stream invertebrate species such as stoneflies, mayflies, and caddisflies, all of which are important indicators of stream condition and are integral in the regulatory definition of stream impairment. Our concern is that criteria intended to protect most (e.g., 90% or 95%) of the species with chloride data might actually protect a much smaller proportion of all species that occur in a natural community because the natural community includes many species known to be sensitive to environmental change while the laboratory studies are biased toward species known to be at least moderately tolerant of environmental change. This is one reason to approach the acute and chronic criteria with a strong safety factor.

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3) Data available are primarily from acute toxicity studies, but the chronic criterion may be more important for long-term structuring stream communities and maintaining designated use for aquatic life. For example, fish tend to be moderately tolerant of acute chloride stress relative to macroinvertebrates, but they are one of the more sensitive taxa to chronic chloride stress. For example, fat head minnows (Birge et al. 1985) experienced the greatest mortality between days 9 and 21 and therefore had one of the highest acute-to-chronic ratios examined. The dearth of chronic studies on both invertebrates and fish is troubling. It is likely that, like some amphibians (e.g., spotted salamander), embryonic and early life stages of some fish will be more sensitive than is currently recognized.

4) The majority of chloride criteria developed to date are limited to or dominated by data on NaCl chloride toxicity, the least toxic salt. This point is routinely justified by the fact that NaCl is the most anthropogenically abundant of these four salts. However, no special guidance is given for permitting salt applications or industrial effluents known to include significant amounts of chloride derived from the more toxic non-sodium salts, including Marcellus Shale wastewater.

5) Using the data provided in Stephan 2009a (Table 2 herein), we have calculated both the acute (CMC) and chronic (CCC) criteria using the methods of the EPA (Stephan et al. 1985, EPA 1988), Evans and Frick (Evans and Frick 2001), British Columbia (Nagpal et al. 2003), and Iowa (Iowa DNR 2009) and have compared the range of values with the proposed PA values (Table 3). The range of acute values is 564 – 830 mg/l Cl- and the range of the chronic values is 91 – 428 mg/l Cl-. This comparison eliminates the variability in the choices each of the authors have made with regard to studies included or excluded. We note that the PA proposed acute value is the least protective criterion, primarily because it is not based on more recent acute toxicity studies. We recommend that PA adopt an acute criterion that is reflective of these new data. The method adopted by British Columbia is the most protective of aquatic life among these approaches. BC invoked a precautionary principle that acknowledged both the uncertainty of the available data and analyses and the importance of protecting their aquatic life. Since BC adopted their criteria, only new acute datasets have become available and the values in Table 3 utilize those data but use the BC approach to arrive at a final value (i.e., lowest SMAV/2[safety factor]). The BC use of a safety factor of 2 for the acute criteria was also consistent with what the EPA had done. However, BC was the only entity to apply a safety factor for the chronic criterion (5). We feel that the use of a safety factor for chronic criteria derived from the use of an ACR is clearly justified given the very limited number of chronic toxicity studies, and the desire to protect species that may be more sensitive than those used in the standard laboratory bioassays. We recommend that PADEP adopt the same methodology that BC has used for calculating both acute and chronic data. We feel that this is particularly important for the chronic criteria, as there is the potential for permitted discharges (particularly from the Marcellus Shale gas drilling industry) to raise chloride concentrations in streams to near the chronic criteria level. Given the paucity of data determining thresholds for chronic effects, this approach is warranted. At the very least, a safety factor should be applied to any of the other methods producing a chronic criterion.

We have a number of concerns that are specific to the actions and options available for PADEP:

6) Protecting CWFs and TSFs based on ACRs that included more chloride-tolerant *Daphnia* is not justified when it may expose rainbow trout to chloride concentrations approaching their chronic

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levels (1,324 mg/l Cl^- killed 46% of individuals in an early life stage test and at 643 mg/l Cl^- killed <4%). Trout are an integral component in the definition of these two aquatic life uses. The proposed chronic value of 230 mg/l is potentially a concern for biotic assemblages in Pennsylvania. For example, Meador (2007) suggests that optimum Cl^- values are low (3-35 mg/l) and we infer that if those Cl^- concentrations are exceeded it may result in changes in fish community structure. Similarly, not having a temperature component also seems to invite season-specific impairments of macroinvertebrates in TSFs and WWFs based on the recent findings of Silver et al. (2009), based on the seasonal movement of organisms into and out of various life history stages, and based on variation in their metabolic rates in response to seasonal changes in water temperature. Adding a temperature component to the chloride criteria would require further research on temperature effects.

7) The Evans and Frick (2001) method has the benefit of being reproducible and open to interpretation. Their use of nearly all of the valid acute LC_{50} data in Fig. 7-2 (Evans and Frick 2001), and the calculation of a sigmoid curve function (including 95% confidence intervals) that describes the percent of genera affected versus chloride concentration, is readily digestible by the public. However, the sigmoid curve function can be generated using various numbers of terms (parameters) in the equation and/or various equations (e.g., sigmoid, logistic, Weibull). The result of choosing a slightly different function can result in differences in acute and chronic values. To use this approach requires a valid justification for the choices made in fitting the curve to these data. Furthermore, these data still represented a small subset of aquatic species, and were biased towards lab friendly species that are easiest to culture (e.g., *Daphnia*). Since the selection of taxa was not a random subset of the aquatic species at large, most criteria based on the animals selected are primarily protective of those species tested (e.g., being protective of 95% of those taxa might only be protective of 50% of all species). This point is not limited to Evans and Frick but is valid for all of the approaches we have reviewed. This is the primary reason that the application of a safety factor is needed. The Evans and Frick (2001) study did not apply a safety factor to either their acute LC_{50} relationship or the derived chronic relationship.

8) More data is generally better, but there is a need for more consideration of how data gets incorporated. The Stephan (2009a,b,c) approach of calculating a predicted genus mean chronic value from the species mean acute values does not seem justified in this case. The GMCVs are not much better than guesses, and there is no attempt to correct for this inherent uncertainty. Adding GMCV values above the lowest four gives the false sense of increased precision of the true distribution of the GMCV, which has the result of increasing the final chronic value (FCV). We feel it would be appropriate to apply a safety factor to the chronic criteria to acknowledge the uncertainty in the FCV.

9) The use of hardness and sulfate equations (Iowa DNR 2009) in PA will improve protections and application of the chloride criteria only to a limited extent since the range of criteria in PA would be narrow (based on EMAP site values for hardness and sulfate in PA). Secondly, the hardness and sulfate exponents in the Iowa criteria were based on data from an acute toxicity study of only one species (*C. dubia*), although four species were studied and three were sensitive to hardness. No data were available on the relationship between hardness or sulfate and chronic toxicity. In the end, Iowa uses a default value for hardness and sulfate if no other data are available. This is akin to setting a fixed criterion value but allowing site-specific deviations if one

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gathers the appropriate data. Clearly, more species-specific data are needed to better understand the relationship between chloride toxicity and hardness or sulfate.

10) As noted above, previous reviews of chloride considered only NaCl and considered road salt to be the most likely source of chloride. We feel that the current proposed standard should explicitly acknowledged that these criteria are specific to NaCl derived chloride, and guidance should be given to address cases when significant chloride is derived from salts (i.e., KCl, $MgCl_2$ and $CaCl_2$) that have proven to be more toxic sources of chloride.

Our review of four approaches (Stephan et al. 1985, Evans and Frick 2001, Nagpal et al. 2003, Iowa DNR 2009) for deriving chloride criteria to protect aquatic life identified a number of weaknesses in the available data and the analyses used to derive criteria. We were especially concerned with (1) the near absence of important stream-inhabiting and stream-classifying species such as mayflies, stoneflies, and caddisflies, (2) the dependence on relatively few chronic studies, and (3) the choice of excluding some studies that were very important (e.g., fat head minnow Birge et al. 1985). We believe these weaknesses justify using a very conservative approach to assigning criteria. All four approaches to set acute and chronic criteria would result in chloride concentrations at least several times greater than base flow concentrations commonly observed in Pennsylvania streams in their most natural condition (i.e., Exceptional Value and High Quality Waters). The lowest criteria for chloride were derived by the Canadian Province of British Columbia (Nagpal et al. 2003) – they acknowledged the weaknesses in available data, and applied safety factors of 2 for the acute criterion and 5 for the chronic criterion. Given the limits in the available data, and the potential that treated wastewaters from Marcellus Shale drilling may result in near-criterion chloride concentrations 356 days per year (versus the 30 days of a standard chronic bioassay), we believe the British Columbia criteria (either the originally adopted criteria or our re-calculated criteria in Table 2) would be the most protective of aquatic life for Pennsylvania streams, especially for the trout and many pollution-sensitive macroinvertebrate species that characterize Cold Water Fishes streams.

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Elphick et. al. 2011

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Hazard/Risk Assessment

CHRONIC TOXICITY OF CHLORIDE TO FRESHWATER SPECIES: EFFECTS OF HARDNESS AND IMPLICATIONS FOR WATER QUALITY GUIDELINES

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Abstract—Toxicity tests using nine freshwater species (*Ceriodaphnia dubia*, *Daphnia magna*, *Oncorhynchus mykiss*, *Pimephales promelas*, *Lumbriculus variegatus*, *Tubifex tubifex*, *Chironomus dilutus*, *Hyallela azteca*, and *Brachionus calyciflorus*) were conducted to evaluate their sensitivity to chloride. Acute-to-chronic ratios (ACRs) from these tests indicate the ACR of 7.59 employed by the United States Environmental Protection Agency (U.S. EPA) in deriving its water quality guideline for chloride may be conservative; a revised ACR of 3.50 is presented here. The endpoints used to calculate the ACR included 24-h to 96-h median lethal concentrations (LC50s) for acute tests, and 48-h to 54-d inhibition concentration (ICx) values for growth or reproduction for chronic exposures. Data from the present chronic toxicity tests, and other investigators, were used to propose a water quality guideline for long-term exposure to chloride using a species sensitivity distribution (SSD) approach. The 5th percentile from the SSD was calculated as 307 mg/L and proposed as the water quality guideline. Cladocerans were the most sensitive species in the dataset. *Ceriodaphnia dubia* was used to evaluate the relationship between water hardness and sensitivity to chloride. A strong relationship was observed and was used to establish a hardness-related equation to modify the proposed water quality guideline on the basis of water hardness, resulting in values ranging from 64 mg/L chloride at 10 mg/L hardness to 388 mg/L chloride at 160 mg/L hardness (as $CaCO_3$). These data suggest that current water quality guidelines for chloride may be overly conservative in water with moderate-to-high hardness, and may not be sufficiently protective under soft-water conditions. Environ. Toxicol. Chem. 2011;30:239–246. © 2010 SETAC

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INTRODUCTION

Chloride is ubiquitous in natural waters and is essential in a wide range of biological functions, including facilitating a variety of ion-exchange mechanisms through trans-membrane chloride channels. It forms salts with each of the major cations (Na, K, Ca, and Mg), but is highly soluble and exists primarily in the environment as a dissociated monovalent anion.

Freshwater organisms are generally hyperosmotic in their internal fluids relative to the external environment and maintain an active gradient of chloride across membranes through use of active pumps and/or bicarbonate exchange mechanisms at exterior surfaces such as the gill [1,2]. Increasing concentrations of chloride in the external environment may decrease this gradient and associated energy requirements; however, chloride can exhibit toxicity at elevated concentrations once homeostatic mechanisms are overwhelmed. Toxicity may result from osmotic stress related to overall ionic strength or disruption of individual cellular processes in which chloride plays a role [2].

The toxicity of chloride is of interest in aquatic environments as a result of its tendency to occur at elevated concentrations in effluents from industrial operations that involve subsurface mining (including coal, potash, metal, and diamond mines) [3–5], and oil and gas extraction [6]. In addition, chloride salts are widely used in road salts and, consequently, stormwater and snow-melt runoff often contain high concentrations of chloride in areas of application [7].

The EKATI Diamond Mine, operated by BHP Billiton Diamonds, is located in the southern Arctic ecoregion, 300 km northeast of Yellowknife in the Northwest Territories, Canada. The receiving environment at this mine is comprised of a series of low ionic-strength lakes. Chloride concentrations have increased in the receiving environment as a result of contributions primarily from groundwater and to a lesser extent from dissolution of solids from crushed kimberlite, and use of chloride-containing settling agents. Concentrations have increased from less than detection (<0.5 mg/L) to, in some cases, greater than 150 mg/L in receiving water bodies. Modeling of the discharge and receiving environment water, through the remainder of the mine life and into the closure period, has indicated the potential for the concentrations to continue to increase. Consequently, establishing water quality objectives for chloride for application at this site is a matter of interest.

Water quality guidelines for chloride are typically derived on the basis of toxicity tests using sodium chloride, because this cationic counter-ion contributes less toxicity than other major cations, such as K, Mg, and Ca [8]. Thus, the Na salt provides the most accurate measure for the toxicity of chloride itself by minimizing the toxicity contributed by the counter cation. The United States Environmental Protection Agency (U.S. EPA) published water quality criteria for chloride based on data for sodium chloride in 1988. The final acute value for chloride was 1,720 mg/L and the chronic criterion was 230 mg/L [9]. The chronic toxicity test data available were insufficient to calculate a chronic criterion directly and, consequently, the chronic value was calculated by dividing the final acute value by an acute-to-chronic ratio (ACR) of 7.594. This ACR was calculated as the geometric mean of ACR values from tests with three species: rainbow trout (7.308), fathead minnows (15.17), and *Daphnia pulex* (3.951). These individual estimates varied by more than

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fourfold, resulting in uncertainty in the final ACR estimate, particularly considering the small number of datapoints on which it was based.

No Canadian water quality guidelines for chloride presently exist; however, an evaluation conducted by Environment Canada has calculated a concentration of 212.6 mg/L chloride that is expected to be protective of at least 95% of species in long-term exposures [10]. This estimate was made using a species sensitivity distribution (SSD) approach using acute toxicity data, divided by the ACR value reported by U.S. EPA [9], and was performed as part of an evaluation of risk associated with application of road salts for control of snow and ice [7,10].

Considerable data are available on the acute toxicity of sodium chloride to aquatic organisms [7,9]; however, a general lack of chronic toxicity data exists for this anion. Consequently, guideline derivation and risk assessments for chloride have estimated effects thresholds for long-term exposure by applying an ACR to results from acute toxicity tests to derive a long-term exposure guideline [7,9,10]. However, this approach relies heavily on the accuracy of the ACR employed. The objectives of the present study were to develop additional acute and chronic toxicity data to derive a more robust estimate of the ACR, as well as obtain sufficient chronic data to calculate a chronic guideline directly. In addition, because increasing concentrations of chloride at EKATI are associated with increases in concentrations of other major ions, such as Ca, Mg, K, carbonate, and sulfate, the present study was also designed to evaluate whether increases in ionic strength modify the toxicity of chloride. Water hardness was used as a proxy for increased concentrations of other ions.

The present study was designed to provide information necessary to establish safe levels of chloride in the receiving environment at EKATI. However, the results of the testing conducted here are broadly applicable.

METHODS

Test species were chosen on the basis of providing a suitable representation of invertebrate and fish species for which both acute and chronic exposures could be conducted in the laboratory following standardized procedures. Additional considerations for species selection were: inclusion of organisms that have previously been shown to be sensitive to chloride (e.g., cladocerans and fathead minnows [9]); selection of species that the laboratory had previous experience working with and that were available; selection of invertebrate species that would occur in planktonic (e.g., cladocerans and rotifers) and benthic habitats (e.g., amphipods, chironomids, and oligochates); and selection of species that were either resident, or were suitable surrogates for species that occur in subarctic lakes. Algal species were not tested because toxicity test data were already available for a number of these species, and they had generally exhibited a low degree of sensitivity to this anion [10].

Acute and chronic toxicity tests were conducted using two cladocerans (*Ceriodaphnia dubia* and *Daphnia magna*), two oligochaetes (*Lumbriculus variegatus* and *Tubifex tubifex*), a chironomid (*Chironomus dilutus*), an amphipod (*Hyalella azteca*), a rotifer (*Brachionus calyciflorus*), and two fish (rainbow trout, *Oncorhynchus mykiss*, and fathead minnows, *Pimephales promelas*). The tests followed standardized methods published by the U.S. EPA [11–13], Environment Canada [14,15], American Society for Testing Materials (ASTM) [16–19], or American Public Health Association (APHA) Standard Methods [20], with the exception of the test using *Lumbriculus variegatus*, which was adapted from a U.S. EPA method designed for evaluation of bioaccumulation with this species [13] to incorporate a growth (biomass) endpoint. Test durations, endpoints, and references to the methods followed are provided in Table 1.

Exposures were conducted in constant environment rooms that maintained temperature within 1 °C of the target temperature. Water used in the tests was prepared by supplementing deionized water with reagent grade salts according to procedures specified by U.S. EPA [12], to achieve a hardness of between 80 and 100 mg/L, as $CaCO_3$, with the exception of the rainbow trout tests which were conducted using dechlorinated municipal tapwater, supplemented with salts in the ratios specified by U.S. EPA [12] for hardness adjustment, to a hardness of approximately 40 mg/L, as $CaCO_3$. Test solutions incorporated five concentrations, in addition to the control, following a 0.5-fold dilution series, and were prepared by addition of sodium chloride. The highest test concentration in the tests was 16 g/L as NaCl for acute tests and 8 g/L as NaCl for chronic tests, with the exception of chronic tests using *C. dubia*, *D. magna*, and *B. calyciflorus* which used 3, 15, and 16 mg/L NaCl, respectively, as the highest test concentration.

Chloride concentrations were measured on subsamples from the test solutions. Subsamples were collected at the beginning and end of each of the tests, with the exception of tests using *B. calyciflorus*, which was only subsampled at test initiation, as well as at intermediate intervals during the longer-term chronic toxicity tests, typically at weekly intervals. Concentrations of chloride were averaged for each test solution and the mean measured chloride concentration was used for calculation of the test endpoints.

Chronic toxicity tests using *Tubifex*, *Lumbriculus*, *Hyalella*, and *Chironomus* were performed using clean sediment comprised of a beach-collected sand that was rinsed with laboratory control water and supplemented with peat at a rate of 2% by

Table 1. Duration and endpoints of toxicity tests used to determine acute to chronic ratios for chloride

Species	Common name	Acute test duration	Method	Chronic test duration	Method	Chronic test endpoints
Ceriodaphnia dubia	Water flea	48 h	[12]	7 ± 1 d	[14]	Survival, reproduction
Daphnia magna	Water flea	48 h	[12]	21 d	[19]	Survival, reproduction
Oncorhynchus mykiss	Rainbow trout	96 h	[12]	54 d	[15]	Survival, development, biomass
Pimephales promelas	Fathead minnow	96 h	[12]	33 d	[11]	Survival, development, biomass
Lumbriculus variegatus	California blackworm	96 h	[16]	28 d	[13]	Survival, reproduction
Tubifex tubifex	Sludge worm	96 h	[16]	28 d	[18]	Survival, reproduction
Chironomus dilutus[a]	Midge	96 h	[16]	20 d	[13]	Survival, biomass
Hyallela azteca	Amphipod	96 h	[16]	28 d	[13]	Survival, weight
Brachionus calyciflorus	Rotifer	24 h	[17]	48 h	[20]	Survival, reproduction

[a] Formerly *Chironomus tentans*.

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weight. Test solutions were renewed daily three times a week throughout exposure with freshly prepared chloride-spiked water, at which time Tetramin (for *Chironomus, Lumbriculus,* and *Tubifex*) or digested yeast, cerophyll, and trout chow (YCT) (for *Hyalella*) was added as food. These tests were conducted using four replicates per concentration in glass jars containing 100 ml of sediment and filled to 275 ml with the test solutions. The exposures were conducted at 23 ± 1°C with a 16:8 h light:dark photoperiod. *Lumbriculus* and *Tubifex* tests were conducted using 5 test organisms per replicate, whereas *Hyalella* and *Chironomus* tests used 10 and 12 organisms per replicate, respectively. *Hyalella* tests were initiated with 7- to 8-d-old amphipods, *Chironomus* tests with <24-h posthatch organisms; both of these test species were obtained from Aquatic Biosystems. *Tubifex* and *Lumbriculus* tests were initiated with adults obtained from Aquatic Research Organisms.

Chronic toxicity tests using *Ceriodaphnia* were conduced in 10-ml volumes in 15-ml glass test tubes. Each concentration comprised 10 replicates, each containing a single <24-h-old daphnid obtained from in-house cultures. Solutions were renewed daily, at which time they were fed with a mixture of *Pseudokirchneriella* cells and YCT. Exposures were conducted at 25°C under a 16:8 h light:dark photoperiod. Survival and reproductive output were recorded daily for the three brood, 7 ± 1-d test. Tests with this species were performed regularly as a reference toxicant test and, consequently, the long-term geometric mean (and 2 SD range) from 20 separate tests was used for this water type, because this reflects a more robust approach than using a single test, although these reference toxicant tests did not have analytical confirmation of chloride concentrations.

Daphnia magna tests were conducted in 100-ml volumes in 250-ml glass beakers. Exposures were initiated with <24-h-old organisms obtained from in-house cultures, with one daphnid in each of 10 replicates. Solutions were renewed three times per week, at which time the organisms were fed with a mixture of *Pseudokirchneriella* cells and YCT. Exposures were conducted at 20°C under a 16:8 h light:dark photoperiod. Survival and reproductive output recorded daily for the 21-d duration of the test.

Brachionus calyciflorus were exposed for 48 h in a culture plate using a 0.5-ml exposure volume and eight replicates per concentration, each containing one rotifer. The test was initiated with organisms that were <4-h posthatch, and the solutions were supplemented with *Pseudokirchneriella* as food at test initiation. Exposures were conducted at 25°C in the dark. This test was considered to be a chronic test despite its relatively short duration because of the short life-history of this organism and the fact that the method incorporated a reproductive endpoint within this timeframe. Rotifer cysts were supplied by Micro Bio Tests, and were hatched in control water prior to test initiation.

Chronic toxicity tests with rainbow trout and fathead minnows were initiated with embryo-stage fish; rainbow trout gametes were obtained from Trout Lodge and dry fertilized in the laboratory prior to initiation of exposure, and fathead minnow embryos were obtained from Aquatic Biosystems. In the case of rainbow trout, the exposures were initiated within 30 min, and for fathead minnows, within 36 h of fertilization. Rainbow trout were exposed at 14°C using four replicates of 30 organisms in 500-ml volumes. Once the fish reached the swim-up stage, the number of fish was thinned to 10 per replicate, the exposure volume was increased to 2 L, and the fish were fed daily with *Artemia* nauplii. Fathead minnows were exposed at 25°C using five replicates with 15 organisms per replicate and using 100-ml exposure volumes for the first week, 250-ml for the next two weeks, and 500-ml for the remainder of the exposure period. Fathead minnows were fed twice daily with *Artemia* following hatch.

In general, acute toxicity tests were conducted under the same exposure regime and initiated with the same lifestage as described for the chronic tests, with the exception of the following: Acute tests on sediment-dwelling species were conducted in the absence of sediment; acute tests with *Ceriodaphnia* and *Daphnia* were conducted using five organisms per replicate; and acute tests using rainbow trout and fathead minnows were initiated using juvenile fish. Acute toxicity tests were conducted using four replicates and were performed under static conditions for 96 h, with the exception of tests using *Daphnia* and *Ceriodaphnia*, which were exposed for 48 h, and *Brachionus* which was exposed for 24 h. Acute tests were conducted without feeding, with the exception of the *Hyalella* test, which was fed with YCT after 48 h of exposure.

In addition, a series of toxicity tests were conducted using *C. dubia* to evaluate the relationship between water hardness and chloride toxicity using 7-d survival and reproduction tests. In advance of the tests, the organisms were cultured in water with hardnesses of 10, 20, 40, 80, 160, and 320 mg/L, as $CaCO_3$, for a minimum of two generations (more than two weeks) in order for the cladocerans to acclimate to the water hardness. Test water was prepared by addition of reagent grade salts to deionized water to achieve the target hardnesses; characteristics of the water types are summarized in Table 2. After the acclimation period, toxicity tests using sodium chloride were conducted with waters at each hardness using the organisms acclimated to the corresponding hardness (i.e., 10, 20, 40, 80, 160, and 320 mg/L). The tests were conducted according to the procedures outlined previously for chronic toxicity tests with chloride-spiked water using this species. *Ceriodaphnia dubia* was selected for this evaluation because this species was among the most sensitive to chloride, and could be acclimated to the range of required water hardnesses, and because of its relatively short test duration (~7 d) which enabled acclimation and testing within a reasonable period.

Statistical analyses were conducted using Comprehensive Environmental Toxicity Information System (CETIS) statistical

Table 2. Characteristics of waters used to evaluate the effect of hardness on toxicity of chloride to *Ceriodaphnia dubia*[a]

Hardness (mg/L as $CaCO_3$)	pH	Chloride (mg/L)	Sulfate (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)
10	6.8	0.2	11.3	3.3	0.3	2.2	1.5
20	7.0	0.5	22.6	6.6	0.5	4.4	3.0
40	7.2	1.0	45.1	13.1	1.0	8.8	6.1
80	7.8	1.9	90.2	26.3	2.1	17.6	12.1
160	8.2	3.8	180.5	52.6	4.2	35.3	24.2
320	8.3	7.6	360.9	105.1	8.4	70.6	48.5

[a] Concentrations are nominal, based on the quantities of salts added.

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software package (Tidepool Scientific Software) on the basis of measured concentrations of chloride. Analyses followed procedures recommended by U.S. EPA for statistical analyses of toxicological data [11,12]. Median lethal concentration (LC50) estimates were calculated using Probit regression or, if assumptions for this method were not met, with Trimmed Spearman–Karber. Inhibition concentration values (IC*x*) associated with 10, 25, and 50% responses from chronic toxicity tests were calculated using linear interpolation. ACR values were calculated by dividing the IC25 from the chronic test by the LC50 from the acute test with the same species.

An SSD was calculated for chloride according to procedures specified by Environment Canada [21]. This procedure involves calculating toxicological thresholds for available data, and plotting a cumulative distribution of the dataset. No-observed-effect concentration (NOEC) values have often been used in constructing SSDs [22]; however, these values are subject to constraints associated with statistical power of the tests and use of these endpoints has been criticized [23]. Thus, consistent with Environment Canada guidelines [21], toxicological thresholds were defined as the most appropriate IC*x* value reflecting the threshold for toxicity in the test. Ideally, the IC10 was considered to be the toxicological threshold; however, if the IC10 value was lower than the NOEC, the test was not considered to be sufficiently robust to provide a reasonable estimate of the IC10, in which case, the IC25 was used as the toxicological threshold. In the event that suitable point estimates were not available for a given test, the next most appropriate endpoint was selected based on the following order of preference: maximum-acceptable-toxicant concentration (MATC) > NOEC > lowest-observed-effect concentration (LOEC) > median effect concentration (EC50). Only the most sensitive endpoint from long-term tests (e.g., reproduction, growth) was included in the distribution. In cases where multiple endpoints were available from different studies, a geometric mean of the values was used in the distribution.

Nonlinear regression was conducted using CETIS to model the distribution and calculate the 5th percentile of the distribution; this value, referred to as the HC5, is considered by Environment Canada to be protective of overall ecosystem health and function [21]. Models tested included normal, log normal, logistic, log logistic, log Gompertz and Weibull; relative fit of the models was evaluated on the basis of corrected second order Akaike information criteria (AIC), and the fit of individual candidate models with the smallest and similar AIC values were inspected to select the curve that best described the distribution, with particular attention to the lower tail of the distribution where the HC5 is located. Normal distribution of the dataset was tested using a Shapiro–Wilk test for normality ($p < 0.01$).

RESULTS AND DISCUSSION

All of the acute and chronic toxicity tests conducted in the present study met control performance requirements, with the exception of the chronic test with *Hyalella*, which had 62.5% survival and was lower than the control acceptance criterion of 80% survival. Survival in the three lowest test concentrations in this test was consistent with the control performance, ranging from 62.5 to 75% and a typical dose–response curve was obtained with the entire dataset. Consequently, the data from this test appear to provide useful information, despite not meeting the control performance specifications of the method. Interestingly, the chronic test using *Hyalella* was less sensitive to chloride than the acute test with this species, suggesting that the presence of control sediment and peat may ameliorate the toxicity of chloride; organic carbon influences the toxicity of a number of metals [24,25], but it is not known if this might explain decreased toxicity in this case.

Results of the chronic toxicity tests are presented in Table 3, and acute and chronic toxicity test data and calculated ACR values for nine species tested in this investigation are summarized in Table 4. The ACRs calculated in the present study include a second measure of the ACR for each of the three genera that were previously used in the development of the U.S. EPA chloride water quality guideline. The values used by U.S. EPA are also provided in Table 4. The genus mean ACRs were recalculated for each of these three genera, on the basis of the geometric mean of the two values. The overall ACR, calculated as the geometric mean of the ACR values for all nine species, was 3.50. Thus, the results of these tests suggest that the estimate for the ACR provided in the U.S. EPA guideline (7.59) likely overestimated the actual value by approximately twofold. Since this ACR value was employed by both the U.S. EPA in deriving the 1988 chronic guideline for chloride and by Environment Canada in conducting a risk assessment for road salts, these studies likely resulted in benchmarks that were unnecessarily conservative to be protective of long-term ecosystem health.

Where sufficient data exist, it is preferable to calculate long-term exposure guidelines directly on the basis of chronic toxicity test results, rather than relying on use of an ACR to calculate this value. As a result of the toxicity testing conducted here, a number of additional chronic toxicity values are now

Table 3. Results of sublethal toxicity tests[a]

Species	Endpoint	IC10[b]	IC25[b]	IC50[b]	NOEC	LOEC
Ceriodaphnia dubia	Reproduction	NR	454 (251–819)[c]	697 (540–901)[c]	NC	NC
Daphnia magna	Reproduction	NR	421 (262–825)	1,037 (684–1,491)	<506	506
Oncorhynchus mykiss	Biomass	NR	1,174 (733–1,344)	1,559 (1,362–1,679)	1,104	2,327
Pimephales promelas	Biomass	NR	704 (486–973)	958 (700–1,582)	558	1,058
Lumbriculus variegatus	Biomass	NR	825 (549–1,256)	1,366 (1,199–1,541)	<366	366
Tubifex tubifex	Reproduction	519 (235–529)	606 (391–632)	752 (628–803)	462	964
Chironomus dilutus	Biomass	2,316 (NC)	2,590 (2,118–2,590)	3,047 (2,732–3,047)	2,133	3,960
Hyallela azteca	Biomass	NR	1,705 (440–1,907)	2,298 (1,852–2,937)	2,210	4,237
Brachionus calyciflorus	Reproduction	1,241 (211–1,345)	1,505 (540–1,670)	1,945 (1,631–2,263)	1,120	2,330

[a] NOEC = no-observed-effect concentration; LOEC = lowest-observed-effect concentration; NR = not reported, because the IC10 was lower than the NOEC. Thus, the test data were not considered sufficiently robust to calculate an IC10; NC = not calculated, since these point estimate data were derived from multiple tests (i.e., 20).

[b] IC = inhibition concentration values (IC*x*) associated with 10, 25, and 50%.

[c] Mean (±two standard deviations) for 20 tests conducted as reference toxicant tests.

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Table 4. Results of toxicity tests and acute-to-chronic ratio calculations[a]

Genus	Acute test LC50 (mg/L Cl)	Chronic test IC25 (mg/L Cl)	Acute–chronic ratio from the present study	Acute–chronic ratio from U.S. EPA [9]	Combined acute–chronic ratio
Ceriodaphnia	1,068 (603–1,533)[b]	454 (251–819)[b]	2.35	NC	2.35
Daphnia	3,630 (3,172–4,154)	421 (262–825)	8.62	3.95	5.84
Oncorhynchus	6,030 (5,916–6,145)	1,174 (733–1,344)	5.14	7.31	6.13
Pimephales	4,079 (3,644–4,565)	704 (486–973)	5.80	15.17	9.38
Lumbriculus	3,100 (2,759–3,483)	825 (549–1,256)	3.76	NC	3.76
Tubifex	5,648 (5,219–6,111)	606 (391–632)	9.31	NC	9.31
Chironomus	5,867 (5,452–6,313)	2,590 (2,118–2,590)	2.27	NC	2.27
Hyalella	1,382 (1,276–1,496)	1,186 (693–1,516)[c]	1.17	NC	1.17
Brachionus	1,645 (1,588–1,703)	1,505 (540–1,670)	1.09	NC	1.09
Geometric mean acute-to-chronic ratio			3.40	7.59	3.50

[a] LC50 = median lethal concentration; IC25 = 25% inhibition concentration; NC = not calculated by the U.S. EPA [9].
[b] Mean (±2 SD) for 20 tests conducted as reference toxicant tests.
[c] The chronic test for *Hyalella* was less sensitive than the acute test and, consequently, for calculation of the acute-to-chronic ratio, the chronic test value was assumed to be the LC25 (25% lethal concentration) from the acute test. The actual IC25 for biomass of *Hyalella* was 1,705 mg/L.

available for the toxicity of chloride; these values, combined with those from the literature, provide sufficient data to calculate a long-term exposure guideline directly using an SSD approach. Additional data using in the SSD include data that were reported in the U.S. EPA water quality guideline for *D. pulex* [26], *P. promelas* [26], *Nitzschia linearis* [27], *Chlamydomonas reinhardtii* [28], and *Chlorella emersonii* [29], as well as other data from the literature for *Lemna minor* [30] and *Stenonema modestum* [31]. To meet the recommendations of Environment Canada [21], point estimates from these studies (i.e., IC10 or IC25 values) were used where possible; sufficient data were present in one of these documents to recalculate the threshold using point estimates, rather than relying on the hypothesis tests that were reported in that study [26]. The data used in calculation of the SSD are shown in Table 5.

A subset of data points that were used in the U.S. EPA water quality guideline development were excluded here. For example, data for rainbow trout, attributed to Spehar and cited by U.S. EPA [9], were not available for review because this study was apparently not published. In addition, data for the sensitivity of a number of unicellular freshwater algae were excluded from the SSD because these papers only reported tolerance to chloride, rather than evaluating inhibition of growth compared to control performance [32,33].

Differing opinions have been expressed in the literature on the number of species required to construct an SSD, with as few as six [21], and up to 15 to 55 species being considered ideal to achieve an HC5 estimate with minimal variance [34]. In addition, the composition of the species assemblage reflected in the dataset can alter the outcome, particularly in cases where the toxicological mode-of-action varies between species, and the dataset needs to reflect the ecosystem being protected [35]. The dataset shown here has 15 data points, including nine invertebrates, two fish, two algae, one plant, and one diatom. The cumulative distribution appears to fit a single distribution, without any indication of a bimodal distribution (Fig. 1). Furthermore, a Shapiro–Wilk test for normality demonstrated that the dataset was normally distributed ($p = 0.55$), indicating that no unusual patterns in the data occurred. Thus, it appears that the species reflected in the dataset provide a reasonable distribution from which to calculate an HC5.

The HC5 was calculated using a Weibull distribution to model the SSD dataset using nonlinear regression. Log logistic and log normal models produced a similar fit to the Weibull

Table 5. Chronic toxicity test data used for calculation of the species sensitivity distribution[a]

Species	Category	Threshold value (mg/L Cl)		Source
Daphnia pulex	Cladoceran	Reproduction; 21 d IC10[b]	368	[26]
Daphnia magna	Cladoceran	Reproduction; 21 d IC25	421	Present study
Ceriodaphnia dubia	Cladoceran	Reproduction; 7 d IC25	454	Present study
Tubifex tubifex	Oligochaete	Reproduction; 28 d IC25	519	Present study
Pimephales promelas	Fish (non-salmonid)	Survival; 33 d LC10[b]	598	[26][c]
		Biomass; 32 d IC25	704	Present study
		Geometric mean	649	
Lumbriculus variegatus	Oligochaete	Reproduction; 28 d IC25	825	Present study
Lemna minor	Plant	Growth; 96 h MATC	1,172	[30]
Oncorhynchus mykiss	Fish (salmonid)	Biomass; 56 d IC25	1,174	Present study
Nitzschia linearis	Diatom	Growth; 5 d EC50	1,482	[27]
Brachionus calyciflorus	Rotifer	Reproduction; 48 h IC25	1,505	Present study
Hyalella azteca	Amphipod	Growth; 28 d IC25	1,705	Present study
Chironomus dilutus	Midge	Growth; 20 d IC25	2,316	Present study
Chlamydomonas reinhardtii	Alga	Growth; 6 d EC~50	3,014	[28]
Stenonema modestum	Mayfly	Survival; 14 d MATC	3,074	[31]
Chlorella emersonii	Alga	Growth; 8–14 d MATC	7,000	[29]

[a] IC = inhibition concentration values (ICx) associated with 10 and 25%; LC10 = 10% lethal concentration; MATC = maximum acceptable toxicant concentration; EC50 = median effect concentration.
[b] Point estimates were calculated using linear interpolation based on original data provided in Birge et al. [26].
[c] Point estimates were calculated using multiple linear estimation (Probit) based on original data provided in Birge et al. [26].

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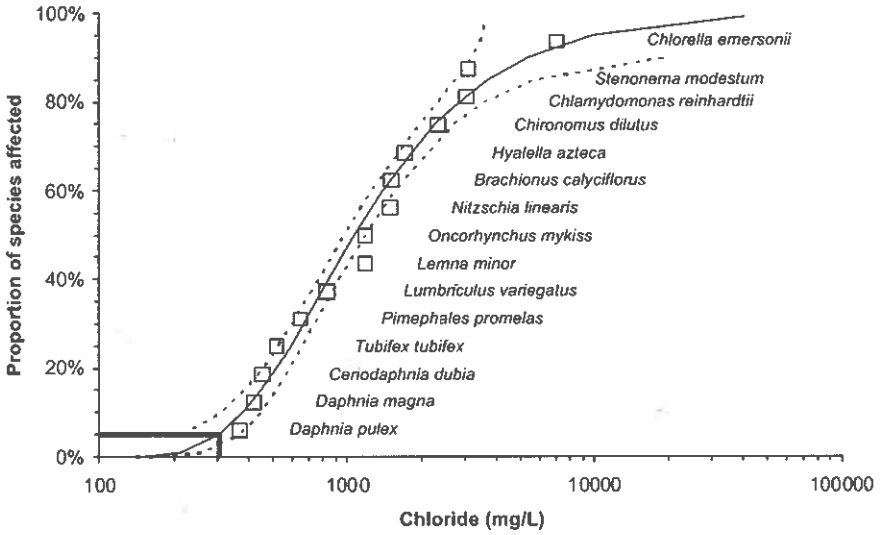


Fig. 1. Species sensitivity distribution for chronic toxicity test data using chloride. The squares represent the empirical data, the solid line represents the modeled distribution, and the dashed lines represent the 95% confidence limits.

distribution (i.e., produced similar AIC values); however, the Weibull model was selected because it provided a closer fit to the data in the lower tail of the distribution, by inspection. The HC5 (and 95% confidence intervals) calculated on this basis was 307 (217 to 369) mg/L (Fig. 1). This value is lower than all of the thresholds reported in Table 4 and appears to be appropriately protective to apply as a long-term objective for chloride, at least under moderately hard conditions.

The results of toxicity tests using *C. dubia* conducted at various hardnesses are provided in Table 6. A clear decrease in the toxicity of chloride was observed with increasing hardness across the range of 10 to 160 mg/L hardness. Lasier et al. [36] also reported lower chronic toxicity of chloride in higher hardness water with this species, and Mount et al. [8] reported decreased acute toxicity of chloride to *C. dubia* when tested as a combination of sodium chloride and calcium chloride (resulting in higher hardness), compared with sodium chloride alone. Interestingly, these authors also reported that the toxicity of the combined salts was lower than calcium chloride alone, which would be even higher in hardness than the mixture. These data suggest that decreased toxicity corresponding to increasing hardness may relate to maintenance of a tolerable balance in molar ratios of cations, rather than a mechanistic effect of hardness (i.e., Ca or Mg ions) itself. Regardless, the data presented here demonstrate a clear reduction in toxicity of sodium chloride in solutions with higher hardness, with water hardness potentially being a proxy for higher overall ionic strength or more balanced ionic ratios of major ions.

Table 6. Results of *Ceriodaphnia dubia* chronic toxicity tests conducted across a range of hardnesses[a]

Hardness (mg/L as $CaCO_3$)	Chloride toxicity endpoints (mg/L Cl)		
	Ceriodaphnia reproduction (IC25 [95% CL])	*Ceriodaphnia* reproduction (IC50 [95% CL])	*Ceriodaphnia* survival (LC50 [95% CL])
10	117 (94–169)	161 (126–211)	132 (107–161)
20	264 (104–280)	301 (275–362)	316 (268–373)
40	146 (82–277)	481 (207–541)	540 (460–633)
80	454 (251–819)[b]	697.4 (540–901)[b]	1,134 (858–1,410)[b]
160	580 (210–733)	895 (706–1,177)	1,240 (1,025–1,501)
320	521 (361–588)	700 (613–784)	1,303 (1,019–1,665)

[a] IC = inhibition concentration values (ICx) associated with 25 and 50%; CL = confidence limits; LC50 = median lethal concentration.
[b] Mean and 2 SD range of 20 data points for chronic toxicity tests using chloride.

A logarithmic regression of the data for hardnesses of 10 through 160 mg/L resulted in R^2 values of 0.95, 0.99, and 0.78 for LC50, IC50, and IC25 values, respectively, indicating a strong positive relationship between these parameters (Fig. 2). Above a hardness of 160 mg/L, an additional reduction in toxicity was not as apparent, with generally similar values for sensitivity to chloride at hardnesses of 160 and 320 mg/L.

The majority of toxicity data used to establish the SSD value of 307 mg/L were derived from toxicity tests conducted under moderately hard water conditions (80 to 100 mg/L, as $CaCO_3$). Consequently, this value may not be sufficiently conservative for soft-water conditions, and appears to be unnecessarily conservative at hardnesses exceeding 100 mg/L. Using the slope of the hardness toxicity relationship shown in Figure 2, the results from the SSD can be hardness-adjusted to accommodate this relationship in a similar manner to water quality guidelines for metals such as Zn, Cu, Cd, and Ni.

The relationship between IC25 values and hardness across a range of 10 to 160 mg/L resulted in a logarithmic trendline described by Equation 1.

$$IC25_{(\text{hardness } x)} = [161 \cdot \ln_{(\text{hardness } x)}] - 281.73 \quad (1)$$

Thus, using the water quality benchmark of 307 derived from the SSD for a hardness of 80 mg/L, and the IC25 for *C. dubia* of 423.78 mg/L chloride (calculated from Eqn. 1, for a hardness of 80 mg/L), the objective can be linked to hardness by incorporating this equation into Equation 2.

$$\begin{aligned} WQO_{(\text{hardness } x)} &= [WQO_{(\text{hardness } 80)}/IC25_{(\text{hardness } 80)}] \\ &\cdot [161 \cdot \ln_{(\text{hardness})} - 281.73] = (307/423.78) \\ &\cdot [161 \cdot \ln(\text{hardness}) - 281.73] \\ &= [116.63 \cdot \ln(\text{hardness})] - 204.09 \end{aligned} \quad (2)$$

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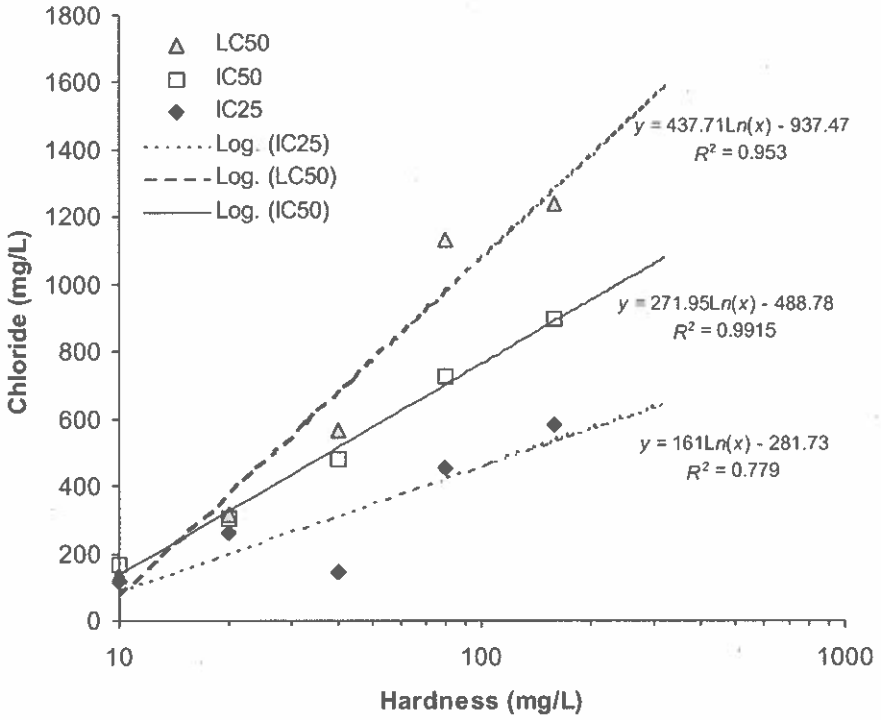


Fig. 2. Relationship between hardness and sensitivity to chloride for reproduction (IC25 and IC50 inhibition concentrations) and survival median lethal concentration (LC50) endpoints.

where: $WQO_{(hardness\ x)}$ = Water quality objective for chloride at hardness (x);

$WQO_{(hardness\ 80)}$ = Water quality objective for chloride at hardness 80 mg/L (i.e., the HC5 from the SSD); $IC25_{(hardness\ 80)}$ = Concentration resulting in a 25% reduction in reproduction of *C. dubia* at hardness 80 mg/L $CaCO_3$.

Thus, the hardness-specific WQO for chloride across a range of 10 to 160 mg/L hardness is established as

$$WQO = [116.63 \cdot \ln(\text{hardness})] - 204.09$$

Using the water quality benchmarks provided in Table 7should provide sufficient protection against adverse effects in receiving environments impacted by chloride.

Although data relating water hardness to the toxicity of chloride are only available for one species (i.e., *C. dubia*), it appears reasonable to assume that a similar response would also occur with other cladocerans, and potentially with other species as well, although uncertainly exists as to the extent to which that would be the case. Regardless, the range of water quality guidelines proposed in Table 7 (i.e., 64 to 388 for hardnesses ranging from 10 to 160 mg/L) is lower than the threshold for toxicity to any non-cladoceran species reported in Table 4. Thus, even if this phenomenon was limited to the cladocera, incorporation of hardness into a guideline would not appear to result in risk to other taxa, and takes account of the higher sensitivity of cladocerans to chloride under low hardness conditions.

Table 7. Hardness-dependent water quality benchmarks for chloride, calculated on the basis of application of the relationship between IC25 (inhibition concentration value associated with 25%) for *Ceriodaphnia dubia* reproduction and water hardness to the 5th percentile of the species sensitivity distribution (HC5)

Water hardness (mg/L $CaCO_3$)	Water quality objective for chloride $WQO_{(hardness\ x)}$ (mg/L)
10	64
20	145
40	226
60	273
80	307
100	333
120	354
140	372
160	388
>160	Not established

The results presented here suggest that current U.S. EPA water quality guidelines for chloride may not be sufficiently protective of aquatic life under soft-water conditions. This finding has particular significance in areas of road salt use, because snow-melt runoff is very low in hardness and can contain significant concentrations of chloride. Use of road salt formulations that combine calcium chloride with sodium chloride would appear to result in lower risk for adverse effects in the environment because this would confer an increased hardness to runoff and, consequently, lower risk of adverse effects. Conversely, the data presented here suggest that current water quality guidelines for chloride may be unnecessarily conservative in waters with moderate or high hardness.

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REFERENCES

1. Hammer UT. 1986. *Saline Lake Ecosystems of the World*. Dr. W. Junk Publishers, Boston, MA, USA.
2. De Boek G, Vlaeminck A, Van der Linden A, Blust R. 2000. The energy metabolism of common carp (*Cyprinus carpio*) when exposed to salt stress: An increase in energy expenditure or effects of starvation? *Physiol Biochem Zool* 73:102–111.

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3. Bernt E, Bengt H. 1996. Treatment of saline wastewater for zero discharge at the Debiensko coal mines in Poland. *Desalination* 105:115–123.
4. Jiries A, El-Hassan T, Al-Hwaiti M, Seiler K. 2004. Evaluation of the effluent water quality produced at phosphate mines in central Jordan. *Mine Water Environ* 23:133–137.
5. Mironenko V, Atroshchenko F. 2000. Hydrogeoecological problems in developing the diamond bearing deposits in northern regions of Russia. In Grant SA, Iskandar IK, eds, *Contaminant Hydrology: Cold Regions Modeling*. CRC, Boca Raton, FL, USA.
6. Van Voast WA. 2003. Geochemical signature of formation waters associated with coalbed methane. *AAPG Bull* 87:667–676.
7. Evans M, Frick E. 2000. The effects of road salts on aquatic ecosystems. NWRI Report 02-308. National Water Research Institute, Saskatoon, SK, Canada.
8. Mount DR, Gulley DD, Hockett JR, Garrison JD, Evans JM. 1997. Statistical models to predict the toxicity of major ions to *Ceriodaphnia dubia*, *Daphnia magna* and *Pimephales promelas* (fathead minnows). *Environ Toxicol Chem* 16:2009–2019.
9. U.S. Environmental Protection Agency. 1988. Ambient water quality criteria for chloride. EPA-440-5-88-001. Office of Water, Washington, DC.
10. Environment Canada. 2001. Priority substances list assessment report: Road salts. Ottawa, ON.
11. U.S. Environmental Protection Agency. 2002. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms, 4th ed. EPA 821-R-02-013. Washington, DC.
12. U.S. Environmental Protection Agency. 2002. Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms, 5th ed. EPA-821-R-02-012. Washington, DC.
13. U.S. Environmental Protection Agency. 2000. Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates, 2nd ed. EPA 600/R-99/064. Office of Research and Development, Duluth, MN.
14. Environment Canada. 1992. Biological test method: Test of reproduction and survival using the cladoceran *Ceriodaphnia dubia*. EPS 1/RM/21. Ottawa, ON.
15. Environment Canada. 1998. Biological test method: Toxicity tests using early life stages of salmonid fish (rainbow trout), 2nd ed. EPS/1/RM/28. Ottawa, ON.
16. American Society for Testing and Materials. 1997. Standard guide for conducting acute toxicity tests on aqueous ambient samples and effluents with fishes, macroinvertebrates, and amphibians. E1192-97. West Conshohocken, PA.
17. American Society for Testing and Materials. 1991. Standard guide for acute toxicity test with the rotifer *Brachionus*. E1440-91. West Conshohocken, PA.
18. American Society for Testing and Materials. 2005. Standard test method for measuring the toxicity of sediment-associated contaminants with freshwater invertebrates. E1706-05. West Conshohocken, PA.
19. American Society for Testing and Materials. 1997. Standard guide for conducting *Daphnia magna* life-cycle toxicity tests. E1193-97. West Conshohocken, PA.
20. Eaton AD, Clesceri LS, Rice EW, Greenberg AE, eds. 2005. *Standard Methods for the Examination of Water and Wastewater*. 21st ed. American Public Health Association, Water Environment Federation, American Water Works Association, Washington, DC.
21. Canadian Council of Ministers of the Environment. 2007. *A protocol for the derivation of water quality guidelines for the protection of aquatic life*. Winnipeg, MN, pp 39.
22. Aldenberg T, Slob W. 1993. Confidence limits for hazardous concentrations based on logistically distributed NOEC toxicity data. *Ecotoxicol Environ Saf* 25:48–63.
23. Chapman PM, Caldwell RS, Chapman PF. 1996. A warning: NOECs are inappropriate for regulatory use. *Environ Toxicol Chem* 15:77–79.
24. Chapman P, Wang F, Janssen C, Persoone G, Allen H. 1998. Ecotoxicology of metals in aquatic sediments: Binding and release, bioavailability, risk assessment, and remediation. *Can J Fish Aquat Sci* 55:2221–2243.
25. Bryan GW, Langston WJ. 1992. Bioavailability, accumulation and effects of heavy metals in sediments with special reference to United Kingdom estuaries: A review. *Environ Pollut* 76:89–131.
26. Birge WJ, Black JA, Westerman TM, Short SB, Taylor DM, Bruser DM, Wallingford ED. 1985. Recommendations on numerical values for regulating iron and chloride concentrations for the purpose of protecting warmwater species of aquatic life in the commonwealth of Kentucky. Memorandum of Agreement No. 5429. Kentucky Natural Resources and Environmental Protection Cabinet, Lexington, KY, USA.
27. Patrick R, Cairns J, Scheier A. The relative sensitivity of diatoms, snails and fish to twenty common constituents of industrial wastes. *Prog Fish-Cul* 30:137–140.
28. Reynoso GT, de Gamboa BA, Mendoza SR. 1982. Induction of resistance to salinity in the freshwater alga *Chlamydomonas reinhardtii*. *Environ Sci Res* 23:531–534.
29. Setter TL, Greenway H, Kuo J. 1982. Inhibition of cell division by high external NaCl concentrations in synchronized cultures of *Chlorella emersonii*. *Aust J Plant Physiol* 9:179–196.
30. Taraldsen JE, Norberg-King TL. 1990. New method for determining effluent toxicity using duckweed (*Lemna minor*). *Environ Toxicol Chem* 9:761–767.
31. Diamond JM, Winchester EL, Mackler DG, Gruber D. 1992. Use of the mayfly *Stenonema modestum* (Heptageniidae) in subacute toxicity assessments. *Environ Toxicol Chem* 11:415–425.
32. Kessler E. 1974. Physiologische und biochemische Beiträge zur taxonomie der getting *Chlorella*. *Arch Microbiol* 100:51–56.
33. Schiewer VU. 1974. Salt tolerance and the influence of increasing NaCl-concentrations on the contents of nitrogen, carbohydrates, pigments and the production of extracellular carbohydrates in some freshwater blue-green algae. *Arch Hydrobiol Suppl* 46:171–184.
34. Newman MC, Ownby DR, Mezin LCA, Powell DC, Christensen DLR, Lerberg SB, Anderson BA. 2000. Applying species-sensitivity distributions in ecological risk assessment: Assumptions of distribution type and sufficient numbers of species. *Environ Toxicol Chem* 19:508–515.
35. Maltby L, Blake N, Brock TCM, Van den Brink PJ. 2005. Insecticide species sensitivity distributions: Importance of test species selection and relevance to aquatic ecosystems. *Environ Toxicol Chem* 24:379–388.
36. Lasier PJ, Winger PV, Hardin IR. 2006. Effect of hardness and alkalinity in test waters on the reproduction of *Ceriodaphnia dubia*. *Environ Toxicol Chem* 25:2781–2786.

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Assessing the toxicity of sodium chloride to the glochidia of freshwater mussels: Implications for salinization of surface waters

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Freshwater mussel larvae were acutely sensitive to sodium chloride, such that chloride levels in some Canadian rivers may pose a threat to the survival of this early life stage.

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ABSTRACT

Chloride concentrations in surface waters have increased significantly, a rise attributed to road salt use. In Canada, this may be a concern for endangered freshwater mussels, many with ranges limited to southern Ontario, Canada's most road-dense region. The acute toxicity of NaCl was determined for glochidia, the mussel's larval stage. The 24 h EC50s of four (including two Canadian endangered) species ranged from 113–1430 mg Cl L^{-1} (reconstituted water, 100 mg $CaCO_3$ L^{-1}). To determine how mussels would respond to a chloride pulse, natural river water (hardness 278–322 mg $CaCO_3$ L^{-1}) was augmented with salt. *Lampsilis fasciola* glochidia were significantly less sensitive to salt in natural water (EC50s 1265–1559 mg Cl L^{-1}) than in reconstituted water (EC50 285 mg L^{-1}). Chloride data from mussel habitats revealed chloride reaches levels acutely toxic to glochidia (1300 mg L^{-1}). The increased salinization of freshwater could negatively impact freshwater mussels, including numerous species at risk.

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1. Introduction

The increase in the chloride concentration of North American surface waters over the past 30 years has been correlated with the increased application of de-icing salts on paved surfaces (Kaushal et al., 2005; Jackson and Jobbágy, 2005). Kaushal et al. (2005) demonstrated that chloride levels in rivers and streams were correlated with the percentage of impermeable surfaces in the watershed. This increased salinization of freshwater has implications for both human and ecosystem health. Chloride concentrations in some drinking water reservoirs now exceed the level for potable water (Kaushal et al., 2005) and numerous urban streams frequently exceed the levels considered harmful to aquatic life (Evans and Frick, 2001; Trowbridge et al., 2010). In addition to the seasonal influx of salt in snowmelt and runoff, groundwater (Howard and Haynes, 1993; Kelly et al., 2008; Roy and Bickerton, 2010) and soils (Kincaid and Findlay, 2009) can also act as reservoirs releasing chloride throughout the year. Therefore, it is quite probable that the full impact of freshwater salinization has yet to be realized, not only because millions of tons of road salt are applied each year (Environment Canada and Health Canada, 2001), but also because delayed and longer-term inputs of chloride from contaminated soils and groundwater are expected (Kelly et al., 2008; Kincaid and Findlay, 2009). Kaushal et al., (2005) suggested that baseline salinity in the Northeastern United States is approaching levels where significant changes in ecological communities and ecosystem function are expected. Recent studies suggest that such shifts may in fact already be occurring for some contaminant sensitive groups. For example, Collins and Russell (2009) concluded that exposure to road salt affects amphibian community structure and species richness by excluding salt-sensitive species from high chloride environments.

Freshwater mussels, one of the most imperiled groups of organisms (Ricciardi and Rasmussen, 1999; Lydeard et al., 2004), are also known to be particularly sensitive to some waterborne contaminants. In fact environmental pollution is considered to be one of the factors responsible for their decline (Strayer et al., 2004; Lydeard et al., 2004). Nearly 70% of North American freshwater mussels are designated as either threatened, endangered, or in decline (Williams et al., 1993; Neves et al., 1997). Recent studies have reported that for some contaminants, freshwater mussel larvae and juveniles are much more sensitive than standard test organisms, leading to concerns that water quality regulations may not protect freshwater mussels (Augspurger et al., 2003; Wang et al., 2007, 2009; March et al., 2007). In Canada, the geographical distribution of freshwater mussels is thought to be limited by temperature, either because the mussels themselves or their fish hosts reach their lower limit of thermal tolerance (Metcalfe-Smith et al., 1998). Many species reach the northern limit of their range in

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the lower Great Lakes Basin, with 40 of Canada's 53 freshwater mussels species found in this area (Metcalfe-Smith et al., 1998). Of particular concern is that the range of eight Canadian mussel species classified as federally endangered are limited to the heavily populated and road dense southern Ontario. However, it is unknown whether the contamination of mussel habitats by chloride will affect the mussels, particularly their sensitive early life stages. The parasitic larvae of freshwater mussels, called glochidia, are released from the brooding chambers (marsupia) in the female's gills into the water column in order to make contact with fish hosts. In Canada, most glochidia are released between May and October, depending upon species specific temperature cues for release. Fortunately, the typical release period does not coincide with the seasonal influx of chloride associated with snowmelt runoff, but the steady increase in baseline chloride levels along with periodic summer chloride pulses from stormwater runoff and groundwater upwelling (Howard and Haynes, 1993; Kincaid and Findlay, 2009) may pose a risk to this imperiled, but ecologically significant group of animals.

This study examined acute sodium chloride (NaCl) toxicity in glochidia and compared median effective concentrations (EC50s) to chloride concentrations in the mussel's natural habitat. Specifically, sensitivity was determined for five species of mussels, three of which are designated as federally endangered in Canada. Toxicity tests with glochidia and NaCl were conducted in both standard reconstituted waters and natural waters. Reconstituted water exposures were used to determine the sensitivity of glochidia to chloride in relation to other aquatic organisms and the effect of water hardness on chloride toxicity. Natural water exposures employed water collected from four southern Ontario rivers that support diverse mussel populations (9–34 species). The aim of the natural water exposures was to determine how glochidia would respond to an episodic pulse of chloride in their habitat.

2. Materials and methods

2.1. Mussel collection and laboratory care

Gravid female mussels were collected from streams and rivers in southern Ontario. The period of gravidity varied with species such that *Lampsilis siliquoidea* (Barnes 1823) (fatmucket) and *Lampsilis cardium* (Rafinesque 1820) (plain pocketbook) were collected in May, *Lampsilis fasciola* (Rafinesque 1820) (wavy-rayed lampmussel) in mid-July, and *Epioblasma torulosa rangiana* (Lea 1838) (northern riffleshell) and *Ptychobranchus fasciolaris* (Rafinesque 1820) (kidneyshell) in early September. The endangered *L. fasciola*, *P. fasciolaris* and *E. torulosa rangiana* were collected under Canadian Species at Risk Permits (SECT 08 SCI 007, SECT 73 SARA C&A 09-012). Because the availability of gravid females varied each year, toxicity tests were conducted over two field seasons (2008–2009). In addition, acute chloride sensitivity of *L. siliquoidea* glochidia was assessed using gravid females collected from two different watersheds (one in each of 2008 and 2009) and toxicity tests with *L. fasciola* were also conducted in both years but using different gravid females collected from the same field site. Although mussels for this study were collected in Ontario, all species examined are also found in the U.S. (Parmalee and Bogan, 1998).

Gravid mussels were held at the University of Guelph's Aqualab facility and maintained in a flow-through system with well water held at 10 ± 2 °C (to prevent the glochidia release). Mussels were fed approximately 1.2×10^{10} algae cells per mussel per day with a commercial shellfish diet (Instant Algae Shellfish Diet 1800®, Richmond Hill, ON). Glochidia for testing were collected by flushing the marsupia (i.e., brooding chambers) with a water-filled syringe. The viability of each mussel's glochidia was assessed (described below) prior to use. Prior to initiating an exposure, glochidia collected from gravid mussels held at 10 °C, were gradually (over 2–3 h) acclimated to the exposure temperature (21 °C) through dilutions with room temperature reconstituted water. Glochidia were pooled from a minimum of three gravid females for each experiment. For the endangered species, glochidia were only collected from one marsupium gill, and each mussel was returned to the location from which they were collected to facilitate the release of remaining glochidia in their natural habitat.

2.2. Toxicity testing

Acute toxicity tests with glochidia were modeled after the American Society for Testing and Materials' method for conducting toxicity tests with the early life stages of freshwater mussels (ASTM, 2006). Briefly, the viability of glochidia were evaluated after exposure to waterborne contaminants. In order to parasitize fish, glochidia must be viable, which means they must be able to close their valves and clamp down on a fish's gill in order to encyst. Glochidia viability (i.e., ability to close valves) was assessed prior to exposure and after 24 h of exposure in a sub-sample (100–200) of the glochidia (500–1000) through the addition of a saturated salt solution (NaCl 240 g L^{-1}). Viability was calculated using the following equation: Percent Viability = 100 × (Number of closed glochidia after NaCl addition − Number of closed glochidia before NaCl addition)/(Number of closed glochidia after NaCl addition + Number of open glochidia after NaCl addition). Results are expressed as (chloride) effective median concentrations (EC50) rather than median lethal concentrations (LC50), but as they are obligatory parasites, for practical purposes non-viable glochidia should be considered 'dead' because they would be unable to attach to a host fish and complete their life cycle.

The ASTM (2006) method indicates that glochidia control survival remain above 90%. Therefore, for toxicity tests conducted in reconstituted water, pre-exposure ($t = 0$) and post-exposure ($t = 24$ h) control survival (i.e. viability) were determined. In addition, for toxicity tests conducted in natural waters, 24 h control survival in each river water (without salt augmentation) was determined.

An aqueous stock made from certified ACS grade (Fisher Scientific) sodium chloride (NaCl) was used to create exposure solutions. Waters (reconstituted or field-collected) were spiked with NaCl (nominal, 0–10 g NaCl L^{-1}) and held in the dark at 4 °C for 48 h before initiation of an exposure. Exposures were conducted in 250 mL glass beakers, under a 16:8 light:dark cycle at 21 ± 2 °C. Water quality including dissolved oxygen (DO), pH, alkalinity, dissolved organic carbon (DOC), water hardness as well as the concentration of major ions (Na, K, Ca) and trace metals were assessed at exposure initiation. DO, pH and Cl were also measured upon completion of an exposure. Water analysis was conducted by the Canadian National Laboratory for Environmental Testing (Environment Canada, Burlington, ON). Chloride was measured by Ion Chromatography (detection limit (DL) 0.02 mg L^{-1}). Mean chloride recovery was 100.4% (STD 0.36) using the National Water Research Institute's (NWRI) certified reference material ION-915. Metals, including copper, were measured by ICP-SFMS (copper DL 0.02 µg L^{-1}). Mean copper recovery was 100% (STD 0.16) using the National Research Council of Canada's certified reference material SLRS-4. DOC (DL 0.1 mg L^{-1}) was measured by a UV Persulfate Total Organic Carbon Analyzer. Mean DOC recovery was 95.5% (STD 0.2) using NWRI's certified reference material WINN-02. Major ions (e.g. potassium, DL 0.01 mg L^{-1}) were analyzed by Atomic Absorption Spectrometry. Mean potassium recovery was 99.4% (STD 0.4) using VHG Labs (New Hampshire) certified reference material QWSMIN. Glassware was acid washed with 10% nitric acid (Reagent Grade, Fisher Scientific) prior to use and solutions were made with Millipore™ water.

2.3. Chloride sensitivity in reconstituted waters

A series of toxicity tests were conducted with NaCl and reconstituted waters (ASTM, 2003). For each species studied at least one acute toxicity test was conducted in moderately-hard reconstituted water (95–115 mg $CaCO_3$ L^{-1}). In addition, a series of exposures were conducted in reconstituted waters of varying hardness (range 47–322 mg $CaCO_3$ L^{-1}) using *L. siliquoidea* glochidia.

2.4. Chloride sensitivity in natural waters

A series of toxicity tests were conducted with water collected from four significant mussel habitats in southern Ontario (Table 1). River water (10 L) was collected just below the surface where the water was visibly flowing. Water samples were held in the dark at 4 °C until used in an exposure (maximum one week). Acute exposures in NaCl-spiked natural waters were conducted with *L. fasciola* glochidia as described above.

In addition to the *L. fasciola* natural water exposures, another natural water test was conducted with *P. fasciolaris* glochidia. Unlike the other species examined which release free glochidia, *P. fasciolaris* produces conglutinates. These small packets of glochidia (100–200) resemble fish prey and serve to enhance infection of host fish. Two intact conglutinates were used in each replicate test concentration. One conglutinate was opened (by gently tearing casing with fine forceps) after 24 h and the other after 48 h of exposure to assess the viability of the encased glochidia (24 h data shown). Because the number of conglutinates was limited, an exposure with chloride-spiked natural water was selected as the most ecologically relevant test to conduct with this endangered species.

2.5. Statistical analysis

Chloride EC50s and EC20s were determined by Probit Analysis (Statistical Package for the Social Sciences (SPSS)) version 11.0 using measured chloride concentrations and presented with 95% confidence intervals (CI) (e.g. EC50 (95% CI). EC50s and EC20s were considered to be significantly different when their 95% CI did not overlap (Environment Canada, 2005). Linear regression analysis was conducted (SigmaStat version 3.2) to examine the relationship between water hardness and chloride toxicity (EC50s). Note: Although EC50s and EC20s are reported with respect to the chloride component of NaCl, no attempt was made to determine the toxic

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Table 1
Summary of selected water chemistry[a] parameters for four Canadian rivers used in acute sodium chloride exposures with *Lampsilis fasciola* glochidia, along with pre-exposure ($t = 0$) viability, and post-exposure ($t = 24$ h) reconstituted water and un-spiked river water control survival.

Water source[b]	Chloride ($mg\,L^{-1}$)	Potassium ($mg\,L^{-1}$)	Copper ($\mu g\,L^{-1}$)	DOC ($mg\,L^{-1}$)	pH	Water hardness ($mg\,CaCO_3\,L^{-1}$)	% Viability, $t = 0$	% Viability reconstituted water, $t = 24$	% Viability river water, $t = 24$ h
Sydenham River	34.1	4.6	6.0	4.5	8.25	292	91.5	91.7	92.8
Grand River	66.8	3.3	4.9	6.2	8.62	278	91.5	91.7	89.1
Maitland River	57.4	5.8	5.6	6.7	8.32	322	91.0	87.1	85.1
Thames River	75.2	4.7	4.9	4.4	8.29	306	91.0	87.1	78.1

[a] Measured chloride, potassium, copper, dissolved organic carbon (DOC), pH, and water hardness values represent background concentrations in un-spiked river water.
[b] Rivers located in Ontario, Canada.

mode of action of NaCl in glochidia, therefore this study cannot distinguish whether glochidia are responding to the chloride ion or the sodium ion.

2.6. Chloride concentrations and mussel distribution data in southern Ontario

To assess the potential threat that chloride poses to freshwater mussels, the chloride levels in key mussel habitats in southern Ontario were examined. In Ontario, watersheds are managed locally by Conservation Authorities. The Canadian Department of Fisheries and Oceans has produced distribution lists of endangered mussels and fish species for each Conservation Authority (CA). Therefore, mussel distribution data and chloride concentrations are presented according to CA. Four CAs were selected for in-depth analysis of field-measured chloride levels and laboratory toxicity tests with waters from these habitats. The CAs selected along with their main mussel habitat (i.e. river) were the Grand River CA (Grand River), St. Clair Region CA (Sydenham River), Maitland Valley CA (Maitland River), and Upper Thames River and Lower Thames Valley CAs (Thames River). For the purposes of this summary, data from the Upper and Lower Thames CAs were combined. Chloride concentrations measured from 1998 to 2008 at 105 sites across the CAs were determined by the (Ontario) Provincial Water Quality Monitoring Network (PWQMN) and provided by the Ontario Ministry of the Environment (PWQMN, 2009).

Individual chloride concentrations at each site were averaged over time. These 'site averages' were then averaged to determine an overall mean for each CA, referred herein to as a "CA Mean". Site averages, rather than individual readings were used to calculate each CA Mean to prevent skewing of the mean by differences in sampling frequency or extreme readings. The 'CA Range' demonstrates the maximum and minimum individual chloride concentrations across the CA over the 10 years examined. The number of endangered mussel species reported for each CA was obtained from Canadian Department of Fisheries and Oceans (DFO) maps (DFO, 2010).

3. Results

3.1. Chloride sensitivity in reconstituted waters

Glochidia control survival (24 h) for the four mussel species employed in NaCl exposures with moderately-hard reconstituted water is presented in Table 2. With one exception (*L. siliquoidea*, 2008), all tests met the ASTM (2006) requirement of less than 10% drop in control survival. The 24 h chloride EC50s ranged from 113 mg Cl L^{-1} for *L. fasciola* (2008) to 1430 mg Cl L^{-1} for *L. siliquoidea* (2009) (Fig. 1). In addition to interspecific variation, *L. siliquoidea* glochidia collected from different water bodies exhibited significantly different EC50s. Those collected from Cox Creek (2008) produced an EC50 of 168 (135–198) mg Cl L^{-1}, while those collected from the Maitland River (2009) produced an EC50 of 1430 (1350–2953) mg Cl L^{-1}. In contrast, both tests (2008, 2009) of *L. fasciola* glochidia from a single field site produced relatively similar EC50s (113 (63–163), 285 (163–451) mg Cl L^{-1}, respectively).

A series of exposures with *L. siliquoidea* glochidia demonstrated that chloride sensitivity is influenced by water hardness (Table 3). A linear relationship between the 24 h chloride EC50s and water hardness ($r^2 = 0.97$) was observed for water hardness between 47 and 172 mg $CaCO_3$ L^{-1}, but no further protection was afforded when hardness increased to 322 mg $CaCO_3$ L^{-1}.

Table 2
Pre-exposure ($t = 0$) viability and post-exposure ($t = 24$ h) control survival for freshwater mussel glochidia as well as observed 24 h chloride EC50s (95% confidence intervals) from sodium chloride exposures conducted in reconstituted water.

Mussel species	% Viability ($t = 0$)	% Viability ($t = 24$)	EC50 (95% CI) ($mg\,Cl\,L^{-1}$)
Lampsilis siliquoidea[a] (2008)	91.3	77.4	168 (135–189)
Lampsilis siliquoidea (2009)	93.4	93.2	1430 (1350–2953)
Lampsilis cardium	91.1	88.3	817 (770–869)
Lampsilis fasciola[b] (2008)	91.9	92.2	113 (63–163)
Lampsilis fasciola (2009)	93.8	91.4	285 (163–451)
Epioblasma torulosa rangiana	95.2	91.3	244 (230–260)

[a] Gravid *L. siliquoidea* were collected from different water bodies in 2008 and 2009.
[b] Gravid *L. fasciola* were collected from the same site in 2008 and 2009.

3.2. Chloride sensitivity in natural waters

Control survival of *L. fasciola* glochidia in the field-collected waters was more variable (78–93%) than in reconstituted water (87–92%) (Table 1). The 24 h chloride EC50 values for *L. fasciola* glochidia were similar across the natural waters tested (1265–1559 mg Cl L^{-1}) (Table 4), but all were significantly higher than the EC50 (285 (163–451) mg Cl L^{-1}) produced in reconstituted water with glochidia from the same gravid females. The 24 h natural water control survival for *P. fasciolaris*'s conglutinate encased glochidia was 95% and the EC50 was 3416 (3059–3835) mg Cl L^{-1}.

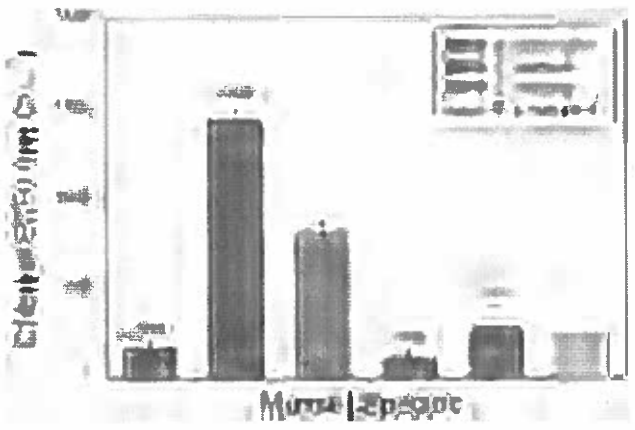


Fig. 1. Chloride EC50s (24 h) for glochidia (larvae) of four species of freshwater mussels. Exposures were conducted in reconstituted moderately-hard water (95–115 mg $CaCO_3$ $mg\,L^{-1}$). Error bars represent 95% confidence intervals around the EC50. Asterisks indicate Canadian endangered species. Toxicity tests with *Lampsilis siliquoidea* and *Lampsilis fasciola* were conducted in both 2008 and 2009. *L. siliquoidea* were collected from different water bodies. *L. fasciola* were collected from the same field site both years.

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Table 3
Concentrations of chloride, potassium, and water hardness for reconstituted waters employed in acute sodium chloride exposures with *Lampsilis siliquoidea* glochidia as well the pre-exposure ($t = 0$) viability, post-exposure ($t = 24$ h) control survival, and observed 24 h chloride EC50.

Reconstituted water	Chloride (mg L^{-1})	Potassium (mg L^{-1})	Water hardness (mg $CaCO_3$ L^{-1})	% Viability ($t = 0$)	% Viability ($t = 24$)	EC50 (95% CI) (mg Cl L^{-1})
Soft	1.8	1.0	47	89.5	87.7	763 (523–1214)
Moderately-hard	2.8	2.4	99	93.4	93.2	1430 (1350–1518)
Hard	5.5	4.7	172	89.5	86.4	1962 (1447–2953)
Very hard	8.9	9.4	322	93.4	90.7	1870 (1595–2225)

3.3. Chloride concentrations and mussel distribution in southern Ontario

A summary of chloride concentrations in four rivers in southern Ontario, along with the number of mussels species found in each habitat is presented in Table 4. Water hardness for the selected rivers ranged from 278 to 322 mg $CaCO_3$ L^{-1}. Although the range in mean chloride concentration was narrow (38–58 mg Cl L^{-1}), the range of individual measured chloride concentrations over the 10 years examined was much broader, covering 2–1300 mg L^{-1}.

4. Discussion

4.1. Chloride sensitivity in reconstituted waters

Acute toxicity testing in reconstituted water revealed that glochidia were sensitive to chloride, although significant interspecific and in one case intraspecific variation was observed. The EC50 values for free glochidia of the four mussel species tested ranged from 113 to 1430 mg Cl L^{-1} (Fig. 1). This 13 fold difference in chloride sensitivity between mussel species was not unlike the variation observed by Wang et al. (2007) (12 fold for 9 species) and Gillis et al. (2008) (5 fold for 8 species) in the acute sensitivity of glochidia to copper. Although chloride toxicity data for glochidia is limited, NaCl has been used as a reference toxicant for glochidia toxicity tests. Bringolf et al. (2007) reported EC50s from 0.55 to 3.3 g NaCl L^{-1} (334–2008 mg Cl L^{-1}) for five species of mussel glochidia, Valenti et al. (2007) reported EC50s from 2.68 to 3.08 g NaCl L^{-1} (1625–1868 mg Cl L^{-1}) for three species, and finally Cope et al. (2008) reported EC50s of 2.0 and 2.7 g NaCl L^{-1} (1213–1638 mg Cl L^{-1}) for *L. siliquoidea* glochidia. In this study there also appears to be intraspecific variation in chloride sensitivity. Although *L. fasciola* collected from the same site (Grand River, ON) on two different occasions produced somewhat similar EC50s (113 and 285 mg Cl L^{-1}), *L. siliquoidea* glochidia from two separate water bodies produced EC50s that varied by eight fold (Maitland River, 1430 mg L^{-1}; Cox Creek 168 mg L^{-1}). Perhaps the discrepancy is simply due to the fact that one batch of glochidia was healthier (Maitland River, control survival 93.2%) than the other (Cox Creek, control survival 77.4%) or perhaps prior exposure or even acquired tolerance may alter the response of glochidia to contaminants. But regardless, these data indicate that mussels from different water bodies may respond differently to chloride. While this observation was only based on the chloride sensitivity of one mussel species from two watersheds, possible differences in contaminant sensitivity across watersheds should be considered when selecting gravid females for toxicity testing with glochidia.

Even taking the variability between species into account, glochidia are still notably more sensitive to chloride than most previously tested aquatic organisms. While a full review of chloride toxicity in freshwater organisms is beyond the scope of this paper, Table 5 illustrates that compared to other groups, freshwater mussel larvae, were more sensitive to chloride. Particularly interesting is that some species of mussel glochidia (Fig. 1) experience chloride toxicity at a fraction of the concentration required to kill *Daphnia* (Mount et al., 1997; Harmon et al., 2003), a standard test organism often used to assess the toxicity of chemicals and effluents. Implications of this sensitivity for natural populations of freshwater mussels are discussed below.

4.2. Effect of water hardness

Water hardness had a significant effect on the sensitivity of glochidia to chloride. A two fold increase in the EC50 was observed when hardness increased from 47 to 99 mg $CaCO_3$ L^{-1}, but further increases in hardness were less effective at protecting glochidia (Table 3). The ameliorating effect of water hardness on chloride toxicity has been previously documented, in fact the state of Iowa has recently (2009) updated water quality criteria for chloride to adjust for water hardness (Iowa Department of Natural Resources,

Table 4
Summary of chloride concentrations in four significant mussel habitats in southern Ontario, the total number of mussel species and species at risk found in each habitat, as well as the observed 24 h chloride EC50s and EC20s for *Lampsilis fasciola* glochidia in toxicity tests conducted with salt-spiked samples of those waters.

Conservation authority	CA mean chloride (mg L^{-1})	CA range chloride (mg L^{-1})	Observed EC50 (mg L^{-1})	Observed EC20 (mg L^{-1})	Total mussel species	Mussels species at risk[a,b]
Grand River	53 (1), $n = 45$	2–507	1313 (1239–1394)	432 (365–496)	25[c]	9
St. Clair Region	42 (14), $n = 9$	8–149	1559 (1338–1824)	403 (155–617)	34[d]	12
Maitland Valley	38 (29), $n = 13$	7–212	1391 (1308–1481)	261 (174–342)	9[e]	2
Upper Thames River & LowerThames Valley	58 (38), $n = 38$	6–1300	1265 (1167–1372)	153 (34–258)	26[f]	11

Watersheds in Ontario are organized by Conservation Authority (CA). Chloride data provided by the Ontario Ministry of the Environment (2009). Mean chloride values and ranges are for data collected from 1998 to 2008. Values reported as 'Mean' are the average of all site averages (repeated sampling at one site over time) for each CA. The number of individual site averages used to determine a 'CA Mean' (with standard deviation) is reported as *n*.

[a] Endangered species in Canada are designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2007).
[b] Endangered species data, Department of Fisheries and Oceans, 2010.
[c] Metcalfe-Smith et al., 2000.
[d] Jacques Whitford Environment Limited, 2004.
[e] D.J. McGoldrick, J.L. Metcalfe-Smith, Environment Canada, Burlington, ON, Canada, unpublished data.
[f] Morris and Edwards, 2007.

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Table 5
Acute toxicity of chloride (LC50s or EC50s) to various aquatic organisms illustrating the range of previously reported[a] sensitivities for each group.

Taxonomic Group	Species	Exposure duration (h)	LC50 (mg Cl L^{-1})	Reference
Molluscs	Glochidia[b] (4 species)	24	113–1430	Current study
	Glochidia[b] (5 species)	24	334–2008	Bringolf et al. (2007)
	Glochidia[b] (3 species)	24	1625–1868	Valenti et al. (2007)
	Glochidia[b] (1 species)	24	1213–1638	Cope et al. (2008)
	Physa sp. (snail)	96	3257	Clemens and Jones (1954)
Cladocerans	*Daphnia ambigua*	48	1213	Harmon et al. (2003)
	Daphnia magna	48	2893	Mount et al. (1997)
Amphibians	*Ambystoma maculatum* (larvae)	96	1178	Collins and Russell (2009)
	Bufo americanus (larvae)	96	3926	Collins and Russell (2009)
Fish	*Pimephales promelas*	96	3876	Mount et al. (1997)
	Fundulus kansae	96	9706	Clemens and Jones (1954)

[a] Data were limited to peer-reviewed publications.
[b] Free glochidia (i.e. not encased in conglutinates).

2009). The protection provided by hard water is beneficial for the freshwater mussels of southern Ontario as many key mussel habitats have very hard water (Table 1).

4.3. Chloride sensitivity in natural waters

L. fasciola glochidia were significantly less sensitive to salt in natural water than in reconstituted water. Some of the discrepancy can be explained by difference in water hardness because all of the natural waters tested were much harder (278–322 mg $CaCO_3$ L^{-1}) than the moderately-hard reconstituted water (100 $CaCO_3$ L^{-1}) used in the *L. fasciola* exposures. However, the four fold difference in EC50s is much larger than would be expected based solely on the difference in hardness because the *L. siliquoidea* exposures with a similar increase (100–322 mg $CaCO_3$ L^{-1}) produced less than a 30% difference in the chloride EC50. These data suggest that in addition to the protection provided by elevated water hardness that other water chemistry factors contributed to the reduced toxicity of chloride in natural waters.

The EC50 (3416 mg Cl L^{-1}) of conglutinate encased *P. fasciolaris* glochidia exposed to the salt-augmented water of the Grand River is nearly three times that of *L. fasciola* glochidia in the same water. This could simply be another example of intraspecific variation in glochidia contaminant sensitivity, or it could indicate that the life history strategy of encasing glochidia in conglutinates not only facilitates host transfer, but may also provide protection for the encased glochidia from chloride and potentially other ionic waterborne contaminants. For the current study it is not possible to determine the reason for the higher EC50 in conglutinate encased glochidia, although a previous study demonstrated that *P. fasciolaris* conglutinate encased glochidia were four fold less sensitive to copper than glochidia released from their conglutinate (Gillis et al., 2008).

The advantage of using reconstituted waters in toxicity tests is that they provide consistency and permit comparison between studies and between species; the disadvantage is that EC50s produced in reconstituted water may not necessarily predict how an organism will respond to that contaminant in its natural environment. On the other hand, one disadvantage of natural water exposures is that other contaminants may be present which can contribute to toxicity. Perhaps the variable (78–93%) control survival in the natural waters examined was due to other contaminants. One such contaminant of concern is potassium which is much more toxic than chloride. Imlay (1973) observed that only 2 of 10 rivers in the United States with potassium concentrations greater than 4 mg L^{-1} supported freshwater mussels, whereas 28 of 39 rivers with levels less than 4 mg L^{-1} were found to support mussels. All four natural waters tested were at or near this apparent threshold (Table 1). Moreover, preliminary data (Gillis unpublished) indicate that glochidia are sensitivity to potassium (*L. fasciola* 24 h moderately-hard reconstituted water LC50, 10 mg K L^{-1}). The potential effect of elevated potassium on freshwater mussel recovery requires further study especially because potassium chloride is currently being used as an alternative to sodium chloride for winter road maintenance (Evans and Frick, 2001). There have also been concerns that in some water bodies copper may be negatively impacting freshwater mussels (March et al., 2007; Ward et al., 2007). Background copper levels in the natural waters tested ranged from 5 to 6 μg L^{-1} (Table 1), but considering the level of DOC in these waters (>4 mg C L^{-1}) it is unlikely that copper contributed to the observed toxicity (Gillis et al., 2010; Wang et al., 2009). Unfortunately no comment can be made on the potential contribution of organic contaminants (such as pesticides) to the variation in control survival because these water samples were not analyzed for organics.

4.4. Implications for native populations of mussels

The rivers and streams of the lower Great Lakes Basin contain the richest assemblage of freshwater mussels in Canada (Metcalfe-Smith et al., 1998). After surveying historic (pre-1960) and more recent (up to 1996) mussel distribution data for southern Ontario, Metcalfe-Smith et al. (1998) concluded that significant species losses (15–30%) had already occurred, thereby verifying that the freshwater mussel decline documented in the U.S. (Neves et al., 1997) is also occurring in Canada. Although, many factors from exotic species to habitat loss (Williams et al., 1993; Bogan, 1993; Gillis and Mackie, 1994) are thought to have contributed to the decline of freshwater mussels, the role of waterborne contaminants remains uncertain. The chloride levels in the mussel habitats examined along with the heightened sensitivity of glochidia to NaCl suggest that chloride may in fact be impacting freshwater mussels in the lower Great Lake Basin. Even though the 'Mean' chloride concentrations (10–50 mg Cl L^{-1}) indicate that during the majority of the year, chloride levels are below the EC50, there are many documented instances where chloride concentrations would be toxic to glochidia. Even considering the higher EC50s produced in field-collected water (1265–1559 mg Cl L^{-1}), some rivers such as the Thames River, a habitat that supports eleven federally endangered species of mussels can exceed (1300 mg L^{-1}) the level found to be toxic to 50% of the glochidia.

Based on the results of this study, it is clear that even short-term spikes in chloride during the period of glochidia release would have

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a negative impact on the successful reproduction of freshwater mussels. Fortunately for most species, timing appears to be in the glochidia's favor, because the largest chloride spikes typically coincide with snowmelt (PWQMN, 2009), months before glochidia are released into the water column. However, many mussel species are referred to as long term brooders. This means that glochidia are held in the marsupial gills throughout the winter and released the following spring (Barnhart et al., 2008). Although there is evidence that brooding glochidia are less sensitive to waterborne copper than those released to the water column (Jacobson et al., 1997), it is unknown whether brooding glochidia are affected by the chloride laden waters their mothers are exposed to in early spring. While glochidia are only present in the water column during the spring and summer months, juvenile mussels, which have also been shown to be sensitive to some waterborne contaminants (Wang et al., 2007) would be exposed to chloride throughout the year. Another potential and likely year-round source of chloride is contaminated groundwater (Kincaid and Findlay, 2009). Juvenile mussels, because they remain burrowed in the sediment for their first few years of life, would be most at risk from elevated chloride from groundwater upwelling. Although the present study examined the potential risk of chloride toxicity in lotic habitats of freshwater mussels, urban basin analysis suggests the potential for chloride toxicity may be even greater in lentic habitats. Chloride contributes to densimetric stratification of receiving waters (Marsalek, 2003; Eyles and Meriano, 2010) which results in higher chloride concentrations just above the sediment-water interface in static or slow moving water bodies. Such stratification could exacerbate the risk of acute chloride toxicity for freshwater mussels living in embayments and lakes subjected to road salt runoff.

5. Conclusion

This study has demonstrated that compared to most other aquatic organisms that glochidia are very sensitive to chloride. It has also been demonstrated that increased water hardness and natural river water offer 'protection' from acute chloride toxicity. But even considering these ameliorating factors, the level of chloride, likely from road salt runoff, in key mussel habitats in the lower Great Lakes Basin, may pose a threat to the successful reproduction and thus recovery of endangered freshwater mussels in this area.

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References

ASTM E729-96, 2003. Standard Guide for Conducting Acute Toxicity Tests on Test Materials with Fishes, Macroinvertebrates and Amphibians. ASTM International, West Conshohocken, PA.

ASTM E2455-05, 2006. Standard Guide for Conducting Laboratory Toxicity Tests with Freshwater Mussels. ASTM International, West Conshohocken, PA.

Augspurger, T., Keller, A.E., Black, M.C., Cope, W.G., Dwyer, F.J., 2003. Water quality guidance for the protection of freshwater mussels (Unionidae) from ammonia exposure. Environmental Toxicology and Chemistry 22, 2569–2575.

Barnhart, M.C., Haag, W.R., Roston, W.N., 2008. Adaptations to host infection and larval parasitism in Unionoida. Journal of the North American Benthological Society 27, 370–394.

Bogan, A.E., 1993. Freshwater bivalve extinctions (Mollusca: Unionidae): a search for causes. American Zoologist 33, 599–609.

Bringolf, R.B., Cope, W.G., Barnhart, M.C., Mosher, S., Lazaro, P.R., Shea, D., 2007. Acute and chronic toxicity of pesticide formulations (atrazine, chlorpyrifos and permethrin) to glochidia and juveniles of *Lampsilis siliquoidea*. Environmental Toxicology and Chemistry 26, 2086–2093.

Clemens, H.P., Jones, W.H., 1954. Toxicity of brine water from oil wells. Transactions of the American Fisheries Society 84, 97–109.

Collins, S.J., Russell, R.W., 2009. Toxicity of road salt to Nova Scotia amphibians. Environmental Pollution 157, 320–324.

Cope, W.G., Bringolf, R.B., Buchwalter, D.B., Newton, T.J., Ingersoll, C.G., Wang, N., Augspurger, T., Dwyer, F.J., Barnhart, F.C., Neves, R.J., Hammer, E., 2008. Differential exposure, duration, and sensitivity of unionoidean bivalve life stages to environmental contaminants. Journal of the North American Benthological Society 27, 451–462.

COSEWIC, 2007. Canadian Species at Risk. Available at. Committee on the Status of Endangered Wildlife in Canada. www.cosewic.gc.ca.

Department of Fisheries and Oceans, 2010. Distribution maps for mussel and fish species at risk. Available at. www.conservation-ontario.on.ca/projects/DFO.html.

Environment Canada and Health Canada, 2001. Priority Substances List Assessment Report for Road Salts, ISBN 0-662-31018-7 Cat. No. En40-215/63E.

Environment Canada, 2005. Guidance Document on Statistical Methods for Environmental Toxicity Tests. Method Development and Applications Section. Environmental Technology Centre, Environment Canada. Report EPS 1/RM/46.

Evans, M., Frick, C., 2001. The effects of road salts on aquatic ecosystems. National Water Research Institute Contribution Series No. 02-308.

Eyles, N., Meriano, M., 2010. Road-impacted sediment and water in a Lake Ontario watershed and lagoon, City of Pickering, Ontario, Canada: an example of urban basin analysis. Sedimentary Geology 224, 15–28.

Gillis, P.L., Mackie, G.L., 1994. Impact of the zebra mussel, *Dreissena polymorpha*, on populations of Unionidae (Bivalvia) in Lake St. Clair. Canadian Journal of Zoology 72, 1260–1271.

Gillis, P.L., Mitchell, R.J., Schwalb, A.N., McNichols, K.A., Mackie, G.L., Wood, C.M., Ackerman, J.D., 2008. Sensitivity of the glochidia (larvae) of freshwater mussels to copper: assessing the effect of water hardness and dissolved organic carbon on the sensitivity of endangered species. Aquatic Toxicology 88, 137–145.

Gillis, P.L., McGeer, J.C., Wilkie, W.P., Mackie, G.L., Ackerman, J.D., 2010. The effect of natural dissolved organic carbon on the acute toxicity of copper to larval freshwater mussels (glochidia). Environmental Toxicology and Chemistry 29, 2519–2528.

Harmon, S.M., Specht, W.L., Chandler, G.T., 2003. A comparison of the Daphnids *Ceriodaphnia dubia* and *Daphnia ambigua* for their utilization in routine toxicity testing in the Southeastern United States. Archives of Environmental Contamination and Toxicology 45, 79–85.

Howard, K.W.F., Haynes, J., 1993. Groundwater contamination due to road de-icing chemicals – salt balance implications. Geoscience Canada 20, 1–8.

Imlay, M.J., 1973. Effects of potassium on survival and distribution of freshwater mussels. Malacologia 2, 97–113.

Iowa Department of Natural Resources, 2009. Water quality standards review: chloride, sulfate and total dissolved solids. Available at. http://www.iowadnr.gov/water/standards/chloride.html.

Jackson, R.B., Jobbágy, E.G., 2005. From icy roads to salty streams. Proceedings of the National Academy of Sciences of the United States of America 102, 14487–14488.

Jacobson, P.J., Neves, R.J., Cherry, D.S., Farris, J.L., 1997. Sensitivity of glochidial stages of freshwater mussels (Bivalvia: Unionidae) to copper. Environmental Toxicology and Chemistry 16, 2384–2392.

Jacques Whitford Environment Limited, 2004. Sydenham River Recovery Project: Synthesis and Analysis of Background Data; Project No. ONO50368: Ottawa, ON.

Kaushal, S.S., Groffman, P.M., Likens, G.E., Belt, K.T., Stack, W.P., Kelly, V.R., Band, L.E., Fisher, G.T., 2005. Increased salinization of fresh water in the northeastern United States. Proceedings of the National Academy of Sciences of the United States of America 102, 13515–13520.

Kelly, V.R., Lovett, G.M., Weathers, K.C., Findlay, S.E.G., Strayer, D.L., Burns, D.J., Likens, G.E., 2008. Long-term sodium chloride retention in a rural watershed: legacy effects of road salt on streamwater concentration. Environmental Science and Technology 42, 410–415.

Kincaid, D.W., Findlay, S.E., 2009. Sources of elevated chloride in local streams: groundwater and soil as potential reservoirs. Water, Air, and Soil Pollution 203, 335–342.

Lydeard, C., Cowie, R.H., Onder, W.F., Bogan, A.E., Bouchet, P., Clark, S.A., Cummings, K.S., Fresh, T.J., Gorgominy, O., Herbert, D.G., Hershler, R., Perez, K.E., Roth, B., Seddon, M., Strong, E.E., Thompson, F.G., 2004. The global decline of nonmarine mollusks. BioScience 54, 321–330.

March, F.A., Dwyer, F.J., Augspurger, T., Ingersoll, C.G., Wang, N., Mebane, C.A., 2007. An evaluation of water quality guidance and standards for copper. Environmental Toxicology and Chemistry 26, 2066–2074.

Marsalek, J., 2003. Road salts in urban storm water: an emerging issue in storm water management in cold climates. Water Science and Technology 48, 61–70.

Metcalfe-Smith, J.L., Staton, S.K., Mackie, G.L., Lane, N.M., 1998. Changes in the biodiversity of 9 freshwater mussels in the Canadian waters of the lower Great Lakes drainage basin over the past 140 years. Journal of Great Lakes Research 24, 845–858.

Metcalfe-Smith, J.L., Mackie, G.L., Di Maio, J., Staton, S.K., 2000. Changes over time in the diversity and distribution of freshwater mussels (Unionidae) in the Grand River, Southwestern Ontario. Journal of Great Lakes Research 26, 445–459.

Morris, T.J., Edwards, A., 2007. Freshwater Mussel Communities of the Thames River, Ontario: 2004–2005. Manuscript 2810. Canadian Manuscript Report of Fisheries and Aquatic Sciences, Ottawa, ON.

Electronic Filing: Received, Clerk's Office 3/14/2019

Mount, D.R., Gulley, D.D., Hockett, J.R., Garrison, T.D., Evans, J.M., 1997. Statistical models to predict the toxicity of major ions to *Ceriodaphia dubia*, *Daphnia magna*, and *Pimephales promelas* (Fathead minnows). Environmental Toxicology and Chemistry 16, 2009–2019.

Neves, R.J., Bogan, A.E., Williams, J.D., Ahlstedt, S.A., Hartfield, P.W., 1997. Status of aquatic mollusks in the southeastern United States: a downward spiral of diversity. In: Benz, G.W., Collins, D.E. (Eds.), Aquatic Fauna in Peril: The Southeastern Perspective Special Publication 1. Southeast Aquatic Research Institute; Lenz Design and Communications, Decatur, GA, pp. 43–85.

Parmalee, P.W., Bogan, A.E., 1998. The Freshwater Mussels of Tennessee. University of Tennessee Press, Knoxville, TN, pp 328.

PWQMN. Provincial Water Quality Monitoring Network, 2009. Dataset Records: 2009. Available at. Ontario Ministry of the Environment. http://www.ene.gov.on.ca/envision/water/pwqmn/index.htm.

Ricciardi, A., Rasmussen, J.B., 1999. Extinction rates of North American freshwater fauna. Conservation Biology 13, 1220–1222.

Roy, J.W., Bickerton, G., 2010. Proactive screening approach for detecting groundwater contaminants along urban streams at the reach-scale. Environmental Science and Technology 44, 6088–6094.

Strayer, D.L., Downing, J.A., Haag, W.R., King, T.L., Layzer, J.B., Newton, T.J., Nichols, S.J., 2004. Changing perspectives on pearly mussels, North America's most imperiled species. BioScience 54, 429–439.

Trowbridge, P.R., Kahl, J.S., Sassan, D.A., Heath, D.L., Walsh, E.M., 2010. Relating road salt to exceedances of the water quality standard for chloride in New Hampshire streams. Environmental Science and Technology 44, 4903–4909.

Valenti, T.W., Cherry, D.S., Neves, R.J., Locke, B.A., Schmerfeld, J.J., 2007. Case study: sensitivity of mussel glochidia and regulatory test organisms to mercury and a reference toxicant. In: Farris, J.L., Van Hassel, J.H. (Eds.), Freshwater Bivalve Ecotoxicology. CRC Press, Pensacola, FL, pp. 351–367.

Wang, N., Ingersoll, C.G., Hardesty, D.K., Ivey, C.D., Kunz, J.L., May, T.W., Dwyer, F.J., Roberts, A.D., Augspurger, T., Kane, C.M., Neves, R.J., Barnhart, M.C., 2007. Acute toxicity of copper, ammonia, and chlorine to glochidia and juvenile mussels. Environmental Toxicology and Chemistry 26, 2036–2047.

Wang, N., Mebane, C.A., Kunz, J.L., Ingersoll, C.G., May, T.W., Arnold, W.R., Santore, R.C., Augspurger, T., Dwyer, F.J., Barnhart, M.C., 2009. Evaluation of acute copper toxicity to juvenile freshwater mussels (fatmucket, *Lampsilis siliquoidea*) in natural and reconstituted waters. Environmental Toxicology and Chemistry 28, 2367–2377.

Ward, S., Augspurger, T., Dwyer, F.J., Kane, C., Ingersoll, C.G., 2007. Risk assessment of water quality in three North Carolina streams supporting federally-endangered freshwater mussels. Environmental Toxicology and Chemistry 26, 2075–2085.

Williams, J.D., Warren, M.L., Cummings, K.S., Harris, J.L., Neves, R.J., 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18, 6–22.

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Temperature affects acute mayfly responses to elevated salinity: implications for toxicity of road de-icing salts

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Salinity in freshwater ecosystems has increased significantly at numerous locations throughout the world, and this increase often reflects the use or production of salts from road de-icing, mining/oil and gas drilling activities, or agricultural production. When related to de-icing salts, highest salinity often occurs in winter when water temperature is often low relative to mean annual temperature at a site. Our study examined acute (96 h) responses to elevated salinity (NaCl) concentrations at five to seven temperature treatments (5–25°C) for four mayfly species (Baetidae: *Neocloeon triangulifer*, *Procloeon fragile*; Heptageniidae: *Maccaffertium modestum*; Leptophlebiidae: *Leptophlebia cupida*) that are widely distributed across eastern North America. Based on acute LC50s at 20°C, *P. fragile* was most sensitive (LC50 = 767 mg l^{-1}, 1447 µS cm^{-1}), followed by *N. triangulifer* (2755 mg l^{-1}, 5104 µS cm^{-1}), *M. modestum* (2760 mg l^{-1}, 5118 µS cm^{-1}) and *L. cupida* (4588 mg l^{-1}, 8485 µS cm^{-1}). Acute LC50s decreased as temperature increased for all four species (n = 5–7, R^2 = 0.65–0.88, p = 0.052–0.002). Thus, acute salt toxicity is strongly temperature dependent for the mayfly species we tested, which suggests that brief periods of elevated salinity during cold seasons or in colder locations may be ecologically less toxic than predicted by standard 20 or 25°C laboratory bioassays.

This article is part of the theme issue 'Salt in freshwaters: causes, ecological consequences and future prospects'.

1. Introduction

Salinity in fresh waters is naturally variable, primarily reflecting differences in concentrations of dissolved inorganic cations calcium, magnesium and sodium, and anions carbonate, sulfate and chloride [1,2]. The differences in ion concentrations among fresh waters primarily reflect the weathering of soil and bedrock underlying a watershed, atmospheric deposition, and the evaporation–precipitation cycle. Sodium is generally less common than calcium and magnesium, and chloride is generally less common than carbonate or sulfate in natural waters. Elevated Na and Cl concentrations have been observed in effluents from wastewater treatment plants that reflect use of water softeners, table salt in the human diet, and disinfection before discharge [3,4], in wastewaters from some industrial, coal mining, and oil and gas production activities [5–7], in runoff and groundwater associated with various agricultural practices [8], and in road runoff following applications of de-icing products such as rock salt and anti-icing brines [9–13]. Recent analyses of multi-year data have found that sodium and chloride concentrations in surface waters have been increasing over the last two to five decades, at multiple locations (e.g. [14–18], and more recently [19–21]). This increase in sodium and chloride is part of a worldwide trend for increasing salinity along with pH and alkalinity [22–27], which was recently labelled the Freshwater Salinization Syndrome [28,29].

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With these increases in ambient salinity, there has been renewed interest in the toxicity of salt in our aquatic ecosystems. Building on early toxicity tests [30], researchers have again begun examining salt toxicity by focusing on specific ions such as sodium, magnesium, chloride, carbonate, and sulfate (e.g. delivered as NaCl, $MgCl_2$, Na_2SO_4) for a variety of aquatic algae [31], insects and other macroinvertebrates [32–41], mussels [42–46], zooplankton [47,48], amphibians [49,50], and fish [32,51–53]. Other researchers have approached salt toxicity as a function of total salinity (as salt concentration or electrical conductivity), rather than as an ion-specific issue (e.g. [54–57]). The challenge in both cases is general applicability of findings as it is well known that ion composition is important to overall salt toxicity [30,58–62]. Additional references can be found in review articles [63–69]. Salt toxicity has been found to vary greatly among aquatic species, with recent data showing that some mayflies and juvenile mussels are among the most sensitive species tested [34,52,56,70]. The combination of salt sensitivity and elevated ambient salinity suggests that, at least at times, salt may reach levels that may have a negative affect on aquatic organisms [10,31,71–76].

There are two challenges in understanding the potential salinity toxicity under field conditions in colder climates where de-icing salts can increase salinity dramatically during snow/ice storms. First, most salt toxicity studies have been conducted at constant 17–25°C, which are the recommended test temperatures for standard acute and chronic toxicity tests for many species, [77,78]. However, in colder climates where de-icing salts are frequently used, water temperature can vary naturally across seasons, with winter lows of 0–10°C versus summer highs of 20–30°C (e.g. figure 1). In addition, there can be significant differences among years (e.g. an interannual range of 10°C or more; figure 1). It has been found that temperature can affect toxicity of many chemicals [79–86]. For most toxins and species, the relationship between temperature and toxicity is positive—increases in temperature result in increased toxicity (i.e. a lower LC50). Mayer & Ellersieck [80] summarized the relationship as a 10°C increase in temperature results in a two- to fourfold decrease in the LC50. Second, streams and rivers that exhibit a long-term increase in Na and Cl concentrations also often exhibit a strong seasonal cycle that includes frequent, short-term snow and ice events when salinity can be many times greater than at base flow (figure 2) [87,88]. This is a sharp contrast to streams with little urbanization (e.g. figure 1 and [88]). Unfortunately, the magnitude and duration of these events are often not well quantified in the historic data because these data are primarily periodic grab samples while snow and ice events are better described with a continuously recording sensor. While the recent studies of salt toxicity have addressed the range of conditions needed to set regulatory limits [47,89], they have not included seasonal temperature variation as part of their analyses.

This paper describes a series of experiments that examine lethal responses of mayfly (Ephemeroptera) larvae in acute (96 h) exposures to elevated salinity (i.e. NaCl added to moderately hard source water) at five to seven different temperatures. The results show how understanding the experimental relationship between temperature and salt toxicity can provide important insight into the toxicity of ambient salt concentrations, especially those originating from winter de-icing programmes.

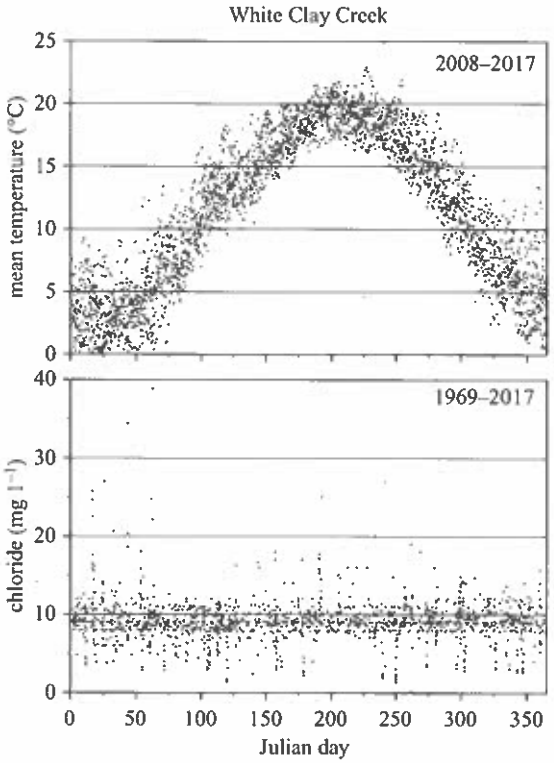


Figure 1. Long-term seasonal variation (date plotted as Julian day) in water temperature (mean daily from various continuous recorders, 2008–2017) and chloride concentration (from grab samples, 1969–2017) for White Clay Creek at the Stroud Water Research Center, 39°51′38.41″ N, 75°47′01.96″ W. Values greater than 20 mg Cl l^{-1} are presumably evidence of local de-icing efforts during winter. (Online version in colour.)

2. Methods

(a) Source water

Water for all tests was collected from White Clay Creek at the Stroud Water Research Center (39°51′38.41″ N, 75°47′01.96″ W), Chester Co. Pennsylvania, a limestone-influenced, headwater stream that drains a 7 km^2, rural (less than 0.5% developed) watershed and is moderately hard (mean 97 mg CO_3^{2-} l^{-1}) with relatively low salinity (143.8 mg l^{-1}, table 1). Seasonal patterns in temperature and chloride (as an indicator of de-icing salts affecting background salinity) from long-term data for White Clay Creek are shown in figure 1. The temperature treatments (see below) are representative of the range of conditions these test mayfly populations have experienced for generations in White Clay Creek. In contrast, the relatively low salinity in the historic data suggests that these wild mayfly populations from White Clay Creek have not been exposed to sodium or chloride concentrations similar to those in our experimental treatments in the last 50 years. Background concentrations on four dates when water was collected for laboratory bioassays averaged 6.6 mg l^{-1} for sodium and 12.3 mg l^{-1} for chloride (table 1).

To provide context for laboratory results, field data were collected every 5 min (30 Mar 2017–1 May 2018) with a Decagon CTD-10 (electrical conductivity or specific conductance corrected to 25°C, temperature, depth) sensor in Rocky Run, First State National Historic Park, New Castle County, Delaware, USA (39°49′00.45″ N and 75°33′02.84″ W), which drains a highly urbanized (60% developed), 2 km^2 watershed about 20 km from the Stroud Water Research Center. Salinity for Rocky Run was estimated from the conductivity : salinity relationship used in our experiments with White Clay Creek water, where salinity =

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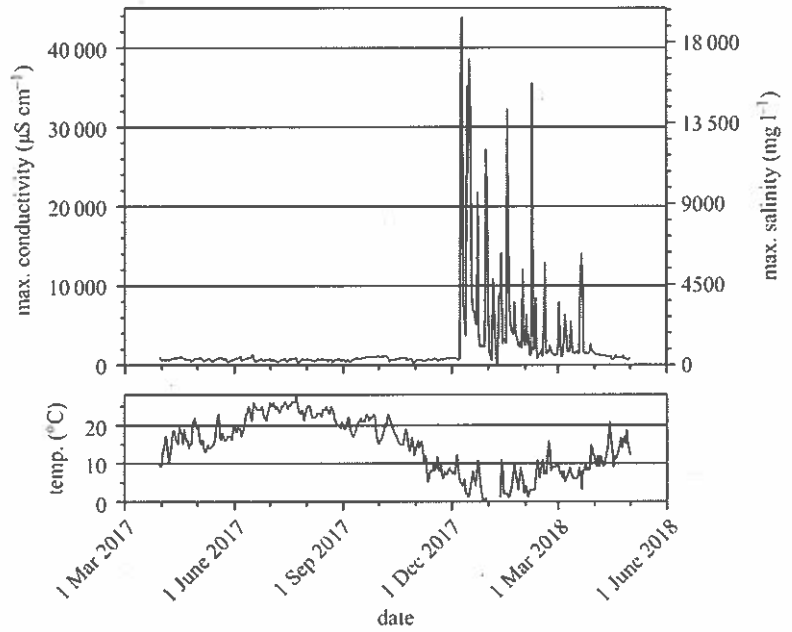


Figure 2. Seasonal variation (from 30 March 2017 to 1 May 2018) in maximum daily salinity as conductivity ($\mu S\ cm^{-1}$) and $mg\ l^{-1}$, and maximum daily temperature (°C) for Rocky Run, First State National Historic Park, New Castle County, Delaware. (Online version in colour.)

Table 1. Chemical characteristics of moderately hard water from White Clay Creek, PA used in acute toxicity tests in 2016. TDS, total dissolved salts.

date:	4 Apr 2016	16 Apr 2016	12 May 2016	5 June 2016	
time:	06.30	07.00	08.30	11.45	mean
pH	7.7	8.2	7.7	7.8	7.9
conductivity ($\mu S\ cm^{-1}$)	238	232	239	241	238
alkalinity ($mg\ l^{-1}$)	71.3	66.0	67.8	69.2	68.6
hardness ($mg\ CO_3^{2-}\ l^{-1}$)	96	93	97	100	97
Ca^{2+} ($mg\ l^{-1}$)	23.9	23.9	24.7	26.6	24.8
Mg^{2+} ($mg\ l^{-1}$)	8.8	8.0	8.6	8.2	8.4
K^+ ($mg\ l^{-1}$)	2.0	1.6	1.7	1.9	1.8
Na^+ ($mg\ l^{-1}$)	7.1	6.1	6.5	6.5	6.6
Cl^- ($mg\ l^{-1}$)	13.0	12.1	12.0	12.2	12.3
SO_4^{2-} ($mg\ l^{-1}$)	17.0	17.6	17.5	17.2	17.3
TDS ($mg\ l^{-1}$)	139	160	152	152	152.5

(electrical conductivity − 23.099)/1.844, where salinity is in $mg\ l^{-1}$, and electrical conductivity is in $\mu S\ cm^{-1}$ at 25°C.

(b) Study species

Mayflies were chosen for this study because Ephemeroptera are ecologically significant in most streams and rivers, and they are considered pollution sensitive and have historically played important roles in water quality monitoring programmes [90–92]. We quantified acute responses to short-term (96 h) chloride exposures for four mayfly species that are common in White Clay Creek (where test species were collected) and widely distributed in eastern North America. *Neocloeon triangulifer* (McDunnough 1931) was until recently called *Centroptilum triangulifer* [93] and before that *Cloeon triangulifer* [94]. It is a parthenogenetic (clonal) mayfly species [95,96] that is most abundant during summer, when it has a relatively rapid larval development (egg hatch to adult in 25–30 days at 20°C). We worked with Stroud Water Research Center (SWRC) Clone WCC-2®, which occurs in low larval numbers during the winter, with minimal growth below 9.6°C. This specific clone has also been recently used in a number of experiments examining the toxic effects of cadmium, mercury, selenium and zinc [97–102], and chloride and sulfate salts [34,36,38–40]. *Procloeon fragile* (McDunnough 1923) was for many years called *Centroptilum fragile* [94]. It is a sexual mayfly species that exhibits a life history similar to that of *N. triangulifer* except that it has a winter egg diapause. *Maccaffertium modestum* (Banks, 1910) was long known as *Stenonema modestum*, but was recently reclassified [103]. It is a sexual

Table 2. Acute (96 h) salinity toxicity (LC50; geometric mean with 95% CI) expressed as mg l^{-1} and µS cm^{-1} for four mayfly species exposed to elevated NaCl in five to seven constant temperature (°C) treatments.

	LC50 per temperature treatment (geometric mean with 95% CI, mg l^{-1} and µS cm^{-1})						
species	5°C	7.5°C	10°C	12.5°C	15°C	20°C	25°C
salinity (mg l^{-1})							
N. triangulifer	9655 (8751–10 653)	10 462 (9655–11 337)	6719 (5541–8148)	5101 (4843–5373)	2573 (389–17 017)	2755 (2018–3762)	364 (171–773)
P. fragile			6874 (4595–10 284)	4115 (3111–5443)	3239 (1662–6312)	767 (187–3146)	766 (748–784)
L. cupida	10 086 (9037–11 257)	10 152 (9299–11 083)	10 439 (8551–12 743)	11 908 (11 650–12 172)	8368 (6955–10 067)	4588 (3108–6774)	3216 (1821–5678)
M. modestum		7236 (6005–8719)	5429 (2442–12 067)	7792 (5483–11 075)	7808 (3742–16 293)	2760 (1436–5303)	1656 (680–4035)
electrical cond. (µS cm^{-1})							
N. triangulifer	17 829 (16 161–19 668)	19 317 (17 829–20 929)	12 414 (10 241–15 049)	9430 (8953–9932)	4788 (739–31 042)	5104 (3745–6958)	698 (335–1453)
P. fragile			12 700 (8495–18 986)	7612 (5759–10 060)	5997 (3086–11 656)	1447 (367–5707)	1435 (1402–1469)
L. cupida	18 623 (16 688–20 782)	18 744 (17 172–20 461)	19 273 (15 792–23 522)	21 983 (21 506–22 470)	15 454 (12 849–18 587)	8485 (5754–12 514)	5955 (3381–10 487)
M. modestum		13 366 (11 096–16 102)	10 036 (4525–22 260)	14 393 (10 133–20 444)	14 425 (6923–30 053)	5118 (2676–9788)	3081 (1274–7451)

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species that exhibits a bivoltine or multivoltine life history at White Clay Creek, with larval development of about 80 days at 20°C. *Leptophlebia cupida* (Say 1923) is a sexual mayfly species that exhibits a univoltine life history that begins with eggs hatching in mid-June and adult emergence the following April.

(i) Experimental treatments

We quantified acute responses of four mayfly species in short-term (96 h) exposures to elevated NaCl (A.C.S. reagent; J.T. Baker 33624-05). NaCl was chosen for these experiments because it represents 90–98% of the rock salt (halite) used for de-icing roads [104]. We conducted 100 temperature-specific acute tests (each test had one replicate of 20 individuals for each salinity treatment), with 20 newly hatched 1st instar larvae for *N. triangulifer*, *P. fragile*, *L. cupida* or *M. modestum* placed in a 30 ml beaker containing 15 ml of treatment solution. Newly hatched larvae were chosen because younger/smaller individuals are often more sensitive than older/larger individuals of the same species [55,105–107].

Each toxicity test had six treatments: a control (0 mg NaCl l^{-1} added to White Clay water) and five elevated salinity treatments that represented a 50% dilution series (i.e. 412, 824, 1649, 3297, 6594 mg NaCl l^{-1} added to White Clay water for *N. triangulifer* and *P. fragile*, and 824, 1649, 3297, 6594, 13 188 mg NaCl l^{-1} added to White Clay water for *L. cupida* and *M. modestum*). These were static (no renewal) experiments, conducted at five to seven constant (±0.1°C) temperature treatments (i.e. 10, 12.5, 15, 20, 25°C for all species, with the addition of a 7.5°C treatment for *M. modestum* and 5 and 7.5°C treatments for *N. triangulifer* and *L. cupida*). A diatom slurry (i.e. *ca* 20 µl of biofilm scrapings suspended in White Clay water) was provided as food in each test vessel for *N. triangulifer* and *P. fragile*. Food was not provided in *L. cupida* and *M. modestum* tests. Four replicate tests were run for each temperature treatment. Photoperiod (light : dark) was 16 : 8 h during the tests. Temperature in the rearing system was recorded every 5 min, and calibrated with a certified thermometer. Salinity across treatments was monitored with a calibrated conductivity meter.

Mayfly response was reported as survivorship after 96 h, and summarized as the lethal salinity associated with 50% mortality (or LC50) estimated using the nonparametric trimmed-Spearman–Karber method [76,108] of test population at a specific temperature. The relationship between temperature and LC50 for each species was assessed with a simple linear regression of geometric means. Linear regressions were used because it was a simple assessment of the relationship between five to seven temperature treatments and salinity toxicity, and because regression slope was consistent across the temperature range, which facilitates interpretation and incorporation into regulatory standards.

3. Results and discussion

(a) Interspecific differences in mayfly sensitivity to elevated salinity

Control survival was greater than 90% in most of the acute toxicity tests reported for *P. fragile*, *N. triangulifer* and *L. cupida*, and those tests with slightly higher control mortality were still included in these analyses as their dose-responses were similar to other tests. Survival was less than 90% for many tests with *M. modestum* (suggesting this species should be fed during 96 h tests), but the response to temperature was similar to the other mayfly species and is included in this report. However, because of low control survival, the LC50s for *M. modestum* should be used with caution until further verification.

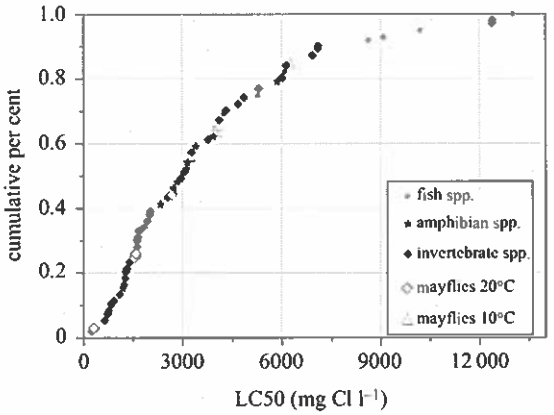


Figure 3. Relative sensitivities for the mayflies *N. triangulifer*, *P. fragile*, *M. modestum*, and *L. cupida* based on LC50s (expressed as mg Cl l^{-1}, electronic supplementary material, table S1) for 10 and 20°C (table 2) plotted with fish, amphibian and invertebrate data included in fig. 3 from [52].

Mean LC50s estimated by the nonparametric trimmed-Spearman–Karber method are expressed as salinity (mg l^{-1}) and electrical conductance (µS cm^{-1}) in table 2. We prefer to compare toxicities among mayflies at 20°C because it appears in some mayfly species we have examined that 25°C is physiologically stressful, independent of the chemical stressor being evaluated. Based on acute LC50s at 20°C, *P. fragile* was most sensitive (LC50 = 767 mg l^{-1}, 1447 µS cm^{-1}), followed by *N. triangulifer* (2755 mg l^{-1}, 5104 µS cm^{-1}) and *M. modestum* (2760 mg l^{-1}, 5118 µS cm^{-1}), and finally *L. cupida* (4588 mg l^{-1}, 8485 µS cm^{-1}) (table 2). NaCl toxicity for *N. triangulifer* has been examined in earlier studies [34,36,39], but all at 25°C. The acute LC50 for *N. triangulifer* at 25°C in our study was markedly lower than LC50 we observed at 20°C as well as the LC50s estimated by Soucek & Dickinson [34], Struewing *et al.* [36], and Soucek *et al.* [39]. Our LC50s for 25°C for all four mayfly species were not out of line with LC50s from colder temperature treatments, and the temperature versus LC50 regressions fitted the data relatively well (see below), so we do not currently have an explanation for differences observed among the studies of *N. triangulifer*. When salinity was expressed as electrical conductivity (µS cm^{-1} or mS cm^{-1}), the LC50s we observed for the baetids *P. fragile* and *N. triangulifer* (1447–5104 µS cm^{-1}) were similar to those observed for the baetid *Centroptilum* sp. (1.8–5.6 mS cm^{-1} in [59], and 10 mS cm^{-1} in [57]), and less than was observed for the baetid *Cloeon* sp. (21 mS cm^{-1} in [57]).

Mayflies are generally considered pollution sensitive, and are important contributors to metrics used to assess pollution impacts [90–92]. When we compared the LC50s for our mayflies at 20°C (expressed as mg Cl l^{-1}, electronic supplementary material, table S1) relative to the acute LC50s included in fig. 3 of [52], *P. fragile* was among the most sensitive species, *M. modestum* and *N. triangulifer* was moderately sensitive (*ca* 25th percentile) and *L. cupida* was average (45th percentile) (figure 3). Relative sensitivity for mayflies in our study would be even higher if we used LC50s from the common test temperature of 25°C (table 2)—*P. fragile*, *N. triangulifer* and *M. modestum* would be among the most sensitive, and *L. cupida* would be moderately sensitive.

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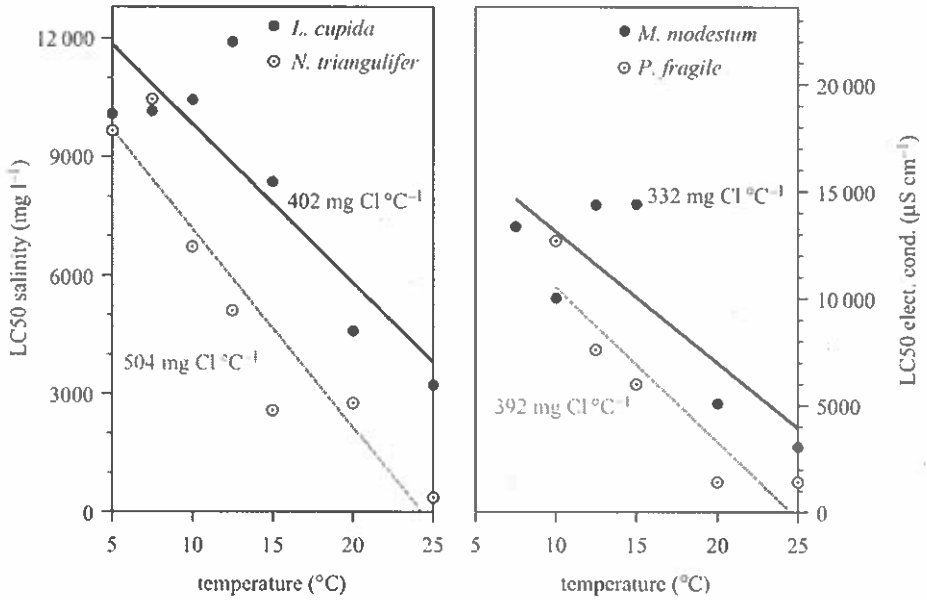


Figure 4. Simple linear regressions describing the relationship between temperature and acute salinity LC50s for the mayflies *L. cupida*, *N. triangulifer*, *M. modestum* and *P. fragile*.

Table 3. Simple linear regression results for figure 4 describing the relationship between temperature and acute salinity toxicity expressed as LC50 (geometric means, mg l^{-1}).

species	*N*	Pr > F	R^2	intercept	slope
N. triangulifer	7	0.002	0.881	12 211.2	−503.7
P. fragile	5	0.026	0.850	9616.0	−391.8
L. cupida	7	0.011	0.756	13 851.5	−402.2
M. modestum	6	0.052	0.653	10 425.3	−331.9

Conversely, the mayflies in our study would not be considered sensitive if we used LC50s from the 10°C test temperature (figure 3) We saw similar relative sensitivity when our study mayflies were compared to the mayflies and other macroinvertebrates presented in Wang *et al.* [70], and in the broader global survey of salinity sensitivity for mayflies and other macroinvertebrates in Kefford *et al.* [56].

The four mayfly species included in our study were not selected based on presumed or known pollution sensitivity. In fact, it is possible there are mayfly species that are as or more sensitive to elevated salinity than the species we examined. Our data, in combination with other published observations such as Wang *et al.* [70] and Kefford *et al.* [56], support the general belief that mayflies as a group are relatively sensitive to elevated salinity, although the physiological mechanisms surrounding mayfly sensitivity to salt remain to be determined [109]. Cormier *et al.* [110] defined a maximum acute benchmark of 680µS cm^{-1} for salinity derived from field observations of occurrence for 142 stream macroinvertebrate genera and annual chemistry data. While this hypothetical benchmark might not be directly comparable with our laboratory studies (Cormier *et al.* [110] eliminated several sites with high chloride), 680 µS cm^{-1} (=369 mg l^{-1} in our study) would appear to be over-protective for all species based on the LC50s at 5–10°C, and protective for *N. triangulifer*, *M. modestum* and *L. cupida*, and possibly *P. fragile*, based on the LC50s at 20°C. The benchmark might not be protective for *P. fragile* and *N. triangulifer* based on the LC50s at 25°C.

It is important to note that salinity toxicity is known to vary among salts and dilution waters tested [30,39,41,47,58–61], so our toxicities for elevated salinity that is predominately NaCl must be used with caution when referring to other de-icing and anti-icing salts such as $MgCl_2$, $CaCl_2$, KCl or calcium magnesium acetate ($CaMg_2(CH_3COO)_6$), to the 'chemical cocktail' that characterizes the Freshwater Salinization Syndrome [29], or to ambient waters with natural salinities that are markedly lower or higher than in White Clay Creek (e.g. a soft-water stream or a limestone stream).

(b) Changes in salinity toxicity in response to temperature

The relationship between salinity toxicity and temperature is important because, in regions where de-icing salts are frequently used, water temperature can change significantly with seasons (figure 1). Moreover, salinity from de-icing efforts peaks following snow and ice events when stream temperature is often nearest its lowest level, and well below the 20 or 25°C temperature used in standard bioassays (figure 2). We observed a significant or nearly significant ($n = 5–7$, $R^2 = 0.65–0.88$, $p = 0.052–0.002$) decrease in toxicity (i.e. acute LC50s increased) as temperature decreased for all four species (figure 4 and table 3). Based on the

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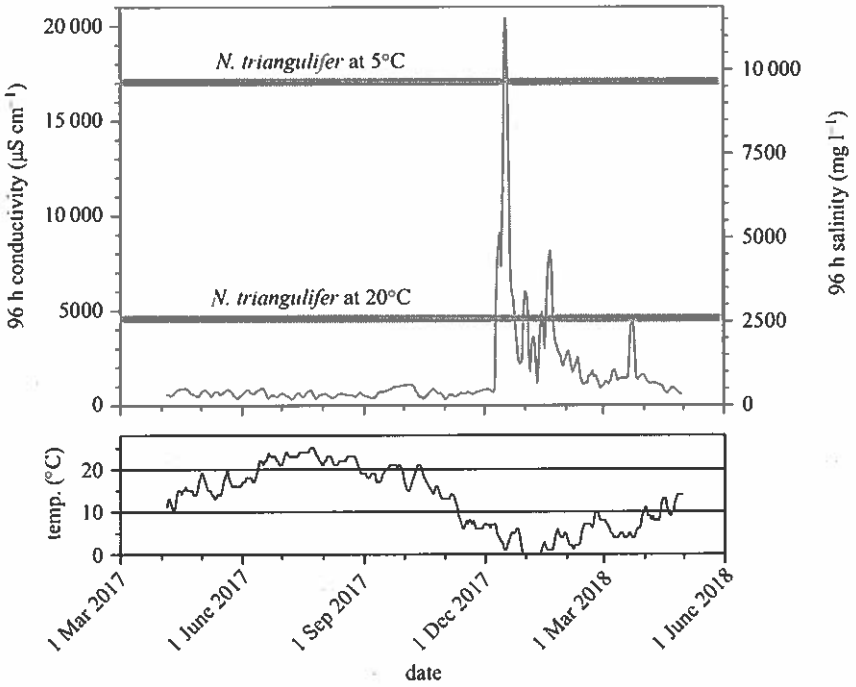


Figure 5. Plot showing mean 96 h LC50 for *N. triangulifer* at 5 and 20°C with seasonal variation (from 30 March 2017 to 1 May 2018) in 96 h running salinity as conductivity (µS cm^{-1}) and mg l^{-1}, and 96 h mean running daily temperature (°C) for Rocky Run, First State National Historic Park, New Castle County, Delaware, USA. (Online version in colour.)

regression slopes, the rate of change was similar for *P. fragile*, *M. modestum* and *L. cupida*. Their LC50s decreased between 332 and 402 mg l^{-1} for each 1°C increase in temperature. The response for *N. triangulifer* was somewhat stronger and its LC50s decreased 504 mg l^{-1} for each 1°C increase in temperature. The LC50s for *L. cupida* and *M. modestum* increased 1.7–1.9-fold for each 10°C decrease in temperature while the LC50s for *N. triangulifer* and *P. fragile* increased 3.5–3.6-fold for each 10°C decrease. This difference between *L. cupida* and *M. modestum* versus *P. fragile* reflects the estimated LC50s relative to the rate of change per °C. The species with lowest LC50 (*P. fragile*) increased proportionally more per °C than species with higher LC50s (*L. cupida* and *M. modestum*). The higher proportional change for *N. triangulifer* reflects a moderately low LC50 with a higher rate of change per °C. Our results almost match the summarization by Mayer & Ellersieck [80] that a 10°C increase in temperature results in a two- to fourfold decrease in the LC50. There are a few studies where reduced salt toxicity has been observed at lower versus higher temperature [73,111,112], but the relationship between acute salt toxicity and temperature has not been quantified in a manner that can be applied to water quality criteria (table 3).

To illustrate how the interaction between temperature and salinity toxicity provides important perspective to understanding aquatic ecosystems receiving de-icing salts, we took the raw data used to generate figure 2 and calculated 96 h (i.e. the duration of the acute toxicity tests) running mean values for conductivity, salinity (from conductivity) and temperature (figure 5). We then added the LC50 for *N. triangulifer* at 5°C and 20°C to figure 5. Based on the LC50 at 20°C, there were 21 dates that were preceded by 96 h with an average salinity that exceeded the LC50 at 20°C. In contrast, based on the LC50 at 5°C (which is more representative of thermal conditions at the time of elevated salinity), there were only two dates that were preceded by 96 h with an average salinity that exceeded the LC50 at 5°C. Thus, accounting for lower salt toxicity for an acute exposure at low temperature can change one's perspective on the apparent toxicity of ambient conditions during winter. However, it is important to note that, even after accounting for lower toxicity at 5–10°C, salinity in Rocky Run still appears to have been acutely toxic (i.e. ≥50% mortality in a 96 h period) for all four mayflies we examined. This suggests that elevated salinity (e.g. averaging 9500–11 500 mg l^{-1} for 96 h) during winter when snow and ice management programmes are being implemented may contribute to the overall impairment of the macroinvertebrate assemblage in Rocky Run, and probably other small urban streams that receive salt-laden runoff from roads, car parks and pavements. However, this is not to suggest that elevated (but not peak) salt concentrations during winter are not contributing to overall impairment. These non-peak exposures are more frequent (i.e. exposure time can be longer), and based on results for polar marine invertebrates, exposure time must be considered in the evaluation and interpretation of potential impact of toxicants at cold temperature [113,114].

(c) Regulatory and management implications of the relationship between salinity toxicity and temperature

As salinization of freshwater ecosystems resulting from de-icing and anti-icing salts continues, the regulatory and management challenge for winter road maintenance programmes will be to balance the need to protect public safety and reduce the economic costs of winter storms with the need to protect environmental health and infrastructure integrity related to excess salt, and to address potential drinking water/public health related to increased dietary intake of

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sodium [4,21,115,116]. Our study found low temperature can reduce the frequency or intensity of salt-related toxic events expected based on winter de-icing activities that increase NaCl concentrations. But it also shows that NaCl concentrations during winter can be so high that NaCl-related toxic events may still occur even after accounting for low temperature. Our results can also be applied to other activities that result in acute exposure to elevated salt. For example, spills or discharges of high salinity wastewaters such as oil and gas brine [6,7] may have more of an impact in summer, when both the stored wastewater and receiving stream water are seasonally warmer, than in winter, when both are cool. The negative relationship between temperature and salt toxicity we observed highlights the potential importance in considering water temperature when interpreting current environmental conditions or events, or setting regulatory standards for salinity or NaCl.

Data accessibility. Data are available as electronic supplementary material.

Authors' contributions. Overall project and experimental design: J.K.J. and D.H.F.; experimental set-up and data collection: D.H.F.; data analyses and interpretation: J.K.J. and D.H.F.; drafted manuscript: J.K.J.; edited manuscript: J.K.J. and D.H.F.

Competing interests. We declare we have no competing interests.

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References

1. Wetzel RG. 2001 *Limnology: lake and river ecosystems*, 3rd edn. San Diego, CA: Academic Press.
2. Griffith MB. 2014 Natural variation and current reference for specific conductivity and major ions in wadeable streams of the conterminous USA. *Freshw. Sci.* **33**, 1–17. (doi:10.1086/674704)
3. Kelly WR, Panno SV, Hackley KC. 2012 Impacts of road salt runoff on water quality of the Chicago, Illinois, region. *Environ. Eng. Geosci.* **18**, 65–81. (doi:10.2113/gseegeosci.18.1.65)
4. Kelly WR, Panno SV, Hackley KC, Hwang HH, Martinsek AT, Markus M. 2010 Using chloride and other ions to trace sewage and road salt in the Illinois Waterway. *Appl. Geochem.* **25**, 661–673. (doi:10.1016/j.apgeochem.2010.01.020)
5. Yudovich YE, Ketris MP. 2006 Chlorine in coal: a review. *Int. J. Coal Geol.* **67**, 127–144. (doi:10.1016/j.coal.2005.09.004)
6. Haluszczak LO, Rose AW, Kump LR. 2013 Geochemical evaluation of flowback brine from Marcellus gas wells in Pennsylvania, USA. *Appl. Geochem.* **28**, 55–61. (doi:10.1016/j.apgeochem.2012.10.002)
7. Lauer NE, Harkness JS, Vengosh A. 2016 Brine spills associated with unconventional oil development in North Dakota. *Environ. Sci. Technol.* **50**, 5389–5397. (doi:10.1021/acs.est.5b06349)
8. Estévez E, Rodríguez-Castillo T, González-Ferreras AM, Cañedo-Argüelles M, Barquín J. 2019 Drivers of spatio-temporal patterns of salinity in Spanish rivers: a nationwide assessment. *Phil. Trans. R. Soc. B* **374**, 20180022. (doi:10.1098/rstb.2018.0022)
9. Granato GE. 1996 Deicing chemicals as source of constituents of highway runoff. *Transport Res. Rec.* **1533**, 50–58. (doi:10.3141/1533-08)
10. Corsi SR, Graczyk DJ, Geis SW, Booth NL, Richards KD. 2010 A fresh look at road salt: aquatic toxicity and water-quality impacts on local, regional, and national scale. *Environ. Sci. Technol.* **44**, 7376–7382. (doi:10.1021/es101333u)
11. Corsi SR, De Cicco LA, Lutz MA, Hirsch RM. 2015 River chloride trends in snow-affected urban watersheds: increasing concentrations outpace urban growth rate and are common among all seasons. *Sci. Total Environ.* **508**, 488–497. (doi:10.1016/j.scitotenv.2014.12.012)
12. Kelting DL, Laxson CL, Yerger EC. 2012 Regional analysis of the effect of paved roads on sodium and chloride in lakes. *Water Res.* **46**, 2749–2758. (doi:10.1016/j.watres.2012.02.032)
13. Kerr JG. 2017 Multiple land use activities drive riverine salinization in a large, semi-arid river basin in western Canada. *Limnol. Oceanogr.* **62**, 1331–1345. (doi:10.1002/lno.10498)
14. Godwin KS, Hafner SD, Buff MF. 2003 Long-term trends in sodium and chloride in the Mohawk River, New York: the effect of fifty years of road-salt application. *Environ. Pollut.* **124**, 273–281. (doi:10.1016/S0269-7491(02)00481-5)
15. Interlandi SJ, Crockett CS. 2003 Recent water quality trends in the Schuylkill River, Pennsylvania, USA: a preliminary assessment of the relative influences of climate, river discharge and suburban development. *Water Res.* **37**, 1737–1748. (doi:10.1016/S0043-1354(02)00574-2)
16. Thunqvist EL. 2004 Regional increase of mean chloride concentration in water due to the application of deicing salt. *Sci. Total Environ.* **325**, 29–37. (doi:10.1016/j.scitotenv.2003.11.020)
17. Kaushal SS, Groffman PM, Likens GE, Belt KT, Stack WP, Kelly VR, Band LE, Fisher GT. 2005 Increased salinization of fresh water in the northeastern United States. *Proc. Natl Acad. Sci. USA* **102**, 13 517–13 520. (doi:10.1073/pnas.0506414102)
18. Kelly WR. 2008 Long-term trends in chloride concentrations in shallow aquifers near Chicago. *Ground Water* **46**, 772–781. (doi:10.1111/j.1745-6584.2008.00466.x)
19. Dugan HA *et al.* 2017 Salting our freshwater lakes. *Proc. Natl Acad. Sci. USA* **114**, 4453–4458. (doi:10.1073/pnas.1620211114)
20. Smith AJ, Duffy BT, Onion A, Heitzman DL, Lojpersberger JL, Mosher EA, Novak MA. 2018 Long-term trends in biological indicators and water quality in rivers and streams of New York State (1972–2012). *River Res. Appl.* **34**, 442–450. (doi:10.1002/rra.3272)
21. Stets EG, Lee CJ, Lytle DA, Schock MR. 2018 Increasing chloride in rivers of the conterminous US and linkages to potential corrosivity and lead action level exceedances in drinking water. *Sci. Total Environ.* **613**, 1498–1509. (doi:10.1016/j.scitotenv.2017.07.119)
22. Williams WD. 1987 Salinization of rivers and streams: an important environmental hazard. *Ambio* **15**, 180–185.
23. Williams WD. 2001 Anthropogenic salinisation of inland waters. *Hydrobiologia* **466**, 329–337. (doi:10.1023/A:1014598509028)
24. Bailey, PCE, Boon, PI, Blinn, DW, Williams, WD. 2006 Salinization as an ecological perturbation to rivers, streams and wetlands of arid and semi-arid zones. In *Changeable, changes, changing: the ecology of rivers from the world's dry regions* (ed. R Kingsford), pp. 280–314. Cambridge, UK: Cambridge University Press.
25. Cañedo-Argüelles M *et al.* 2016 Saving freshwater from salts. *Science* **351**, 914–916. (doi:10.1126/science.aad3488)
26. Cañedo-Argüelles M, Kefford BJ, Piscart C, Prat N, Schäfer RB, Schulz CJ. 2013 Salinisation of rivers: an urgent ecological issue. *Environ. Pollut.* **173**, 157–167. (doi:10.1016/j.envpol.2012.10.011)
27. Herbert ER, Boon P, Burgin AJ, Neubauer SC, Franklin RB, Ardón M, Hopfensperger KN, Lamers LP, Gell P. 2015 A global perspective on wetland salinization: ecological consequences of a growing

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threat to freshwater wetlands. *Ecosphere* **6**, 1–43. (doi:10.1890/ES14-00534.1)

28. Kaushal SS, Likens GE, Pace ML, Utz RM, Haq S, Gorman J, Grese M. 2018 Freshwater salinization syndrome on a continental scale. *Proc. Natl Acad. Sci. USA* **115**, E574–E583. (doi:10.1073/pnas.1711234115)
29. Kaushal SS *et al.* 2019 Novel 'chemical cocktails' in inland waters are a consequence of the freshwater salinization syndrome. *Phil. Trans. R. Soc. B* **374**, 20180017. (doi:10.1098/rstb.2018.0017)
30. Mount DR, Gulley DD, Hockett JR, Garrison TD, Evans JM. 1997 Statistical models to predict the toxicity of major ions to *Ceriodaphnia dubia, Daphnia magna* and *Pimephales promelas* (fathead minnows). *Environ. Toxicol. Chem.* **16**, 2009–2019. (doi:10.1897/1551-5028(1997)016<2009:SMTPTT>2.3.CO;2)
31. Porter-Goff ER, Frost PC, Xenopoulos MA. 2013 Changes in riverine benthic diatom community structure along a chloride gradient. *Ecol. Indic.* **32**, 97–106. (doi:10.1016/j.ecolind.2013.03.017)
32. Elphick JRF, Bergh KD, Bailey HC. 2011 Chronic toxicity of chloride to freshwater species: effects of hardness and implications for water quality guidelines. *Environ. Toxicol. Chem.* **30**, 239–246. (doi:10.1002/etc.365)
33. Baek MJ, Yoon TJ, Kim DG, Lee CY, Cho K, Bae YJ. 2014 Effects of road deicer runoff on benthic macroinvertebrate communities in Korean freshwaters with toxicity tests of calcium chloride ($CaCl_2$). *Water Air Soil Pollut.* **225**, 1961–1966. (doi:10.1007/s11270-014-1961-6)
34. Soucek DJ, Dickinson A. 2015 Full-life chronic toxicity of sodium salts to the mayfly *Neocloeon triangulifer* in tests with laboratory cultured food. *Environ. Toxicol. Chem.* **34**, 2126–2137. (doi:10.1002/etc.3038)
35. Soucek DJ, Mount DR, Dickinson A, Hockett JR, McEwen AR. 2015 Contrasting effects of chloride on growth, reproduction, and toxicant sensitivity in two genetically distinct strains of *Hyalella azteca*. *Environ. Toxicol. Chem.* **34**, 2354–2362. (doi:10.1002/etc.3070)
36. Struewing KA, Lazorchak JM, Weaver PC, Johnson BR, Funk DH, Buchwalter DB. 2015 Part 2: sensitivity comparisons of the mayfly *Centroptilum triangulifer* to *Ceriodaphnia dubia* and *Daphnia magna* using standard reference toxicants; NaCl, KCl and $CuSO_4$. *Chemosphere* **139**, 597–603. (doi:10.1016/j.chemosphere.2014.04.096)
37. Kotalik CJ, Clements WH, Cadmus P. 2017 Effects of magnesium chloride road deicer on montane stream benthic communities. *Hydrobiologia* **799**, 193–202. (doi:10.1007/s10750-017-3212-5)
38. Scheibener S, Conley JM, Buchwalter D. 2017 Sulfate transport kinetics and toxicity are modulated by sodium in aquatic insects. *Aquat. Toxicol.* **190**, 62–69. (doi:10.1016/j.aquatox.2017.06.027)
39. Soucek DJ, Mount DR, Dickinson A, Hockett JR. 2018 Influence of dilution water ionic composition on acute major ion toxicity to the mayfly *Neocloeon triangulifer*. *Environ. Toxicol. Chem.* **37**, 1330–1339. (doi:10.1002/etc.4072)
40. Buchwalter D, Scheibener S, Chou H, Soucek D, Elphick J. 2019 Are sulfate effects in the mayfly *Neocloeon triangulifer* driven by the cost of ion regulation? *Phil. Trans. R. Soc. B* **374**, 20180013. (doi:10.1098/rstb.2018.0013)
41. Hills KA, Hyne RV, Kefford BJ. 2019 Species of freshwater invertebrates that are sensitive to one saline water are mostly sensitive to another saline water but an exception exists. *Phil. Trans. R. Soc. B* **374**, 20180003. (doi:10.1098/rstb.2018.0003)
42. Gillis PL. 2011 Assessing the toxicity of sodium chloride to the glochidia of freshwater mussels: implications for salinization of surface waters. *Environ. Pollut.* **159**, 1702–1708. (doi:10.1016/j.envpol.2011.02.032)
43. Roy JW, McInnis R, Bickerton G, Gillis PL. 2015 Assessing potential toxicity of chloride-affected groundwater discharging to an urban stream using juvenile freshwater mussels (*Lampsilis siliquoidea*). *Sci. Total Environ.* **532**, 309–315. (doi:10.1016/j.scitotenv.2015.06.023)
44. Beggel S, Geist J. 2015 Acute effects of salinity exposure on glochidia viability and host infection of the freshwater mussel *Anodonta anatina* (Linnaeus, 1758). *Sci. Total Environ.* **502**, 659–665. (doi:10.1016/j.scitotenv.2014.09.067)
45. Prosser RS, Rochfort Q, McInnis R, Exall K, Gillis PL. 2017 Assessing the toxicity and risk of salt-impacted winter road runoff to the early life stages of freshwater mussels in the Canadian province of Ontario. *Environ. Pollut.* **230**, 589–597. (doi:10.1016/j.envpol.2017.07.001)
46. Wang N, Ivey CD, Dorman RA, Ingersoll CG, Steevens J, Hammer EJ, Bauer CR, Mount DR. 2018 Acute toxicity of sodium chloride and potassium chloride to a unionid mussel (*Lampsilis siliquoidea*) in water exposures. *Environ. Toxicol. Chem.* (doi:10.1002/etc.4206)
47. Soucek DJ, Linton TK, Tarr CD, Dickinson A, Wickramanayake N, Delos CG, Cruz LA. 2011 Influence of water hardness and sulfate on the acute toxicity of chloride to sensitive freshwater invertebrates. *Environ. Toxicol. Chem.* **30**, 930–938. (doi:10.1002/etc.454)
48. Mount DR *et al.* 2016 The acute toxicity of major ion salts to *Ceriodaphnia dubia*: I. Influence of background water chemistry. *Environ. Toxicol. Chem.* **35**, 3039–3057 (doi:10.1002/etc.3487)
49. Sanzo D, Hecnar SJ. 2006 Effects of road de-icing salt (NaCl) on larval wood frogs (*Rana sylvatica*). *Environ. Pollut.* **140**, 247–256. (doi:10.1016/j.envpol.2005.07.013)
50. Collins SJ, Russell RW. 2009 Toxicity of road salt to Nova Scotia amphibians. *Environ. Pollut.* **157**, 320–324. (doi:10.1016/j.envpol.2008.06.032)
51. Vosylienė MZ, Baltrėnas P, Kazlauskienė A. 2006 Toxicity of road maintenance salts to rainbow trout *Oncorhynchus mykiss*. *Ekologija* **2**, 15–20.
52. Canadian Council of Ministers of Environment (CCME). 2011 *Canadian water quality guidelines for the protection of aquatic life: chloride*. Gatineau, Canada: Environment Canada.
53. Hintz WD, Relyea RA. 2017 Impacts of road deicing salts on the early-life growth and development of a stream salmonid: salt type matters. *Environ. Pollut.* **223**, 409–415. (doi:10.1016/j.envpol.2017.01.040)
54. Kefford BJ, Papas PJ, Nugegoda D. 2003 Relative salinity tolerance of macroinvertebrates from the Barwon River, Victoria, Australia. *Mar. Freshw. Res.* **54**, 755–765. (doi:10.1071/MF02081)
55. Kefford BJ, Nugegoda D, Zalizniak L, Fields EJ, Hassell KL. 2007 The salinity tolerance of freshwater macroinvertebrate eggs and hatchlings in comparison to their older life-stages: a diversity of responses. *Aquat. Ecol.* **41**, 335–348. (doi:10.1007/s10452-006-9066-y)
56. Kefford BJ, Hickey GL, Gasith A, Ben-David E, Dunlop JE, Palmer CG, Allan K, Choy SC, Piscart C. 2012 Global scale variation in the salinity sensitivity of riverine macroinvertebrates: eastern Australia, France, Israel and South Africa. *PLoS ONE* **7**, e35224. (doi:10.1371/journal.pone.0035224)
57. Hassell KL, Kefford BJ, Nugegoda D. 2006 Sub-lethal and chronic salinity tolerances of three freshwater insects: *Cloeon* sp. and *Centroptilum* sp. (Ephemeroptera: Baetidae) and *Chironomus* sp. (Diptera: Chironomidae). *J. Exp. Biol.* **209**, 4024–4032. (doi:10.1242/jeb.02457)
58. Goetsch PA, Palmer CG. 1997 Salinity tolerances of selected macroinvertebrates of the Sabie River, Kruger National Park, South Africa. *Arch. Environ. Contam. Toxicol.* **32**, 32–41. (doi:10.1007/s002449900152)
59. Zalizniak L, Kefford BJ, Nugegoda D. 2006 Is all salinity the same? I. The effect of ionic compositions on the salinity tolerance of five species of freshwater invertebrates. *Mar. Freshw. Res.* **57**, 75–82. (doi:10.1071/MF05103)
60. Zalizniak L, Kefford BJ, Nugegoda D. 2009 Effects of different ionic compositions on survival and growth of *Physa acuta*. *Aquat. Ecol.* **43**, 145–156. (doi:10.1007/s10452-007-9144-9)
61. Erickson RJ, Mount DR, Highland TL, Hockett JR, Hoff DJ, Jenson CT, Norberg-King TJ, Peterson KN. 2017 The acute toxicity of major ion salts to *Ceriodaphnia dubia*. II. Empirical relationships in binary salt mixtures. *Environ. Toxicol. Chem.* **36**, 1525–1537. (doi:10.1002/etc.3669)
62. Bogart SJ, Azizishirazi A, Pyle GG. 2019 Challenges and future prospects for developing Ca and Mg water quality guidelines: a meta-analysis. *Phil. Trans. R. Soc. B* **374**, 20180364. (doi:10.1098/rstb.2018.0364)
63. Hart BT, Bailey P, Edwards R, Hortle K, James K, McMahon A, Meredith C, Swadling K. 1991 A review of the salt sensitivity of the Australian freshwater biota. *Hydrobiologia* **210**, 105–144. (doi:10.1007/BF00014327)
64. Evans M, Frick C. 2001 *The effects of road salts on aquatic ecosystems*. NWRI Contribution Series no. 02-308. Burlington, ON, Canada: National Water Research Institute. Saskatoon, SK, Canada: University of Saskatchewan.
65. James KR, Cant B, Ryan T. 2003 Responses of freshwater biota to rising salinity levels and

Electronic Filing: Received, Clerk's Office 3/14/2019

implications for saline water management: a review. *Aust. J. Bot.* **51**, 703–713. (doi:10.1071/BT02110)

66. Ramakrishna DM, Viraraghavan T. 2005 Environmental impact of chemical deicers—a review. *Water Air Soil Pollut.* **166**, 49–63. (doi:10.1007/s11270-005-8265-9)
67. Fay L, Shi X. 2012 Environmental impacts of chemicals for snow and ice control: state of the knowledge. *Water Air Soil Pollut.* **223**, 2751–2770. (doi:10.1007/s11270-011-1064-6)
68. Nazari MH, Fay L, Jungwirth S, Shi X. 2015 Water quality implications and the toxicological effects of chloride-based deicers. In *Environmental sustainability in transportation infrastructure* (eds J Liu *et al.*), pp. 272–292. Reston, VA: American Society of Civil Engineers.
69. Tiwari A, Rachlin JW. 2018 A review of road salt ecological impacts. *Northeast. Nat.* **25**, 123–142. (doi:10.1656/045.025.0110)
70. Wang N *et al.* 2017 Acute sensitivity of a broad range of freshwater mussels to chemicals with different modes of toxic action. *Environ. Toxicol. Chem.* **36**, 786–796. (doi:10.1002/etc.3642)
71. Kefford BJ, Papas PJ, Metzeling L, Nugegoda D. 2004 Do laboratory salinity tolerances of freshwater animals correspond with their field salinity? *Environ. Pollut.* **129**, 355–362. (doi:10.1016/j.envpol.2003.12.005)
72. Kefford BJ, Nugegoda D, Metzeling L, Fields EJ. 2006 Validating species sensitivity distributions using salinity tolerance of riverine macroinvertebrates in the southern Murray–Darling Basin (Victoria, Australia). *Can. J. Fish. Aquat. Sci.* **63**, 1865–1877. (doi:10.1139/f06-080)
73. Silver P, Rupprecht SM, Stauffer MF. 2009 Temperature-dependent effects of road deicing salt on chironomid larvae. *Wetlands* **29**, 942–951. (doi:10.1672/08-212.1)
74. Bartlett AJ, Rochfort Q, Brown LR, Marsalek J. 2012 Causes of toxicity to *Hyalella azteca* in a stormwater management facility receiving highway runoff and snowmelt. Part II: salts, nutrients, and water quality. *Sci. Total Environ.* **414**, 237–247. (doi:10.1016/j.scitotenv.2011.11.036)
75. Allert AL, Cole-Neal CL, Fairchild JF. 2012 Toxicity of chloride under winter low-flow conditions in an urban watershed in central Missouri, USA. *Bull. Environ. Contam. Toxicol.* **89**, 296–301 (doi:10.1007/s00128-012-0673-0)
76. Todd AK, Kaltenecker MG. 2012 Warm season chloride concentrations in stream habitats of freshwater mussel species at risk. *Environ. Pollut.* **171**, 199–206 (doi:10.1016/j.envpol.2012.07.040)
77. United States Environmental Protection Agency (USEPA). 2002 *Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms*, 5th edn. EPA-821-R-02-012. Washington, DC: USEPA.
78. ASTM International. 2014 *Standard guide for conducting acute toxicity testing on test materials with fishes, macroinvertebrates, and amphibians.* ASTM E729-96. West Conshohocken, PA: ASTM International.
79. Cairns Jr J, Heath AG, Parker BC. 1975 Temperature influence on chemical toxicity to aquatic organisms. *J. Water Pollut. Control Fed.* **47**, 267–280.
80. Mayer Jr FL, Ellersieck MR. 1988 Experiences with single-species tests for acute toxic effects on freshwater animals. *Ambio* **17**, 367–375.
81. Persoone G, Van de Vel A, Van Steertegem M, De Nayer B. 1989 Predictive value of laboratory tests with aquatic invertebrates: influence of experimental conditions. *Aquat. Toxicol.* **14**, 149–167. (doi:10.1016/0166- 445X(89)90025-8)
82. Brecken-Folse JAA, Mayer FLL, Pedigo LEE, Marking LLL. 1994 Acute toxicity of 4-nitrophenol, 2,4-dinitrophenol, terbufos and trichlorfon to grass shrimp (*Palaemonetes* spp.) and sheepshead minnows (*Cyprinodon variegatus*) as affected by salinity and temperature. *Environ. Toxicol. Chem.* **13**, 67–77. (doi:10.1002/etc.5620130110)
83. Holmstrup M *et al.* 2010 Interactions between effects of environmental chemicals and natural stressors: a review. *Sci. Total Environ.* **408**, 3746–3762. (doi:10.1016/j.scitotenv.2009.10.067)
84. Patra RW, Chapman JC, Lim RP, Gehrke PC, Sunderam RM. 2015 Interactions between water temperature and contaminant toxicity to freshwater fish. *Environ. Toxicol. Chem.* **34**, 1809–1817. (doi:10.1002/etc.2990)
85. Schmidlin L, von Fumetti S, Nagel P. 2015 Effects of increased temperatures on *Gammarus fossarum* under the influence of copper sulphate. *Ecotoxicology* **24**, 433–444. (doi:10.1007/s10646-014-1392-6)
86. Camp AA, Buchwalter DB. 2016 Can't take the heat: temperature-enhanced toxicity in the mayfly *Isonychia bicolor* exposed to the neonicotinoid insecticide imidacloprid. *Aquat. Toxicol.* **178**, 49–57. (doi:10.1016/j.aquatox.2016.07.011)
87. Rivett MO, Cuthbert MO, Gamble R, Connon LE, Pearson A, Shepley MG, Davis J. 2016 Highway deicing salt dynamic runoff to surface water and subsequent infiltration to groundwater during severe UK winters. *Sci. Total Environ.* **565**, 324–338. (doi:10.1016/j.scitotenv.2016.04.095)
88. Taka M, Kokkonen T, Kuoppamäki K, Niemi T, Sillanpää N, Valtanen M, Warsta L, Setälä H. 2017 Spatio-temporal patterns of major ions in urban stormwater under cold climate. *Hydrol. Process.* **31**, 1564–1577. (doi:10.1002/hyp.11126)
89. Soucek DJ. 2007 Comparison of hardness- and chloride-regulated acute effects of sodium sulfate on two freshwater crustaceans. *Environ. Toxicol. Chem.* **26**, 773–779. (doi:10.1897/06-229R.1)
90. Resh VH, Jackson JK. 1993 Rapid assessment approaches in benthic macroinvertebrate biomonitoring studies. In *Freshwater biomonitoring and benthic macroinvertebrates* (eds DM Rosenberg, VH Resh), pp. 195–233. New York, NY: Chapman and Hall.
91. Lenat DR, Penrose DL. 1996 History of the EPT taxa richness metric. *Bull. North. Am. Benthol. Soc.* **13**, 12–14.
92. Klemm DJ *et al.* 2003 Development and evaluation of a macroinvertebrate biotic integrity index (MBII) for regionally assessing Mid-Atlantic Highlands streams. *Environ. Manage.* **31**, 0656–0669. (doi:10.1007/s00267-002-2945-7)
93. Jacobus LM, Wiersema NA. 2014 The genera *Anafroptilum* Kluge, 2011 and *Neocloeon* Traver, 1932, reinstated status, in North America, with remarks about the global composition of *Centroptilum* Eaton, 1869 (Ephemeroptera: Baetidae). *Zootaxa* **3814**, 385–391. (doi:10.11646/zootaxa.3814.3.5)
94. McCafferty WP, Waltz RD. 1990 Revisionary synopsis of the Baetidae (Ephemeroptera) of North and Middle America. *Trans. Am. Entomol. Soc.* **116**, 769–799.
95. Sweeney BW, Vannote RL. 1984 Influence of food quality and temperature on life history characteristics of the parthenogenetic mayfly, *Cloeon triangulifer*. *Freshw. Biol.* **14**, 621–630. (doi:10.1111/j.1365-2427.1984.tb00181.x)
96. Funk DH, Jackson JK, Sweeney BW. 2006 Taxonomy and genetics of the parthenogenetic mayfly *Centroptilum triangulifer* and its sexual sister *Centroptilum alamance* (Ephemeroptera: Baetidae). *J. North Am. Benthol. Soc.* **25**, 417–429. (doi:10.1899/0887-3593(2006)25[417:TAGOTP]2.0.CO;2)
97. Conley JM, Funk DH, Buchwalter DB. 2009 Selenium bioaccumulation and maternal transfer in the mayfly *Centroptilum triangulifer* in a life-cycle, periphyton-biofilm trophic assay. *Environ. Sci. Technol.* **43**, 7952–7957. (doi:10.1021/es9016377)
98. Conley JM, Funk DH, Cariello NJ, Buchwalter DB. 2011 Food rationing affects dietary selenium bioaccumulation and life cycle performance in the mayfly *Centroptilum triangulifer*. *Ecotoxicology* **20**, 1840–1851. (doi:10.1007/s10646-011-0722-1)
99. Xie L, Flippin JL, Deighton N, Funk DH, Dickey DA, Buchwalter DB. 2009 Mercury (II) bioaccumulation and antioxidant physiology in four aquatic insects. *Environ. Sci. Technol.* **43**, 934–940. (doi:10.1021/es802323r)
100. Xie L, Funk DH, Buchwalter DB. 2010 Trophic transfer of Cd from natural periphyton to the grazing mayfly *Centroptilum triangulifer* in a life cycle test. *Environ. Pollut.* **158**, 272–277. (doi:10.1016/j.envpol.2009.07.010)
101. Xie LT, Buchwalter DB. 2011. Cadmium exposure route affects antioxidant responses in the mayfly *Centroptilum triangulifer*. *Aquat. Toxicol.* **105**, 199–205. (doi:10.1016/j.aquatox.2011.06.009)
102. Kim KS, Funk DH, Buchwalter DB. 2012 Dietary (periphyton) and aqueous Zn bioaccumulation dynamics in the mayfly *Centroptilum triangulifer*. *Ecotoxicology* **21**, 2288–2296. (doi:10.1007/s10646-012-0985-1)
103. Wang T-Q, McCafferty WP. 2004 Heptageniidae (Ephemeroptera) of the world. Part I: phylogenetic higher classification. *Trans. Am. Entomol. Soc.* **130**, 11–45.
104. Titler RV, Curry P. 2011 *Chemical analysis of major constituents and trace contaminants of rock salt.* Harrisburg, PA: Pennsylvania Department of Environmental Protection.

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105. Kiffney PM, Clements WH. 1996 Size-dependent response of macroinvertebrates to metals in experimental streams. *Environ. Toxicol. Chem.* **15**, 1352–1356. (doi:10.1002/etc.5620150814)
106. Kefford BJ, Dalton A, Palmer CG, Nugegoda D. 2004 The salinity tolerance of eggs and hatchlings of selected aquatic macroinvertebrates in south-east Australia and South Africa. *Hydrobiologia* **517**, 179–192. (doi:10.1023/B:HYDR.0000027346.06304.bc)
107. Clements WH, Cadmus P, Brinkman SF. 2013 Responses of aquatic insects to Cu and Zn in stream microcosms: understanding differences between single species tests and field responses. *Environ. Sci. Technol.* **47**, 7506–7513. (doi:10.1021/es401255h)
108. Hamilton MA, Russo RC, Thurston RV. 1977 Trimmed Spearman-Karber method for estimating median lethal concentrations in toxicity bioassays. *Environ. Sci. Technol.* **11**, 714–719. (doi:10.1021/es60130a004)
109. Kefford BJ. 2019 Why are mayflies (Ephemeroptera) lost following small increases in salinity? Three conceptual osmophysiological hypotheses. *Phil. Trans. R. Soc. B* **374**, 20180021. (doi:10.1098/rstb.2018.0021)
110. Cormier SM, Zheng L, Flaherty CM. 2018 Field-based method for evaluating the annual maximum specific conductivity tolerated by freshwater invertebrates. *Sci. Total Environ.* **633**, 1637–1646. (doi:10.1016/j.scitotenv.2018.01.136)
111. Chadwick MA, Feminella JW. 2001 Influence of salinity and temperature on the growth and production of a freshwater mayfly in the Lower Mobile River, Alabama. *Limnol. Oceanogr.* **46**, 532–542. (doi:10.4319/lo.2001.46.3.0532)
112. Lob DW, Silver P. 2012 Effects of elevated salinity from road deicers on *Chironomus riparius* at environmentally realistic springtime temperatures. *Freshw. Sci.* **31**, 1078–1087. (doi:10.1899/12-095.1)
113. Chapman PM. 2016 Toxicity delayed in cold freshwaters? *J. Great Lakes Res.* **42**, 286–289. (doi:10.1016/j.jglr.2015.03.018)
114. Chapman PM, Riddle MJ. 2005 Toxic effects of contaminants in polar marine environments. *Environ. Sci. Technol.* **39**, 200A-6A. (doi:10.1021/es048842b)
115. Kelly VR, Cunningham MA, Curri N, Findlay SE, Carroll SM. 2018 The distribution of road salt in private drinking water wells in a southeastern New York suburban township. *J. Environ. Qual.* **47**, 445–451. (doi:10.2134/jeq2017.03.0124)
116. Shi X, Veneziano D, Xie N, Gong J. 2013 Use of chloride-based ice control products for sustainable winter maintenance: a balanced perspective. *Cold Reg. Sci. Technol.* **86**, 104–112. (doi:10.1016/j.coldregions.2012.11.001)

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THE ACUTE TOXICITY OF MAJOR ION SALTS TO *CERIODAPHNIA DUBIA*: I. INFLUENCE OF BACKGROUND WATER CHEMISTRY

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Abstract: The ions Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, and HCO_3^-/CO_3^{2-} (referred to in the present study as "major ions") are present in all freshwaters and physiologically required by aquatic organisms but can increase to harmful levels from a variety of anthropogenic activities. It is also known that the toxicities of major ion salts can vary depending on the concentrations of other ions, and understanding these relationships is key to establishing appropriate environmental limits. The authors present a series of experiments with *Ceriodaphnia dubia* to evaluate the acute toxicity of 12 major ion salts and to determine how toxicity of these salts varies as a function of background water chemistry. All salts except $CaSO_4$ and $CaCO_3$ were acutely toxic below saturation, with the lowest median lethal concentrations found for K salts. All 10 salts that showed toxicity also showed some degree of reduced toxicity as the ionic content of the background water increased. Experiments that independently varied Ca:Mg ratio, Na:K ratio, Cl:SO_4 ratio, and alkalinity/pH demonstrated that Ca concentration was the primary factor influencing the toxicities of Na and Mg salts, whereas the toxicities of K salts were primarily influenced by the concentration of Na. These experiments also indicated multiple mechanisms of toxicity and suggested important aspects of dosimetry; the toxicities of K, Mg, and Ca salts were best related to the chemical activity of the cation, whereas the toxicities of Na salts also reflected an influence of the anions and were well correlated with osmolarity. Understanding these relationships between major ion toxicity and background water chemistry should aid in the development of sensible risk-assessments and regulatory standards. *Environ Toxicol Chem* 2016;35:3039–3057. Published 2016 Wiley Periodicals Inc. on behalf of SETAC. This article is a US government work and, as such, is in the public domain in the United States of America.

Keywords: Aquatic toxicology Major ions *Ceriodaphnia dubia* Toxicity mechanism Dose–response modeling

INTRODUCTION

Inorganic ions generally present at the highest concentrations in freshwaters are Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, and HCO_3^-/CO_3^{2-} (referred to as "major ions" herein) and are used to describe the basic chemistry of natural waters [1]. All have physiological roles and are actively regulated by aquatic organisms [2] but can also cause toxicity when present in sufficient excess [3]. Concentrations in natural waters are governed by a variety of atmospheric, geochemical, and biological processes [1], but these natural concentrations can be greatly increased by a wide variety of anthropogenic influences, such as mineral mining, oil and gas extraction, irrigation, road deicing, water softening, and wastewaters from various industrial processes.

A variety of studies have shown or implicated major ions as causes of aquatic toxicity in surface waters, with sources such as oil and/or gas production [4,5], irrigation return flows [6,7], mining [8,9], road salt [10], and industrial wastewater [11]. In fact, toxicity identification studies on industrial and municipal effluents have shown major ions to be among the more common causes of effluent toxicity [12]. Field studies in Appalachian streams have also found associations between changes in macrobenthic communities and increased major ion concentrations from mining activities [13–15].

Understanding the aquatic hazards posed by increased major ion concentrations presents a number of challenges. First, concentrations of major ions cannot be manipulated individually because charge balance demands that increased concentrations of any ion be offset by equal and opposite charge from other ions, making it more difficult to infer the effects of individual ions. Second, the relative concentrations of major ions vary widely across watersheds and anthropogenic inputs, and such differences are known to influence aquatic toxicity. For example, based on total salt concentration, a 1:1 mixture (by mass) of NaCl and $CaCl_2$ has substantially lower acute toxicity to *Ceriodaphnia dubia* than either salt alone [3], indicating that toxicity of this salt mixture is not simply additive. Third, the toxicity of a single salt can vary based on the characteristics of the water to which it is added, such as water hardness [16–20] and, more specifically, Ca [21]. Although relationships between water hardness and the toxicity of various other chemicals are often attributed, explicitly or implicitly, to the Ca and Mg ions that comprise most hardness, more detailed studies sometimes show that the concentrations of other ions covarying with hardness are playing important roles. For example, though "hardness" was long reported to influence toxicity of metals such as copper, later research demonstrated more detailed roles of specific ions; this enhanced understanding was incorporated into a more refined toxicity model, the biotic ligand model [22].

In previous work, Mount et al. [3] approached the toxicity of major ion mixtures by developing a multivariate regression model based on a large number of acute toxicity tests conducted with many different combinations of major ion salts. The resulting models predict the survival of 3 test species,

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cladocerans *Ceriodaphnia dubia* and *Daphnia magna*, and the fathead minnow (*Pimephales promelas*) based on concentrations of the 7 major ions. Although this model represented a step forward in addressing the complexities of evaluating ion mixtures and showed effectiveness as a predictive tool [5,23], there are important aspects of major ion toxicity that were not fully addressed. Notable among these was that all of the ion solutions tested were created by adding ions to a single base water. This issue underlies the failure of the model to represent some influences of background water chemistry on ion toxicity, such as the reduction of NaCl and Na_2SO_4 toxicity afforded by adding hardness within ranges common to natural waters [16–21]. Other aspects of the interactions among the ions (e.g., independent vs additive toxicity) also are incompletely addressed by this regression model.

The present study is the first of 3 articles that establish a better foundation for predicting the acute toxicity of elevated major ion concentrations to *C. dubia*. The present study describes a comprehensive study of the influence of background water chemistry that extends earlier work on hardness effects [16–21] to more water chemistry factors and to more major ion salts. Toxicities of major ion salts were evaluated using a wide range of dilution waters; some mimicked natural waters, while others were designed specifically to isolate different components of background water chemistry to better understand their roles in influencing major ion toxicity and thereby determine what is important to risk assessment of ions in natural systems.

These experiments also allowed preliminary consideration of exposure metrics that more effectively describe major ion toxicity to *C. dubia* than total salt concentration. For example, are there different toxicity mechanisms among the salts that need to be addressed? Should the toxicity of a salt be related to an individual ion or both ions, and how should concentrations of multiple ions be combined? Should reductions in toxicity attributable to the formation of complexes between ions and to the general effects of high ion concentrations on chemical reactivity be addressed?

The second article will present results of mixture tests with pairs of salts to more rigorously address the preceding questions. The third will address how the information from the other articles can be incorporated into a mathematical model applicable to any ion mixture and will test the predictions of that model for more complex mixtures relevant to field exposures.

The acute toxicity to *C. dubia* was selected as the endpoint for these efforts because this is a widely distributed organism with considerable sensitivity to ions and for which it was practical to conduct the large number of tests needed to adequately address the multiple factors and interactions of interest. The knowledge gained from the present study with *C. dubia* supports more informed testing and model development for other endpoints and species, which are now under way and will be the subject of additional publications. When combined with the efforts of other investigators, this body of information will support better assessment of the risks of major ions to aquatic communities.

MATERIALS AND METHODS

Test water composition and study design

Twenty-six experiments were conducted on the acute toxicity of individual major ion salts to *C. dubia*. Each experiment consisted of 3 to 8 simultaneous toxicity tests with different combinations of dilution waters and toxicants, for a total of 149 median lethal concentration (LC50) determinations. Test waters were developed from deionized water, sand-filtered and ultraviolet light-treated Lake Superior water (LSW), or a combination of both. Deionized water was produced from a Millipore Super-Q system configured as specified by the US Environmental Protection Agency (USEPA) [24]. Lake Superior water was obtained from an intake located offshore from our laboratory at 46.840°N, 92.004°W; typical hardness and alkalinity are 47 mg/L and 43 mg/L as $CaCO_3$, respectively, with conductivity of 104 µS/cm and pH approximately 7.5. The full ionic composition of LSW is provided in Table 1.

Table 1. Composition of dilution waters

Dilution water description	Abbreviation	Base water	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Cl (mg/L)	SO_4 (mg/L)	Alkalinity (mg $CaCO_3$/L)	Hardness (mg $CaCO_3$/L)
Lake Superior water	LSW		1.62	0.60	14.0	2.92	1.50	3.40	43.0	47.0
Amended Lake Superior water	ALSW	LSW	6.48	1.51	14.6	4.09	7.66	14.9	43.0	53.3
1/3× strength ALSW	1/3× ALSW	1/3× LSW	2.16	0.50	4.87	1.36	2.55	4.97	14.3	17.8
			(4.77)[a]	(1.18)[a]	(4.87)[a]	(1.36)[a]	(5.04)[a]	(7.88)[a]	(14.4)[a]	
3× strength ALSW	3× ALSW	LSW	19.4	4.52	43.8	12.3	23.0	44.7	129	160
			(16.7)[a]	(2.74)[a]	(43.9)[a]	(12.3)[a]	(19.0)[a]	(46.0)[a]	(125)[a]	
Moderately hard reconstituted water	MHRW	Deionized water	26.3	2.10	14.0	12.0	1.90	81.0	57.2	84.4
One-third strength MHRW	1/3× MHRW	Deionized water	8.75	0.70	4.65	4.01	0.63	27.0	19.1	28.1
One-eighth strength MHRW	1/8× MHRW	Deionized water	3.28	0.26	1.75	1.50	0.24	10.1	7.2	10.6
ALSW with high Ca:Mg ratio	High Ca:Mg	0.214× LSW	6.48	1.51	19.0	1.40	7.66	14.9	43.0	53.3
ALSW with low Ca:Mg ratio	Low Ca:Mg	0.214× LSW	6.48	1.51	3.00	11.1	7.66	14.9	43.0	53.3
ALSW with high Cl:SO_4 ratio	High Cl:SO_4	LSW	6.48	1.51	14.6	4.09	14.3	3.40	43.0	53.3
ALSW with low Cl:SO_4 ratio	Low Cl:SO_4	LSW	6.48	1.51	14.6	4.09	1.50	20.7	43.0	53.3
ALSW with high Na:K ratio	High Na:K	0.333× LSW	7.65	0.20	14.6	4.09	7.66	14.9	43.0	53.3
ALSW with low Na:K ratio	Low Na:K	0.333× LSW	1.89	10.0	14.6	4.09	7.66	14.9	43.0	53.3
ALSW with high alkalinity	High Alk	0.233× LSW	28.3	1.51	14.6	4.09	7.66	14.9	90.0	53.3
ALSW with low alkalinity	Low Alk	0.233× LSW	28.3	1.51	14.6	4.09	7.66	14.9	10.0	53.3
ALSW with varying Na		LSW	1.62	1.51	14.6	4.09	1.50	14.9	43.0	53.3
			3.00				3.62			
			10.0				14.4			
			30.0				45.3			
			100				153			
			300				460			

[a]Parentheses denote estimated geometric average ion concentrations at designated hardness for selected U.S. waters.
ALSW = amended Lake Superior water; LSW = Lake Superior water; MHRW = moderately hard reconstituted water.

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Table 2 Major salts tested within each set of experiments

	Experimental Set Description	NaCl	Na_2SO_4	$NaHCO_3$	KCl	K_2SO_4	$KHCO_3$	$MgCl_2$	$MgSO_4$	$MgCO_3$	$CaCl_2$	Na gluconate	Mg gluconate	Ca gluconate	Mannitol
1	1/3× ALSW culture vs 1× ALSW culture, tested in 1/3× ALSW 1/3× MHRW culture vs 1× MHRW culture, tested in 1/3× MHRW	X[a]						X							
2	1/8× MHRW culture vs 1× MHRW culture, tested in 1/8× MHRW	X[b]	X	X	X			X	X		X				
3	MHRW vs ALSW	X	X	X	X	X	X	X	X	X	X				
4	1/3× ALSW vs 3× ALSW	X[c]	X[c]	X	X	X		X	X	X	X				
5	Low Ca:Mg vs high Ca:Mg	X	X	X	X			X	X	X					
6	Low $Cl:SO_4$ vs high $Cl:SO_4$	X	X	X		X			X						
7	Low Na:K vs high Na:K	X	X	X				X	X		X				
8	Low vs high alkalinity	X	X		X			X	X						
9	ALSW with low vs ambient vs high pH	X			X			X							
10	ALSW with varying Na (0.07–13 mM)			X						X					
11	$CaCO_3$ precipitation effects, aged dilution water vs not aged, 1× ALSW vs 3× ALSW											X	X	X	X
12	Organic salts and mannitol, 1× ALSW only	X													

[a]Organisms from both amended ALSW cultures also tested in 1× ALSW.
[b]Organisms from both cultures also tested in 1× MHRW.
[c]Duplicate tests conducted which also included 1× ALSW.
ALSW = amended Lake Superior water; MHRW = moderately hard reconstituted water.

Some test waters were based on the commonly used reconstituted water formulas given by the USEPA [24] and originally proposed by Marking and Dawson [25], specifically the formula for "moderately hard reconstituted water" (MHRW), which was also used by Mount et al. [3]. While commonly used, MHRW (and other reconstituted waters based on this formula) has a chemistry (Table 1) that is atypical for surface waters of the United States: the Ca:Mg ratio is low, the $Cl:SO_4$ ratio is very low, and the Na concentration is extremely high relative to hardness. The high Na concentration is a consequence of using $NaHCO_3$ to impart alkalinity; in nature, alkalinity generally comes from dissolution of carbonate minerals of Ca and Mg, but these have solubilities and dissolution rates that are inconveniently low for water preparation in the laboratory. The low Ca:Mg and $Cl:SO_4$ ratios in MHRW are not a practical requirement, and the reason for their original selection is not clear.

To design a dilution water with chemistry more like natural waters, we analyzed data from the US Geological Survey national stream water-quality monitoring networks [26]. Data records were obtained for 425 sites in operation from 1983 to 1992. Records ($n = 32\,895$) were used that had 1) measurements for all major ions, 2) a charge imbalance of no more than 10%, 3) a hardness ≥ 10 and ≤ 400 mg/L as $CaCO_3$, and 4) pH no lower than 6.0. These data were subjected to regression analyses using Sigmaplot (v11.0; Systat Software) to establish relationships between log(hardness) and the logarithms of various other ion concentrations and ratios. A formula was then developed for an "amended Lake Superior water" (ALSW; Table 1) consistent with these relationships. Salts were added to LSW to increase hardness to the estimated geometric average (53.3 mg $CaCO_3$/L) in the US Geological Survey data for the alkalinity of LSW (43.0 mg $CaCO_3$/L) and to increase other ions to average values for this hardness. Benefits of modifying LSW to create this test dilution water, rather than creating a completely synthetic water from deionized water, are that it provides alkalinity without having to dissolve carbonate salts or add excessive Na and that it will contain trace constituents from the source water that make the water more realistic and possibly beneficial to the test organisms.

The present study was organized into 12 sets of 1 to 4 experiments addressing different aspects of dilution water chemistry or experimental procedure. These sets of experiments and the toxicants that were tested are summarized in Table 2, and the chemistries of the various dilution waters are provided in Table 1. The purpose and design of each experimental set were as follows.

Sets 1 and 2: Effects of acclimation to dilution water. Some previous studies of the effect of dilution water on major ion toxicity to *C. dubia* used organisms that were cultured in the dilution water prior to testing [16–20]. This was not done routinely in the present study because the logistics involved in culturing organisms in so many different dilution waters (Table 1) were prohibitive. However, because a preliminary comparison of NaCl toxicity in MHRW and MHRW diluted by a factor of 3 (1/3× MHRW) showed much less of an impact of this dilution than the 1×, 1/2×, 1/4×, and 1/8× MHRW series tested by Elphick et al. [19], we conducted experiments to determine whether observed salt toxicity in waters more dilute than MHRW or ALSW varied significantly depending on whether the organisms were cultured in these dilute test waters or in the standard-strength water formulations. Initially, organisms from our primary culture (in 1× MHRW) were used to create secondary cultures in 1× MHRW, 1/3× MHRW,

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1× ALSW, and 1/3× ALSW, which were maintained for a minimum of 2 generations before being used in tests. The toxicities of NaCl and $MgCl_2$ in 1/3× MHRW and 1/3× ALSW were simultaneously tested using the cultures from both the dilute water and the corresponding full-strength water (Table 2, set 1). For NaCl, tests were also conducted in 1x ALSW using both the 1× ALSW and 1/3× ALSW cultures. To further explore this issue, we conducted additional acclimation studies (Table 2, set 2) comparing the toxicity of several salts in 1/8× MHRW using *C. dubia* cultured in MHRW and in 1/8× MHRW (the same composition as the 10 and 80 hardness waters in the Elphick et al. [19] study). For NaCl, tests were also conducted in 1× MHRW using both cultures.

Set 3: Salt toxicity in MHRW versus ALSW. Because ALSW was developed in response to concerns about the composition of MHRW and because much existing ion toxicity information was conducted in MHRW or similar waters, comparative toxicities in these 2 waters were of interest. Therefore, a set of experiments (Table 2, set 3) compared the toxicity of all major ion salts in MHRW and ALSW, except for $CaSO_4$ and $CaCO_3$, for which preliminary experiments showed no toxicity at saturation in these waters.

Set 4: Salt toxicity in different strengths of ALSW. Natural waters vary widely in total ion concentration, the 10th and 90th percentiles in our analysis of US Geological Survey data being approximately 1.5 mEq/L and 16 mEq/L for the sum of major cations and anions. To determine the effect of varying overall ion concentrations, another set of experiments (Table 2, set 4) compared toxicities of 9 salts in dilution waters that had one-third and 3 times the ion concentrations of ALSW (1/3× ALSW and 3× ALSW; Table 1). We note that, in natural waters, average concentrations of the various ions do not vary exactly in proportion with total ion concentrations, so 1/3× ALSW and 3× ALSW do not match our estimated field water averages at the same hardnesses, which are also provided in Table 1 for comparison purposes. We elected not to match the field chemistry so that all ions would be in the same proportions across the 1/3×, 1×, and 3× ALSW series but the ion ratios would still be well within the ranges observed in the US Geological Survey data.

The results of these tests were combined with separate data for 1× ALSW (from set 3) to compare across a 1/3×, 1×, and 3× ALSW dilution water series; for NaCl and Na_2SO_4 an additional experiment simultaneously tested this entire series to verify results. Preparation of 1/3× ALSW was simply by dilution of ALSW with deionized water. Creating the 3× ALSW chemistry required dissolution of $CaCO_3$ to provide higher alkalinity while maintaining the desired cation ratios, in addition to adding other more soluble salts. This was accomplished by adding the appropriate amounts of the various salts to LSW in a large graduated cylinder and bubbling CO_2 gas through the solution until pH stabilized near 5.0 and all salts were dissolved. The solution was then aerated with ambient air until pH was approximately 7.8.

Sets 5–7: Effects of modifying specific ion ratios. Most previous work on the effects of dilution water chemistry on major ion toxicity to daphnids has focused on water hardness [16–20] as a generalized parameter without parsing the influence of other ions that covaried with the hardness, although Davies and Hall [21] did identify Ca as being more important than Mg for the effects of hardness on Na_2SO_4 toxicity. Regarding other ions in dilution water, Soucek [17] reported an ameliorative effect of low concentrations of added NaCl on the toxicity of Na_2SO_4 to *Hyalella azteca* (attributed to the chloride requirements for this species) but no such effect on *C. dubia*. At higher NaCl concentrations, there was an exacerbation of Na_2SO_4 toxicity for both species, attributed to additive toxicity of the 2 salts. Soucek et al. [18] also reported a small increase in apparent NaCl toxicity when Na_2SO_4 was added, again attributed to additive toxicity of the 2 salts.

To more completely evaluate the influence of particular dilution water characteristics on the toxicity of major ion salts, we tested selected salts in ALSW modified to provide different ratios of certain ion pairs, based on the tails of the distributions of these ratios in our analysis of US Geological Survey data. Waters with high Ca:Mg (13.6 by mass) and low Ca:Mg (0.27) ratios (Table 2, set 5) were created by changing the salts added to LSW to achieve the target ratios without altering concentrations of any other ions in the water (Table 1). Similar approaches were used to create waters with high and low $Cl:SO_4$ ratios (4.2 and 0.072 by mass; Table 2, set 6) and high and low Na:K ratios (38 and 0.19 by mass; Table 2, set 7). Some of these waters required that LSW be initially diluted with deionized water to lower the concentrations of a target ion to its lowest value, followed by addition of salts to match the ALSW chemistry except for the ion pair being manipulated (Table 1). Where required, the CO_2-aided dissolution of $CaCO_3$ was used to restore alkalinity to waters based on diluted LSW.

Sets 8 and 9: Effects of manipulating alkalinity and pH. The effects of pH and alkalinity were evaluated in 2 ways. First, the alkalinity of ALSW was reduced to 10 mg $CaCO_3$/L and raised to 90 mg $CaCO_3$/L (resulting, respectively, in pHs of 7.3–7.5 and 8.1–8.3; Table 2, set 8). Alkalinity was raised simply by adding $NaHCO_3$, whereas it was lowered by diluting LSW and adding salts to restore all cations and Cl to their same values as in the high-alkalinity water, with SO_4 replacing the alkalinity (Table 1). Second, pH was reduced to approximately 6.8 and raised to approximately 8.5 (Table 2, set 9) without altering alkalinity or other ions by bubbling the ALSW used in test solution preparation with air containing 1% CO_2 and 0% CO_2, respectively, and enclosing test vessels in sealed chambers containing these same CO_2 concentrations [27].

Set 10: Effect of sodium on potassium toxicity. Based on the results of the tests contrasting MHRW and ALSW (set 3), we hypothesized that the toxicity of K salts was dependent on the Na concentration in the dilution water. To evaluate this hypothesis, the toxicity of KCl was tested in 6 different dilution waters with Na ranging from 1.6 mg/L to 300 mg/L (Table 2, set 10). Test waters were prepared by modifying the formulation of ALSW to have no added Na and Cl, then adding NaCl to achieve the desired levels of Na (Table 1).

Set 11: Effects of time-dependent calcium precipitation. Testing of the toxicity of $NaHCO_3$ and $MgCO_3$ resulted in oversaturation of $CaCO_3$ and possible loss of Ca from solution, which would affect toxicity given the established ameliorative effect of Ca. Although Ca was monitored in these tests, the sampling was too limited to precisely determine the Ca concentration to associate with the LC50. Therefore, an additional experiment was conducted to more thoroughly characterize the dependence of any Ca loss on time and test salt concentration. This was a 2 × 2 × 2 factorial experiment, the 3 factors being test salt ($NaHCO_3$, $MgCO_3$), dilution water (1× ALSW, 3× ALSW), and solution age (freshly prepared vs aged for 48 h before introducing test organisms; Table 2, set 11). Extra replicate test cups were prepared to allow sampling of Ca at multiple times and treatment concentrations. This experiment provided not only $NaHCO_3$ and $MgCO_3$ LC50s from tests that

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were monitored better but also data with which to better estimate Ca concentrations at the LC50 in other CO_3/HCO_3 salt tests.

Set 12: Toxicities of gluconate salts and mannitol. Charge balance requires including both cations and anions in any testing of ion toxicity, making it more difficult to infer the relative toxicities of the individual ions. In addition, results of other experiments in the present study led us to hypothesize that the toxicity of some salts might be related to their effect on the osmolarity of the test solution and thus on the osmotic gradient the organism experiences. To provide more information on the role of the individual cations, we tested the toxicity of the gluconate salts of Na, Ca, and Mg (Table 2, set 12). Gluconate is an organic ion that is not expected to be absorbed appreciably and, thus, should act only through its effect on osmotic potential or on charge gradients, providing an informative contrast to Cl, SO_4, and HCO_3/CO_3. This experiment also evaluated the toxicity of mannitol, a sugar alcohol also not expected to be appreciably absorbed, enabling us to manipulate the external osmolarity without adding any ions. NaCl was also included as a reference major ion salt.

Toxicity test procedures

Salts for all 12 combinations of the 4 major cations and 3 major anions; gluconate salts of Na, Ca, and Mg; and mannitol were obtained from Sigma-Aldrich or Fisher Scientific. All chemicals were American Chemical Society reagent grade or better, with the exception of $MgCO_3$ which was specified as meeting US Pharmacopeia requirements. The certificate of analysis for this salt was used to determine the ratio of $MgCO_3$ to total salt weight for computing nominal $MgCO_3$ concentrations. This certificate of analysis also specified the Ca content to be 0.73% of the Mg content, enough to appreciably affect the background Ca; this was used to adjust the nominal Ca background concentration for tests on the toxicity of $MgCO_3$.

Test organisms were <24-h-old *C. dubia* obtained from in-house cultures. Most test organisms were cultured in MHRW, but organisms for testing the effects of acclimation were also cultured in the dilution waters for the tests (for a least 2 wk prior to the tests); and some tests late in the present study were conducted with organisms cultured in ALSW after a switch of our culture to this water. The culture water for each toxicity test is indicated in Table 3. General culture procedures followed those described by the USEPA [24].

Static 48-h toxicity tests were conducted in 30-mL plastic cups (Berry Plastics) filled with 10 mL test solution and held in polystyrene boards with holes sized to the cups. These boards were floated in a temperature-controlled water bath with a glass sheet covering all test cups. Because preliminary studies indicated that the response curves for major ion salts were quite steep, we used closely spaced exposure concentrations, with each test concentration being approximately 80% of the next higher. Test solutions were prepared by combining the applicable salt and dilution water to achieve the highest test concentration (100%). From this, 2 additional solutions, 80% and 64%, were prepared by dilution of the first; then, each of these 3 solutions was serially diluted by 0.5× to produce a total of 9 to 12 exposure concentrations, plus a dilution water control. The highest salt concentration in each test varied according to its expected toxicity (based on a combination of preliminary testing, any preceding experiments, and literature values), but all tests used the same relative dilution spacing. Most experiments were structured to compare toxicity under 2 related conditions (e.g., high and low Ca:Mg); tests were assigned to experiments such that both conditions would be tested simultaneously for a particular salt, using the same preparation of dilution water and the same cohort of test organisms.

All salts except $CaCO_3$, $MgCO_3$, and $CaSO_4$ could be easily dissolved at concentrations high enough to cause mortality. For $CaCO_3$ and $MgCO_3$, the CO_2 procedure in the description of set 4 was used to dissolve the salts. After adjusting to pH 7.8, $MgCO_3$ solutions so prepared were stable for 48 h at lethal concentrations, thereby allowing for testing as for other salts. However, a 15 mM (1500 mg/L) $CaCO_3$ solution dissolved in ALSW using CO_2 showed substantial precipitation and settling once the pH was raised, with the total concentration being only 6.5 mM at test start and dropping to 2.4 mM (2.2 mM dissolved) after 24 h and to 1.2 mM after 48 h, with no mortality observed. For $CaSO_4$, consistent with the findings of Mount et al. [3], a saturated solution at 16.2 mM (2200 mg $CaSO_4$/L) was not acutely toxic to *C. dubia* in MHRW or ALSW. Based on these results, no further testing was conducted with $CaSO_4$ or $CaCO_3$.

Test cups were usually prepared in duplicate, but in a few tests with CO_3/HCO_3 salts more replicates were used to provide test solution for more monitoring of alkalinity or Ca than in other tests. Each cup received food in the form of 100 μL of a 50:50 mixture of yeast, cereal leaves, and trout chow [24] and algae (*Pseudokirchneriella subcapitata* at 3.5×10^7 cells/mL). Food was added based on previous work indicating that it had minimal effect on toxicity of major ions [3] and to avoid possible stress. Test temperature was 25 ± 1 °C with fluorescent lighting on a 16:8-h light: dark photoperiod. Five *C. dubia* neonates were added to each cup, and survival was determined after 24 h and 48 h of exposure; death was defined as no visible movement after gentle prodding and at least 10 s of observation.

Exposure monitoring

Temperature was monitored daily in test cups from each simultaneous test and continuously in the surrounding water bath. Hardness and alkalinity of dilution waters in every test were measured by titration [28]. For tests with $MgCO_3$ and $NaHCO_3$, alkalinity was also measured in the highest test concentration. Conductivity was used to verify that dilution of the salt solutions was done properly and was measured (model 2052; Amber Science) in each treatment at the start of the exposure, in every treatment that had 100% mortality after 24 h, and in all remaining treatments at 48 h. The pH was measured (PH150 with A57198 probe; Beckman Coulter) at the start of each test in the highest concentration and control (in all concentrations for tests with CO_3/HCO_3 salts), in every concentration that had 100% mortality at 24 h, and in all remaining treatments at 48 h. Dissolved oxygen was measured (model 58; Yellow Springs Instruments) in the highest concentration and control at the start of the test, in the highest and lowest concentrations with 100% mortality at 24 h, and in 2 arbitrarily selected treatments at 48 h.

Because of the large number of exposure treatments (~1500), it was not practical to measure major ion concentrations in every treatment. Instead, the analytical sampling program was structured with 2 primary purposes: 1) to verify that the dilution waters and highest concentrations were prepared properly and 2) to verify the exposure concentrations near the LC50. Accordingly, analytical samples were collected at the start of exposure from each dilution water and from the highest concentration of each salt in each dilution water. In addition, analytical samples were collected from each exposure series after 24 h in the lowest concentration with 100% mortality and at 48 h from the concentration nearest the LC50. Beyond this routine sampling program, some tests included additional

Table 3. Results of tests on the acute toxicity of major ion salts, gluconate salts, and mannitol to *Ceriodaphnia dubia* in various tests waters[a]

Set #	Test Chemical	Culture Water	Test Water	LC50 Method	LC50 mg/L (≥95% CL)	LC50 mM (≥95% CL)	Na mM	K mM	Ca mM	Mg mM	Cl mM	SO4 mM	Alk meq/L	pH	LC50 µS/cm	Osmol mOsM
	NaCl	MHRW	0.33× MHRW	Midpoint	1860 (1740–1990)	31.8 (29.8–34.0)	32.2	0.02	0.116	0.16	31.8	0.28	0.38	7.40	3170	61.4
	NaCl	MHRW	MHRW	Probit	2060 (2020–2490)	35.3 (34.5–42.6)	36.5	0.05	0.348	0.50	35.4	0.84	1.14	7.90	3500	70.1
	Na_2SO_4	MHRW	0.33× MHRW	Midpoint	1860 (1730–2010)	13.1 (12.2–14.2)	26.6	0.02	0.116	0.16	0.02	13.4	0.38	7.60	2480	35.7
	Na_2SO_4	MHRW	MHRW	Probit	3060 (2810–3350)	21.5 (19.8–23.6)	44.2	0.05	0.348	0.50	0.05	22.4	1.14	8.00	3680	58.7
	NaCl	ALSW	ALSW	Midpoint	1680 (1560–1790)	28.7 (26.8–30.7)	28.9	0.04	0.364	0.17	28.9	0.16	0.86	7.95	2980	56.1
	NaCl	ALSW	0.33× ALSW	Probit	1560 (1420–1720)	26.7 (24.4–29.4)	26.8	0.01	0.121	0.06	26.8	0.05	0.29	7.55	2700	51.3
	NaCl	0.33× ALSW	0.33× ALSW	Probit	1770 (1580–1980)	30.2 (27.0–33.9)	30.3	0.01	0.121	0.06	30.3	0.05	0.29	7.55	3030	57.9
1	NaCl	0.33× ALSW	ALSW	Probit	1940 (1780–2110)	33.2 (30.5–36.2)	33.5	0.04	0.364	0.17	33.4	0.16	0.86	7.90	3180	64.5
	NaCl	MHRW	MHRW	Probit	1810 (1680–1950)	31.0 (28.8–33.4)	32.1	0.05	0.348	0.50	31.0	0.84	1.14	8.00	3310	62.0
	NaCl	0.33× MHRW	0.33× MHRW	Midpoint	1640 (1530–1760)	28.1 (26.2–30.1)	28.4	0.02	0.116	0.16	28.1	0.28	0.38	7.60	2990	54.4
	NaCl	0.33× MHRW	0.33× MHRW	Probit	1560 (1440–1710)	26.7 (24.6–29.2)	27.1	0.02	0.116	0.16	26.8	0.28	0.38	7.70	2770	51.9
	NaCl	MHRW	0.33× MHRW	Probit	1480 (1340–1640)	25.3 (23.0–28.1)	25.7	0.02	0.116	0.16	25.4	0.28	0.38	7.70	2690	49.3
	$MgCl_2$	0.33× ALSW	0.33× ALSW	Probit	529 (457–612)	5.56 (4.80–6.43)	0.09	0.01	0.121	5.61	11.2	0.05	0.29	7.45	1230	15.9
	$MgCl_2$	ALSW	0.33× ALSW	Probit	667 (556–810)	7.01 (5.84–8.51)	0.09	0.01	0.121	7.06	14.1	0.05	0.29	7.45	1510	19.7
	$MgCl_2$	MHRW	0.33× MHRW	Probit	305 (271–338)	3.20 (2.85–3.55)	0.38	0.02	0.116	3.37	6.42	0.28	0.38	7.55	813	10.2
	$MgCl_2$	0.33× MHRW	0.33× MHRW	Probit	312 (192–417)	3.28 (2.02–4.38)	0.38	0.02	0.116	3.44	6.57	0.28	0.38	7.60	835	10.3
	NaCl	0.125× MHRW	0.125× MHRW	Midpoint	907 (828–993)	15.5 (14.2–17.0)	15.7	0.01	0.044	0.06	15.5	0.11	0.14	7.45	1750	31.0
	NaCl	0.125× MHRW	MHRW	Midpoint	1810 (1640–1990)	30.9 (28.1–34.0)	32.0	0.05	0.348	0.50	31.0	0.84	1.14	8.05	3260	61.9
	NaCl	MHRW	0.125× MHRW	Midpoint	1010 (940–1080)	17.2 (16.1–18.4)	17.3	0.01	0.044	0.06	17.2	0.11	0.14	7.35	1860	34.1
	NaCl	MHRW	MHRW	Probit	1710 (1580–1850)	29.3 (27.1–31.7)	30.4	0.05	0.348	0.50	29.4	0.84	1.14	8.05	3040	58.9
	$MgCl_2$	0.125× MHRW	0.125× MHRW	Probit	69 (53–90)	0.72 (0.56–0.95)	0.14	0.01	0.044	0.79	1.46	0.11	0.14	7.25	229	3.3
	$MgCl_2$	MHRW	0.125× MHRW	Probit	116 (94–202)	1.22 (0.99–2.12)	0.14	0.01	0.044	1.28	2.44	0.11	0.14	7.25	351	8.8
	Na_2SO_4	0.125× MHRW	0.125× MHRW	Midpoint	671 (613–734)	4.72 (4.32–5.17)	9.59	0.01	0.044	0.06	0.01	4.83	0.14	7.40	1070	14.2
2	Na_2SO_4	MHRW	0.125× MHRW	Midpoint	916 (829–1012)	6.45 (5.84–7.12)	13.0	0.01	0.044	0.06	0.01	6.55	0.14	7.20	1360	18.8
	$MgSO_4$	0.125× MHRW	0.125× MHRW	Probit	160 (137–184)	1.33 (1.14–1.53)	0.14	0.01	0.044	1.39	0.01	1.43	0.14	7.05	630	3.6
	$MgSO_4$	MHRW	0.125× MHRW	Probit	291 (264–321)	2.42 (2.19–2.67)	0.14	0.01	0.044	2.48	0.01	2.52	0.14	7.20	978	5.2
	KCl	0.125× MHRW	0.125× MHRW	Probit	177 (159–197)	2.37 (2.13–2.64)	0.14	2.38	0.044	0.06	2.38	0.11	0.14	7.40	389	5.9
	KCl	MHRW	0.125× MHRW	Midpoint	224 (204–245)	3.0 (2.74–3.29)	0.14	3.01	0.044	0.06	3.01	0.11	0.14	7.40	474	7.1
	$NaHCO_3$	0.125× MHRW	0.125× MHRW	Midpoint	1070 (1000–1140)	12.7 (11.9–13.6)	12.9	0.01	0.044	0.06	0.01	0.11	12.9	9.20	1110	23.8
	$NaHCO_3$	MHRW	0.125× MHRW	Midpoint	1000 (920–1090)	11.9 (10.9–13.0)	12.0	0.01	0.044	0.06	0.01	0.11	12.0	9.15	1060	22.4
	$CaCl_2$	0.125× MHRW	0.125× MHRW	Midpoint	1670 (1570–1780)	15.1 (14.2–16.1)	0.14	0.01	15.1	0.06	30.2	0.11	0.14	6.90	2930	41.2
	$CaCl_2$	MHRW	0.125× MHRW	Probit	1660 (1620–1940)	15.0 (14.6–17.5)	0.14	0.01	15.0	0.06	30.0	0.11	0.14	6.95	2920	40.9
	KCl	MHRW	ALSW	Probit	351 (321–384)	4.71 (4.31–5.15)	0.28	4.75	0.364	0.17	4.92	0.16	0.86	7.95	781	11.1
	KCl	MHRW	MHRW	Probit	464 (395–568)	6.22 (5.30–7.62)	1.14	6.28	0.348	0.50	6.28	0.84	1.14	8.10	1140	15.7
	$CaCl_2$	MHRW	ALSW	Probit	1900 (1690–2170)	17.2 (15.2–19.5)	0.28	0.04	17.5	0.17	34.5	0.16	0.86	7.90	3220	46.9
	$CaCl_2$	MHRW	MHRW	Probit	1990 (1760–2260)	18.0 (15.9–20.4)	1.14	0.05	18.3	0.50	36.0	0.84	1.14	7.95	3250	50.3
	$MgCl_2$	MHRW	ALSW	Probit	861 (759–981)	9.04 (7.97–10.3)	0.28	0.04	0.364	9.21	18.3	0.16	0.86	7.85	1900	26.1
	$MgCl_2$	MHRW	MHRW	Probit	733 (615–895)	7.70 (6.46–9.40)	1.14	0.05	0.348	8.19	15.4	0.84	1.14	7.95	1730	24.2
	K_2SO_4	MHRW	ALSW	Midpoint	362 (339–386)	2.08 (1.95–2.22)	0.28	4.19	0.364	0.17	0.22	2.23	0.86	7.90	690	7.7
	K_2SO_4	MHRW	MHRW	Midpoint	606 (557–659)	3.48 (3.20–3.78)	1.14	7.01	0.348	0.50	0.05	4.32	1.14	8.05	1150	13.2
	Na_2SO_4	MHRW	ALSW	Midpoint	3410 (3150–3700)	24.0 (22.2–26.0)	48.3	0.04	0.364	0.17	0.22	24.18	0.86	7.90	4080	63.4
3	Na_2SO_4	MHRW	MHRW	Midpoint	3260 (3060–3460)	22.9 (21.5–24.4)	47.0	0.05	0.348	0.50	0.05	23.76	1.14	8.00	3970	62.2

(*continued*)

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Table 3. (*Continued*)

Set #	Test Chemical	Culture Water	Test Water	LC50 Method	LC50 mg/L (≥95% CL)	LC50 mM (≥95% CL)	Na mM	K mM	Ca mM	Mg mM	Cl mM	SO4 mM	Alk meq/L	pH	LC50 µS/cm	Osmol mOsM
	$MgSO_4$	MHRW	ALSW	Probit	2040 (1880–2230)	16.9 (15.6–18.5)	0.28	0.04	0.364	17.1	0.22	17.10	0.86	7.85	2240	25.2
	$MgSO_4$	MHRW	MHRW	Probit	1990 (1830–2180)	16.6 (15.2–18.1)	1.14	0.05	0.348	17.1	0.05	17.4	1.14	8.00	2280	26.3
	$KHCO_3$	MHRW	ALSW	Probit	322 (306–340)	3.22 (3.06–3.40)	0.28	3.25	0.364	0.17	0.22	0.16	4.08	8.70	487	8.0
	$KHCO_3$	MHRW	MHRW	Probit	454 (407–507)	4.53 (4.07–5.06)	1.14	4.59	0.348	0.50	0.05	0.84	5.68	8.85	844	13.3
	$NaHCO_3$	MHRW	ALSW	Midpoint	1980 (1880–2090)	23.6 (22.3–24.9)	23.8	0.04	0.187[b]	0.17	0.22	0.16	24.4	9.35	1940	41.7
	$NaHCO_3$	MHRW	MHRW	Probit	1610 (1440–1700)	19.1 (17.2–20.3)	20.3	0.05	0.141[b]	0.50	0.05	0.84	20.3	9.25	1680	36.6
	NaCl	MHRW	ALSW	Probit	1910 (1730–2110)	32.7 (29.6–36.1)	33.0	0.04	0.364	0.17	32.9	0.16	0.86	8.00	3110	63.6
	NaCl	MHRW	MHRW	Midpoint	2000 (1830–2190)	34.3 (31.4–37.5)	35.4	0.05	0.348	0.50	34.4	0.84	1.14	8.10	3470	68.1
	$MgCO_3$	MHRW	ALSW	Midpoint	906 (859–956)	10.8 (10.2–11.3)	0.28	0.04	0.443	10.9	0.22	0.16	22.4	9.25	1160	23.2
	$MgCO_3$	MHRW	MHRW	Midpoint	892 (848–938)	10.6 (10.1–11.1)	1.14	0.05	0.426	11.1	0.05	0.84	22.3	9.25	1230	25.2
	$NaHCO_3$	MHRW	0.33× ALSW	Midpoint	1950 (1780–2130)	23.2 (21.2–25.4)	23.3	0.01	0.121	0.06	0.07	0.05	23.5	9.30	1800	40.3
	$NaHCO_3$	MHRW	3.0× ALSW	Probit	1710 (1560–1890)	20.4 (18.6–22.5)	21.2	0.12	0.231[b]	0.50	0.65	0.47	23.0	9.35	1800	39.1
	NaCl	MHRW	0.33× ALSW	Midpoint	1640 (1530–1760)	28.1 (26.2–30.0)	28.2	0.01	0.121	0.06	28.1	0.05	0.29	7.40	2700	53.9
	NaCl	MHRW	3.0× ALSW	Probit	1980 (1770–2160)	33.8 (30.2–36.9)	34.7	0.12	1.093	0.50	34.5	0.47	2.58	8.30	3490	69.1
	Na_2SO_4	MHRW	0.33× ALSW	Probit	1940 (1770–2100)	13.6 (12.5–14.8)	27.3	0.01	0.121	0.06	0.07	13.7	0.29	7.55	2480	36.5
	Na_2SO_4	MHRW	3.0× ALSW	Midpoint	3350 (3140–3570)	23.6 (22.1–25.2)	47.0	0.12	1.093	0.50	0.65	23.8	2.58	8.45	4090	65.4
	KCl	MHRW	0.33× ALSW	Midpoint	192 (180–205)	2.58 (2.41–2.75)	0.09	2.59	0.121	0.06	2.65	0.05	0.29	7.65	430	5.7
	KCl	MHRW	3.0× ALSW	Probit	481 (432–534)	6.45 (5.79–7.16)	0.85	6.57	1.093	0.50	7.10	0.47	2.58	8.45	1220	18.1
	$MgSO_4$	MHRW	0.33× ALSW	Midpoint	1590 (1440–1770)	13.2 (11.9–14.7)	0.09	0.01	0.121	13.3	0.07	13.3	0.29	7.45	1780	19.4
	$MgSO_4$	MHRW	3.0× ALSW	Midpoint	2860 (2620–3130)	23.8 (21.7–26.0)	0.85	0.12	1.093	24.3	0.65	24.2	2.58	8.35	2910	36.9
	$MgCl_2$	MHRW	0.33× ALSW	Probit	374 (344–409)	3.93 (3.61–4.30)	0.09	0.01	0.121	3.98	7.93	0.05	0.29	7.25	910	11.6
4	$MgCl_2$	MHRW	3.0× ALSW	Probit	1290 (1160–1490)	13.6 (12.2–15.7)	0.85	0.12	1.093	14.0	27.8	0.47	2.58	8.35	2760	40.8
	$CaCl_2$	ALSW	0.3× ALSW	Midpoint	1600 (1490–1710)	14.4 (13.4–15.4)	0.09	0.01	14.5	0.06	28.8	0.05	0.29	7.35	2870	38.7
	$CaCl_2$	ALSW	3.0× ALSW	Midpoint	2000 (1870–2130)	18.0 (16.9–19.2)	0.85	0.12	19.1	0.50	36.7	0.47	2.58	7.95	3510	52.4
	K_2SO_4	ALSW	0.3× ALSW	Probit	234 (215–254)	1.34 (1.23–1.46)	0.09	2.70	0.121	0.06	0.07	1.39	0.29	7.40	426	4.5
	K_2SO_4	ALSW	3.0× ALSW	Midpoint	518 (449–598)	2.97 (2.58–3.43)	0.85	6.06	1.093	0.50	0.65	3.44	2.58	8.50	1120	13.7
	$MgCO_3$	ALSW	0.3× ALSW	Midpoint	390 (365–417)	4.63 (4.33–4.95)	0.09	0.01	0.155	4.68	0.07	0.05	9.54	8.95	619	11.8
	$MgCO_3$	ALSW	3.0× ALSW	Midpoint	977 (916–1041)	11.6 (10.9–12.4)	0.85	0.12	0.318[b]	12.1	0.65	0.47	25.8	9.15	1280	28.9
	NaCl	ALSW	0.33× ALSW	Midpoint	1700 (1600–1800)	29.1 (27.4–30.9)	29.2	0.01	0.121	0.06	29.1	0.05	0.29	7.50	2960	55.7
	NaCl	ALSW	ALSW	Probit	1910 (1760–2070)	32.6 (30.1–35.4)	32.9	0.04	0.364	0.17	32.8	0.16	0.86	7.90	3320	63.5
	NaCl	ALSW	3.0× ALSW	Midpoint	2420 (2210–2660)	41.5 (37.8–45.5)	42.3	0.12	1.093	0.50	42.1	0.47	2.58	8.40	4110	83.1
	Na_2SO_4	ALSW	0.33× ALSW	Midpoint	1890 (1760–2020)	13.3 (12.4–14.2)	26.7	0.01	0.121	0.06	0.07	13.4	0.29	7.55	2480	35.7
	Na_2SO_4	ALSW	ALSW	Midpoint	3440 (3220–3670)	24.2 (22.6–25.8)	48.7	0.04	0.364	0.17	0.22	24.4	0.86	7.95	4000	63.8
	Na_2SO_4	ALSW	3.0× ALSW	Probit	3520 (3200–3880)	24.8 (22.5–27.3)	50.4	0.12	1.093	0.50	0.65	25.3	2.58	8.50	4280	68.5
	NaCl	MHRW	Low Ca:Mg	Midpoint	1580 (1420–1740)	27.0 (24.3–29.8)	27.2	0.04	0.075	0.46	27.2	0.15	0.86	7.90	2790	53.0
	NaCl	MHRW	HighCa:Mg	Midpoint	1920 (1790–2050)	32.8 (30.7–35.0)	33.1	0.04	0.475	0.06	33.0	0.15	0.86	7.90	3218	63.8
	$NaHCO_3$	MHRW	Low Ca:Mg	Midpoint	1540 (1440–1640)	18.3 (17.2–19.5)	18.6	0.04	0.075	0.46	0.22	0.15	19.2	9.25	1611	33.8
	$NaHCO_3$	MHRW	HighCa:Mg	Midpoint	2000 (1870–2140)	23.8 (22.2–25.5)	24.1	0.04	0.200[b]	0.06	0.22	0.15	24.6	9.30	1970	41.2
	Na_2SO_4	MHRW	Low Ca:Mg	Probit	1430 (1340–1560)	10.1 (9.41–11.0)	20.4	0.04	0.075	0.46	0.22	10.2	0.86	7.95	2027	28.6
5	Na_2SO_4	MHRW	HighCa:Mg	Midpoint	3140 (2940–3360)	22.1 (20.7–23.6)	44.5	0.04	0.475	0.06	0.22	22.3	0.86	8.00	3822	58.7
	KCl	MHRW	Low Ca:Mg	Midpoint	245 (229–263)	3.29 (3.07–3.53)	0.28	3.32	0.075	0.46	3.50	0.15	0.86	7.95	626	8.4
	KCl	MHRW	HighCa:Mg	Midpoint	281 (258–306)	3.77 (3.46–4.10)	0.28	3.81	0.475	0.06	3.99	0.15	0.86	7.95	663	9.3

(*continued*)

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Table 3. (*Continued*)

Set #	Test Chemical	Culture Water	Test Water	LC50 Method	LC50 mg/L (>95% CL)	LC50 mM (>95% CL)	Na mM	K mM	Ca mM	Mg mM	Cl mM	SO4 mM	Alk meq/L	pH	LC50 µS/cm	Osmol mOsM
	$MgSO_4$	MHRW	Low Ca:Mg	Probit	935 (857–1020)	7.77 (7.12–8.52)	0.28	0.04	0.075	8.23	0.22	7.92	0.86	7.90	1292	13.3
	$MgSO_4$	MHRW	HighCa:Mg	Midpoint	2060 (1920–2200)	17.1 (15.9–18.3)	0.28	0.04	0.475	17.1	0.22	17.2	0.86	7.95	2232	25.4
	$MgCl_2$	MHRW	Low Ca:Mg	Probit	223 (203–245)	2.34 (2.13–2.57)	0.28	0.04	0.075	2.80	4.90	0.15	0.86	7.90	654	8.5
	$MgCl_2$	MHRW	HighCa:Mg	Probit	935 (865–1015)	9.82 (9.09–10.7)	0.28	0.04	0.475	9.88	19.9	0.15	0.86	7.90	2041	28.1
	Na_2SO_4	MHRW	Low Cl:SO4	Midpoint	3430 (3200–3670)	24.1 (22.5–25.8)	48.5	0.04	0.365	0.17	0.04	24.3	0.86	8.00	4001	63.5
	Na_2SO_4	MHRW	HighCl:SO4	Probit	2990 (2770–3250)	21.1 (19.5–22.9)	42.4	0.04	0.365	0.17	0.40	21.1	0.86	7.95	3632	56.2
	K_2SO_4	MHRW	Low Cl:SO4	Midpoint	377 (355–401)	2.16 (2.04–2.30)	0.28	4.37	0.365	0.17	0.04	2.38	0.86	8.00	710	7.8
	K_2SO_4	MHRW	HighCl:SO4	Midpoint	349 (322–379)	2.00 (1.85–2.17)	0.28	4.04	0.365	0.17	0.40	2.04	0.86	8.00	669	7.6
	$MgSO_4$	MHRW	Low Cl:SO4	Midpoint	1980 (1800–2170)	16.4 (15.0–18.0)	0.28	0.04	0.365	16.6	0.04	16.6	0.86	7.90	2172	24.4
6	$MgSO_4$	MHRW	HighCl:SO4	Probit	1860 (1670–2080)	15.5 (13.9–17.3)	0.28	0.04	0.365	15.6	0.40	15.5	0.86	7.90	2097	23.4
	$NaHCO_3$	MHRW	Low Cl:SO4	Probit	1990 (1830–2180)	23.7 (21.8–26.0)	24.0	0.04	0.190[b]	0.17	0.04	0.22	24.6	9.35	1927	41.9
	$NaHCO_3$	MHRW	HighCl:SO4	Midpoint	2050 (1910–2200)	24.4 (22.8–26.1)	24.7	0.04	0.166[b]	0.17	0.40	0.04	25.2	9.35	2003	42.2
	NaCl	MHRW	Low Cl:SO4	Probit	1660 (1500–1840)	28.4 (25.7–31.5)	28.7	0.04	0.365	0.17	28.4	0.22	0.86	7.95	2816	55.5
	NaCl	MHRW	HighCl:SO4	Midpoint	1700 (1600–1800)	29.1 (27.4–30.9)	29.4	0.04	0.365	0.17	29.5	0.04	0.86	7.90	2921	57.0
	$MgCO_3$	MHRW	Low Cl:SO4	Probit	948 (874–1030)	11.2 (10.4–12.2)	0.28	0.04	0.447	11.4	0.04	0.22	23.4	9.20	1149	24.7
	$MgCO_3$	MHRW	HighCl:SO4	Midpoint	894 (836–957)	10.6 (9.92–11.4)	0.28	0.04	0.442	10.8	0.40	0.04	22.1	9.20	1131	23.8
	NaCl	ALSW	Low K ALSW	Midpoint	1920 (1800–2040)	32.8 (30.9–35.0)	33.2	0.01	0.364	0.17	33.[illegible]	0.16	0.86	7.85	3110	63.9
	NaCl	ALSW	High K ALSW	Probit	1980 (1830–2160)	34.0 (31.3–37.0)	34.0	0.26	0.364	0.17	34.1	0.16	0.86	7.85	3216	66.0
	Na_2SO_4	ALSW	Low K ALSW	Probit	2920 (2650–3230)	20.6 (18.7–22.8)	41.5	0.01	0.364	0.17	0.22	20.8	0.86	7.90	3351	54.9
	Na_2SO_4	ALSW	High K ALSW	Probit	3420 (3140–3730)	24.0 (22.1–26.3)	48.2	0.26	0.364	0.17	0.22	24.2	0.86	7.85	3858	63.5
	$NaHCO_3$	ALSW	Low K ALSW	Midpoint	2090 (1960–2220)	24.8 (23.3–26.5)	25.2	0.01	0.139[b]	0.17	0.22	0.16	25.7	9.35	1867	43.8
7	$NaHCO_3$	ALSW	High K ALSW	Midpoint	2220 (2010–2450)	26.4 (23.9–29.1)	26.5	0.26	0.192[b]	0.17	0.22	0.16	27.2	9.35	2007	46.2
	$CaCl_2$	ALSW	Low K ALSW	Probit	1870 (1690–2050)	16.9 (15.2–18.5)	0.33	0.01	17.2	0.17	34.0	0.16	0.86	7.90	3168	46.2
	$CaCl_2$	ALSW	High K ALSW	Probit	1710 (1550–1880)	15.4 (14.0–17.0)	0.08	0.26	15.8	0.17	31.1	0.16	0.86	7.85	2942	42.5
	$MgCl_2$	ALSW	Low K ALSW	Probit	970 (853–1103)	10.2 (8.96–11.6)	0.33	0.01	0.364	10.4	20.6	0.16	0.86	7.85	2022	29.1
	$MgCl_2$	ALSW	High K ALSW	Probit	912 (794–1050)	9.58 (8.34–11.0)	0.08	0.26	0.364	9.75	19.4	0.16	0.86	7.90	1968	27.5
	$MgSO_4$	ALSW	Low K ALSW	Probit	2030 (1790–2300)	16.8 (14.9–19.1)	0.33	0.01	0.364	17.0	0.22	17.0	0.86	7.95	2232	25.1
	$MgSO_4$	ALSW	High K ALSW	Probit	2240 (1980–2470)	18.6 (16.5–20.5)	0.08	0.26	0.364	18.8	0.22	18.8	0.86	8.00	2329	27.3
	KCl	MHRW	Low Alk ALSW	Midpoint	673 (632–718)	9.03 (8.48–9.63)	1.23	9.07	0.364	0.17	9.24	0.95	0.20	7.45	1433	20.2
	KCl	MHRW	High Alk ALSW	Probit	533 (487–584)	7.15 (6.53–7.83)	1.23	7.19	0.364	0.17	7.37	0.16	1.80	8.30	1188	17.6
	NaCl	MHRW	Low Alk ALSW	Probit	1860 (1690–2050)	31.8 (28.9–35.1)	33.1	0.04	0.364	0.17	32.1	0.95	0.20	7.40	3316	62.9
	NaCl	MHRW	High Alk ALSW	Probit	1970 (1790–2120)	33.8 (30.6–36.3)	35.0	0.04	0.364	0.17	34.0	0.16	1.80	8.25	3474	67.3
	$MgCl_2$	MHRW	Low Alk ALSW	Probit	899 (784–1008)	9.44 (8.23–10.6)	1.23	0.04	0.364	9.61	19.1	0.95	0.20	7.30	2076	27.9
8	$MgCl_2$	MHRW	High Alk ALSW	Midpoint	611 (571–654)	6.42 (6.00–6.87)	1.23	0.04	0.364	6.59	13.0	0.16	1.80	8.25	1542	21.0
	Na_2SO_4	MHRW	Low Alk ALSW	Probit	2960 (2700–3240)	20.8 (19.0–22.8)	42.9	0.04	0.364	0.17	0.22	21.8	0.20	7.45	3736	56.3
	Na_2SO_4	MHRW	High Alk ALSW	Probit	2830 (2560–3130)	19.9 (18.0–22.0)	41.0	0.04	0.364	0.17	0.22	20.1	1.80	8.25	3481	54.9
	$MgSO_4$	MHRW	Low Alk ALSW	Midpoint	2250 (2010–2510)	18.7 (16.7–20.8)	1.23	0.04	0.364	18.8	0.22	19.6	0.20	7.30	2475	28.2
	$MgSO_4$	MHRW	High Alk ALSW	Probit	2060 (1850–2450)	17.2 (15.4–20.3)	1.23	0.04	0.364	17.3	0.22	17.3	1.80	8.20	2263	27.1
	$MgCl_2$	MHRW	Low Alk ALSW	Probit	865 (754–985)	9.09 (7.92–10.4)	1.23	0.04	0.364	9.25	18.4	0.95	0.20	7.25	1986	27.0
	$MgCl_2$	MHRW	High Alk ALSW	Probit	623 (559–692)	6.54 (5.87–7.27)	1.23	0.04	0.364	6.71	13.3	0.16	1.80	8.10	1546	21.4
	NaCl	ALSW	ALSW	Probit	2080 (1890–2280)	35.5 (32.3–39.1)	35.8	0.04	0.364	0.17	35.8	0.16	0.86	7.85	3342	68.9
	NaCl	ALSW	Low pH ALSW	Midpoint	2160 (1980–2370)	37.0 (33.9–40.5)	37.3	0.04	0.364	0.17	37.2	0.16	0.86	6.75	3459	71.9
9	NaCl	ALSW	High pH ALSW	Probit	1880 (1730–2050)	32.2 (29.7–35.0)	32.5	0.04	0.364	0.17	32.4	0.16	0.86	8.20	3116	62.7
	$MgCl_2$	ALSW	ALSW	Probit	938 (841–1090)	9.85 (8.83–11.4)	0.28	0.04	0.364	10.0	19.9	0.16	0.86	7.85	2045	28.2

(*continued*)

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Table 3. (*Continued*)

Set #	Test Chemical	Culture Water	Test Water	LC50 Method	LC50 mg/L (≥95% CL)	LC50 mM (≥95% CL)	Na mM	K mM	Ca mM	Mg mM	Cl mM	SO4 mM	Alk meq/L	pH	LC50 µS/cm	Osmol mOsM
	$MgCl_2$	ALSW	Low pH ALSW	Probit	1040 (894–1230)	10.9 (9.39–13.0)	0.28	0.04	0.364	11.0	22.0	0.16	0.86	6.75	2057	31.0
	$MgCl_2$	ALSW	High pH ALSW	Probit	1130 (1040–1280)	11.9 (10.9–13.4)	0.28	0.04	0.364	12.0	23.9	0.16	0.86	8.50	2257	33.2
	KCl	MHRW	1.6 Na ALSW	Probit	153 (141–167)	2.05 (1.89–2.24)	0.07	2.09	0.364	0.17	2.09	0.16	0.86	7.95	422	5.6
	KCl	MHRW	3 Na ALSW	Probit	241 (206–268)	3.23 (2.76–3.59)	0.13	3.27	0.364	0.17	3.34	0.16	0.86	8.00	599	8.0
10	KCl	MHRW	10 Na ALSW	Midpoint	393 (360–429)	5.27 (4.83–5.75)	0.43	5.31	0.364	0.17	5.68	0.16	0.86	7.95	872	12.5
	KCl	MHRW	30 Na ALSW	Midpoint	513 (469–560)	6.88 (6.29–7.51)	1.30	6.92	0.364	0.17	8.16	0.16	0.86	7.95	1193	17.3
	KCl	MHRW	100 Na ALSW	Midpoint	644 (602–690)	8.64 (8.08–9.26)	4.35	8.68	0.364	0.17	13.0	0.16	0.86	7.95	1656	26.4
	KCl	MHRW	300 Na ALSW	Probit	752 (641–1360)	10.1 (8.60–18.2)	13.0	10.13	0.364	0.17	23.1	0.16	0.86	7.90	2616	45.3
	$NaHCO_3$	ALSW	ALSW Aged	Midpoint	1660 (1531–1790)	19.7 (18.2–21.3)	20.0	0.04	0.134[c]	0.17	0.22	0.16	20.6	9.35	1670	35.5
	$NaHCO_3$	ALSW	3.0× ALSW Aged	Midpoint	1670 (1530–1810)	19.8 (18.3–21.5)	20.7	0.12	0.126[c]	0.50	0.65	0.47	22.4	9.35	1793	38.2
	$NaHCO_3$	ALSW	ALSW Fresh	Probit	2150 (1990–2320)	25.6 (23.7–27.6)	25.9	0.04	0.207[c]	0.17	0.22	0.16	26.4	9.15	2087	47.2
11	$NaHCO_3$	ALSW	3.0× ALSW Fresh	Midpoint	2240 (2080–2420)	26.7 (24.8–28.8)	27.5	0.12	0.139[c]	0.50	0.65	0.47	29.3	9.10	2284	51.7
	$MgCO_3$	ALSW	ALSW Aged	Probit	767 (699–843)	9.10 (8.29–10.0)	0.28	0.04	0.431	9.27	0.22	0.16	19.0	9.30	1043	20.9
	$MgCO_3$	ALSW	3.0× ALSW Aged	Probit	507 (467–551)	6.01 (5.54–6.54)	0.85	0.12	0.147[c]	6.52	0.65	0.47	14.6	9.30	879	18.0
	$MgCO_3$	ALSW	ALSW Fresh	Midpoint	792 (736–853)	9.39 (8.73–10.1)	0.28	0.04	0.433	9.56	0.22	0.16	19.6	9.15	1054	23.8
	$MgCO_3$	ALSW	3.0× ALSW Fresh	Probit	635 (529–752)	7.53 (6.27–8.92)	0.85	0.12	0.152[c]	8.04	0.65	0.47	17.6	9.00	941	18.4
	NaCl	ALSW	ALSW	Midpoint	1950 (1840–2070)	33.4 (31.5–35.5)	33.7	0.04	0.364	0.17	33.6	0.16	0.86	7.85	3296	65.0
	Mannitol	ALSW	ALSW	Probit		73.7 (66.2–82.1)	0.28	0.04	0.364	0.17	0.22	0.16	0.86	7.75		75.7
12	NaGluconate	ALSW	ALSW	Midpoint		39.2 (36.8–42.0)	39.5	0.04	0.364	0.17	0.22	0.16	0.86	7.85	2188	76.1
	CaGluconate	ALSW	ALSW	Probit		32.9 (29.9–36.2)	0.28	0.04	33.3	0.17	0.22	0.16	0.86	7.80	2074	84.6
	MgGluconate	ALSW	ALSW	Probit		17.1 (14.3–18.7)	0.28	0.04	0.364	17.3	0.22	0.16	0.86	7.80	1638	50.6

[a]See text for designations and formulations for test and culture waters; horizontal gaps delineate experiments and horizontal lines delineate experimental sets. For median lethal concentrations (LC50s), "Probit" denotes exposure-effects curve calculation by probit method; "Midpoint" denotes geometric mean of confidence limits; parentheses denote confidence limits; see text for methodology. Except where noted, LC50s and component concentrations are nominal, and expected to be within +/–10% based on analysis of subset of test solutions.

[b]Ca concentrations are an extrapolation of Ca measurements to median lethal concentration based on model for time dependence of Ca as a function of alkalinity; see Supplemental Data for more information.

[c]Ca concentrations are a weighted average of measurements and 24 and 48 hours that bracket the median lethal concentration.

ALSW = amended Lake Superior water; LC50 = median lethal concentration; MHRW = moderately hard reconstituted water.

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sampling from intermediate treatments at the beginning and end of exposure to verify that exposure concentrations were stable over the course of the exposure. Every dilution water was analyzed for all 4 cations plus Cl and SO_4. Because cation analysis was more time-efficient than anion analysis, exposure concentrations of the salt tested were verified by analyzing for its cation. For tests of the toxicity of CO_3/HCO_3 salts, which caused oversaturation of $CaCO_3$ even at the low Ca concentrations in dilution water, Ca concentrations were also measured. In the Ca precipitation experiment with $NaHCO_3$ and $MgCO_3$ (set 11), extra test chambers were used to monitor Ca at 0 h, 24 h, and 48 h at the 25%, 50%, and 100% treatment concentrations, in addition to the cation samples normally taken.

For cation analysis, filtered (0.45-μm nylon syringe filter; Grainger) and unfiltered samples were collected in early experiments; but these analyses consistently showed no significant difference between the 2, so later cation samples were not filtered, except for tests with $NaHCO_3$ and $MgCO_3$ in which $CaCO_3$ precipitation was a concern. Samples for cation analysis were acidified by adding 0.2% (v/v) concentrated HNO_3 and held at room temperature; for tests with $NaHCO_3$ and $MgCO_3$, this amount of acid was increased by an amount calculated to neutralize the extra alkalinity. Cation measurements were made using an Agilent 240 FS flame atomic absorption spectrophotometer (Agilent Technologies), calibrated with a blank and a series of 5 standards, and verified with a quality control standard and an independent calibration standard at both the beginning and the end of the run.

Concentrations of Cl and SO_4 were determined on samples filtered into a polypropylene centrifuge tube, stored under refrigeration, and analyzed within 28 d. Quantifications were made using a Dionex DX600 Ion Chromatograph with an AS50 autosampler, an LC25 chromatography oven, an ED50 electrochemical detector, and a GP50 gradient pump (Thermo Fisher Scientific). A typical instrument run included a blank, a series of 8 standards, a blank spike, and a quality control standard analyzed at both the beginning and the end of the run. Thirteen percent of all ion analyses were run in duplicate; the average relative percentage difference was 1.6% (maximum 8%, standard deviation 1.6%).

Across all test solutions (i.e., samples other than controls) of the 10 major ion salts for which LC50s were determined, comparison of measured and nominal cation concentrations averaged 98.7% with a standard deviation of 4.9% ($n = 329$). Individual results ranged from 83% to 116% of nominal, and 95% fell between 90% and 110% of nominal. Conductivity measurements on all treatments confirmed that the intended gradient of exposure existed among samples not sampled for cation analysis. Based on these results, and the complexity of estimating concentrations in test solutions that were not directly measured, nominal exposure concentrations were used for calculating LC50 values.

Analysis of dilution waters yielded a similarly high average agreement between the measured cation concentrations and nominal values based on past reported measurements (99.3%, $n = 313$) but a higher standard deviation of 10.2%; 97% of values fell between 80% and 120% of nominal and 79% of samples fell between 90% and 110% of nominal. This higher variability is associated with the much lower ion concentrations in control waters, which can inflate percentage error values; in the more dilute waters, K in particular was at very low concentrations, sometimes lower than can be confidently quantified by the methods used (e.g., <0.5 mg/L). Wherever measured concentrations deviated more than 20% from nominal ($n = 8$), all data from that test were reviewed; and in each instance, the information suggested the large deviation was likely spurious (e.g., concentrations of all other ions measured in the same water were close to nominal). Accordingly, ion concentrations in dilution water were also assumed to be equal to nominal in the data analyses, except for Ca concentrations in tests on the toxicity of CO_3/HCO_3 salts, in which case Ca was based on measured concentrations. Because these Ca concentrations varied with time and added salt concentration, this involved interpolation of Ca measurements, which is further discussed in the Supplemental Data.

Data analysis

Concentration–response curves were extremely steep, so that even with the closely spaced exposure concentrations (0.8×), it was common for there to be only 1 (or no) exposure treatment with partial survival less than that attributable to background (control) mortality. For such tests, continuous concentration–effect models cannot be fit to provide point estimates for LC50s. Consequently, a tiered approach was used, based on the type of calculation the data would support. For each test, a background mortality range was defined as all treatments up to the highest concentration at which the fraction of mortality was no greater than at any lower concentration. The number of treatments with partial mortality (i.e., above this background mortality range and below the lowest treatment with complete mortality) was then determined and used to select the type of analysis.

For tests with at least 2 partial mortalities that increased with concentration, a tolerance distribution analysis was conducted, using a 3-parameter model that included a background survival parameter and assumed a log-normal distribution for the lethal concentrations. Parameters were estimated by maximum likelihood analysis using custom software written with Intel Professional Fortran Composer XE 2011. Of the 149 LC50s reported in the present study, 82 supported calculation of such "probit LC50s." The 95% confidence limits were calculated using the likelihood ratio method [29]. Statistical significance of LC50 differences between treatments within an experiment was assessed based on these confidence limits not overlapping, so that such differences have a significance level of at least 95%.

For tests with insufficient partial mortalities for this probit LC50 analysis, the same likelihood ratio method was used to calculate confidence limits for the LC50 (such confidence limits can be assigned even when a unique point estimate for the LC50 cannot be calculated). For these tests, we assigned the geometric mean of these confidence limits to be the point estimate for the LC50 ("midpoint LC50s"). For cases in which there were no partial mortalities, these confidence limits are the bracketing concentrations (the upper end of the background mortality range and the lowest treatment with complete mortality) and the LC50 is equivalent to linear interpolation of survival versus log concentration between these 2 concentrations. To test the performance of this methodology when tolerance distribution assumptions are met, it was applied to simulated data sets generated based on the range of observed parameters, which demonstrated the bias for LC50 estimation to be <1% and the confidence limits to equal or exceed 95%.

These LC50 calculations were based on the nominal concentration of added salt, without consideration of background ion concentrations, because different ion ratios in the dilution water and the added salt make it impossible to express total ion concentrations as an equivalent concentration of salt. Initial comparisons of how dilution water differences affect salt toxicity are also on the basis of added salt for the same reason.

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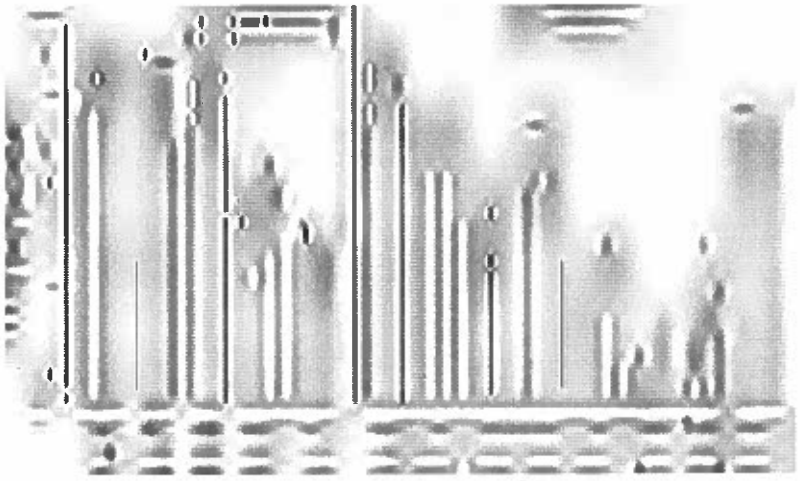


Figure 1. Effects of culturing and testing organisms in different strengths of amended Lake Superior water and moderately hard reconstituted water on median lethal concentrations for selected major ion salts to *Ceriodaphnia dubia*. Error bars denote upper 95% confidence limits, and asterisks denote where confidence limits do not overlap. ALSW = amended Lake Superior water; LC50 = 48-h median lethal concentration; MHRW = moderately hard reconstituted water.

Background concentrations of the component ions of the test salt were <5% in all but 6 tests and never >10%; these had negligible impact on comparisons based on added salt except as noted in *Results and Discussion*. However, for further analyses of the aggregated data, exposure metrics included both background and added ions.

Although test preparation and chemical analysis were based on weight of the salts and the various ions, this is not a good basis for comparing the relative toxicity of the individual salts and ions because the toxic action of these ions should be related to their molarity, not their mass. As such, salt and ion concentrations were converted to molarity, which is the primary basis for toxicity comparisons of the added salts. In addition, evaluation of the dosimetry at these elevated ion concentrations should consider formation of complexes between the various cations and anions, which would affect their chemical reactivities and thus their toxicities. It should also consider that the high ionic strength of these solutions will reduce the reactivity of the ions, as represented in lower activity coefficients, and that exposure metrics thus would be best expressed as chemical activity rather than molarity. To this end, the ion composition at each LC50 was analyzed using the chemical speciation program Visual MINTEQ (Ver 3.0) to estimate chemical speciation and the chemical activity of each chemical species. The osmolarity of each LC50 solution was also calculated based on these MINTEQ activity estimates using the method described by Robinson and Stokes [30].

RESULTS AND DISCUSSION

For each test ($n = 149$), added-salt LC50 values with confidence limits are provided in Table 3, as both milligrams per liter and millimolarity, along with total ion concentrations and osmolarities at these LC50s. The pH associated with each LC50 at the end of exposure is also provided based on measurements in treatments bracketing the LC50. All reported tests had conductivity measurements that varied across treatments in a manner consistent with the intended exposure concentrations, and LC50s directly based on these conductivities are also provided in Table 3. Dissolved oxygen was always above 7.5 mg/L, and temperature was always within 1 °C of 25 °C. Measurements made at the beginning and end of experiments indicated that evapoconcentration during the experiment was low (<5%). Over the background mortality range, as defined in *Data analysis*, survival was ≥90% in all toxicity tests and averaged 98% overall.

Effects of acclimation to dilution water

Figure 1 compares LC50s for *C. dubia* cultured in dilute solutions to those from our standard culture waters. Culturing organisms in 1/3× ALSW or 1/3× MHRW had no significant effect on the toxicities of NaCl and $MgCl_2$, either in test waters at these dilutions or (for NaCl only) in 1× ALSW, the LC50 estimates differing by 20% or less. Culturing organisms in 1/8× MHRW also had no effect on the toxicities of NaCl, $NaHCO_3$, and $CaCl_2$, the LC50s differing by no more than 10%. However, for Na_2SO_4, KCl, $MgCl_2$, and $MgSO_4$, LC50s for 1/8× MHRW test water are 20% to 45% lower for organisms cultured in 1/8× MHRW than those cultured in 1× MHRW, these differences being statistically significant except for $MgCl_2$, for which the LC50 is uncertain because of highly variable responses in this dilute test water.

Thus, "acclimation" to 1/8× MHRW resulted in *C. dubia* being more, rather than less, sensitive to some salts when tested in this dilute solution. Although both we and Elphick et al. [19] established successful cultures in this water, based on our experience with *C. dubia*, such a dilute solution appears to be stressful, an indication of this being the greater variability of organism response to salt toxicity. It is not clear whether this should be considered an artificial stress created by manipulating organisms long adapted to laboratory waters with higher ion concentrations, or a natural consequence for a species not adapted to and not endemic to such dilute waters.

These acclimation experiments were prompted by the work of Elphick et al. [19], who acclimated cultures to dilutions waters (for 2 generations or more) and found that, relative to 1× MHRW, the 7-d NaCl LC50 for *C. dubia* decreased by 2.1-fold in 1/2× MHRW, 3.6-fold in 1/4× MHRW, and 8.4-fold in 1/8× MHRW. In contrast, for organisms both cultured and tested in the waters, we found only a 9% decrease in the NaCl LC50 between 1× MHRW and 1/3× MHRW and only a 1.9-fold decrease between MHRW and 1/8× MHRW (Figure 1). The lack of culture water effect on our LC50s for NaCl suggests that these differences between the 2 studies resulted from other

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factors, such as the longer duration in Elphick et al. [19] or a variability associated with culturing and/or testing *C. dubia* in such dilute waters. More recent communication with J. Elphick has indicated that they have observed variability in NaCl LC50s for *C. dubia* in very dilute test waters (D.R. Mount, personal communication).

Overall, we concluded that the absence of dilution water-specific culturing was not a substantial factor for most of our experiments but that data for the 1/8× MHRW waters should be interpreted with caution. The results presented hereafter will be only for organisms from our standard culture waters and will consider LC50s for the most dilute test waters to be more useful for qualitative insights into ion toxicity rather than establishing quantitative relationships. Any quantitative uncertainties of LC50s for such dilute waters are probably of limited practical concern because few unimpacted surface waters will likely experience elevations of a single salt to toxic levels while other ions remain at such low levels.

Our culture experiments only addressed more dilute waters than our standard culture water because discrepancies of our results from that of Elphick et al. [19] were noted for those waters. Although we did not evaluate effects of culturing at higher ion concentrations, the relationship of our NaCl LC50s to Ca concentration shows good agreement with that of Soucek et al. [18] and Elphick et al. [19], who did culture organisms in their different test waters. Also, Soucek and Kennedy [16] reported only small and statistically nonsignificant differences among Na_2SO_4 LC50s in MHRW for *C. dubia* cultured in MHRW versus MHRW with elevated Na_2SO_4 levels. This suggests that acclimation to higher ion concentrations may not be a significant factor, but more study would be needed to reach a definitive conclusion.

Salt toxicity in MHRW versus ALSW

Figure 2 compares LC50s for 10 major ion salts tested in both ALSW and MHRW. For NaCl, $MgCl_2$, $CaCl_2$, Na_2SO_4, $MgSO_4$, and $MgCO_3$, LC50 differences are <15% and not statistically significant. For $NaHCO_3$, the LC50 is 20% lower for MHRW and is statistically significant; however, this test involved significant precipitation of Ca, and this precipitation was more pronounced in the MHRW test (Table 3). Given previous studies on the effect of hardness on salt toxicity [16–21], such a Ca difference would contribute to the observed LC50 difference. The fact that MHRW provides a higher background Na concentration and alkalinity would also contribute to the difference in LC50s expressed in terms of added $NaHCO_3$.

Only for the 3 K salts are there clear, substantial differences between the 2 dilution waters. The LC50s are 32% to 67% higher for MHRW than for ALSW, and these differences were all statistically significant. Notable compositional differences between these waters (Table 1) include 4-fold higher Na in MHRW (because of the use of $NaHCO_3$ to add alkalinity), 3-fold higher Mg in MHRW (but similar Ca), 5-fold higher SO_4, and 3-fold lower Cl. The higher Na for MHRW is of particular interest because Na and K are linked physiologically through the central role of Na K adenosine triphosphatases in ion regulation and other key cellular processes [2]. Additional information regarding this issue is provided below (see *Effects of sodium on potassium toxicity*).

Comparing the LC50s in Figure 2 across salts also supports some inferences regarding the contributions of individual ions to toxicity. On a total molarity basis, the Na salts are significantly less toxic than salts of other cations with the same anion. On a total molarity basis NaCl is also significantly less toxic than the other Na salts. For Na_2SO_4, the greater toxicity could be caused by it containing 2, instead of 1, Na atoms, in addition to any anion effects. For $NaHCO_3$, the greater toxicity should be partly the result of lower Ca concentrations (Table 3) from the $CaCO_3$ precipitation induced by this salt. These differences among Na salts will be further addressed below (see *Effects of calcium on the toxicities of sodium salts*).

The K salts are much more toxic than the corresponding salts with other cations, especially Na (Figure 2). The ratio of the Na salt LC50 to the K salt LC50 ranges across the different anions from 4.2 to 6.6 for MHRW and from 5.8 to 9.1 for ALSW, with smaller ratios for MHRW resulting from the aforementioned dilution water effect on K toxicity. These large ratios indicate that K is the principal source of toxicity for these salts because the anion concentrations at the LC50s for K salts are in all cases a small fraction of those present at the LC50s for the Na salts. The LC50 on a molarity basis for K_2SO_4 is approximately half that of KCl, consistent with toxicity being related to the molarity of K rather than the molarity of the salt. Factors controlling K salt toxicity are explored further below (see *Effects of sodium on potassium toxicity*).

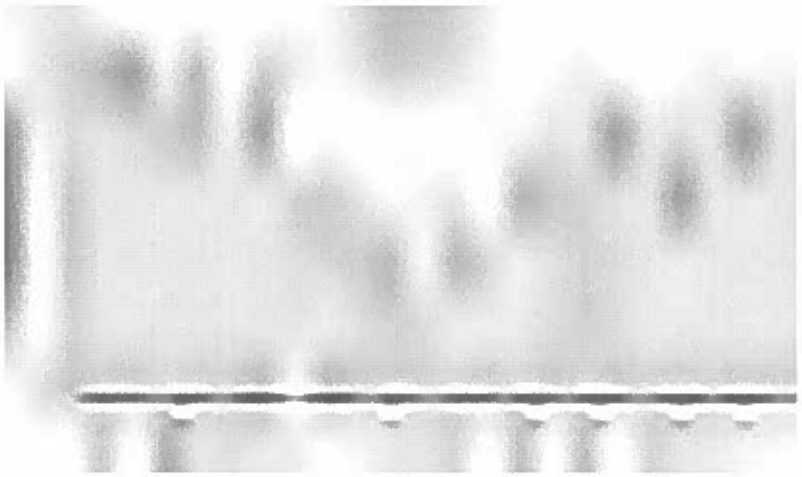


Figure 2. Median lethal concentrations for major ion salts to *Ceriodaphnia dubia* in moderately hard reconstituted water and amended Lake Superior water. Error bars denote upper 95% confidence limits, and asterisks denote where confidence limits do not overlap. ALSW = amended Lake Superior water; LC50 = 48-h median lethal concentration; MHRW = moderately hard reconstituted water.

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Although less toxic than the K salts in these test waters, the Mg salts are also significantly more toxic than their corresponding Na salts (ratios of 1.4–4.4; Figure 2), suggesting that, like K, Mg is also more important to the toxicity of these salts than are the anions. On a total molarity basis, $MgSO_4$ was approximately 2-fold less toxic than $MgCl_2$. Given the same Mg stoichiometry in each salt, this suggests that the toxicity of Mg is differentially modified by the anions, perhaps by SO_4 complexing Mg and thus reducing its toxicity. Unlike for $NaHCO_3$, there was no Ca precipitation in the tests with $MgCO_3$ (Table 3; and see Supplemental Data for more information on Ca precipitation relationships), and $MgCO_3$ was only slightly less toxic than $MgCl_2$. The relationship of these toxicity differences among Mg salts to ion speciation and activity is discussed later (see *Effects of calcium on the toxicities of magnesium salts*).

For Ca, only the Cl salt was acutely toxic below its solubility. On a total molarity basis, $CaCl_2$ is more toxic (by 1.9 fold) than NaCl (Figure 2); however, because $CaCl_2$ has twice as many chlorides as NaCl, this result by itself provides no clear evidence regarding relative ion toxicities.

Salt toxicity in different strengths of ALSW

Figure 3 shows the effect of varying all ions in dilution water by comparing LC50s for 1/3×, 1×, and 3× ALSW. These comparisons were developed by combining data from simultaneous tests in 1/3× and 3× ALSW with the 1× ALSW data generated separately (Figure 2). Also, NaCl and Na_2SO_4 were evaluated in an additional experiment with all 3 waters tested simultaneously (marked "dup" in Figure 3); this was done to determine if combining data across experiments might influence conclusions. For the 3× ALSW water, ions in the dilution water equaled between 3% and 8% of the added salt LC50, so that any amelioration of toxicity in this water would be slightly underestimated when based just on the added salt.

For the K salts, there is a 2.3-fold to 2.5-fold increase in LC50s from 1/3× to 3× ALSW (Figure 3), with the LC50 for 1× ALSW being near the midpoint of these ranges. Because all ions varied proportionately between these dilution waters, the specific factors responsible for these differences are not directly identifiable. However, the decreased toxicity from 1× to 3× ALSW (entailing a 3-fold change in both Na and hardness) is similar to the change between ALSW and MHRW (Figure 2), between which Na differs 4-fold but hardness is just 1.5-fold different and Ca is virtually constant, suggesting that Na is more important than other cations to these toxicity differences.

For the Mg salts, there are substantial increases in the LC50s from 1/3× to 3× ALSW, totaling 3.4-fold, 2.5-fold, and 1.8-fold for $MgCl_2$, $MgCO_3$, and $MgSO_4$, respectively (Figure 3). For $MgCO_3$, the lack of difference between 1× and 3× ALSW is associated with substantial precipitation of $CaCO_3$ in 3× ALSW (Table 3). For $MgCl_2$ and $MgSO_4$, the LC50 increases between 1× and 3× ALSW are similar to the corresponding K salts; but because these Mg salts show no LC50 difference between ALSW and MHRW whereas the K salts do, the underlying reasons must be different. These effects of dilution water strength should reflect the effects of the anions on the speciation of Mg and Ca; whether such consideration of speciation accounts well for LC50 differences among dilution waters, and among the salts, is addressed later.

For the Na salts, LC50s show responses to ALSW strength that are different from each other and from the K and Mg salts (Figure 3). The LC50 for Na_2SO_4 increases by 1.8-fold from 1/3× to 3× ALSW in both replicate tests, similar to $MgSO_4$ and K_2SO_4; but the increase is all between 1/3× to 1× ALSW. The LC50 for NaCl increases much less from 1/3× to 3× ALSW (1.2-fold and 1.4-fold in the different replicates). For $NaHCO_3$, there is a nonsignificant but slight decrease of the LC50 from 1/3× to 3× ALSW. This is again associated with precipitation of Ca, this precipitation being more extensive in the higher ALSW strengths, leading to Ca concentrations actually being similar across these waters (Table 3) despite the original formulations being 9-fold different. Possible reasons for these LC50 differences across Na salts, including chemical speciation and the ameliorative effects of Ca, are further addressed below (see *Effects of calcium on the toxicities of sodium salts*).

For $CaCl_2$, there is an increase of only 1.2-fold in the LC50 from 1/3× to 3× ALSW of marginal statistical significance. This small dependence of Ca toxicity on ALSW strength, compared with the large dependence of Mg toxicity, results in the toxicity of $MgCl_2$ being very similar to $CaCl_2$ in 3× ALSW (a factor of 1.3 difference) and very different in 1/3× ALSW (a

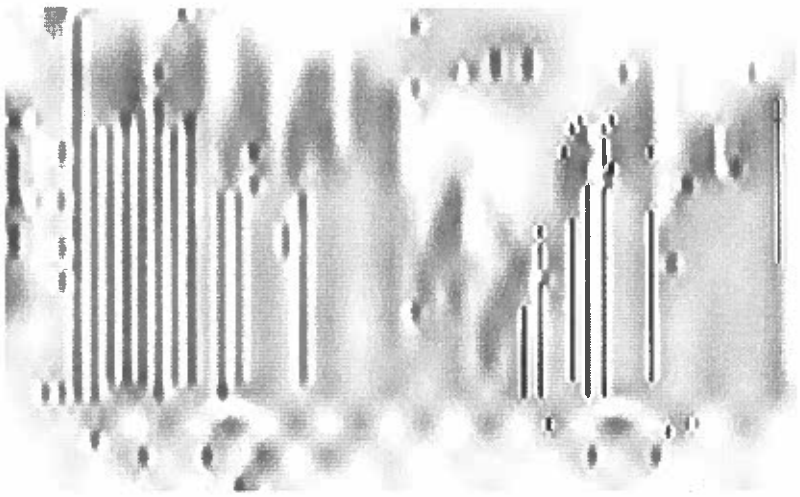


Figure 3. Median lethal concentrations for selected major ion salts to *Ceriodaphnia dubia* in different strengths of amended Lake Superior water (ALSW). Error bars denote upper 95% confidence limits, and asterisks denote where confidence limits do not overlap for 0.33× and 3× ALSW. LC50 = 48-h median lethal concentration.

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factor of 3.7 difference). To the extent that the toxicity of $MgCl_2$ (or another salt) depends on Ca, judging relative potencies is best done at high, but nontoxic, Ca concentrations because any adverse consequences of low Ca cannot, by definition, affect Ca toxicity. Thus, Ca and Mg should be considered to have similar intrinsic toxicities.

Effects of manipulating specific ion ratios

To evaluate the factors behind the responses in the 1/3× versus 3× ALSW and MHRW versus ALSW, 3 sets of experiments were conducted in which the Ca:Mg, Cl:SO_4, and Na:K ratios were manipulated whereas other ions remained constant. The LC50s for $MgCl_2$, Na_2SO_4, and $MgSO_4$ are at least 2-fold greater at high Ca:Mg than low (Figure 4). Because total hardness and all other ion concentrations were the same in high Ca:Mg and low Ca:Mg waters, these differences are presumably attributable to Ca, rather than overall hardness. These same salts have large LC50 differences in the 1/3× versus 3× ALSW comparisons (Figure 3), for which Ca also changed substantially (in concert with other ions), but small LC50 differences for the MHRW versus ALSW comparisons (Figure 2), for which Ca was essentially the same but other ions varied markedly. Overall, this suggests that Ca is the important factor in differences among these various dilution waters for these salts. The LC50s of NaCl and $NaHCO_3$ had smaller (20–30%) increases at high Ca:Mg (Figure 4), but the magnitude of these effects is also consistent with the results shown in Figures 2 and 3 and their associated Ca concentrations (Table 3). In contrast, although KCl has a higher (15%) LC50 at high Ca:Mg, this is not statistically significant and is much smaller than the LC50 differences for both the MHRW and ALSW comparison (Figure 2) and the 1/3× to 3× ALSW comparison (Figure 3) for this salt. This reinforces the earlier suggestion of the importance of Na to K salt toxicity (see *Salt toxicity in MHRW versus ALSW*).

When the Cl:SO_4 ratio was altered (Figure 4), no significant differences in LC50s (<15%) exist for any of the tested salts (Table 2), indicating that these anions are not important characteristics of dilution water for major ion toxicity to *C. dubia*. When the Na:K ratio was altered (Table 3), there also are no significant effects on the LC50s of the tested salts. No K salts were included in Na:K ratio studies because the effect of Na on K salt toxicity was evaluated separately.

Effects of manipulating alkalinity and pH

Two sets of toxicity tests evaluated the effects of dilution water alkalinity and pH on salt toxicity (Figure 5). In the first set, alkalinity was decreased (by dilution, then restoring other ions) and increased (by $NaHCO_3$ addition) relative to 1× ALSW water, resulting in pHs of approximately 7.4 and 8.3 in the low-alkalinity and high-alkalinity treatments, respectively, compared with a typical pH of approximately 7.9 in ALSW. The effects of these combined changes in alkalinity and pH on LC50s are <10% and not statistically significant for NaCl, Na_2SO_4, and $MgSO_4$, but are larger and statistically significant for $MgCl_2$ and KCl. For $MgCl_2$, increasing the alkalinity decreased the LC50 by 1.4-fold. This test was repeated, yielding virtually identical results (Table 3). We initially speculated that complexation by the higher HCO_3/CO_3 decreased Ca activity and thus increased toxicity. However, to maintain a constant Na concentration in these tests, the low-alkalinity water had higher SO_4, which also complexes Ca. As a result, the calculated Ca activity in the high-alkalinity treatment is actually higher than that in the low-alkalinity treatment, so it would not explain the observed LC50 shift. We similarly have no explanation for the lower LC50 (20%) for KCl at high alkalinity. One area of needed future work is direct ion activity measurements to verify speciation model calculations before further exploring the cause of these effects.

In the second set of tests, pH was manipulated by CO_2 partial pressure, leaving alkalinity and all other ions constant as pH varied. For this experiment, pH had no effect on NaCl toxicity over the pH range 6.75 to 8.20 or on $MgCl_2$ toxicity over the pH range 6.75 to 8.50 (Figure 5). (The high pH treatment for the NaCl tests had lower pH than for the $MgCl_2$ tests because of an air leak in the chamber for the low CO_2 treatment, so that the range of tested pHs was less than intended.) This insensitivity of toxicity to pH manipulation suggests that something other than pH itself is responsible for the effects of altered alkalinity on $MgCl_2$ toxicity noted in the previous experiment. However, although these tests at different pHs and alkalinities indicate limited or no effect of these factors on the toxicity of SO_4 and Cl salts, they do not

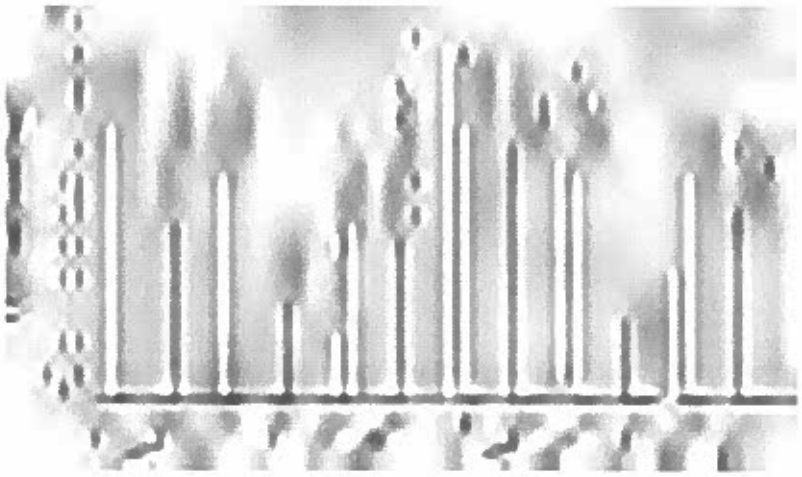


Figure 4. Median lethal concentrations for selected major ion salts to *Ceriodaphnia dubia* in amended Lake Superior water modified to have different ratios of Ca to Mg and different ratios of Cl to SO_4. Error bars denote upper 95% confidence limits, and asterisks denote where confidence limits do not overlap. LC50 = 48-h median lethal concentration.

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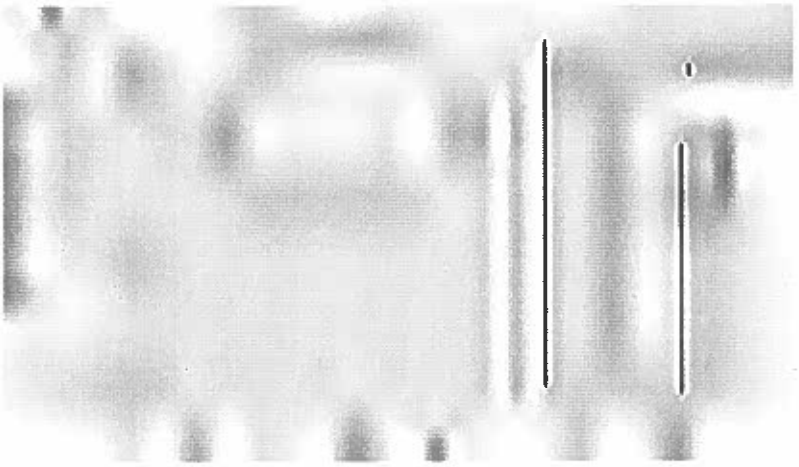


Figure 5. Median lethal concentrations for selected major ion salts to *Ceriodaphnia dubia* in amended Lake Superior water modified to have different alkalinities and pH or different pH with alkalinity unchanged. Error bars denote upper 95% confidence limits, and asterisks denote where confidence limits do not overlap. LC50 = 48-h median lethal concentration.

encompass the much higher pHs and buffering levels of the tests with HCO_3/CO_3 salts. Therefore, pH might still have a role in the relative toxicity of those salts.

Effects of sodium on potassium toxicity

To evaluate the suspected effect of Na on the toxicity of K salts, 6 dilution waters were prepared, each having the composition of ALSW except that the Na^+ concentrations were varied to be 0.070 mM (background in LSW), 0.13 mM, 0.43 mM, 1.3 mM, 4.3 mM, and 13 mM (1.62 mg/L, 3 mg/L, 10 mg/L, 30 mg/L, 100 mg/L, and 300 mg/L), added as NaCl so that the anion was the same as for the toxicant, KCl. The LC50 of KCl differs consistently and substantially across these dilution waters (Figure 6), from a low of 2.05 mM (153 mg/L) at the lowest Na to a high of 10.1 mM (752 mg /L) at the highest Na. The magnitudes of these changes are consistent with the behavior observed for KCl in the MHRW versus ALSW and 1/3× versus 3× ALSW experiments (Figures 2 and 3 and included in Figure 6).

Mount et al. [3] and our initial experiments (Figure 2) demonstrated that K is the most toxic of the major ions to *C. dubia* and, as a result, the effects of K seem to greatly exceed any effect of the different anions. This is demonstrated in Figure 6, which shows agreement of other K salts and dilution waters with the experiment regarding KCl toxicity across different NaCl levels. Note that by compiling data for tests conducted across a variety of dilution water compositions, the correlation of Na with other major ions that might exist in a single experiment is reduced, strengthening the case for Na being the primary factor influencing toxicity of K salts. There might be some lesser effects of other factors, as evidenced by slightly lower LC50s (expressed as K) for $KHCO_3$ than for KCl and K_2SO_4 (Figures 2 and 6). As noted previously, the carbonate tests entailed much higher pH and buffering for which effects are uncertain. However, any such effects appear to be of less consequence than the primary effect of Na on K toxicity.

One implication of the Na dependence of K toxicity demonstrated in the present study is that the high toxicity of K in typical test waters with low Na may be of limited field relevance because K would be unlikely to be present at toxic concentrations when Na is so low. For example, the K-dominated effluent evaluated by Jop and Askew [11] had approximately 1.5 mM Na, which would put the expected acute LC50 for K at 10 mM or higher (Figure 6). This is similar to the toxicity of Mg salts and only 2-fold to 3-fold more toxic than Na salts.

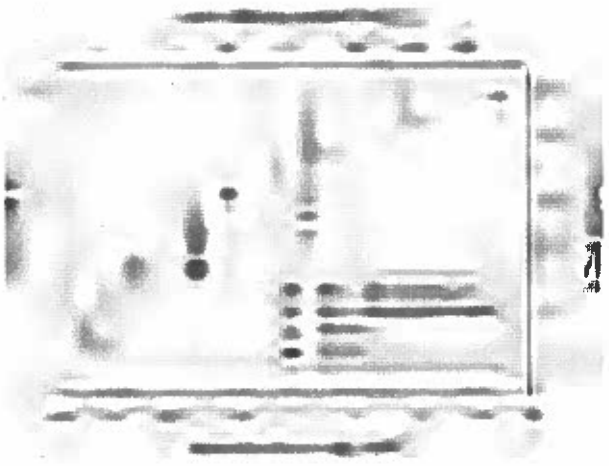


Figure 6. Effect of Na on median lethal concentrations for K salts to *Ceriodaphnia dubia*. Error bars denote 95% confidence limits. LC50 = 48-h median lethal concentration.

Effects of calcium on the toxicities of sodium salts

Aside from the effect of Na on the toxicity of K, Ca is the only other ion in the present study which exerted a substantial influence on the acute toxicity of major ion salts to *C. dubia*. Several studies have shown that hardness influences major ion toxicity to *C. dubia* [16–20], though the way in which hardness was manipulated differed across studies. Experiments by Soucek et al. [16–18] varied hardness by adding $CaCl_2 + MgCl_2$ (for NaCl toxicity tests) or $CaSO_4 + MgSO_4$ (for Na_2SO_4 toxicity tests) in fixed ratios and keeping the remaining ions constant, whereas Elphick et al. [19,20] varied all ions proportionately (as in the 1/8×, 1/3×, and 1× MHRW waters used in the present study). In the present experiments, the combination of manipulating all ions simultaneously in some tests and only specific ion pairs in others (at constant hardness) allowed us to conclude that the "hardness effect" on the toxicity of Na salts is primarily an effect of Ca, rather than total hardness or the other ions that covary with hardness. The same conclusion was reached by Davies and Hall [21], who manipulated both

total hardness and the Ca:Mg ratio to show the dominance of Ca in determining toxicity of Na_2SO_4 to *D. magna*.

Figure 7 shows the relationship of LC50s to Ca for all our Na salt toxicity tests using organisms cultured in 1× ALSW or MHRW. Each panel considers different exposure metrics for how LC50 and Ca are expressed. As a comparative performance measure for these different metrics, residual standard deviations of the logLC50s (RSD_{log}) around the mean trend of logLC50 with Ca are provided. Mean data trends were calculated by least-square regression of logLC50 versus logCa using Sigmaplot with a model for an exponential rise to a maximum. This is not intended to provide a definitive model for the relationship of toxicity to Ca but rather only an empirical description of the mean data trend suitable for calculating the RSD_{log}.

In Figure 7A, LC50s are plotted as millimolarity of added salt and Ca is plotted as total concentration (measured Ca for $NaHCO_3$ tests, nominal for others). Although the 3 inorganic salts have a similar and substantial (2-fold to 3-fold) dependence on Ca, there is an apparent difference in the relative toxicities of the salts, with LC50s being ordered NaCl ≈ Na gluconate > $NaHCO_3$ > Na_2SO_4. The RSD_{log} is 0.110, for which ±2 SDs corresponds to nearly a 3-fold range in LC50 at a fixed Ca concentration, indicative of the substantial variability among the different salts.

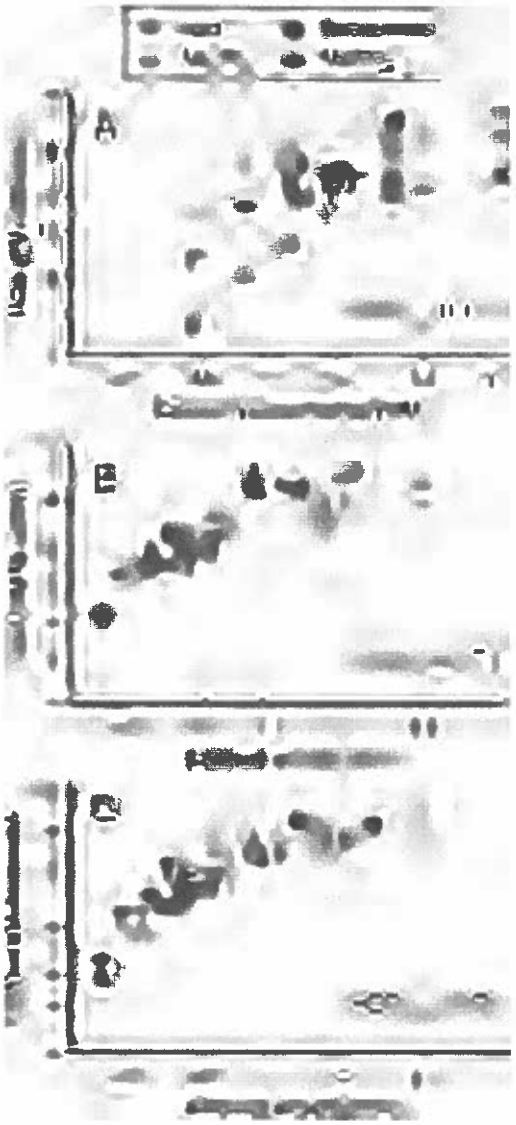


Figure 7. Effect of Ca on 48-h median lethal concentrations (LC50s) for Na salts to *Ceriodaphnia dubia* using different exposure metrics. (A) Metrics are LC50 as concentration of added salt and Ca concentration. (B) Metrics are Na and Ca activities. (C) The LC50 metric is changed to osmolarity. RSD_{log} denotes the residual standard deviation of log(LC50)s from their mean trend with Ca.

Because chemical reactions are governed by chemical activity rather than concentration, the relative toxicities of salts and their relationships to Ca should be based on chemical activities rather than total concentrations, as in Figure 7A. Activities will differ from total concentrations because of formation of chemical complexes as well as reduced activity coefficients associated with high ion concentrations (especially for the divalent Ca ion), and these factors will differ among the salts and dilution waters. Another issue for comparing toxicities across these salts is that, per mole of salt, Na_2SO_4 provides twice as many Na ions and 1.5 times as many total ions as do the other salts. To address these issues, in Figure 7B, Ca is plotted as Ca activity and the LC50s are based on the activity of Na. This results in much closer agreement among the salts, with the RSD_{log} reduced to 0.071 and the ±2 SD range for LC50 reduced to less than 2-fold; NaCl and $NaHCO_3$ now show similar toxicity because complexation of Ca by CO_3 and HCO_3 in the $NaHCO_3$ exposures causes Ca activity to be lower than that in NaCl exposures at the same total Ca concentration. Accounting for Na_2SO_4 having twice as many Na atoms as other Na salts has also made its LC50s more similar to the other salts; however, Na_2SO_4 now appears to be less, rather than more, toxic than NaCl, based on the repeated tests with Na_2SO_4 and NaCl in 1× ALSW and other waters with similar Ca concentration (i.e., the cluster of red triangles near 0.1 mM Ca activity and green circles near 0.2 mM Ca activity). This continued discrepancy between Na_2SO_4 and NaCl suggests that the anions play some role in determining toxicity beyond their effects on cation speciation.

A simple metric for expressing the aggregate effect of Na and anions is osmolarity, which reflects the combined, unweighted influence of all dissolved species. Figure 7C provides LC50s on the basis of calculated osmolarity, resulting in excellent agreement among all the tests of Na salt toxicity. The LC50s for the different salts now overlap within experimental variability; the RSD_{log} is reduced to 0.052 and the ±2 SD range to 1.6-fold. Further support for using osmolarity as an exposure metric comes from the test conducted with mannitol (black star in Figure 7C), whose LC50 is not significantly different from those of the Na salts even though its only expected effect would be on osmolarity. While this case for osmolarity is simply correlative and does not establish osmotic potential as the primary stressor, an exposure metric such as osmolarity that includes multiple ions in a nonspecific manner is indicated by these data.

Effects of calcium on magnesium toxicity

Figure 8 examines the relationship of LC50s to Ca for all our Mg salt toxicity tests using organisms cultured in 1× ALSW or MHRW. The panels address different exposure metrics parallel to those examined in Figure 7 for Na salts and include RSD_{log} as a performance measure for these different expressions of exposure.

In Figure 8A, LC50s are plotted as millimolarity of added salt and Ca is plotted as total concentration (measured Ca as appropriate for $MgCO_3$ tests, nominal for others). There is an even greater effect of Ca (~ 10-fold LC50 range over the 0.05–1.0 mM Ca range) for Mg salts than for Na salts (note scale change from Figure 7). On the basis of total added salt

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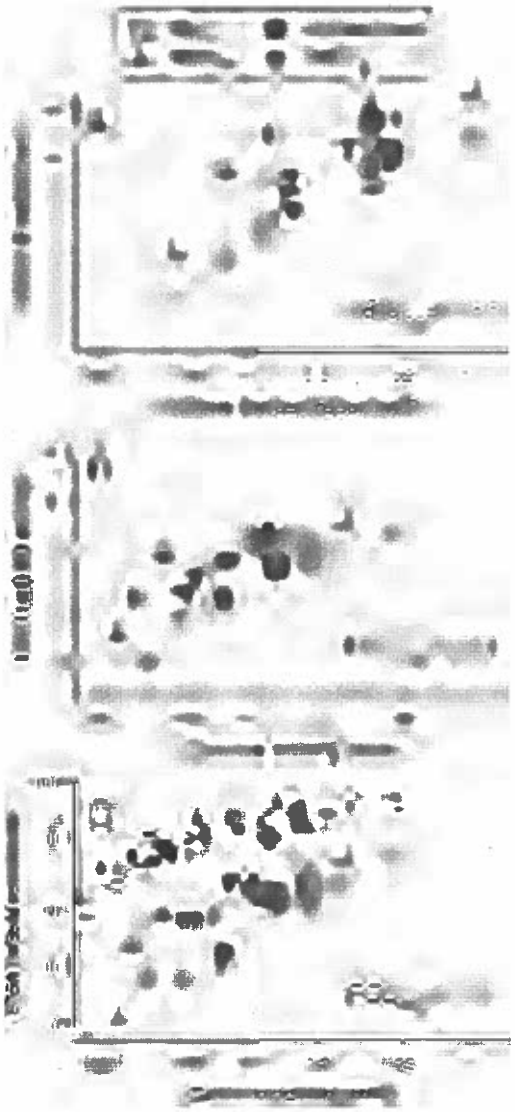


Figure 8. Effect of Ca on 48-h median lethal concentrations (LC50s) for Mg salts to *Ceriodaphnia dubia* using different exposure metrics. (**A**) Metrics are LC50 as concentration of added salt and Ca concentration. (**B**) Metrics are Mg and Ca activities. (**C**) The LC50 metric is changed to osmolarity, and black dots provide comparison to Na salt data from Figure 7C. RSD_{log} denotes the residual standard deviation of log(LC50)s from their mean trend with Ca.

concentrations, the salts have different apparent toxicities, with $MgSO_4$ and Mg gluconate being approximately 2-fold to 3-fold less toxic than $MgCl_2$ and $MgCO_3$. These differences make the RSD_{log} (0.167) even larger than for Na salts (Figure 7A), corresponding to a ±2 SD range of almost 5-fold at a fixed Ca concentration.

Expressing exposure on the basis of chemical activities of Mg and Ca (Figure 8B) reduces the residual variability and the differences between the salts because of the different degrees of complexation of both Ca and Mg by the different anions. The total range of the LC50s is also less because of a concentration dependence for complexation and activity coefficients. However, the closer agreement among the data is mainly for Ca activity >0.05 mM; at lower Ca activity, there remains considerable disparity between $MgSO_4$ and $MgCl_2$. As noted earlier (see *Effects of acclimation to dilution water*), these tests in very dilute test water raised some concerns about variable response and stresses associated with low ions, which might involve effects other than from Mg and Ca. Thus, although basing LC50s on Mg activity does provide a better metric than total Mg concentration, it does not account for all factors of significance. For all the data, the RSD_{log} is reduced to 0.123; but if only the data at Ca activity >0.05 mM are considered, the RSD_{log} is 0.102 and the ±2 SD range is then 2.5-fold, half of what is was for LC50s based on total added salt concentration.

Although osmolarity provides a possible unifying exposure metric for Na salts (Figure 7C), it is not a useful metric for Mg salt toxicity (Figure 8C). Using osmolarity to express Mg salt toxicity did not improve, but rather increased, the RSD_{log} of the data. More importantly, the osmolarities at the LC50 for Mg salts are 2-fold to 4-fold lower than those for Na salts at the same Ca activity. This indicates specific action of Mg and is incompatible with using a nonspecific, total ion metric such as osmolarity for the toxicity of Mg salts.

Our results indicate a strong effect of Ca on $MgSO_4$ and $MgCl_2$ toxicity, nearly a 10-fold change in LC50s from the Ca concentration in 1/8× MHRW (0.044 mM) to that in 1× MHRW (0.35 mM), with Figure 1 indicating even lower LC50s at 1/8× MHRW if organisms are cultured in this water. This is in contrast to results from van Dam et al. [31] for an Australian cladoceran (*Moinodaphnia macleayi*) collected from and cultured in very low ionic strength water (Ca <0.02 mM). In 6-d to 7-d reproductions tests, the $MgSO_4$ concentration reducing reproduction by 50% for *M. macleayi* was 2.6 mM in the culture water but only 2-fold higher (5.0 mM) when $CaSO_4$ was added to increase the Ca concentration by roughly 20-fold, to 0.34 mM. While there are several possible explanations for the difference in Ca effect for the 2 species, the van Dam et al. [31] study does reinforce concerns that species like *C. dubia* tested at very low ionic strength may not respond the same way as species (or strains) naturally adapted to low ionic strength water.

The toxicity of calcium

Because of solubility constraints, only limited testing of Ca salts could be conducted; and conclusions about any specific Ca toxicity could not be made based on simple comparisons of the toxicities of $CaCl_2$ and NaCl in our standard test waters. However, there are some indications that the toxicity of $CaCl_2$ is dominated by the cation, as are the toxicities of K and Mg salts. First, any comparison of the toxicity of $CaCl_2$ to NaCl should be made for NaCl tests in the dilution waters with the highest Ca. Otherwise, the comparison is confounded by the exacerbation of Na toxicity by low Ca. For the $CaCl_2$ tests (Table 3), osmolarities at the LC50s average 45 milliosmoles/L (range, 39–52), well below the average osmolarity of 76 milliosmoles/L (range, 69–83) for the NaCl tests in 3× ALSW. Unless the Cl from these 2 salts acts differently, this indicates some Ca-specific toxicity beyond the toxicity exerted by Na and the various anions (Figure 7). Second, in ALSW, the calculated Ca activity is 7.5 mM for $CaCl_2$ and 8.1 mM for Ca gluconate; such similarity would not be expected if these disparate anions were contributing to toxicity. However, the conclusion that there is some specific toxicity of Ca is tentative and will be further addressed in the next article in this series.

Relationship of toxicity to conductivity

Figure 9 replots the data from Figures 7 and 8 with LC50s based on conductivity. Given the results already presented for the toxicity of different salts, it is not surprising that these conductivity LC50s also show a strong dependence of toxicity on Ca and substantial variation across the different salts. The

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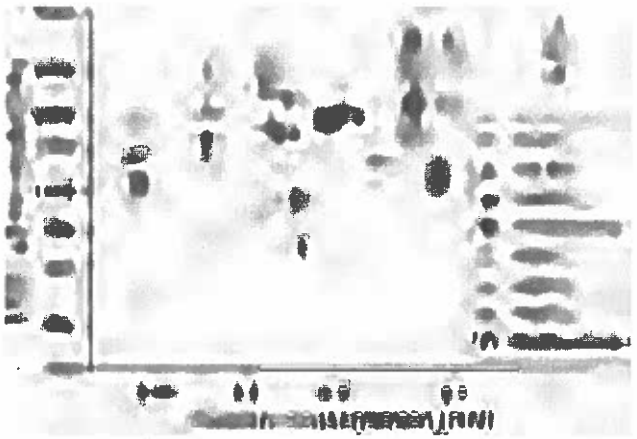


Figure 9. Median lethal concentration of Na and Mg salts expressed as conductivity. LC50 = 48-h median lethal concentration.

total range of conductivity LC50s is approximately 10-fold, with up to a 5-fold range among salts at the same Ca concentration. This indicates that assessment approaches using conductivity as an exposure metric should have a restricted scope of applicability regarding relative ion concentrations, as is the case for the conductivity benchmark of Cormier et al. [14,15].

SUMMARY AND IMPLICATIONS

In the present study, the key influences of background water chemistry on the acute toxicity of major ions salts to *C. dubia* were the effect of Na on toxicity of K salts and the effects of Ca on the toxicity of Na and Mg salts. Although the practical implications of the Na effect on K toxicity are limited because of the unlikelihood of K-dominated exposures, this result does mean that when K exposures are of concern [11] effects concentrations based on typical laboratory tests with low Na concentrations would overestimate risk. Regarding the Ca effects, although a hardness dependence of toxicity was already known for some Na and Mg salts [16–20] and Davies and Hall [21] implicated Ca as the specific factor for Na_2SO_4 toxicity, our results more thoroughly establish a role of Ca for a variety of salts. Predicting salt toxicity across waters will thus be more accurate if done on the basis of Ca rather than hardness, but the benefits of accuracy must be weighed against the availability of Ca versus hardness data. Uncertainties associated with using hardness as a surrogate for Ca can be addressed based on the regional variability of the Ca:Mg ratio, the resultant uncertainty on Ca, and the consequent uncertainty on toxicity estimated from Ca (e.g., Figures 7 and 8); in many cases, the resultant uncertainty should be limited.

An important tool in addressing the toxicity of ion mixtures has been the model of Mount et al. [3], and part of the purpose of the present study was to address some limitations of that model. The present results do indicate that not addressing the hardness (or Ca specifically) of the background water can introduce uncertainty into this model and raise questions regarding how joint toxicity across the different ions was addressed by Mount et al. [3]. However, any quantitative evaluation of that model relative to our results must wait for the alternative model to be presented in our subsequent article.

In addition to describing the dependence of major ion salt toxicities on background water chemistry, the results of the present study allowed some inferences about mechanisms and some conclusions about how salt toxicity dosimetry should be expressed. At least 3 separate mechanisms were apparent. First, a K-related mechanism is indicated by the high toxicities of K salts, the dependence of this toxicity on Na concentration, and its good correlation to K concentration. Second, a Mg-related mechanism is indicated based on the greater toxicity of Mg salts than Na salts and the correlation of Mg salt toxicity to Mg activity. Third, a mechanism related to multiple ions is indicated, based 1) on Na salts being less toxic than salts of other cations, 2) on anions affecting the toxicity of Na salts, 3) on the good correlation of this toxicity to osmolarity, and 4) on the agreement of toxicity from Na gluconate and mannitol with that of inorganic Na salts when expressed as osmolarity. Calcium salt toxicity also likely represents a mechanism different from that of Na salts because of the greater toxicity of $CaCl_2$ compared with Na salts tested at high but nontoxic Ca concentrations; however, this might be the same mechanism as Mg, which has similar toxicity to Ca when tested in waters with higher Ca background.

Regarding dosimetry, rigorously understanding and describing salt toxicity requires examining toxicity on the basis of chemical activities and consideration of various ion interactions. The cation-related mechanisms would be expected to be best related to cation activities, and the multiple ion mechanism associated with Na salts requires some measure, such as osmolarity, which addresses multiple chemical species. These conclusions regarding mechanisms and dosimetry are preliminary and will be further addressed in the subsequent articles mentioned in the *Introduction*, but it is evident that regulations based solely on a single ion may lack robustness from failing to address the relative toxicities and interactions of multiple ions.

One limitation of the present results is that they just concern the toxicities of single salts, with other ions being at low to moderate background concentrations reported for US waters. Most field situations would involve enrichment of more ions—to well above ambient levels, if not to toxic levels. For example, it would not be expected that Mg would be enriched to toxic levels while Ca stays at background levels, and the high toxicity of K salts depends on very low Na concentrations, which would be an unusual exposure scenario. The exposure metrics and relationships noted in the present study would be expected to apply to more complex mixtures (e.g., all ions contributing to osmolarity), but there is a need to better define the scope of applicability of these relationships. Their extension to more complex mixtures will be the subject of subsequent articles.

Although a complete model for the acute toxicity of major ions to *C. dubia* will be forthcoming, Figures 6 through 8 make it clear that this will be complicated, involving chemical speciation calculations, multiple toxicity mechanisms, and interactions among 7 toxicants. Any practical application will require simplifications, but we feel that the detail provided in the present study and in later articles will provide a starting point for determining what simplifications are possible and how they should be structured. Another application issue concerns the relevance of acute ion toxicity for *C. dubia* to the assessment of an entire aquatic community, especially in low-ion, lotic systems. This toxicity endpoint is the starting point for work that will address more endpoints and species. However, the relationships developed for *C. dubia* will be directly relevant to many aquatic systems and will also have value in developing and interpreting major ion toxicity data for other species.

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Supplemental Data—The Supplemental Data are available on the Wiley Online Library at DOI: 10.1002/etc.3487.

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Disclaimer—The views expressed in the present study are those of the authors and do not necessarily reflect the views or policies of the US Environmental Protection Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Data availability—Data are available through the USEPA Environmental Dataset Gateway (https://edg.epa.gov/metadata/catalog/main/home.page) or on request from the corresponding author (erickson.russell@epa.gov).

REFERENCES

1. Drever JI. 1988. *The Geochemistry of Natural Waters*. Prentice Hall, Englewood Cliffs, NJ, USA.
2. Bradley T. 2009. *Animal Osmoregulation*. Oxford University Press, New York, NY, USA.
3. Mount DR, Gulley DD, Hockett JR, Garrison TD, Evans JM. 1997. Statistical models to predict the toxicity of major ions to *Ceriodaphnia dubia*, *Daphnia magna* and *Pimephales promelas* (fathead minnows). *Environ Toxicol Chem* 16:2009–2019.
4. Boulter AM, Lamming FN, Faraq AM, Bergman HL. 1992. Environmental effects of saline oil-field discharges on surface waters. *Environ Toxicol Chem* 11:1187–1195.
5. Mount DR, Drottar KR, Gulley DD, Fillo JP, O'Neill PE. 1993. Use of laboratory toxicity data for evaluating the environmental acceptability of produced water discharge to surface waters. In Ray JP, Engelhart FR, eds, *Produced Water—Technological/Environmental Issues and Solutions*. Plenum, New York, NY, USA, pp 175–182.
6. Ingersoll CG, Dwyer FJ, Burch SA, Nelson MK, Buckler DR, Hunn JB. 1992. The use of freshwater and saltwater animals to distinguish between the toxic effects of salinity and contaminants in irrigation drain water. *Environ Toxicol Chem* 11:503–511.
7. Dickerson KK, Hubert WA, Bergman HL. 1996. Toxicity assessment of water from lakes and wetlands receiving irrigation drainwater. *Environ Toxicol Chem* 15:1097–1101.
8. Chapman PM, Bailey H, Canaria E. 2000. Toxicity of total dissolved solids associated with two mine effluents to chironomid larvae and early life stages of rainbow trout. *Environ Toxicol Chem* 19:210–214.
9. Kennedy AJ, Cherry DS, Currie RJ. 2003. Field and laboratory assessment of a coal processing effluent in the Leading Creek watershed, Meigs County, Ohio. *Arch Environ Contam Toxicol* 44:324–331.
10. Findlay SEG, Kelly VR. 2011. Emerging indirect and long-term road salt effects on ecosystems. *Ann N Y Acad Sci* 1223:58–68.
11. Jop KM, Askew AM. 1994. Toxicity identification evaluation using a short-term chronic test with *Ceriodaphnia dubia*. *Bull Environ Contam Toxicol* 53:91–97.
12. Ankley GT, Hockett JR, Mount DI, Mount DR. 2011. Early evolution of the toxicity identification evaluation process: Contributions from the United States Environmental Protection Agency effluent testing program. In Brack W, ed, *Effects Directed Analysis of Complex Environmental Contamination*. Springer, New York, NY, USA.
13. Pond GJ, Passmore ME, Borsuk FA, Reynolds L, Rose CJ. 2008. Downstream effects of mountaintop coal mining: Comparing biological conditions using family- and genus-level macroinvertebrate bioassessment tools. *Journal of the North American Benthological Society* 27:717–737.
14. Cormier SM, Suter GW II. 2013. A method for deriving water-quality benchmarks using field data. *Environ Toxicol Chem* 32:255–262.
15. Cormier SM, Suter GW II, Zheng L. 2013. Derivation of a benchmark for freshwater ionic strength. *Environ Toxicol Chem* 32:263–271.
16. Soucek DJ, Kennedy AJ. 2005. Effects of hardness, chloride, and acclimation on the acute toxicity of sulfate to freshwater invertebrates. *Environ Toxicol Chem* 24:1204–1210.
17. Soucek DJ. 2007. Comparison of hardness-and chloride-regulated acute effects of sodium sulfate on two freshwater crustaceans. *Environ Toxicol Chem* 26:773–779.
18. Soucek DJ, Linton TK, Tarr CD, Dickinson A, Wickramanayake N, Delos CG, Cruz LA. 2011. Influence of water hardness and sulfate on the acute toxicity of chloride to sensitive freshwater invertebrates. *Environ Toxicol Chem* 30:930–938.
19. Elphick JR, Bergh KD, Bailey HC. 2011. Chronic toxicity of chloride to freshwater species: Effects of hardness and implications for water quality guidelines. *Environ Toxicol Chem* 30:239–246.
20. Elphick JR, Davies M, Gilron G, Canaria EC, Lo B, Bailey HC. 2011. An aquatic toxicological evaluation of sulfate: The case for considering hardness as a modifying factor in setting water quality guidelines. *Environ Toxicol Chem* 30:247–253.
21. Davies TD, Hall KJ. 2007. Importance of calcium in modifying the acute toxicity of sodium sulphate to *Hyalella azteca* and *Daphnia magna*. *Environ Toxicol Chem* 26:1243–1247.
22. Di Toro DM, Allen HE, Bergman HL, Meyer JS, Paquin PR, Santore RC. 2001. Biotic ligand model of the acute toxicity of metals. 1. Technical basis. *Environ Toxicol Chem* 20:2383–2396.
23. Tietge JE, Hockett JR, Evans JM. 1997. Major ion toxicity of six produced waters to three freshwater species: Application of ion toxicity models and TIE procedures. *Environ Toxicol Chem* 16:2002–2008.
24. US Environmental Protection Agency. 2002. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms. EPA/821/R-02/013. Washington, DC.
25. Marking LL, Dawson VK. 1973. *Toxicity of quinaldine sulfate to fish. Investigations in Fish Control 48. US* Fish and Wildlife Service, Washington, DC.
26. Alexander RB, Ludtke AS, Fitzgerald KK, Shertz TL. 1996. Data from selected US Geological Survey national stream water-quality monitoring networks (WQN) on CD-ROM. Report 96-337. US Geological Survey, Reston, VA.
27. Mount DR, Mount DI. 1992. A simple method of pH control for static and static-renewal aquatic toxicity tests. *Environ Toxicol Chem* 11:609–614.
28. American Public Health Association, American Water Works Association, and the Water Environment Federation. 1998. *Standard Methods for the Examination of Water and Wastewater*. 20th ed. Washington, DC.
29. Williams DA. 1986. Interval estimation of the median lethal dose. *Biometrics* 42:641–645.
30. Robinson RA, Stokes RH. 1959. *Electrolyte Solutions*. Academic, London, UK.
31. van Dam RA, Hogan AC, McCullough CD, Houston MA, Humphrey CL, Harford AJ. 2010. Aquatic toxicity of magnesium sulfate, and the influence of calcium, in very low ionic concentration water. *Environ Toxicol Chem* 29:410–421.

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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF CLEAN WATER

TRIENNIAL REVIEW OF WATER QUALITY STANDARDS

RATIONALE FOR THE DEVELOPMENT OF AMBIENT WATER QUALITY CRITERIA FOR

CHLORIDE

PROTECTION OF AQUATIC LIFE

Introduction

Section 303(c)(1) of the Clean Water Act (33 U.S.C.A § 1313(c)(1)) requires that states periodically, but at least once every three years, review and revise as necessary their water quality standards. Water quality standards are instream water quality goals that are implemented by imposing specific regulatory requirements (such as treatment requirements and effluent limits) on individual sources of pollution. As part of the current review, the chloride criterion is being evaluated.

Chloride occurs naturally in the aquatic environment, especially in waters flowing through geologic formations of marine origin. The major anthropogenic sources of chloride include deicing salt for roads, urban and agricultural runoff, treated industrial waste, discharges from municipal wastewater plants and the drilling of oil and gas wells (EPA, 1988). Elevated levels of chloride are toxic to aquatic life in freshwater environments. A state-wide aquatic life criterion for chloride would provide an appropriate level of protection for all of Pennsylvania's waters.

Pennsylvania's existing chloride criterion was developed primarily for the protection of potable water supplies (PWS). It is not applied in all waters of this Commonwealth, but rather only at the point of water supply intake, pursuant to 25 Pa. Code § 96.3(d) (relating to water quality protection requirements). The current PWS criterion for chloride is included in Table 3 at 25 Pa. Code § 93.7 (relating to specific water quality criteria) and establishes a maximum level of 250 milligrams of chloride per liter of water, applicable only at the point of all existing or planned surface PWS withdrawals, unless otherwise specified by regulation.

The Pennsylvania Department of Environmental Protection has developed draft water quality criteria for chloride for the protection of aquatic life. The draft criterion is based on current science that shows that the water hardness and sulfate concentrations affect chloride toxicity to aquatic organisms. This relationship is incorporated into the newly developed equation used for calculating the acute and chronic numeric criteria for chloride in Pennsylvania waters. The Department is recommending that this chloride criterion be applied in all waters for the protection of aquatic life.

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History

The U.S Environmental Protection Agency (EPA) published Ambient Water Quality Criteria (AWQC) for Chloride in February 1988, which summarized the published toxicity data that was available at that time for chlorides on freshwater plant and animal species. The acute and chronic effects of chlorides on aquatic animals were documented, along with the chronic effects of chloride on aquatic plants. The findings of 106 published scientific studies were considered in the development of the national aquatic life criteria for chloride. EPA developed the chloride criteria in 1988 for protection against adverse acute and chronic impacts on freshwater aquatic life based on the Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses, NTIS PB85-227049 (Stephan, et al., 1985). EPA determined the four-day (chronic) and one-hour acute average concentrations based upon how quickly some aquatic species reacted to higher concentrations of pollutants. The Criteria Continuous Concentration (CCC) and Criteria Maximum Concentration (CMC) values should not be exceeded more than once every three years on the average (US EPA, 1988).

The 4-day average (CCC) criterion = 230 mg/l

The 1-hour average (CMC) criterion = 860 mg/l

In 2005, the state of Iowa with the help of EPA Region 5 began an investigation into updating the existing chloride AWQC. The revised WQS was promulgated by Iowa in 2009. EPA Office of Research and Development scientists served to link the relationship of chloride toxicity to aquatic organisms with water hardness and sulfate concentration. This relationship provided the basis for the revised WQS promulgated in Iowa.

The Department has reviewed the equation-based aquatic life criteria for chloride as developed by EPA and successfully implemented in Iowa. The researchers at the Great Lakes Environmental Center (GLEC) in Columbus, OH and the Illinois Natural History Survey (INHS) in Champaign, IL worked collaboratively under a contract with the EPA to determine the toxicity of chloride in freshwater invertebrate species. The research demonstrated a strong correlation between chloride toxicity and hardness and to a lesser extent with sulfate. The final results of this toxicity testing were published in the report "Acute Toxicity of Chloride to Select Freshwater Invertebrates" US EPA, October 28, 2008. Iowa Department of Natural Resources (IDNR) selected the appropriate acute and chronic criteria equations after considering input from many sources and two equations were promulgated by Iowa. Both the one-hour acute and ninety-six hour chronic criteria values should not be exceeded more than once every three years on the average (personal communication: Connie Dou, IDNR, November 2011).

Test Compound Determination

Chloride is one of the major anions commonly found in surface and wastewater. It is a constituent of naturally occurring minerals; it readily dissolves in water, and is important to living systems. As a solid, chloride is typically found as a salt bonded with a cation such as

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calcium, sodium, magnesium, or potassium. The salinity of a water body is measured by its total salt composition. Freshwater lakes are dominated by the cations: Ca^{2+}, Mg^{2+}, K^{+} and Na^{+} and the anions $HCO3^{-}$, SO_4^{2-} and Cl^{-}. (Wetzel, 1983) Data obtained from stream surveys of Pennsylvania waters confirmed this determination: the ionic composition is >40% $HCO3^{-}$/ Ca^{2+}, followed by SO_4^{2}, Mg^{2+}, Na^{+}, K^{+} and Cl^{-}. Pennsylvania waters are calcium/bicarbonate dominant.

Chloride toxicity tests have been conducted through the addition of chloride salts such as sodium chloride (NaCl), calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$) and potassium chloride (KCL). Results of tests with potassium and magnesium chloride suggest toxic effects observed can be due to the potassium and magnesium cation, rather than the chloride ion. It has been observed that the toxic effects of calcium chloride and sodium chloride are due to the chloride anion. In establishing the effect concentrations of the chloride ion, exposure to KCL and $MgCl_2$ salts are lower (more toxic) than the effect concentration of the exposures to $CaCl_2$ and NaCl salts (Canadian Council of Ministers of the Environment, 2011). Therefore the approximate order of chloride salt toxicity to freshwater organisms is KCL > $MgCL_2$ > $CaCl_2$ > NaCl (Mount et al 1997). Based on this information, chloride toxicity to freshwater organisms was evaluated using tests dosed with NaCl to ensure the effect concentrations were derived from tests where effects were based on the chloride anion, not the associated cations.

Other Modifying Factors

A long term study by Elphick et al. indicates that increased hardness may have an effect on the toxicity of chloride. GLEC and INHS (2008) also conducted some short-term exposure tests indicating that a hardness-chloride toxicity relationship exists for the water flea *Ceriodahpnia dubia*, the fingernail clam *Sphaerium simile*, the Oligochaete *Tubifex tubifex* and the aquatic snail *Gyraulus parvus*. (CCME, 2011)

EPA contracted with the GLEC and the INHS (2009) to perform toxicity testing for chloride. The results showed that chloride toxicity is heavily dependent on water hardness, and to a lesser degree, sulfate levels in water. PA Department staff has been monitoring sulfate and hardness levels at Water Quality Network (WQN) stations throughout PA. This data confirms that PA source waters have a varied amount of hardness and sulfate concentrations. As an example, the Aughwick Creek watershed is located in southcentral Pennsylvania. In this single watershed, the hardness values range from 10 mg/l in the small freestone streams to 250 mg/l in areas of limestone geology. There is a full range of hardness values between the 10 mg/l and 250 mg/l as the tributaries flowing through various geologies coalesce and mix. This is not an unusual situation as there are extensive limestone deposits in the Commonwealth. Pennsylvania has a legacy of abandoned coal mines that can discharge high levels of sulfate. Instream sulfate levels are elevated where there are concentrations of these abandoned discharges. Where there is a legacy of abandoned coal mines the sulfates often range between 100 to 500 mg/l and sometimes higher. In contrast, the streams in the less affected parts of the state have sulfate values less than 50 mg/l. Urban streams often have sulfate between 50 mg/l and 100 mg/l. The variation in the hardness and sulfate concentrations throughout the state confirms that it is appropriate to develop an equation based criterion that includes a modification for hardness and sulfate.

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PA Site Specific Research/Literature Review

The Department contracted with the Stroud Water Research Center, in Avondale, Pennsylvania to perform chloride toxicity testing. The study was designed to provide the additional information needed to support the development of a chloride criterion that is protective across the range of aquatic habitats and species found in Pennsylvania waters. Benthic macroinvertebrates were used in this eco-toxicity study of chloride because they are an ecologically important group of aquatic organisms and are common components of the Pennsylvania bio-monitoring multi-metrics used in standard water quality assessment protocols (e.g., PA IBI; PADEP 2013)

The following mayfly species were included in the study: *Neocloeon triangulifer*, previously classified as *Centroptilum* (Jacobus and Wiersema, 2014), *Anafromtilum semirufum*, *Procloeon fragile*, *Ephemerella invaria*, *Maccaffertium modestum* and *Leptophlebia cupida*. All six species were evaluated for short term (acute) exposures to chloride. Chloride sensitivities were determined using sodium chloride because sodium is known to have little effect on the toxicity of chloride (Stroud 2015). Four species (*N. triangulifer*, *A. semirufum*, *P. fragile*, *M. modestum*) were subjected to a whole-life (chronic) toxicity test. The chronic test began with newly hatched larvae and ended when all larvae had emerged as adults (i.e., 20-48 days). The development time for a complete life cycle of *M. modestum* is 60-80 days. The experiment was ended before the adult emergence; therefore the chronic study of *M. modestum* was omitted.

The acute and chronic data obtained from the Stroud study was incorporated into the data set used to determine Pennsylvania-specific chloride criteria. It has been shown that some aquatic organisms show significantly more sensitivity when tested in reconstituted laboratory water compared to natural waters (CCME, 2011). The Stroud study was conducted in water from three source water streams: Spruce Run, a soft water stream (hardness 6 mg/L) in Union County, PA; House Run, a moderately hard water stream (hardness 94 mg/L) in Greene County, PA and Cedar Run, a hard water (hardness 212 mg/L) stream in Union County, PA. The reference stream was White Clay Creek which is a moderately hard water stream (hardness 89 mg/L) located at the Stroud Water Research Center in Chester County, PA, where all the study species were originally collected. (Stroud, 2015)

Other toxics data sources used:

Toxics data that was compiled by Charles Stephan, November 06, 2007 – This document contains acceptable acute and chronic data obtained from several significant studies (Birge et al., 1985; Spehar 1987; Cowgill and Milazza 1990; and Wisloh 2007). It also contains a list of the studies reviewed previous to 2007 that were not approved and the reasons for the disapproval.

Data from Canadian Council of Minister of the Environment, 2011 – This document contained additional studies (Harmon et al 2003; Collins & Russell 2009; Gillis 2011, GLEC & INHS 2008; Elphick et al 2011; Wang and Ingersoll 2010; US EPA 2010, Valenti et al 2007; Bringolf et al 2007) In particular, the Valenti et al, Bringolf et al and Gillis studies contained valuable data on sensitive and endangered mussels. This document also contains studies that have relevant chronic toxicity data.

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US EPA, 2015 – EPA's data set contained additional peer reviewed studies. (GLEC and INHS 2010; Wang et al 2013; Garner and Royer 2010; Soucek 2012, 2013; Environ 2009; Sanzo and Hecnar 2006; Garibay and Hall 2004).

In addition, PA DEP staff evaluated Maryland's Freshwater Chloride Development Methodology and reviewed the data used in their chloride criteria development. (MDE, 2013)

Acute criteria determination

Acute values were used from all acceptable data contained in the reports listed above. This resulted in 219 acute toxicity results for aquatic species (51 genera). The LC50's are in mg/L for all acceptable data, including Stroud mayfly data. The four genera most sensitive to acute testing were *Epioblasma* (freshwater mussel); *Sphaerium* (fingernail clam); *Neocloeon* (mayfly); and *Lampsilis* (freshwater mussel). The genus mean acute value (GMAV) for the most sensitive organism (*Epioblasma*) was 698 mg/L. This value was lower than the calculated final acute value (FAV) of 874.8 mg/L. In order to protect for this sensitive freshwater mussel, the species mean acute value (SMAV) for the *Epioblasma* (698 mg/L) was used as the FAV. The final acute value is 349 mg/L, which will be incorporated into the hardness/sulfate modifying equation to determine the final acute chloride criterion.

Acute Data

Genus	GMAV (mg/L)	Genus	GMAV (mg/L)	Genus	GMAV (mg/L)
Epioblasma	698	*Physa*	2667	*Aciperser*	5903
Sphaerium	785	*Rana*	2680	*Cyprinella*	5956
Neocloeon	959	*Pseudacris*	2882	*Lepidostoma*	6000
Lampsilis	991	*Lirceus*	2950	*Lepomis*	6634
Anafroptilum	1090	*Macaffertium*	3052	*Carassius*	6959
Ambystoma	1178	*Planorbella*	3731	*Gambusia*	7786
Ceriodaphnia	1197	*Ephemerella*	3759	*Oncorhynchus*	8379
Elliptio	1437	*Limnodrilus*	3761	*Libellulidae*	9671
Procloeon	1449	*Bufo*	3926	*Fundulus*	9706
Megalonaisas	1517	*Caecidotea*	4049	*Gasterosteus*	10200
Lasmigona	1577	*Lumbriculus*	4254	*Cambarus*	10557
Margaritifera	1577	*Nephelopsis*	4310	*Anguilla*	11929
Brachionus	1645	*Erpobdella*	4550	*Agria*	14255
Daphnia	1765	*Ameriurus*	4849		
Isonychia	1880	*Pimephales*	5010		
Musculium	1930	*Tubifex*	5311		
Villosa	2215	*Chironomus*	5371		
Gyraulus	2430	*Leptophlebia*	5473		
Diaptomus	2571	*Lithobates*	5846		

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Rank	Genus/ Species	GMAV mg/L
4	*Lampsilis (freshwater mussel)*	991
3	*Neocloeon (mayfly)*	959
2	*Sphaerium (fingernail clam)*	785
1	*Epioblasma (freshwater mussel)*	698

Chronic criteria determination

The chronic toxicity data set included 10 aquatic species. *Pimephales promelas*, *Oncorhynchus mykiss*, *Daphnia ambigua*, *Daphnia magna*, *Daphnia pulex*, *Ceriodaphnia dubia*, *Lumbriculus variegatus*, *Neocloeon triangulifer*, *Anafroptilum semirufum* and *Procloeon fragile*. The final calculated acute/chronic ratio (FACR) from the acceptable data is 6.2. The final chronic value is 112.7 mg/L (113 mg/L), which will be incorporated into the hardness/sulfate modifying equation to determine the final chronic chloride criterion.

Species	SCV mg/L	SAV (mg/L)	GM ACR	Source
Pimephales promelas	433.1	6570	10.2	Birge et al 1985
	598	4079		Elphick et al. 2011
Oncorhynchus mykiss	922.7	8379	9.1	Stephan 2007
Daphnia ambigua	259	1213	5.4	Harmon et al 2003
Daphnia magna	2382	4731		Stephan 2007
	421	3630		Elphick et al. 2011
Daphnia pulex	372	1470		Stephan 2007
Ceriodaphnia dubia	925	1395	2.6	Stephan 2007
	425	1677		Stephan 2007
	454	1068		CCME, 2011
Lumbriculus variegatus	825	3100	3.8	Elphick et al. 2011
Neocloeon triangulifer	109	704	8.4	Stroud, 2015
	175	2141		Stroud, 2015
	188	1420		Stroud, 2015
Anafroptilum semirufum	114	107	8.3	Stroud, 2015
	279	1827		Stroud, 2015
	128	1336		Stroud, 2015
Procloeon fragile	168	472	6.1	Stroud, 2015
	332	2110		Stroud, 2015
	245	1765		Stroud, 2015
		Final ACR	**6.2**	

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Chronic Data Ranked

Rank	Species	SMCV mg/L
4	*Daphnia ambigua* (water flea)	259
3	*Procloeon fragile* (mayfly)	248
2	*Anafroptilum semirufum* (mayfly)	174
1	*Neocloeon triangulifer* (mayfly)	157

FAV	874.8
FAV for lowest GMAV	698
FACR	6.2
CMC based on FAV for lowest GMAV	349
CCC	112.7

Chloride Criteria Development

The hardness and sulfate values used to derive the appropriate chloride criteria shall be determined by instream measurements, statewide water quality network (WQN) or other values as approved by the Department. The proposed chloride criterion is calculated using the following equations that incorporate the hardness and sulfate modifiers based on the GLEC studies:

Acute Chloride Criterion Equation – One hour average concentration should not exceed

$$\text{Acute Criterion (mg/L)} = \mathbf{349}(\text{Hardness})^{0.2058}(\text{Sulfate})^{-0.0745}$$

Chronic Chloride Criterion Equation – 4 day average concentration should not exceed

$$\text{Chronic Criterion (mg/L)} = \mathbf{113}(\text{Hardness})^{0.2058}(\text{Sulfate})^{-0.0745}$$

Recommendation

On April 17, 2012 the EQB adopted a proposed rulemaking for the promulgation of an aquatic life criterion for chloride. Based on the comments received during the public comment period, which ended August 8, 2012, the Department, in this new proposed rulemaking has re-evaluated and incorporated Pennsylvania-specific data into the determination of the chloride criterion. The Department has developed a state-specific equation-based aquatic life criterion for chloride. It incorporates additional state-specific aquatic toxicity data, as related to the ion composition of our waterbodies, and the necessary adjustment for the effects of hardness and sulfate on the toxicity of chloride.

The Department recommends adopting the Pennsylvania-specific equation-based aquatic life criterion for chloride.

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Literature Cited

Canadian Council of Ministers of the Environment (CCME) 2011. Canadian Water Quality Guidelines : Chloride Ion. Scientific Criteria Document. Winnipeg, Canada.

Patricia L. Gillis, Feb 24, 2011. Assessing the toxicity of sodium chloride to the glochidia of freshwater mussels: Implications for salinization of surface waters. Environmental Pollution vol. 159 (2011) 1702-1708.

Iowa Department of Natural Resources. Feb 9, 2009. Water Quality Standards Review: Chloride, Sulfate, and Total Dissolved Solids. (Also available from: http://www.iowadnr.gov/portals/idnr/uploads/water/standards/ws_review.pdf)

JAMES R.F. ELPHICK, KELLI D. BERGH, and HOWARD C. BAILEY, 2010. Chronic Toxicity of Chloride to Freshwater Species: Effects of Hardness and Implications for Water Quality Guidelines. Environmental Toxicology and Chemistry, Vol. 30, No. 1, pp. 239–246, 2011.

Maryland Department of the Environment (MDE), August, 2013. Freshwater Chloride Criterion Development Methodology.

PADEP. 2002. Water quality standards implementation – chloride and sulfate (final rulemaking). Pennsylvania Bulletin, 32PaB6101.

Stephan, Charles 2007. US EPA Personal Communication, Data cl study.

Stephan, Charles. 2009. Environmental Scientist United States Environmental Protection Agency. Personal Communication

STEPHAN, C.E., D.I.MOUNT, D.J. HANSEN, J.H. GENTILE, G.A. CHAPMAN, AND W.A. BRUNGS. 1985. Guidelines for deriving numerical national water quality criteria for the protection of aquatic organisms and their uses. PB85-227049.

STROUD WATER RESEARCH CENTER. January 29, 2015. Ecotoxological responses of stream mayflies exposed to elevated chloride in source waters that differ in hardness. Pub Number 20140.

US EPA. 1988. Ambient water quality criteria for chloride. EPA 440/5-88-001. (available from: <http://www.epa.gov/waterscience/criteria/library/ambientwqc/chloride1988.pdf>).

US EPA. 1995. Water quality guidance for the Great Lakes system. Federal Register Vol. 60, No. 56, Pg. 15387.

Electronic Filing: Received, Clerk's Office 3/14/2019

US EPA. October 28, 2008. Acute Toxicity of Chloride to Select FW Invertebrates. EPA Contract Number: 68-C-04-006, Work Assignment 4-34 Sub-task 1-15. (Prepared for the USEPA by the GLEC and the INHS. http://www.dnr.mo.gov/env/wpp/rules/rir/so4-cl-GLEC-INHSchloriderpt.pdf)

US EPA. December 2010. Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses.

US EPA. 2015. Chloride Toxicity Data Set.

Electronic Filing: Received, Clerk's Office 3/14/2019

Soucek and Dickinson 2015

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FULL-LIFE CHRONIC TOXICITY OF SODIUM SALTS TO THE MAYFLY *NEOCLOEON TRIANGULIFER* IN TESTS WITH LABORATORY CULTURED FOOD

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(Submitted 8 January 2015; Returned for Revision 6 February 2015; Accepted 24 April 2015)

Abstract: Although insects occur in nearly all freshwater ecosystems, few sensitive insect models exist for use in determining the toxicity of contaminants. The objectives of the present study were to adapt previously developed culturing and toxicity testing methods for the mayfly *Neocloeon triangulifer* (Ephemeroptera: Baetidae), and to further develop a method for chronic toxicity tests spanning organism ages of less than 24 h post hatch to adult emergence, using a laboratory cultured diatom diet. The authors conducted 96-h fed acute tests and full-life chronic toxicity tests with sodium chloride, sodium nitrate, and sodium sulfate. The authors generated 96-h median lethal concentrations (LC50s) of 1062 mg Cl/L (mean of 3 tests), 179 mg N-NO_3/L, and 1227 mg SO_4/L. Acute to chronic ratios ranged from 2.1 to 6.4 for chloride, 2.5 to 5.1 for nitrate, and 2.3 to 8.5 for sulfate. The endpoints related to survival and development time were consistently the most sensitive in the tests. The chronic values generated for chloride were in the same range as those generated by others using natural foods. Furthermore, our weight-versus-fecundity plots were similar to those previously published using the food culturing method on which the present authors' method was based, indicating good potential for standardization. The authors believe that the continued use of this sensitive mayfly species in laboratory studies will help to close the gap in understanding between standard laboratory toxicity test results and field-based observations of community impairment. *Environ Toxicol Chem* 2015;34:2126–2137. © 2015 SETAC

Keywords: Mayfly Toxicity testing Chronic toxicity Major ions

INTRODUCTION

Despite the fact that insects occur in nearly all freshwater ecosystems and are often the dominant class of macroinvertebrate in those systems [1], few insect models exist for use in determining the toxicity of contaminants. Among the most commonly used insect species in toxicity testing are the midges *Chironomus riparius* and *Chironomus dilutus*, which can be cultured in the laboratory but tend to be among the more insensitive invertebrates. Efforts have been made to assess the potential for use of abundant, wild-caught mayflies (Ephemeroptera) for standardized toxicity test development [2,3], but knowledge of exposure history, health, and age of test organisms before testing provides for better interlaboratory test result comparisons [4].

A major step toward the development of a sensitive insect model organism for toxicity testing was taken when Sweeney and Vannote [5] characterized the effects of several variables on life history characteristics of the parthenogenetic mayfly *Neocloeon triangulifer* McDunnough (originally described as *Cloeon triangulifer* [6], later transferred to *Centroptilum* [7], and most recently assigned to *Neocloeon* [8]). The same research group (Stroud Water Research Center) later developed a method of culturing this organism in the laboratory and using it in toxicity tests [9]. The advantage of *N. triangulifer* is that because it is parthenogenetic, it does not require a large amount of space for mating to take place; female clones can emerge into small containers (e.g., 300-mL beakers) and then deposit viable eggs. Furthermore, parthenogenic organisms in general are desirable for use in toxicity testing because being clonal eliminates genetic variability as a confounding factor. The Stroud Water Research Center group uses naturally colonized periphyton plates to feed the organisms, and this approach has now been adapted by others to conduct toxicological investigations with various contaminants [10–13].

Because food quality and quantity appear to influence the response of *N. triangulifer* to contaminants [10,11,13], developing a cultured food consisting of 1 or more diatom species is necessary to further allow standardization and more widespread use of this organism in toxicity testing. Great progress has been made toward this end by Weaver et al. [14], who developed a method of culturing 3 different diatom species (*Mayamea atomus, Nitzschia* cf. *pusilla*, and *Achnanthidium minutissimum*) in the laboratory, and then using stocks of monocultures of the species to colonize microscope slides, which are then offered to nymphs as biofilms. This approach was successfully used to culture 13 successive generations of the organisms, and both acute and short-term chronic (i.e., less than full-life) toxicity data have been generated using organisms cultured with this food [15].

Previously reported chronic toxicity tests with this species (or genus) have been conducted using wild-caught individuals [16], using cultured individuals with naturally colonized periphyton plates ([9–13,17,18]; J. Jackson, Stroud Water Research Center, Avondale, PA, USA, unpublished data), or for less than a full life cycle [15,19]. The objectives of the present study were to adapt the previously developed diatom culturing and toxicity testing methods for *N. triangulifer* [14,15] and to further develop a method for chronic toxicity tests spanning organism ages of less than 24 h post hatch to adult emergence, with the goal of producing data that are suitable for use in the development of chronic water quality criteria, as prescribed by Stephan et al. [20] (i.e., similar in scope to the daphnid and mysid life-cycle tests). We chose 3 sodium salts that are contaminants of interest in the Great Lakes region: sodium chloride, sodium nitrate, and sodium sulfate (E. Hammer, United States Environmental Protection Agency [USEPA],

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Washington, DC, USA, personal communication), and conducted 96-h fed acute tests and full-life chronic toxicity tests so that acute-to-chronic ratios could be calculated.

METHODS

Culturing of test organisms and food

Mayfly and diatom biofilm culturing methods were based on those developed by Weaver et al. [14], with several modifications. As recommended [14], we initially used 3 species of diatom for feeding of mayflies, but we stopped using *Achnanthidium* sp. because it was more difficult to culture than the other diatoms, and culture results indicated that it was not necessary (DJ Soucek, personal observation). Diatoms used to feed mayflies included *Mayamea* sp. and *Nitzschia* sp. Both diatoms were obtained from Carolina Biological Supply, sold as *Navicula* sp. and *Synedra* sp., respectively. We had the genus-level identities taxonomically confirmed by an expert (S. Decelles) at USEPA-ORD, Cincinnati, Ohio, USA.

Mixed diatom stocks

To culture diatoms, we autoclaved (30 min at 121 °C, liquid cycle) a 4-L flask containing 4 L filtered (Whatman 934-AH) dechlorinated tap water and a 2-inch-long, Teflon-coated stir bar. After allowing it to cool, sterile technique was used to add 1.3 mL Kent Proculture Professional F/2 Algal culture formula A, 1.3 mL Kent Proculture Professional F/2 Algal culture formula B, 150 mg sodium metasilicate ($Na_2SiO_3 \cdot 9H_2O$), and 200 mL fresh diatom stock solution (just removed from stir-plate). Both diatom species were present in combination in stock cultures. We had initially kept the species stocks separate, but combining the species in stocks did not appear to impact the performance of the mayflies, so we adopted the combined stock approach. The flasks were placed on stir-plates with moderate to fast stirring (a large vortex was visible) in an environmental chamber set for a 16:8-h light:dark photoperiod and 25 °C. Diatom stocks were allowed to grow for 5 d, then 200 mL stock was used to seed the next flask and cages for mixed diatom slides (see below *Mixed-diatom slides*). Stocks were not refrigerated before seeding subsequent flasks or mixed-diatom slide cages.

Mixed-diatom slides

To culture mixed-diatom slides, 15 fully frosted microscope slides (catalogue no. 12-544-5CY, Fisherscience) were placed in a single layer (with frosted side facing up) on the bottom of a 7.2-L (189 mm × 297 mm × 128 mm) autoclavable polysulfone mouse cage (#PC7115HT, Ace Caging) filled with 2.5 L filtered (Whatman 934-AH) dechlorinated tap water. The container with the slides was autoclaved (30 min at 121 °C, liquid cycle) and allowed to cool. Sterile technique was used to add 1.3 mL Kent Proculture Professional F/2 Algal culture formula A, 1.3 mL Kent Proculture Professional F/2 Algal culture formula B, 150 mg sodium metasilicate ($Na_2SiO_3 \cdot 9H_2O$; dissolved in a small amount of deionized water before addition), and 200 mL fresh (never refrigerated) mixed-diatom stock. The container with slides was covered with clear plastic wrap and placed in an environmental chamber set for a 16:8-h light:dark photoperiod and 25 °C. Slides tended to have the most robust biofilms if used within approximately 6 d to 10 d after inoculation, but slides as old as 1 mo were used with success as long as most of the material appeared to be distinct round or spindle-shaped diatom cells when examined under a compound microscope. Poor-quality slides would have very few distinct cells on microscopic examination and would be mostly masses of amorphous material. If, after approximately 5 d, the biofilms appeared to be thin, we mildly aerated cages containing slides rather than adding more nutrients. We made the observation that color of the biofilm slides, as apparent to the naked eye, was not necessarily predictive of good mayfly performance. Therefore, before feeding to mayflies in toxicity tests or cultures, diatom biofilms were examined under a compound microscope to ensure that most of the biofilm material was distinct diatom cells, rather than being amorphous material.

Mayfly nymph rearing method

Mayflies (*Neocloeon triangulifer*; Stroud Water Research Center Clone #WCC-2) were reared in an environmental chamber at 25 °C, and a 16:8-h light:dark photoperiod. Culture water was a reconstituted water (hereafter referred to as Duluth 100) with a nominal hardness of 100 mg/L as $CaCO_3$, prepared according to a formula developed at the USEPA laboratory in Duluth, Minnesota, USA. To make this water, the following salt concentrations were added to deionized water from a Barnstead "E-pure" filtration system: $KHCO_3$, 10 mg/L; $NaHCO_3$, 125 mg/L; $MgSO_4$, 38 mg/L; $CaSO_4$, 40 mg/L; $CaCl_2$, 43 mg/L; NaBr, 0.05 mg/L. This water recipe was designed with the goal of better mimicking chemistry of "typical" North American freshwaters relative to other commonly used reconstituted waters (D. Mount, USEPA, Washington, DC, USA, personal communication). When eggs hatched, approximately 250 mL culture water was added to a 300-mL "I-chem" jar. All water was filtered using Whatman #934-AH glass microfiber filters. One mixed diatom slide was added to the jar. Newly hatched mayfly larvae (100–1000s) were then added to the jar, the lid was loosely placed, and the jar was covered with aluminum foil to block direct overhead lighting. When mayflies were 4 d to 8 d old (usually 6 d or 7 d), 40 individuals were placed in a 1-L beaker containing 400 mL Duluth 100 reconstituted water, and fed as described for the I-chem jar. The diatom slide was placed in the beaker before adding mayflies to avoid injury. Again, the container was covered with aluminum foil to block direct overhead lighting. When mayflies were 11 d to 12 d old, 20 individuals were transferred to a 19-cm × 24-cm × 6.5-cm Pyrex casserole dish containing 1.5 L Duluth 100 water and 5 mixed diatom slides. Slides were replaced when diatom biofilms were depleted, and water was changed twice per week or more if water appeared to be littered with loose diatoms and waste products. The container was covered loosely with foil. Using this method, aeration was not necessary at any point during mayfly culturing.

When pre-emergent nymph stages (determined by presence of black wing pads) appeared (days 20–23), they were placed in a 300-mL I-chem jar containing culture water and a mixed diatom slide. A screened cover was placed on the jar to allow for emergence of sub-imagoes and molting to imago stage (within 24 h after pre-emergent nymph stage). To induce the imago to release its eggs, we held it by the wings with forceps and touched its abdomen to culture water held in a small petri dish. This procedure was conducted with the aid of a dissecting microscope. Eggs were then pipetted into a scintillation vial; when possible, eggs of 3 females were combined in each vial. Eggs were either allowed to hatch or placed in an environmental chamber at 10 °C for later use. We observed a predictable relationship between the number of days eggs were held at 10 °C and the number of days to hatch on transfer of eggs to 25 °C (Figure 1). In some cases, eggs hatched over multiple days. For the purposes of generating a predictive equation for time to egg hatch, we used half-day intervals; for

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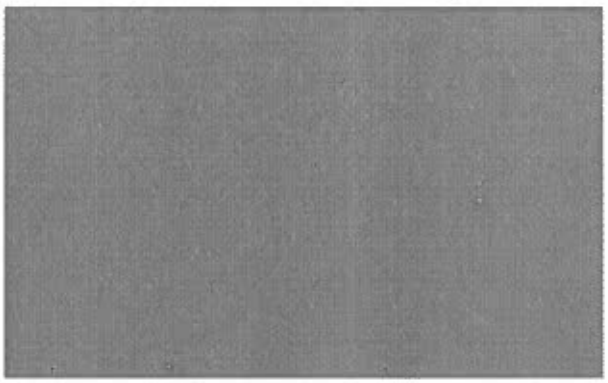


Figure 1. Predictive relationship between the number of days *Neocloeon triangulifer* eggs are held at 10 °C and number of days to hatch on moving eggs to 25 °C.

example, if approximately equal numbers of eggs hatched on days 2 and 3 after placement in 25 °C, we used 2.5 d in the regression model. The predictive model is as follows: # days to hatch on moving eggs to 25 °C = 0.0009 (# days at 10 °C)^2 − 0.1385(# days at 10 °C) + 6.809.

Test chemicals and dilution water

The nitrate, chloride, and sulfate sources for acute and chronic toxicity tests were reagent-grade sodium salts ($NaNO_3$ CAS # 7631-99-4; NaCl CAS # 7647-14-5; Na_2SO_4 CAS # 777-82-6). All acute and chronic tests were conducted in Duluth 100 hard water. As noted in the section *Mayfly nymph rearing method*, this was also the mayfly culture water, and eggs were stored in this water, so no acclimation was required.

Starvation test

To confirm previous observations that young mayflies are unable to survive extended periods without food [15], we conducted a starvation experiment in which we placed 1 <24-h-old mayfly into each of twenty 30-mL beakers containing 20 mL Duluth 100 water at 25 °C. We added no food to the beakers and observed mortality over the next 48 h. All organisms were alive at 24 h, but by the next day (48 h), survival was down to 22% (Figure 2). Based on this finding, all acute toxicity tests were fed a scraping of mixed diatom biofilm (described in *Acute test procedures*). Because all tests were conducted with sodium salts, food was not expected to impact availability of the contaminants, and analytical chemistry confirmed this (described in *Acute test procedures*).

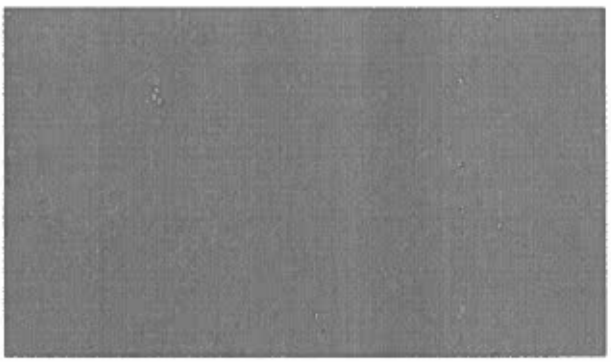


Figure 2. Percentage of survival of *Neocloeon triangulifer* larvae over time with no food. Organisms were less than 24 h old at the start of the test.

Table 1. Test conditions for acute toxicity tests with *Neocloeon triangulifer*

Condition	Value
1. Temperature (°C)	25 ± 1
2. Photoperiod (light:dark)	16:8
3. Test chamber size	30 mL
4. Test solution volume	20 mL
5. Age of organisms	<24 h
6. Dilution water	Duluth 100
7. Substrate	None
8. No. of organisms per chamber	5
9. No. of chambers/treatment	4
10. Food	Scraping of live diatom biofilm
11. Aeration	None
12. Test type	Static
13. Renewal frequency	None
14. Test duration	96 h
15. Control survival	≥90%
15. Endpoint	Survival

Acute test procedures

Static, nonrenewal, acute toxicity tests were conducted according to guidelines detailed in ASTM International E729-96 [4]. Treatments comprised a 50% dilution series. Five concentrations were tested in addition to controls. Further general details on test conditions are provided in Table 1. Organisms were less than 24 h old at the beginning of the test. Test chambers were fed by grasping a mixed diatom slide (cultured as described previously in *Mixed-diatom slides*) with a forceps, and scraping off an approximately 5-mm × 10-mm × 25-mm area of biofilm with another clean microscope slide, and releasing the biofilm into the test chamber. Chambers were fed on day 0 only, because 1 biofilm scraping was more than enough for the 96-h test duration. Mortality was assessed daily, using a dissecting microscope. Individuals were considered dead if they did not respond to gentle prodding with a blunt instrument. All median lethal concentration (LC50) values were calculated by using the trimmed Spearman-Karber method [21].

Standard water chemistry parameters were measured at both the beginning and the end of each exposure period, including temperature, pH, conductivity, and dissolved oxygen. Alkalinity and hardness were measured at the beginning of the test only. The pH measurements were made by using an Accumet (Fisher Scientific) model AB15 pH meter equipped with an Accumet gel-filled combination electrode (accuracy < ±0.05 pH at 25 °C). Dissolved oxygen was measured using an air-calibrated Yellow Springs Instruments (RDP) model 55 meter. Conductivity measurements were made using a Mettler Toledo (Fisher Scientific) model MC226 conductivity/total dissolved solids meter. Alkalinity and hardness were measured by titration [22]. Water samples from each treatment were collected at the beginning and end of acute tests and submitted to the Illinois State Water Survey analytical laboratory for measurement of nitrate, chloride, and sulfate concentrations as appropriate, using ion chromatography. Conductivity varied with salt concentration in all 3 tests. For the NaCl tests, mean (±standard deviation [SD]) temperature, pH, dissolved oxygen, alkalinity, and hardness were 25.0 ± 0.2 °C, 8.3 ± 0.1, 7.5 ± 0.3 mg/L, 84 ± 2 mg/L as $CaCO_3$, and 93 ± 1 mg/L as $CaCO_3$, respectively. For the $NaNO_3$ test, the values were 24.7 ± 0.3 °C, 8.3 ± 0.1, 7.8 ± 0.1 mg/L, 83 ± 1 mg/L as $CaCO_3$, and 99 ± 1 mg/L as $CaCO_3$, respectively. For the Na_2SO_4 test, the values were 24.8 ± 0.2 °C, 8.3 ± 0.1, 7.6 ± 0.2 mg/L, 84 ± 2 mg/L as $CaCO_3$, and 99 ± 1 mg/L as $CaCO_3$, respectively. For the NaCl test, measured chloride concentrations averaged 103%

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of nominal (range, 100–106%); for the $NaNO_3$ test, measured $N\text{-}NO_3$ averaged 105% of nominal (range, 103–107%); for the Na_2SO_4 test, measured sulfate averaged 107% of nominal (range, 101–110%). All reported LC50 values are based on measured concentrations.

Chronic toxicity testing procedures

For chronic toxicity tests, 6 treatments, including a control (dilution water), were tested. Nominal chloride concentrations for the treatments were as follows: 37 mg Cl^-/L (control), 70 mg Cl^-/L, 112 mg Cl^-/L, 196 mg Cl^-/L, 364 mg Cl^-/L, and 700 mg Cl^-/L. Nominal $N\text{-}NO_3$ concentrations were as follows: 0 mg $N\text{-}NO_3$/L (control), 12.5 mg $N\text{-}NO_3$/L, 25 mg $N\text{-}NO_3$/L, 50 mg $N\text{-}NO_3$/L, 100 mg $N\text{-}NO_3$/L, and 200 mg $N\text{-}NO_3$/L. Nominal SO_4^{2-} concentrations were as follows: 59 mg SO_4^{2-}/L (control), 136 mg SO_4^{2-}/L, 214 mg SO_4^{2-}/L, 369 mg SO_4^{2-}/L, 679 mg SO_4^{2-}/L, and 1300 mg SO_4^{2-}/L.

Test conditions are summarized in Table 2. In an attempt to minimize the mass of diatoms required for each test chamber, we initially used the model of the ASTM International *Ceriodaphnia dubia* chronic method [23], in which 1 organism is added per test chamber, and each treatment has 10 replicates. The NaCl and $NaNO_3$ chronic tests were conducted in this manner, but for the Na_2SO_4 chronic test, we used 2 organisms per test chamber (a total of 20 organisms per treatment) to decrease the chance of random control mortalities causing test failure. Because having 2 individuals per chamber did not require substantially higher numbers of diatom slides through the course of the test, we recommend using this organism loading rate for further tests.

Before the start of a test, a vial containing eggs from 3 females was moved from the 10 °C environmental chamber to the 25 °C chamber to encourage hatching of the eggs. The test began when sufficient numbers hatched to conduct the test; organisms were less than 24 h old at the start. Tests were conducted at 25 ± 1 °C and a 16:8-h light:dark photoperiod. All test chambers were covered with plastic wrap to minimize evaporation and with aluminum foil to eliminate direct overhead light. Light intensity in test chambers was approximately 110 lux to 160 lux. The test chambers at the beginning of the test were 30-mL glass beakers with 20 mL test water (or control). No substrate was used, but a scraping from a mixed diatom biofilm slide was added to each beaker for food as described previously in *Acute test procedures* for acute testing. Chambers were fed on day 0 and day 5, then on every water change day thereafter. Beginning on day 17 and until the end of the tests, biofilm scrapings were added to test chambers daily. Beakers were never allowed to be empty of food before the next feeding. We used scrapings of live biofilms for food, because numerous previous experiments using concentrated, refrigerated mixed diatom suspension made from concentrated stocks of freshwater diatoms, as recommended by Struewing et al. [15], resulted in lack of development of nymphs (DJ Soucek, personal observation). Water was not renewed for the first 4 d of the test, because the small size of the test organisms at that time made handling a potential source of error. Beginning on day 5 and every Monday, Wednesday, and Friday thereafter, complete water changes were conducted, with organisms being transferred to new beakers with freshly made water. Organisms were held in 30-mL beakers until day 14, when they were moved to 150-mL glass beakers with 100 mL test water. The 150-mL beakers were used until just before emergence.

Mayflies began to reach the pre-emergent nymph stage on day 20 to day 22, depending on the test. Slower developing individuals took as many as 36 d to reach this stage, but most had done so by day 25 in all 3 tests. When pre-emergent nymph stages were observed, they were transferred to 300-mL glass beakers with 125 mL appropriate test or control water and food. In early experiments to test this method, we added a clean microscope slide placed at a slant in the beaker to provide a surface for organisms to walk up and exit the water surface, but we later learned that this was not necessary. The larger beakers were used to provide more space for the flying sub-imagoes/imagoes, and they were covered individually with plastic wrap to prevent escape of the organisms. Sub-imagoes and imagoes were able to rest by clinging to the beaker wall or plastic wrap cover. For the NaCl and $NaNO_3$ tests, each organism had its own emergence chamber. In the case of the Na_2SO_4 chronic, which had 2 organisms per chamber at the beginning of the test, if both individuals reached pre-emergent nymph stage on the same day, they were placed in the same emergence chamber. Otherwise, each individual had its own emergence chamber. The pre-emergent nymph-staged nymphs were observed in the morning, and by the next morning, if successful, they had molted through the sub-imago stage to the imago stage. Imagoes then were grasped by the wings with a forceps, and weighed live to the nearest 0.001 mg by using a Cahn C-35 microbalance. Then, holding them again by the wings using a forceps, we held the ventral surface of their abdomen to Duluth 100 water held in a thick depression slide (85 mm × 14 mm × 33 mm), allowing the adult to release its eggs. When this procedure is performed under a dissecting scope, a faint yellowish coloration formed by the eggs is visible in the side of the abdomen. When all of the eggs are released, this coloration is no longer visible. In addition, we watched through the scope as the eggs were released and continued to hold the abdomen to the water for some time after eggs stopped appearing, to ensure that all eggs

Table 2. Test conditions for chronic toxicity tests with *Neocloeon triangulifer*

Condition	Value
1. Temperature (°C)	25 ± 1
2. Photoperiod (light: dark)	16:8
3. Test chamber size/solution volume	Day 0–14: 30 mL/20 mL; day 14 pre-emergent nymph stage: 150 mL/100 mL; emergence chamber: 300 mL/125 mL
4. Age of organisms at start of test	<24 h
5. Dilution water	Duluth 100
6. Substrate	None
7. No. of organisms per chamber	2 (2 of our tests had 1 per chamber)
8. No. of chambers/treatment	10
9. Food	Scrapings of live diatom biofilms from slides Day 0–16 on water change days; thereafter, daily
10. Aeration	None
11. Test type	Static/renewal
12. Renewal frequency	Days 0–4: none; day 5—end of test: MWF
13. Control survival[a]	≥80%
14. Endpoints	%Survival to pre-emergent nymph, % pre-emergent nymph when controls finished, no. of days to pre-emergent nymph, % emergence, pre-egg laying wet weight of adult, no. of eggs/original female

[a]Control survival was evaluated as no. of organisms surviving to pre-emergent nymph stage.
MWF = Monday, Wednesday, Friday.

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were released. With the eggs in the depression slide, we used a dissection probe to break the surface tension, allowing the eggs to fall to the bottom of the depression. The concave nature of the depression caused eggs to gather in the bottom. We then used the probe to spread the eggs into a monolayer, and photographed the monolayer using an Olympus Q-color 3 camera mounted on a dissecting scope and QCapture Ver 2.7.3 software. The images were then printed to hard copy, and eggs were counted manually.

Standard water chemistry parameters were measured throughout the exposure period, including temperature, pH, conductivity, dissolved oxygen, alkalinity, and hardness, as detailed previously in *Acute test procedures* for acute toxicity tests. Water samples from each treatment were submitted to the Illinois State Water Survey analytical laboratory for confirmation of chloride, sulfate, or nitrate concentrations by using ion chromatography. With the exception of conductivity, which varied with salt concentration in all 3 tests, measured water quality parameters varied little in the chronic toxicity tests. For the NaCl test, mean (±SD) temperature, pH, dissolved oxygen, alkalinity, and hardness were 25.2 ± 0.5 °C, 8.3 ± 0.1 mg/L, 7.4 ± 0.4 (lowest value = 6.8) mg/L, 86 ± 4 mg/L as $CaCO_3$, and 94 ± 3 mg/L as $CaCO_3$, respectively. For the $NaNO_3$ test, the values were 25.2 ± 0.3 °C, 8.3 ± 0.1 mg/L, 7.5 ± 0.5 (lowest value = 6.6) mg/L, 85 ± 5 mg/L as $CaCO_3$, and 95 ± 7 mg/L as $CaCO_3$, respectively. For the Na_2SO_4 test, the values were 25.0 ± 0.3 °C, 8.4 ± 0.1 mg/L, 7.3 ± 0.4 (lowest value = 6.1) mg/L, 83 ± 3 mg/L as $CaCO_3$, and 95 ± 4 mg/L as $CaCO_3$, respectively. For the NaCl test, measured chloride concentrations averaged 100% of nominal (range, 92–109%); for the $NaNO_3$ test, measured $N\text{-}NO_3$ averaged 102% of nominal (range, 96–107%); for the Na_2SO_4 test, measured sulfate averaged 97% of nominal (range, 90–106%).

Endpoints measured included percentage of survival to pre-emergent nymph stage; percentage of pre-emergent nymph when controls finished (% pre-emergent nymph when controls finished, calculated as the number of individuals in a treatment that had successfully reached pre-emergent nymph stage by the day the last individual in the control reached pre-emergent nymph stage); mean number of days until pre-emergent nymph stage; percentage of emergence (calculated as the number successfully emerging to imago stage divided by the number of individuals at the start of the test), mean pre-egg-laying wet (live) weight of imago; number of eggs per female (i.e., number of eggs per emerging female, a measure of mean individual fecundity); number of eggs per original female (i.e., overall number of eggs produced in a treatment divided by the number of individuals at the start of the test). The latter endpoint is analogous to population growth rate, which would include development time as well, but because the results of the 2 calculations were highly correlated, we only included number of eggs per original female in the present study. Another endpoint reported by the Stroud Water Research Center (J. Jackson, Stroud Water Research Center, Avondale, PA, USA, unpublished data) was instantaneous growth rate, which incorporates adult and hatchling mass and development time. This endpoint was not responsive to any of the salts tested in the present study, so for the sake of brevity, we have not included it. Percentage of survival was analyzed statistically by using Fisher's exact test, and means for the remaining endpoints except for percentage of emergence and number of eggs per original female were compared by using analysis of variance with post hoc pairwise comparisons conducted using Tukey's honest significant difference. Dunnett's test was not used for post hoc tests for sublethal endpoints, because the treatments did not have equal replication because of mortality. The maximum allowable toxicant concentration was calculated as the geometric mean of the no observable effect concentration (NOEC: the highest concentration at which means were not significantly different from the control) and the least observable effect concentration: the lowest concentration at which means were significantly different from that of the control). When possible, 20% effective concentrations (EC20s) were calculated by using TRAP software (Ver 1.21A; R.J. Erickson, USEPA, MED, Duluth, MN, USA).

RESULTS

Acute toxicity tests

In the five 96-h, fed, acute toxicity tests conducted with *Neocloeon triangulifer* (3 with sodium chloride and 1 each with sodium sulfate and sodium nitrate), control survival was 100% in all cases except for the sodium sulfate test, which had 95% control survival. For the sodium chloride tests, individual 96-h LC50s (95% confidence intervals) were 1140 (994–1309) mg Cl/L, 910 (719–1153) mg Cl/L, and 1153 (96–1374) mg Cl/L. The geometric mean of these 3 tests (1062 mg Cl/L) was used to calculate the acute-to-chronic ratios for chloride. The 96-h LC50 for the nitrate test was 179 (165–205) mg $N\text{-}NO_3$/L, and the value for the sulfate test was 1227 (1073–1404) mg SO_4/L.

Chronic toxicity tests

Chloride test. Survival to pre-emergent nymph stage was high for the controls and the 3 lowest-exposure treatments (Table 3). In the 194-mg/L treatment, 1 individual was killed because of technician error, so survival was 8 of 9 individuals/replicates. The 362-mg/L and 701-mg/L treatments had significantly lower survival to pre-emergent nymph stage than the other treatments. All of the organisms in the 701-mg/L treatment were dead by day 4, and all mortality in the 362-mg/L treatment occurred on day 7 or before (Figure 3A). Percentage of pre-emergent nymph when controls finished was slightly more sensitive than the percentage of survival to pre-emergent nymph stage (20% vs 60%, respectively, in the 362 mg Cl^-/L treatment), but calculated effects levels were similar in the 2 endpoints. Controls reached the pre-emergent nymph stage by day 23 on average, as did the 70-mg/L, 112-mg/L, and 194-mg/L treatments. Organisms that survived in the 362-mg/L treatment had significantly delayed (by ~3 d) development to pre-emergent nymph stage. The percentage of emergence was relatively high in the controls, but although the highest concentration had no emergence, no dose–response relationship was observed for this endpoint. The measured maximum allowable toxicant concentration and EC20 (95% confidence interval) for percentage of pre-emergent nymph when controls finished were 265 mg Cl^-/L and 165 mg Cl^-/L (119–230 mg Cl^-/L), respectively, and for percentage of survival to pre-emergent nymph stage were 265 mg Cl^-/L and 190 mg Cl^-/L (129–280 mg Cl^-/L), respectively. We could not calculate an EC20 for number of days to pre-emergent nymph stage (as 1/mean number of days) or percentage of emergence because of insufficient slope, but the maximum allowable toxicant concentrations were 265 mg Cl^-/L and 504 mg Cl^-/L, respectively.

The sublethal endpoints of pre-egg-laying weight, number of eggs per female, and number of eggs per original female were not as sensitive as the survival-related endpoints. In fact, mean weights and number of eggs for the surviving individuals in the 362-mg Cl^-/L treatment were nominally higher than those for

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Table 3. Chronic chloride (as NaCl) toxicity data for the mayfly *Neocloeon triangulifer*[a]

$[Cl^-]$[b] (mg/L)	Conductivity[c] (µmhos/cm)	% pre-emergent nymph WCF[d]	% survival to pre-emergent nymph stage	No. of days to pre-emergent nymph	% emergence	Pre-egg laying weight (mg)	No. of eggs per female	No. of eggs per original female
27	371 ± 11	100 A	100 A	23.3 ± 1.1 A	70 A	3.131 ± 0.311 A	1446 ± 146 A	964
70	516 ± 15	100 A	100 A	23.1 ± 0.7 A	50 A	2.949 ± 0.290 A	1302 ± 216 A	651
112	658 ± 15	90 A	90 A	23.1 ± 0.6 A	40 A	3.075 ± 0.293 A	1326 ± 107 A	531
194	939 ± 11	89 A	89 A	23.0 ± 0.5 A	78 A	2.996 ± 0.145 A	1206 ± 163 A	938
362	1479 ± 33	20 B	60 B	26.5 ± 2.0 B	60 A	3.246 ± 0.179 A	1497 ± 113 A	898
701	2550 (n = 1)	0 B	0 B	NA	0 B	NA	NA	0
MATC (mg Cl/L)		265	265	265	504	NC	NC	NC
EC20 (mg Cl/L)		165	190	NC	NC	NC	NC	NC
EC20 95% CI		119–230	129–280	NC	NC	NC	NC	NC
ACR[e]		6.4	5.6	4.0	2.1	NC	NC	NC

[a]Within endpoint columns, means followed by different capital letters are significantly different ($p < 0.05$).
[b]Mean measured Cl^- concentrations are shown.
[c]Conductivity values shown are means (±Standard deviation) of all measurements for the duration of the test.
[d]WCF = when controls finished (i.e., on the day of the appearance of the last pre-emergent nymph stage in the control).
[e]Calculated using the geometric mean of three 96-h LC50 (1062 mg Cl/L) divided by EC20 when available, otherwise by maximum acceptable toxicant concentration.
MATC = maximum acceptable toxicant concentration; WCF = when controls finished; NA = not applicable; NC = not calculated (not statistically possible); EC20 = 20% effect concentration; CI = confidence interval; ACR = acute to chronic ratio.

any other treatment (Table 3). Neither maximum allowable toxicant concentrations nor EC20s could be calculated for any of these 3 endpoints. However, variability for these endpoints was relatively low, with coefficients of variation ranging from a minimum of 5 to a maximum of 17, suggesting that they may be useful endpoints for other contaminants with different modes of action.

With EC20s or maximum allowable toxicant concentrations ranging from 165 mg Cl^-/L to 504 mg Cl^-/L, and a mean 96-h LC50 of 1062 mg Cl^-/L, the acute to chronic ratios for chloride ranged from 2.1 to 6.4 (Table 3).

Nitrate test

Percentage of survival to pre-emergent nymph stage was high for the controls and up to 51 mg N-NO_3/L (Table 4). None of the mayflies in the 101-mg/L and 201-mg/L treatments survived to pre-emergent nymph stage. All of the organisms in the highest treatment were dead by day 16. In contrast to the chloride chronic test in which all mortality in the second highest exposure concentration occurred on day 7 or before, in the nitrate test, all mortality in the 101-mg/L treatment occurred on or after day 20, when organisms in other treatments were reaching the pre-emergent nymph stage (Figure 3B). Percentage of pre-emergent nymph when controls finished was more sensitive than percentage of survival to pre-emergent nymph stage, with a maximum allowable toxicant concentration of 36 mg/L compared with 72 mg/L for the latter. The EC20s could not be calculated for either of the survival endpoints because of inadequate partial effects. Controls reached the pre-emergent nymph stage by day 21 on average, and the 12.8 mg/L and 26 mg/L treatments had similar means for number of days to pre-emergent nymph stage (Table 4). Organisms in the 51-mg/L treatment reached the pre-emergent nymph stage on day 22 on average, and this mean was significantly different from that of the control. Although none of the organisms in the 101-mg N-NO_3/L treatment reached the pre-emergent nymph stage, 1 individual in this treatment was alive until day 31. Percentage of emergence was 60% in the controls but even higher in the 12.8-mg/L and 26-mg/L treatments.

As was true of the chloride chronic test, the sublethal endpoints of pre-egg-laying weight and number of eggs per

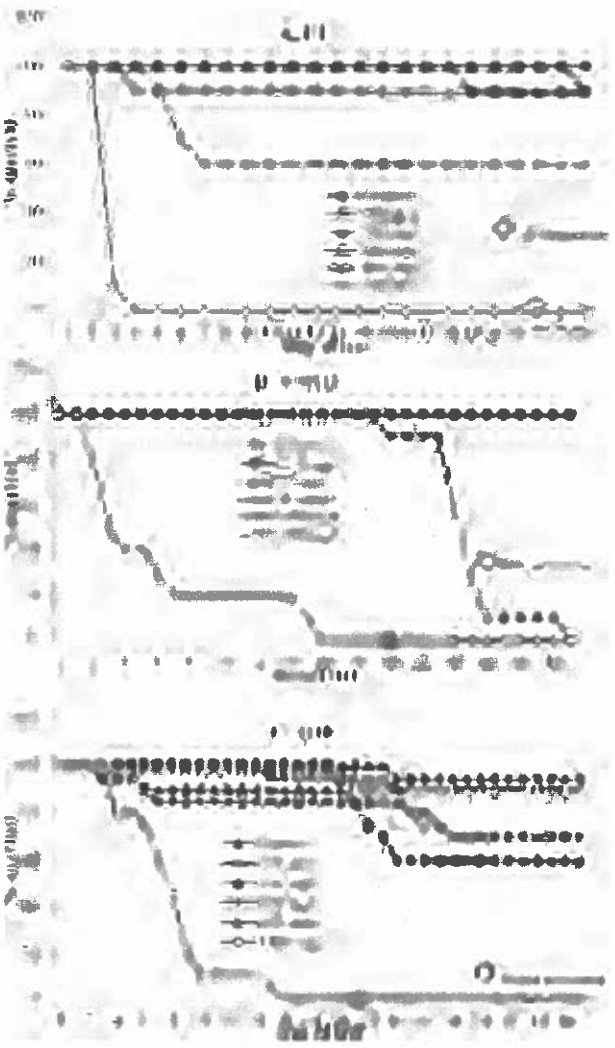


Figure 3. Survival of *Neocloeon triangulifer* larvae to pre-emergent nymph stage at different (A) sodium chloride, (B) sodium nitrate, and (C) sodium sulfate concentrations. Nominal treatment concentrations are shown in legend. Measured values are presented in Tables 4 and 5, respectively.

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Table 4. Chronic nitrate (as $NaNO_3$) toxicity data for the mayfly *Neocloeon triangulifer*[a]

[$N\text{-}NO_3^-$][b] (mg/L)	Conductivity[c] (µmhos/cm)	% pre-emergent nymph WCF[d]	% survival to pre-emergent nymph stage	No. of days to pre-emergent nymph	% emergence	Pre-egg laying weight (mg)	No. of eggs per female	No. of eggs per original female
0.03	374 ± 23	100 A	100 A	21.3 ± 0.6 A	60 A	3.030 ± 0.278 A	1395 ± 244 A	837
12.8	481 ± 17	100 A	100 A	20.7 ± 0.6 A	90 A	3.263 ± 0.179 A	1647 ± 117 A	1483
26	593 ± 22	100 A	100 A	20.4 ± 0.6 A	66 A	3.232 ± 0.103 A	1500 ± 202 A	1000
51	804 ± 24	60 B	100 A	22.4 ± 1.1 B	40 A	3.283 ± 0.239 A	1614 ± 144 A	646
101	1209 ± 30	0 B	0 B	NA	0 B	NA	NA	0
201	2042 ± 73	0 B	0 B	NA	0 B	NA	NA	0
MATC (mg $N\text{-}NO_3$/L)		36	72	36	72	NC	NC	NC
EC20 (mg $N\text{-}NO_3$/L)		NC	NC	NC	39	NC	NC	35
EC20 95% CI		NC	NC	NC	9.2–69	NC	NC	14–85
ACR[e]		5.0	2.5	5.0	4.6	NC	NC	5.1

[a]Within endpoint columns, means followed by different capital letters are significantly different ($p < 0.05$).
[b]Mean measured $N\text{-}NO_3^-$ concentrations are shown.
[c]Conductivity values shown are means (±Standard deviation) of all measurements for the duration of the test.
[d]WCF = when controls finished (i.e., on the day of the appearance of the last pre-emergent nymph stage in the control).
[e]Calculated using 96-h LC50 (179 mg $N\text{-}NO_3$/L) divided by EC20 when available, otherwise by maximum acceptable toxicant concentration.
MATC = maximum acceptable toxicant concentration; NA = not applicable; NC = not calculated (not statistically possible); EC20 = 20% effect concentration; CI = confidence interval; ACR = acute to chronic ratio.

female were not as sensitive as survival or number of days to pre-emergent nymph stage (Table 4). In fact, mean weights and number of eggs for the surviving individuals in the nitrate-exposed treatments were nominally higher than those in the control. We were, however, able to calculate an EC20 for number of eggs per original female of 35 mg $N\text{-}NO_3$/L, which was the lowest chronic value obtained. Variability for pre-egg-laying weight and number of eggs per female were relatively low, with coefficients of variation ranging from 3 to 17.

With EC20s or maximum allowable toxicant concentrations ranging from 35 mg $N\text{-}NO_3$/L to 72 mg $N\text{-}NO_3$/L, and a 96-h LC50 of 179 mg $N\text{-}NO_3$/L, the acute-to-chronic ratios ranged from 2.5 to 5.1 for nitrate (Table 4).

Sulfate test

Percentage of survival to pre-emergent nymph stage was high for the controls and the 129 mg SO_4/L treatment, but was significantly reduced at 209 mg/L and above (Table 5). None of the mayflies in the 1277-mg/L treatments survived to pre-emergent nymph stage. As was the case for the nitrate test, all of the organisms in the highest treatment were dead by day 16 (Figure 3C). For the other treatments that had 60% to 70% survival to pre-emergent nymph stage, most of the mortality occurred after day 21, similar to what was observed in the nitrate test. Percentage of pre-emergent nymph when controls finished was again more sensitive than percentage of survival to pre-emergent nymph stage. Both endpoints had the same maximum allowable toxicant concentration (164 mg/L), but the EC20 for percentage of pre-emergent nymph when controls finished (170 mg/L) was substantially lower than that of the percentage of survival to pre-emergent nymph stage (289 mg/L). Controls reached the pre-emergent nymph stage by day 23 on average, and 2 treatments had significant delays in development, with the 359-mg/L treatment averaging 26 d and the 661-mg/L treatment averaging 32 d (Table 5). None of the organisms in the 1277-mg/L treatment reached the pre-emergent nymph stage. Percentage of emergence was 70% in the controls and roughly decreased with increasing sulfate dose, resulting in an EC20 of 145 mg/L (Table 5).

Again, the sublethal endpoints of pre-egg-laying weight and number of eggs were not as sensitive as survival or number of

Table 5. Chronic sulfate (as Na_2SO_4) toxicity data for the mayfly *Neocloeon triangulifer*[a]

[SO_4^{2-}][b] (mg/L)	Conductivity[c] (µmhos/cm)	% pre-emergent nymph WCF[d]	% survival to pre-emergent nymph stage	No. of days to pre-emergent nymph	% emergence	Pre-egg laying weight (mg)	No. of eggs per female	No. of eggs per original female
57	371 ± 12	95 A	95 A	23.0 ± 1.0 A	70 A	2.550 ± 0.282 A	1124 ± 148 A	749
129	540 ± 10	85 A	90 A	23.5 ± 1.3 A	45 A	2.428 ± 0.410 A	1060 ± 220 A	446
209	715 ± 9	60 B	60 B	23.4 ± 1.1 A	55 A	2.624 ± 0.383 A	1177 ± 209 A	648
359	1057 ± 11	40 B	70 B	26.1 ± 2.1 B	30 B	2.629 ± 0.229 A	1141 ± 130 A	342
661	1719 ± 17	0 B	70 B	32.2 ± 1.7 B	30 B	3.219 ± 0.367 B	1354 ± 150 A	406
1277	3003 ± 39	0 B	0 B	NA	0 B	NA	NA	0
MATC (mg SO_4/L)		164	164	274	274	NC	NC	NC
EC20 (mg SO_4/L)		170	289	528	145	NC	NC	281
EC20 95% CI		128–226	139–437	492–566	69–305	NC	NC	70–1138
ACR[e]		7.2	4.2	2.3	8.5	NC	NC	4.4

[a]Within endpoint columns, means followed by different capital letters are significantly different ($p < 0.05$).
[b]Mean measured SO_4^{2-} concentrations are shown.
[c]Conductivity values shown are means (±Standard deviation) of all measurements for the duration of the test.
[d]WCF = when controls finished (i.e., on the day of the appearance of the last pre-emergent nymph stage in the control).
[e]Calculated using 96-h LC50 (1227 mg SO_4/L) divided by EC20 when available, otherwise by MATC.
MATC = maximum acceptable toxicant concentration; NA = not applicable; NC = not calculated (not statistically possible or valid); EC20 = 20% effect concentration; CI = confidence interval; ACR = acute to chronic ratio.

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days to pre-emergent nymph stage (Table 5), but we were able to calculate an EC20 for number of eggs per original female of 281 mg SO_4/L. Mean weights for the surviving individuals in the 661-mg/L treatment were significantly higher than those in the control, likely because of the longer development time. Again, variability for pre-egg-laying weight and number of eggs per female were relatively low, with coefficients of variation ranging from 9 to 21.

With EC20s ranging from 145 SO_4/L to 528 mg SO_4/L, and a 96-h LC50 of 1227 mg SO_4/L, the acute-to-chronic ratios ranged from 2.3 to 8.5 for sulfate (Table 5).

Relative sensitivity of endpoints

We were able to generate at least 4 acute-to-chronic ratios for each of the 3 chronic tests conducted (Table 6). To assess the relative sensitivity of the various endpoints over the 3 tests, we calculated relative acute-to-chronic ratios by dividing each individual acute-to-chronic ratio by the highest acute-to-chronic ratio for each particular test, thereby creating a ranking with a maximum of 1.00 (highest acute-to-chronic ratio) and a minimum of 0 (no acute-to-chronic ratio calculated). By taking the average relative acute-to-chronic ratio for each endpoint, we determined that percentage of pre-emergent nymph when controls finished was the most sensitive endpoint across the 3 tests, with an average relative acute-to-chronic ratio of 0.94, and pre-egg-laying weight and number of eggs per female were the least sensitive, with no acute-to-chronic ratios calculated (Table 6).

DISCUSSION

Our mean 96-h chloride LC50 of 1062 mg Cl/L at 25 °C and a hardness of 93 mg/L was higher than the 48-h LC50 of 399 mg Cl/L (calculated from the reported value for NaCl) reported by Struewing et al. [15] at the same temperature and a similar hardness. However, in the same paper, Struewing et al. [15] reported a 14-d LC50 of 505 mg Cl/L, which, being higher than their 48-h LC50, suggests that perhaps their reported acute tests were an overestimate of sensitivity. Based on results of separate experiments conducted in our laboratory (see Supplemental Data, Table S1), possibly this discrepancy is attributable to the feeding method used by the respective laboratories. The Struewing [15] study fed acute tests using a concentrated mixed diatom suspension, whereas the present study used live diatom biofilm scrapings as food. We conducted acute toxicity tests with *N. triangulifer* using both food types (refrigerated mixed diatom suspension and live biofilm scrapings) but otherwise with identical methods, and obtained substantially different LC50 values (~2-fold difference with non-overlapping confidence intervals) in the chloride salt tests (Supplemental Data, Table S1). Interestingly, although a similar difference was observed in tests with potassium chloride, the same comparisons with sulfate and nitrate salts resulted in LC50s that were quite similar between food types (Supplemental Data, Table S1), so this appears to be a phenomenon specific to chloride. At this time we are unable to speculate as to the mechanism for this difference. Our acute chloride toxicity results lie between those previously mentioned [15] and the findings of the Stroud Water Research Center (J. Jackson, Stroud Water Research Center, Avondale, PA, USA, unpublished data), who generated 48-h LC50s in tests conducted at 20 °C of 1423 mg Cl/L at a hardness of 22 to 42 (Dyberry Creek dilution water), and 2459 mg Cl/L at a hardness of approximately 100 (White Clay Creek dilution water), using naturally colonized live algal biofilm plates as food. With longer duration and a higher test temperature, believing that the Stroud Water Research Center results would be similar to ours is reasonable. All of these described tests were conducted with first instar larvae.

Our full-life chronic toxicity values for chloride, EC20s of 165 mg Cl/L to 190 mg Cl/L, and maximum allowable toxicant concentrations of 265 Cl/L to 504 mg Cl/L are similar to 14-d 25% inhibitory concentrations (IC25s) reported by Struewing et al. [15] in water with a similar hardness (~90 mg/L). Their values ranged from 139 Cl/L to 224 mg Cl/L (calculated from reported NaCl IC25s). Their acute-to-chronic ratios ranged from 0.79 to 2.9, whereas ours ranged from 2.1 to 6.4, a function of our higher LC50. Although they found weight and body length to be sensitive endpoints, our survival and development time data were more sensitive to chloride. A potential explanation for this different finding is that our weights were for egg-bearing adults that successfully emerged, whereas Struewing et al. [15] measured weight on approximately 14-d-old nymphs. Because we observed developmental delays (greater mean number of days to reach pre-emergent nymph stage at 362 mg Cl/L compared with lower treatments), we likely would have obtained similar results regarding weight if we ended the test at 14 d. Comparing endpoints is difficult because of the disparity in test duration, but another difference in the 2 test systems is that, again, Struewing et al. [15] fed their organisms a loose suspension of diatoms, whereas we fed ours live diatom biofilm scrapings. In our preliminary experiments, we were unable to bring mayflies to adulthood by using a refrigerated loose diatom suspension, even when plenty of excess food was available.

Table 6. Actual and relative acute to chronic ratios generated in the present study for three chronic toxicity tests with sodium salts[a]

Endpoint	Cl test		$N\text{-}NO_3$ test		SO_4 test		Average relative ACR
	ACR	Relative ACR	ACR	Relative ACR	ACR	Relative ACR	
% pre-emergent nymph WCF[b]	6.4	1.00	5.0	0.98	7.2	0.85	0.94
% survival to pre-emergent nymph stage	5.6	0.88	2.5	0.49	4.2	0.49	0.62
No. of days to pre-emergent nymph	4.0	0.63	5.0	0.98	2.3	0.27	0.63
% emergence	2.1	0.33	4.6	0.90	8.5	1.00	0.74
Weight[c]	NC	0	NC	0	NC	0	0
No. of eggs/female	NC	0	NC	0	NC	0	0
No. of eggs/original female	NC	0	5.1	1.00	4.4	0.52	0.51

[a]Relative acute-to-chronic ratios were calculated by dividing each individual acute-to-chronic ratio for a given test by the highest acute-to-chronic ratio for that test. A high relative acute-to-chronic ratio indicates high sensitivity (i.e., a larger difference between the chronic endpoint and the 96-h LC50).
[b]WCF = when controls finished (i.e., when the last control individual has reached pre-emergent nymph stage).
[c]Weight = pre-egg-laying live weight of adults.
ACR = acute to chronic ratio; WCF = when controls finished; NC = not calculated; LC50 = median lethal concentration.

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The Stroud Water Research Center (J. Jackson, Stroud Water Research Center, Avondale, PA, USA, unpublished data) reported full-life chronic chloride toxicity to *N. triangulifer*, using naturally colonized periphyton plates as food. Their most sensitive endpoints were development time and instantaneous growth rate. Despite their testing at 20 °C, their maximum allowable toxicant concentrations in water with a similar hardness to ours (White Clay Creek) ranged from 177 Cl/L to 708 mg Cl/L. Thus, our full-life chronic method using laboratory-cultured food appears to produce chronic values similar to those produced using natural food sources.

In other chronic toxicity studies using this species or closely related mayflies with chloride dominated salts, Hassell et al. [16] obtained 21-d conductivity LC50s of 890 µS/cm to 2700 µS/cm in 2 different dilution waters at 15 °C, using wild-caught *Centroptilum* sp., and Johnson et al. [18] reported an EC20 of 672 µS/cm at 24.5 °C in a mesocosm study with *N. triangulifer*, using a combination of $CaCl_2$ and NaCl. Both of these tests were conducted with natural foods: conditioned leaves for the former and naturally colonizing periphyton for the latter. In our chloride test, we calculated a conductivity EC20 of 895 µS/cm (709–1129 µS/cm) for the most sensitive endpoint, so again, our test with cultured food can produce similar results to those with natural foods.

Other mayfly genera have been investigated for sodium chloride sensitivity in subchronic tests. For example, Diamond et al. [24] tested *Stenonema modestum* (Heptageniidae) at 12 °C in 14-d exposures. The maximum allowable toxicant concentrations for survival and molting endpoints ranged from 1410 mg Cl/L to 3798 mg Cl/L (calculated from salt concentrations). Echols et al. [3] observed a mean *Isonychia bicolor* 7-d NOEC of 855 mg Cl/L at 20 °C to 23 °C. Goetsch and Palmer [25] reported a 96-h LC50 between 1500 mg Cl/L and 2500 mg Cl/L for *Tricorythus* sp. in an unfed test at 10 °C to 16 °C. K. Allan recorded a 72-h conductivity LC50 of 12 600 µS/cm for the leptophlebiid mayfly *Nousia* sp. using sodium and chloride–dominated saline waters. A 7-d acclimation to higher salinity water did not significantly alter conductivity LC50s for that species (K. Allan, 2006, Master's thesis, University of Tasmania, Hobart, TAS, Australia). Although these effect levels are higher than those observed in our NaCl chronic test, comparisons are tenuous because of the differences in test temperatures, duration, endpoints, and the fact that all of these studies used wild-collected organisms.

Much less information is available in the literature on chronic toxicity of sulfate salts to *N. triangulifer* and related species. Kunz et al. [12] conducted static, nonrenewal exposures of first instar nymphs through adult emergence (~35 d) at ambient laboratory temperatures of 21 °C, using naturally colonized periphyton plates (from Stroud Water Research Center) as food and survival (emergence) and biomass as endpoints. They developed reconstituted waters to simulate major ion compositions typical of streams impacted by coal mining in Appalachian streams. One of the waters tested ("Upper Dempsey") was dominated by Na and SO_4, but in contrast to our findings, it did not cause significant toxicity at the highest test concentration (~640 mg SO_4/L). We observed EC20s ranging from 145 SO_4/L to 528 mg SO_4/L, but our test was conducted at a hardness of 95 mg/L, whereas the Kunz et al. [12] test was conducted at a hardness of 220 mg/L. Hardness has been shown to have a strong influence on sodium sulfate toxicity to other species [26,27]. In 2 other reconstituted waters having an ionic composition dominated by Ca, Mg, HCO_3, and SO_4, Kunz et al. [12] did observe significant toxicity to *N. triangulifer* at sulfate concentrations ranging from 386 mg/L ("Winding Shoals" water) to approximately 770 mg/L ("Boardtree" water; sulfate not measured). In terms of conductivity, the Winding Shoals and Boardtree waters were toxic to *N. triangulifer* at approximately 800 µS/cm and 1300 µS/cm, respectively [12]. We calculated a conductivity EC20 for our sodium sulfate test of 725 µS/cm.

Goetsch and Palmer [25] reported a 96-h LC50 of 532 mg SO_4/L for the mayfly *Tricorythus* sp. in sodium sulfate exposures at approximately 10 °C to 15 °C. This is substantially lower than our 96-h LC50 of 1227 mg SO_4/L, but in addition to using a different species with potentially different sensitivity to sulfate, the *Tricorythus* test was conducted at a moderately lower hardness (~70 mg/L as $CaCO_3$), and the test was not fed. Conversely, our conductivity EC20 (725 µS/cm) for *N. triangulifer* is quite similar to 7-d maximum allowable toxicant concentrations reported by Kennedy et al. [28] (737–773 µS/cm) for *Isonychia bicolor* exposed to a simulated mine effluent dominated by sodium and sulfate.

To our knowledge, these are the first acute and chronic nitrate toxicity values reported for *N. triangulifer*, but our lowest maximum allowable toxicant concentrations (36 mg N-NO_3/L) and EC20 (35 mg N-NO_3/L) are strikingly similar to a 20-d threshold effect concentration (equivalent to an maximum allowable toxicant concentration) reported for the New Zealand leptophlebiid *Deleatidium* sp. [29]. Our 96-h LC50 for *N. triangulifer* (179 mg N-NO_3/L) would place this species fifth in sensitivity among the invertebrate data previously compiled [30]. Our lowest chronic value is similar but nominally less sensitive than the mean maximum allowable toxicant concentration (22 mg N-NO_3/L, calculated from NOEC and least observable effect concentration values) reported for the water flea *Ceriodaphnia dubia* [31], but it is substantially more sensitive than *Daphnia magna* (mean maximum allowable toxicant concentration = 507 mg N-NO_3/L [31]), and the apple snail *Pomacea paludosa* (mean 14-d EC50 = 560 mg N-NO_3/L) [32].

For each of our 3 full-life chronic toxicity tests, we evaluated 7 endpoints: 2 involving survival to pre-emergent nymph stage, 1 involving development time, 1 involving adult emergence rates, and 3 involving adult weight or fecundity. Based on average relative acute-to-chronic ratio (Table 6), the most sensitive endpoints in our tests were those involved with survival, emergence, and development time. This suggests that exposure to sublethal concentrations of these sodium salts in the field may not affect somatic growth or fecundity directly, but could have phenological effects that may indirectly impact population growth. The weight and number of eggs per female endpoints were not sensitive in any of our 3 tests; however, others, using different testing scenarios, have found growth and biomass endpoints to be sensitive ([12,15,18]; J. Jackson, Stroud Water Research Center, Avondale, PA, USA, unpublished data). As stated previously, this disparity can in part be attributed to differences in when tests are ended, for example, based on our development time results (number of days to pre-emergent nymph stage), had we ended our tests at day 14 as in Struewing et al. [15], we likely would have seen differences among treatments in organism weights. Furthermore, we believe that even in a test conducted according to the method in our present study, weight and fecundity endpoints should be evaluated because chemicals with different modes of action than those tested in the present study may cause different types of effects.

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In our chloride chronic test, nearly all mortality occurred by day 7, whereas in the nitrate chronic, mortality in the highest concentration occurred early in the test (beginning on day 2), but in the second highest concentration, no mortality occurred until pre-emergent nymph stages were appearing in other treatments (day 20; Figure 3). A similar pattern was observed in the sodium sulfate chronic. This suggests that the most sensitive life stage may be dependent on the contaminant, but it also supports the findings of others [19,33], who in field and laboratory studies exposing *N. triangulifer* to metals found that metamorphosis to the imago was a highly sensitive life-stage.

Based on our starvation test, acceptable control survival (≥90%) appears to not be possible in an unfed 48-h or 96-h acute toxicity test conducted at 25 °C. Similar results were reported for this species by Struewing et al. [15], who had 11% survival after 48-h in USEPA moderately hard reconstituted water with no food, and by the Stroud Water Research Center (J. Jackson, Stroud Water Research Center, Avondale, PA, USA, unpublished data), who in 4 of 5 waters tested had approximately 10% survival or less after 48 h. The ASTM International [4] method for conducting acute toxicity tests states that organisms should not be fed during acute toxicity tests, although it makes an exception for mysid shrimp, which are severely stressed if not fed. In the present study, the nature of the chemicals tested is such that the presence of food would not be expected to alter bioavailability of the contaminants, but the need to feed *N. triangulifer* in acute tests will be a factor to consider in tests with other contaminant types. Poteat and Buchwalter [34] contend that in the case of metals in particular, dietary uptake is a more ecologically valid measurement for aquatic insects than dissolved exposures, but in general, water quality criteria development still uses data from waterborne exposures, so this is an issue that may require some flexibility.

We compared the relationship between pre-egg-laying weight and the number of eggs produced per female in the present study with that reported in Weaver et al. [14], and although our fecundity numbers were consistently lower than those predicted by their equation (Figure 4), the slopes of the lines were quite similar whether we used only control data (Figure 4A) or both control and exposure data (Figure 4B). If we use our data to predict a minimum adult weight at which 1000 eggs or more would be produced in the same manner as that described in Weaver et al. [14], we obtain values of 2.95 mg for control-only data, and 2.72 for control plus exposure data. These numbers bracket the previously reported value of 2.8 mg [14]. In other words, using our "controls only" equation to predict number of eggs based on a weight of 2.0 mg results in a value that is 80% of the result using the Weaver et al. [14] equation, and at a weight of 3.8 mg (just above our maximum), our equation produced a number of eggs value that was 94% of that using the Weaver et al. [14] equation. These slight differences may be attributable to acclimation to different waters or different sources of within-laboratory error, but the overall similarity of these relationships obtained using similar methods of producing laboratory-cultured food indicates good potential for standardization.

In the process of adapting the Weaver et al. [14] method and developing our own full-life chronic toxicity method, a few of the lessons we learned are as follows. First, for culturing, we have obtained best results when seeding stocks and cages for diatom slides with fresh diatom stocks that have never been refrigerated. Second, further work should be done to specifically characterize ion and nutrient concentrations required for diatom slide and diatom stock media. We currently use dechlorinated

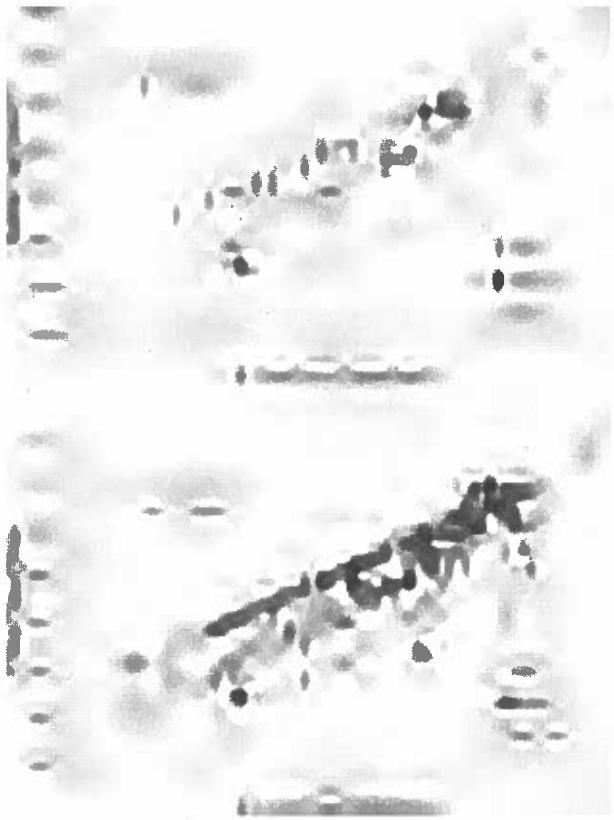


Figure 4. Relationship between pre–egg-laying wet weight of *Neocloeon triangulifer* and number of eggs produced in (A) controls only and (B) all treatments of 3 chronic toxicity tests. Asterisks are number of eggs/female predicted by the equation from Weaver et al. [1] based on our mayfly weights. Dashed lines show 95% confidence intervals for the solid line described by the equation in each panel.

tap water with an added nutrient and trace metal solution to culture diatom stocks and slides. Although we have analyzed tap water samples for ionic composition, this is likely variable over time because of the nature of municipal water supplies. One of the most variable aspects of the current method remains the quality of diatom slides, and better knowledge of specific ion requirements for diatoms will help to reduce this variability. Third, our results suggest that mayflies require live biofilms for robust development to adulthood. In numerous attempts, feeding concentrated mixed diatom suspensions that have been refrigerated did not result in development to pre-emergent nymph stage. Fourth, before feeding live biofilms to mayflies, a sample of the biofilm slide must be examined under a compound microscope to ensure that most of the cells are intact, and that the biofilm is not made up of amorphous material. Color of the biofilm does not appear to be a good predictor of food quality. Finally, having a higher percentage of emergence in controls during chronic toxicity tests would be desirable. One current thought is that because the lowest nitrate concentration had 90% emergence during that test, perhaps the addition of a low concentration of nitrate to culture medium and test dilution water would improve the food quality and therefore increase the rate of emergence.

Mayflies have received much attention recently because of their apparent sensitivity to mining influences in Appalachian headwater streams, with declines attributed to elevated conductivity, a surrogate measure of major ion concentrations of total dissolved solids [35–38]. Until recently, a disconnect

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has been perceived between what major ion concentrations are toxic to organisms in the laboratory versus what concentrations cause impairment to endemic benthic macroinvertebrate communities. Although no laboratory exposure system can completely replicate exposure scenarios experienced by organisms in situ, our observation of effects at various life-stages and documentation of potential phenological impacts brings some environmental relevance in addition to the fact that this is an organism that better represents benthic macroinvertebrate communities than standard crustacean models. We believe that the continued use of this sensitive mayfly species in laboratory studies will help to close this gap in understanding.

SUPPLEMENTAL DATA

Table S1. (15 KB DOC).

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Data availability—Contact David Soucek at soucek@illinois.edu for available data.

REFERENCES

1. Merritt RW, Cummins KW, Berg MB, Holzenthal RW, Prather AL, Marshall MA. 2008. *Introduction to the Aquatic Insects of North America*. 4th ed. Kendall Hunt Publishing, Dubuque, IA, USA.
2. Echols BS, Currie RJ, Cherry DS. 2010. Preliminary results of laboratory toxicity tests with the mayfly, *Isonychia bicolor* (Ephemeroptera: Isonychiidae) for development as a standard test organism for evaluating streams in the Appalachian coalfields of Virginia and West Virginia. *Environ Monit Assess* 169:487–500.
3. Echols BS, Currie RJ, Cherry DS, Voshell JR. 2013. Seasonal availability and sensitivity of two field-collected mayflies for the development of a standardized toxicity test. *Environ Monit Assess* 185:1341–1353.
4. ASTM International. 2014. Standard guide for conducting acute toxicity testing on test materials with fishes, macroinvertebrates, and amphibians. ASTM E729-96. ASTM International, West Conshohocken, PA, USA.
5. Sweeney BW, Vannote RL. 1984. Influence of food quality and temperature on life history characteristics of the parthenogenic mayfly, *Cloeon triangulifer*. *Freshwater Biol* 14:621–630.
6. McDunnough J. 1931. New species of North American Ephemeroptera. *Can Entomol* 63:82–93.
7. McCafferty W, Waltz R. 1990. Revisionary synopsis of the Baetidae (Ephemeroptera) of North and Middle America. *Trans Am Entomol Soc (Phi)* 116:769–799.
8. Jacobus LM, Wiersema NA. 2014. The genera *Anafroptilum* Kluge, 2011 and *Neocloeon* Traver, 1932, reinstated status, in North America, with remarks about global composition of *Centroptilum* Eaton, 1869 (Ephemeroptera: Baetidae). *Zootaxa* 3814:385–391.
9. Sweeney BW, Funk DH, Standley LJ. 1993. Use of the stream mayfly *Cloeon triangulifer* as a bioassay organism: Life history response and body burden following exposure to technical chlordane. *Environ Toxicol Chem* 12:115–125.
10. Conley JM, Funk DH, Buchwalter DB. 2009. Selenium bioaccumulation and maternal transfer in the mayfly *Centroptilum triangulifer* in a life-cycle, periphyton-biofilm trophic assay. *Environ Sci Technol* 43:7952–7957.
11. Conley JM, Funk DH, Cariello NJ, Buchwalter DB. 2011. Food rationing affects dietary selenium bioaccumulation and life cycle performance in the mayfly *Centroptilum triangulifer*. *Ecotoxicology* 20:1840–1851.
12. Kunz JL, Conley JM, Buchwalter DB, Norberg-King TJ, Kemble NE, Wang N, Ingersoll CG. 2013. Use of reconstituted waters to evaluate effects of elevated major ions associated with mountaintop coal mining on freshwater invertebrates. *Environ Toxicol Chem* 32:2826–2835.
13. Xie L, Funk DH, Buchwalter DB. 2010. Trophic transfer of Cd from natural periphyton to the grazing mayfly *Centroptilum triangulifer* in a life cycle test. *Environ Pollut* 158:272–277.
14. Weaver PC, Lazorchak JM, Struewing KA, DeCelles SJ, Funk DH, Buchwalter DB, Johnson BR. 2014. Part 1: Laboratory culture of *Centroptilum triangulifer* (Ephemeroptera: Baetiae) using a defined diet of three diatoms. *Chemosphere*, In press, DOI: 10.1016/j.chemosphere.2014.04.092.
15. Struewing KA, Lazorchak JM, Weaver PC, Johnson BR, Funk DH, Buchwalter DB. Part 2: Sensitivity comparisons of the mayfly *Centroptilum triangulifer* to *Ceriodaphnia* dubia and *Daphnia magna* using standard reference toxicants; NaCl, KCL and $CuSO_4$. *Chemosphere*, In press. DOI: 10.1016/j.chemosphere.2014.04.096.
16. Hassell KL, Kefford BJ, Nugegoda D. 2006. Sub-lethal and chronic salinity tolerances of three freshwater insects: *Cloeon* sp. and *Centroptilum* sp. (Ephemeroptera: Baetidae) and *Chironomus* sp. (Diptera: Chironomidae). *J Exp Biol* 209:4024–4032.
17. Conley JM, Funk DH, Hesterberg DH, Hsu LC, Kan J, Liu YT, Buchwalter DB. 2013. Bioconcentration and biotransformation of selenite versus selenite exposed periphyton and subsequent toxicity to the mayfly *Centroptilum triangulifer*. *Environ Sci Technol* 47:7965–7973.
18. Johnson BR, Weaver PC, Nietch CT, Lazorchak JM, Struewing KA, Funk DH. 2015. Elevated major ion concentrations inhibit larval mayfly growth and development. *Environ Toxicol Chem* 34:167–172.
19. Wesner JS, Kraus JM, Schmidt TS, Walters DM, Clements WH. 2014. Metamorphosis enhances the effects of metal exposure on the mayfly, *Centroptilum triangulifer*. *Environ Sci Technol* 48:10415–10422.
20. Stephan CE, Mount DI, Hansen DJ, Gentile JH, Chapman GA, Brungs WH. 1985. Guidelines for deriving numerical national water quality criteria for the protection of aquatic organisms and their uses. PB85–227049, Office of Water, Washington, DC.
21. Hamilton MA, Russo RC, Thurston RV. 1977. Trimmed Spearman-Karber method for estimating lethal concentrations in toxicity bioassays. *Environ Sci Technol* 1:714–719.
22. American Public Health Association, American Water Works Association and Water Environment Federation. 2005. Standard Methods for the Examination of Water and Wastewater, 21st ed. American Public Health Association, Washington, DC.
23. ASTM International. 2013. Standard guide for conducting three-brood, renewal toxicity tests with *Ceriodaphnia dubia*. ASTM E1295-01. ASTM International, West Conshohocken, PA, USA.
24. Diamond JM, Winchester EL, Mackler DG, Gruber D. 1992. Use of the mayfly *Stenonema modestum* (Heptageniidae) in subacute toxicity assessments. *Environ Toxicol Chem* 11:415–425.
25. Goetsch PA, Palmer CG. 1997. Salinity tolerances of selected macroinvertebrates of the Sabie River, Kruger National Park, South Africa. *Arch Environ Contam Toxicol* 32:32–41.
26. Soucek DJ, Kennedy AJ. 2005. Effects of hardness, chloride, and acclimation on the acute toxicity of sulfate to freshwater invertebrates. *Environ Toxicol Chem* 24:1204–1210.
27. Soucek DJ. 2007. Comparison of hardness- and chloride-regulated acute effects of sodium sulfate on two freshwater crustaceans. *Environ Toxicol Chem* 26:773–779.
28. Kennedy AJ, Cherry DS, Currie RJ. 2004. Evaluation of ecologically relevant bioassays for a lotic system impacted by a coal-mine effluent, using Isonychia. *Environ Monit Assess* 95:37–55.
29. Hickey CW. 2013. Site-specific nitrate guidelines for Hawke's Bay. NIWA Client Report No: HAM2012-127. National Institute of Water and Atmospheric Research, Newmarket, Auckland, New Zealand.
30. Soucek DJ, Dickinson A. 2012. Acute toxicity of nitrate and nitrite to sensitive freshwater insects, mollusks, and a crustacean. *Arch Environ Contam Toxicol* 62:233–242.
31. Scott G, Crunkilton RL. 2000. Acute and chronic toxicity of nitrate to fathead minnows (*Pimephales promelas*), *Ceriodaphnia dubia*, and *Daphnia magna*. *Environ Toxicol Chem* 19:2918–2922.
32. Corrao NM, Darby PC, Pomory CM. 2006. Nitrate impacts on the Florida apple snail, *Pomacea paludosa*. *Hydrobiologia* 568:135–143.
33. Schmidt TS, Kraus JM, Walters DM, Wanty RB. 2013. Emergence flux declines disproportionately to larval density along a stream metals gradient. *Environ Sci Technol* 47:8784–8792.

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34. Poteat MD, Buchwalter DB. 2014. Four reasons why traditional metal toxicity testing with aquatic insects is irrelevant. *Environ Sci Technol* 48:887–888.
35. Pond GJ. 2010. Patterns of Ephemeroptera taxa loss in Appalachian headwater streams (Kentucky, USA). *Hydrobiologia* 641:185–201.
36. Pond GJ, Passmore ME, Borsuk FA, Reynolds L, Rose CJ. 2008. Downstream effects of mountaintop coal mining: Comparing biological conditions using family- and genus-level macroinvertebrate bioassessment tools. *J N Am Benthol Soc* 27:717–737.
37. Timpano AJ, Schoenholtz SH, Soucek DJ, Zipper CE. 2015. Salinity as a limiting factor for biological condition in mining-influenced Central Appalachian headwater streams. *J Am Water Resour Assoc* 51:240–250.
38. U.S. Environmental Protection Agency (USEPA). 2011. A field-based aquatic life benchmark for conductivity in central Appalachian streams. EPA600-R-10-023F. National Center for Environmental Assessment, Office of Research and Development, Washington, DC.

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Influence of Dilution Water Ionic Composition on Acute Major Ion Toxicity to the Mayfly *Neocloeon triangulifer*

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Abstract: Field and laboratory studies have shown that mayflies (Ephemeroptera) tend to be relatively sensitive to elevated major ion concentrations, but little is known about how ionic composition influences these responses. The present study evaluated the acute toxicity of major ion salts to the mayfly *Neocloeon triangulifer* over a range of background water quality conditions. The mayfly was particularly sensitive to Na_2SO_4, with the median lethal concentration (LC50) of 1338 mg SO_4/L being lower than LC50s reported for 7 other species at that hardness. Increasing hardness of the dilution water from 30 to 150 mg/L (as $CaCO_3$) resulted in doubling of LC50s for sodium salts, and an approximately 1.5-fold increase in LC50 for $MgSO_4$. Potassium salt toxicity was not strongly influenced by hardness, consistent with findings for other species. When hardness was held constant but the Ca to Mg ratio was manipulated, the ameliorative effect on Na_2SO_4 and NaCl did not appear as strong as when hardness was varied; but for $MgSO_4$ the amelioration relative to Ca activity was similar between the 2 experiments. The toxicity of K salts to *N. triangulifer* was similar to Na salts on a millimolar basis, which contrasts with several other species for which K salts have been much more toxic. In addition, the toxicity of KCl to *N. triangulifer* was not notably affected by Na concentration, as has been shown for *Ceriodaphnia dubia*. Finally, plotting LC50s in terms of ion activity (Cl, SO_4, Na, Mg, or K) over the range of Ca activities in dilution water resulted in significant positive relationships, with comparable slopes to those previously observed for *C. dubia* over the same range of Ca activities. *Environ Toxicol Chem* 2018;37:1330–1339. © 2018 SETAC

Keywords: *Neocloeon triangulifer*; Mayfly; Acute toxicity; Major ion; Salinity

INTRODUCTION

The environmental impacts of elevated concentrations of major ions (i.e., Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, and HCO_3^-) have received considerable research attention in the 2 decades since it was recognized that major ion toxicity varies widely depending on the composition of the solution (Mount et al. 1997). The primary sources of elevated major ions in freshwaters were reviewed by Goodfellow et al. (2000), but much of the recent North American literature has focused on issues related to road salting and mining (Corsi et al. 2010; Palmer et al. 2010), with toxicity testing primarily focused on sodium chloride or sodium sulfate tested with standard test organisms, especially crustaceans (Soucek and Kennedy 2005; Davies and Hall 2007; Soucek 2007; Lasier and Hardin 2010; Elphick et al. 2011a, 2011b; Soucek et al. 2011; Mount et al. 2016; Wang et al. 2016).

A number of field studies have shown that mayflies (Ephemeroptera) appear to be more sensitive than other benthic macroinvertebrate taxa to elevated major ion concentrations in streams impacted by mining (Pond et al. 2008; Pond 2010; Cormier et al. 2013; Timpano et al. 2015; Boehme et al. 2016), and several recent laboratory studies have generated chronic toxicity data confirming this sensitivity (Kennedy et al. 2004; Hassell et al. 2006; Kunz et al. 2013; Johnson et al. 2015; Soucek and Dickinson 2015; Struewing et al. 2015; J. Jackson, Stroud Water Research Center, Avondale, PA, USA, personal communication). Until relatively recently, difficulties with culturing have precluded the use of mayflies as laboratory toxicity testing organisms to any great extent; however, researchers at Stroud Water Research Center developed a method for testing a parthenogenetic species (*Neocloeon triangulifer*) that readily reproduces under laboratory conditions (Sweeney et al. 1993). Furthermore, recent efforts to develop laboratory cultured diets and chronic toxicity testing methods for mayflies have been successful and will help us move toward standardization of methods for this species (Soucek and Dickinson 2015; Struewing et al. 2015; Weaver et al. 2015). In acute (96-h) exposures

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reported by Soucek and Dickinson (2015), sodium chloride median lethal concentrations (LC50s) for *N. triangulifer* were approximately equal to those reported for the cladoceran *Ceriodaphnia dubia* (Mount et al. 1997), but sodium sulfate LC50s were approximately half those for *C. dubia*. In a full-life chronic toxicity test, the percentage of emergence (the most sensitive endpoint in that test) 20% effect concentration for *N. triangulifer* exposed to sodium sulfate (Soucek and Dickinson 2015) was 15 to 23% of the lowest values reported for other invertebrates including *C. dubia*, *Lampsilis abrupta*, and *Chironomus dilutus* (Wang et al. 2016). The most sensitive chronic response level of *N. triangulifer* to sodium chloride (Soucek and Dickinson 2015) was 36 to 39% of those of *C. dubia* and *Daphnia magna* (Elphick et al. 2011a) and similar to the response of the chloride-sensitive mussel *Lampsilis siliquoidea* (Wang et al. 2015).

The fact that major ion toxicity to standard laboratory test organisms like cladocerans, amphipods, and fish is dependent on the ionic composition of a water or effluent has been well established; for example, several studies have shown that the toxicity of sodium sulfate and sodium chloride decrease with increasing water hardness (Mount et al. 1997, 2016; Soucek and Kennedy 2005; Davies and Hall 2007; Soucek 2007; Elphick et al. 2011a, 2011b; Soucek et al. 2011) and, more specifically, increasing Ca concentration (Davies and Hall 2007; Mount et al. 2016). It is also known that for crustaceans and fish, solutions tend to be more toxic when dominated by particular major ions; *C. dubia* is more sensitive to solutions dominated by K^+, Mg^+, and HCO_3^- than those dominated by Na^+, Cl^-, and SO_4^{2-} (Mount et al. 1997, 2016). Furthermore, recent work has shown that sodium concentration regulates the toxicity of potassium salts to *C. dubia* (Mount et al. 2016). Very little is known about how ionic composition influences responses of *N. triangulifer* to elevated major ions, although Kunz et al. (2013) observed differences in chronic responses of this species to Na^+ and SO_4^{2-} dominated solutions compared to Ca^{2+}, Mg^{2+}, SO_4^{2-}, and HCO_3^- dominated solutions; and Stroud Water Research Center (J. Jackson, personal communication) noted differences in 48-h NaCl LC50s in 2 dilution waters with different hardnesses. Zalizniak et al. (2006) investigated the influence of ionic composition on salinity toxicity to the related Australian mayfly *Centroptilum* sp., but test concentrations were not sufficiently low to have confidence in LC50s. Because *N. triangulifer* appears to be more sensitive to some major ions than other laboratory cultured test organisms, greater knowledge of the influence of dilution water composition on major ion toxicity will be important to refining our ability to evaluate potential risks to aquatic communities.

Although most field studies (e.g., Pond et al. 2008; Cormier et al. 2013; Boehme et al. 2016) and some laboratory or mesocosm studies (Kefford et al. 2003; Hassell et al. 2006; Kunz et al. 2013; Johnson et al. 2015; Clements and Kotalik 2016) report responses to elevated major ions in terms of electrical conductivity, endpoints for major ion laboratory toxicity tests are most frequently reported in terms of anion concentrations (e.g., Soucek and Kennedy 2005; Davies and Hall 2007; Soucek 2007; Lasier and Hardin 2010; Elphick et al. 2011a, 2011b; Soucek et al. 2011; Wang et al. 2016). The focus on anions may be attributable in part to the finding of Mount et al. (1997) that Na and Ca were not significant factors in regressions used to model ion toxicity; however, more recent studies by Erickson et al. (2016) suggested that K, Mg, and Ca salt toxicities to *C. dubia* are related to the cations and that Na salt toxicity may be related to multiple ions or osmolarity (i.e., not necessarily the associated anion). These findings with *C. dubia* indicate the need to reexamine drivers of acute effects attributable to various major ion salts. In the present study, we report acute toxicity of various major ion salts in terms of both anion and cation concentrations, but a subsequent article will be devoted to more explicitly evaluating likely causes of toxicity to this species in major ion salt toxicity tests.

The primary goal of the present study was to determine how changes in ionic composition of dilution water impact responses of *N. triangulifer* to elevated major ions over a range of background water quality conditions. Building on the work of Mount et al. (2016) with *C. dubia*, we investigated how changes in hardness and, more specifically, changes in Ca impact acute toxicity of several major ion salts. We also tested the reciprocal influences of Na on KCl toxicity and K on NaCl toxicity.

METHODS

Culturing of test organisms and food

The parthenogenetic mayfly *N. triangulifer* (family Baetidae; McDunnough 1931) was originally described as *Cloeon triangulifer*, later transferred to the genus *Centroptilum* (McCafferty and Waltz 1990), and most recently assigned to *Neocloeon* (Jacobus and Wiersema 2014). The genetic strain we used was Stroud Water Research Center Clone #WCC-2™. It is reared in the laboratory on a diatom diet, and mayfly and diatom biofilm diet culturing methods were similar to those reported in Soucek and Dickinson (2015). Diatoms used to feed mayflies included *Mayamaea* sp., and *Nitzschia* sp. Both diatoms were obtained from Carolina Biological Supply, sold as *Navicula* sp. and *Synedra* sp., respectively. We had the genus-level identities taxonomically confirmed by an expert (S. Decelles) at the US Environmental Protection Agency (USEPA), Office of Research and Development (Cincinnati, OH).

Mixed diatom stocks. To culture diatoms, we autoclaved (30 min at 121 °C, liquid cycle) a 4-L flask containing 4 L of filtered (Whatman™ 934-AH) dechlorinated tap water and a 2-inch long Teflon®-coated stir bar. After allowing to cool, a sterile technique was used to add 1.3 mL of Kent®–Proculture Professional F/2 Algal culture formula A, 1.3 mL of Kent®–Proculture Professional F/2 Algal culture formula B, 150 mg of sodium metasilicate ($Na_2SiO_3 \times 9H_2O$), and 200 mL of fresh diatom stock solution (just removed from the stir plate). Both diatom species were present in combination in stock cultures. The flasks were placed on stir plates with moderate to fast stirring (a large vortex was visible) in an environmental chamber set for a 16:8-h light:dark photoperiod and 25 °C. Light intensity in the chamber varied between 800 and 1200 lux depending on position in the chamber. Diatom

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stocks were allowed to grow for 5 d, then 200 mL of stock was used to seed the next flask and cages for mixed diatom slides (see *Mixed diatom slides* section). Allowing growth for much more than 5 d appeared to cause depletion of nutrients and cell death. Stocks were not refrigerated prior to seeding subsequent flasks or mixed diatom slide cages.

Mixed diatom slides. To culture mixed diatom slides, 15 fully frosted microscope slides (catalog no. 12-544-5CY, Fisher Scientific) were placed in a single layer (with frosted side facing up) on the bottom of a 7.2-L (189 × 297 × 128 mm) autoclavable polysulfone mouse cage (no. PC7115HT, Allentown, Inc., Allentown, PA) filled with 2.5 L of filtered (Whatman 934-AH) dechlorinated (carbon-filtered and aged) tap water. The container with the slides was autoclaved (30 min at 121 °C, liquid cycle) and allowed to cool. A sterile technique was used to add 1.3 mL of Kent–Proculture Professional F/2 Algal culture formula A, 1.3 mL of Kent–Proculture Professional F/2 Algal culture formula B, 150 mg of sodium metasilicate ($Na_2SiO_3 \times 9$ H_2O; dissolved in a small amount of deionized water prior to addition), and 200 mL of fresh (never refrigerated) mixed diatom stock. The container with slides was covered with clear plastic wrap and placed in an environmental chamber set for a 16:8-h light: dark photoperiod and 25 °C. Light intensity at the level of the slides varied between 300 and 100 lux, depending on position in the chamber. Growth was allowed for 6 to 10 d. Soucek and Dickinson (2015) provided further details on assessing biofilm quality prior to feeding to mayflies.

Mayfly nymph rearing method. Mayflies were reared in an environmental chamber at 25 °C, a 16:8-h light: dark photoperiod, and light intensity of approximately 200 lux. Culture water was a reconstituted water (hereafter referred to as Duluth 100) with a nominal hardness of 100 mg/L as $CaCO_3$, prepared according to a formula developed at the USEPA laboratory in Duluth, Minnesota (Supplemental Data, Tables S1 and S2). This water recipe was designed with the goal of better mimicking the chemistry of "typical" North American freshwaters relative to other commonly used reconstituted waters. When eggs hatched, approximately 250 mL of culture water were added to a 300-mL clear glass jar. All water was filtered using Whatman #934-AH glass microfiber filters. One mixed diatom slide was added to the jar. Newly hatched mayfly larvae (hundreds to thousands) were then added to the jar, the lid was loosely replaced, and the jar was covered with aluminum foil to block direct overhead lighting. When mayflies were 4 to 8 d old (usually 6 or 7 d), 40 individuals were placed in a 1-L glass beaker containing 400 mL Duluth 100 reconstituted water and fed as described for the 300-mL glass jar. The diatom slide was placed in the beaker prior to adding mayflies, to avoid injury. Again, the container was covered with aluminum foil to block direct overhead lighting. When mayflies were 11 to 12 d old, 20 individuals were transferred to a 19 × 24 × 6.5–cm Pyrex casserole dish containing 1.5 L of Duluth 100 water and 5 mixed diatom slides. Slides were replaced when diatom biofilms were depleted, and water was changed twice per week or more if water appeared to be littered with loose diatoms and waste products. The container was covered loosely with foil. Using this method, aeration was not necessary at any point during mayfly culturing.

When preemergent nymph stages (determined by the presence of black wing pads) appeared (days 20–23), they were placed in a 300-mL I-chem jar containing culture water and a mixed diatom slide. A screened cover was placed on the jar to allow for emergence of subimagoes and molting to imago stage (within 24 h after preemergent nymph stage). To induce the imago to release its eggs, we held it by the wings with forceps and touched its abdomen to water held in a small Petri dish. This procedure was conducted with the aid of a dissecting microscope. Eggs were then pipetted into a scintillation vial; when possible, eggs of 3 females were combined in each vial. Eggs were either allowed to hatch or placed in an environmental chamber at 10 °C for later use.

General acute toxicity testing procedures

Static, nonrenewal, acute toxicity tests were conducted according to guidelines detailed in ASTM International (2014). Five concentrations spaced by 50% dilution were tested in addition to controls, with the highest test concentration made by adding the salt of interest to the dilution water of interest. Further details on test conditions are provided in Supplemental Data, Table S3. Eggs were transferred to test water prior to hatching so that organisms hatched into the water in which they would be tested, and organisms were <24 h old at the beginning of a test. Test chambers were fed by grasping a mixed diatom slide (cultured as described in the section *Mixed diatom slides*) with a forceps, scraping off an area of biofilm of approximately 5 to 10 × 25 mm with another clean microscope slide, and releasing the biofilm into each replicate test chamber. Test organisms were fed because in a previous study first-instar mayflies had 22% survival after 48 h with no food (Soucek and Dickinson 2015). This has been observed by others as well (Struewing et al. 2015; J. Jackson, Stroud Water Research Center, personal communication). Because all tests were conducted with major ions, food was not expected to impact dissolved concentrations of the contaminants, and analytical chemistry confirmed this (detailed in the *Quality assurance/quality control* section). Food was added to test chambers only on day 0 because previous testing demonstrated that one biofilm scraping was more than enough for the 96-h test duration. Mortality was assessed daily using a dissecting microscope. Individuals were considered dead if they did not respond to gentle prodding with a probe.

Temperature, pH, conductivity, and dissolved oxygen were measured in all treatments at the beginning and the end of each exposure period. Alkalinity and hardness were measured in the controls and the highest test treatment at the beginning of the test only. The pH measurements were made using an Accumet® (Fisher Scientific) model AB15 pH meter equipped with an Accumet gel-filled combination electrode (accuracy <±0.05 pH at 25 °C). Dissolved oxygen was measured using an air-calibrated Yellow Springs Instruments model 55 meter. Conductivity measurements were made using a Mettler Toledo® (Fisher Scientific) model MC226 conductivity/total dissolved

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solids meter. Alkalinity and hardness were measured by titration as described by the American Public Health Association (2005). Water samples from each treatment were collected at the beginning and end of tests and submitted to the Illinois State Water Survey analytical laboratory for verification of selected major ion concentrations using ion chromatography.

Experimental approach and dilution waters

We developed a testing approach that covered 3 basic objectives, which are detailed in this section. Recipes for and detailed chemistry of the 9 different dilution waters used are provided in Supplemental Data, Tables S1 and S2. Reagent-grade or certified American Chemical Society–grade salts were used to make all test waters. Solutions enriched with $MgSO_4$ were prepared using $MgSO_4 \times 7H_2O$ or $MgSO_4$ (anhydrous) but are reported as $MgSO_4$.

Hardness comparisons. The first set of tests determined the toxicity NaCl, Na_2SO_4, K_2SO_4, and $MgSO_4$ in dilution waters representing different hardnesses. Waters with nominal hardnesses of 30, 90, 150, and 210 mg/L (as $CaCO_3$) were prepared using recipes developed at the USEPA laboratory in Duluth, Minnesota, which varied all major ions to approximate average concentrations in US surface waters of a given hardness (Supplemental Data, Tables S1 and S2). These test waters differed from culture water (Duluth 100) in that $CaCO_3$ was the main source of carbonate rather than $NaHCO_3$. Carbon dioxide gas (99.9% CO_2) was bubbled through the solution (to pH ~5.2) to dissolve $CaCO_3$, then natural air was bubbled through the solution to bring the pH back to approximately 7.6 for testing.

Ca to Mg comparisons. While hardness tests evaluated the aggregate effect of varying all ions in dilution water, additional tests varying Ca to Mg ratios at constant hardness were used to evaluate the specific role of calcium. Toxicity of NaCl, Na_2SO_4, K_2SO_4, and $MgSO_4$ were tested in waters similar to Duluth 100 water but modified to "low Ca to Mg" (0.5 ratio on a mass basis) and "high Ca to Mg" (5.0 mass ratio) compositions with all other ions held constant (Supplemental Data, Tables S1 and S2). The "Ca to Mg" terminology is in reference to the original dilution water, so in the case of the Mg salt, the Ca to Mg ratio was in reality different from treatment to treatment because of the added Mg. From a practical perspective it was primarily Ca in the dilution water that was being altered.

Na/K interactions. The reciprocal influences of Na on KCl toxicity and K on NaCl toxicity were tested by comparing responses in Duluth 100 water (which served as a low-Na or low-K water) to responses in Duluth 100 water with high Na (150.3 mg Na/L added as NaCl) or high K (15.0 mg K/L added as KCl; see Supplemental Data, Table S2). These comparisons were spurred by the finding of Na-dependent toxicity of KCl in *C. dubia* (Mount et al. 2016) and K-dependent toxicity of Na_2SO_4 in fathead minnows (Wang et al. 2016).

Data analysis

For each acute toxicity test, the dominant anion concentrations were analytically verified in each treatment as described in the *General acute toxicity testing procedures* section. We calculated LC50s for each test in terms of measured dominant anion concentration (milligrams per liter) using the trimmed Spearman-Karber method (Hamilton et al. 1977). Then, based on measured anion concentration, calculated concentration of the associated cation (milligrams per liter), and nominal concentrations of other ions in the dilution water, we estimated all major ion concentrations (millimoles) at the LC50 value for each test (Table 1; Supplemental Data, Table S4). We then used Visual MINTEQ, Ver 3.0 (JP Gustafsson, Royal Institute of Technology, Department of Land and Water Resources Engineering, Stockholm, Sweden) to calculate the activity of all potential ionic species at the LC50 concentration for each test (Supplemental Data, Table S5). For activity modeling, we input fixed pH values based on the average measured pH for each test. Calcium was the most frequently manipulated major ion in dilution waters in the present study, and previous studies with *C. dubia* indicated that Ca influenced toxicity of Na and Mg salts (Mount et al. 2016). Therefore, to evaluate the influence of Ca on major ion toxicity, we created scatter plots with LC50s in terms of Cl, SO_4, Na, Mg, or K activities as dependent variables and Ca activity as the independent variable. For each dependent variable ion, we included all salts tested, for example, for SO_4 LC50s, we included K_2SO4, $MgSO_4$, and Na_2SO_4. We also plotted K salt LC50s against Na activity as the independent variable because Na regulated K salt toxicity to *C. dubia* (Mount et al. 2016).

Quality assurance/quality control

Control survival was 100% in the majority of the acute toxicity tests reported and always ≥90%.

Across all acute toxicity tests conducted, the mean (± standard deviation) overall temperature, pH, and dissolved oxygen values were 25.0 ± 0.4 °C, 8.2 ± 0.3 standard units, and 7.7 ± 1.3 mg/L, respectively. The lowest dissolved oxygen concentration observed in any test was 6.4 mg/L. Specific conductivity, alkalinity, and hardness varied depending on dilution water and test treatment but were consistent with the nominal composition of the treatment.

For the acute toxicity tests with chloride salts, measured Cl^- concentrations averaged 104% of nominal (range, 92–118%). For the acute toxicity tests with sulfate salts, measured SO_4^{2-} concentrations averaged 103% of nominal (range 87–124%). Measured concentrations were used for calculating LC50s, and reported cation concentrations were calculated proportionally based on measured concentrations of anions.

RESULTS AND DISCUSSION

Hardness comparisons

When tested across dilution waters with different hardness, NaCl, Na_2SO_4, and $MgSO_4$ all decreased in toxicity with increasing hardness, though to varying degrees (Table 1 and Figure 1). For

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TABLE 1: Median lethal concentrations at 96 h for *Neocloeon triangulifer* for single major ion salts in various dilution waters

Salt	Dilution water	Measured hardness (mg/L as $CaCO_3$)	LC50 (95% CI) (mg anion/L)	LC50[a] (mg cation/L)
Hardness comparisons				
NaCl	Recon 30	30	490 (424–566)	319
NaCl	Recon 90	88	837 (706–993)	545
NaCl	Recon 150	141	1128 (1059–1201)	735
NaCl	Recon 210	205	1116 (929–1341)	732
Na_2SO_4	Recon 30	31	728 (614–863)	349
Na_2SO_4	Recon 90	88	1338 (1166–1535)	639
Na_2SO_4	Recon 150	142	1758 (1511–2045)	837
Na_2SO_4	Recon 210	210	1822 (1583–2098)	865
K_2SO_4	Recon 30	30	1017 (887–1166)	821
K_2SO_4	Recon 90	87	1070 (918–1248)	854
K_2SO_4	Recon 150	141	1024 (857–1224)	803
K_2SO_4	Recon 210	205	1808 (1580–2069)	1418
K_2SO_4	Recon 210	212	1261 (1107–1437)	973
$MgSO_4$	Recon 30	28	1348 (1231–1478)	341
$MgSO_4$	Recon 90	86	1621 (unreliable)	411
$MgSO_4$	Recon 150	140	2112 (1814–2460)	536
$MgSO_4$	Recon 210	212	1836 (1571–2145)	463
Ca:Mg comparisons				
NaCl	Low Ca:Mg	95	905 (728–1125)	603
NaCl	High Ca:Mg	93	1086 (913–1293)	721
Na_2SO_4	Low Ca:Mg	94	1229 (1022–1477)	595
Na_2SO_4	High Ca:Mg	93	1427 (1211–1682)	689
K_2SO_4	Low Ca:Mg	95	1017 (789–1312)	785
K_2SO_4	High Ca:Mg	93	1164 (1062–1275)	904
$MgSO_4$	Low Ca:Mg	95	872 (758–1002)	224
$MgSO_4$	High Ca:Mg	94	1436 (1152–1790)	355
Na/K interactions				
KCl	Low Na (Duluth 100)	93	1226 (1043–1441)	1326
KCl	High Na	92	1221 (984–1516)	1123
NaCl	Low K (Duluth 100)	92	910 (719–1153)	606
NaCl	Low K (Duluth 100)	94	1153 (968–1374)	764
NaCl	High K	91	1012 (834–1228)	666

[a]Dilution water composition was considered in estimating cation concentration at LC50.
CI = confidence interval; LC50 = median lethal concentration.

both NaCl and Na_2SO_4, the LC50 more than doubled as hardness increased from approximately 30 to 150 mg/L (nominal hardnesses), whereas for $MgSO_4$ the increase was approximately 1.5-fold. Despite this rise, all 3 of these salts showed little difference in toxicity between 150 and 210 mg/L hardness. For K_2SO_4, the pattern was markedly different, with little difference among the 30, 90, and 150 mg/L waters. For the 210 hardness water, the initial test resulted in an LC50 of 1808 mg Cl/L, roughly 1.8 times above that in the lower 3 hardnesses. Because this pattern was unexpected, the test at 210 mg/L hardness was repeated, yielding an LC50 of 1261 mg Cl/L, much closer to the lower 3 (Table 1). Therefore, it is unclear whether K_2SO_4 toxicity is hardness-dependent, but it appears to be less so than the other 3 salts.

Hardness-dependent toxicities of NaCl and Na_2SO_4 have been reported for several other species previously. For NaCl, *C. dubia* (Soucek et al. 2011; Mount et al 2016), the snail *Gyraulus parvus* (Soucek et al. 2011), the unionid mussel *L. siliquoidea* (Gillis 2011), and the worm *Tubifex tubifex* (Soucek et al. 2011) have been observed to exhibit hardness-dependent acute sensitivity. In addition, Stroud Water Research Center (J. Jackson, personal communication) documented decreased NaCl toxicity to the mayflies *N. triangulifer*, *Procloeon rivulare*, and *Pseudocloeon frondale* in 48-h toxicity tests using a natural water with a hardness of 105 mg/L relative to a natural water with a hardness of 22 mg/L. Likewise for Na_2SO_4, hardness-dependent sensitivity has been observed for *C. dubia* (Soucek and Kennedy 2005; Mount et al. 2016), *D. magna* (Davies and Hall 2007), and *Hyalella azteca* (Davies and Hall 2007; Soucek 2007).

Ca to Mg comparisons

In the dilution waters used for hardness comparisons, all of the major ions increased with increasing hardness, not just Ca and Mg (Supplemental Data, Table S2). This was done purposefully to examine trends in waters that simulate how toxicity might vary in natural waters for which concentrations of all major ions generally covary with increasing hardness. Research on other organisms has suggested that the ameliorative effect of hardness is largely attributable to increased Ca specifically (Davies and Hall 2007; Mount et al. 2016); to evaluate this relationship for *N. triangulifer*, we tested the toxicity of the same 4 salts (NaCl, Na_2SO_4, K_2SO_4, and $MgSO_4$) in dilution waters with constant nominal hardness but different Ca to Mg ratios. Both waters had measured hardnesses of 93 to 95, but the low Ca to Mg ratio water had a Ca concentration similar to that in

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FIGURE 1: Influence of Ca in dilution water on the acute toxicity of (A) NaCl, (B) Na_2SO_4, (C) K_2SO_4, and (D) $MgSO_4$ to the mayfly *Neocloeon triangulifer*. "All ions manipulation" are data from the "hardness comparisons" series of tests in the present study; Ca concentrations of 8, 25, 41, and 58 mg/L were waters with 30, 90, 150, and 210 mg/L as $CaCO_3$ nominal hardness, respectively. Error bars are 95% confidence limits. CL = confidence limits; LC50 = median lethal concentration.

the Recon 30 water (nominally 9.3 mg Ca/L), whereas Ca in the high Ca to Mg ratio water was more than 3 times higher (30.3 mg Ca/L), slightly higher than that in Recon 90 (Supplemental Data, Table S2). If the variations in LC50s in the "hardness comparisons" series were attributable only to Ca, we would expect shifts in LC50 from the Ca to Mg manipulation paralleling those in the hardness comparison studies.

In the case of the 2 sodium salts, the actual differences in LC50 from low Ca to Mg ratio to high Ca to Mg ratio were less than predicted by the "hardness comparison" tests (Table 1 and Figure 1). The fact that their LC50s increased less when manipulating only Ca to Mg rather than all ions suggests either that something aside from or in addition to calcium accounted for the decreased toxicity in the "hardness comparisons" series or that the higher overall ion concentrations in the low Ca to Mg water relative to 30 hardness water provided some benefit (Supplemental Data, Table S2). Conversely, the $MgSO_4$ results showed a similar increase in LC50 when only calcium was increased and when all ions increased proportionally as in the hardness comparison (Table 1 and Figure 1); this suggests that calcium accounted for most or all of the modification of toxicity attributable to hardness. The K_2SO_4 results were consistent with the previous tests in the hardness series, showing little, if any, effect of Ca or hardness on toxicity over the range present in the lower 3 hardness waters (Table 1 and Figure 1). The hardness/Ca dependence of toxicity for Na and Mg salts but not K salts, shown in the present study for *N. triangulifer*, is consistent with the findings of Mount et al. (2016) for *C. dubia*.

Na/K interactions

In the Na/K interactions series, we observed essentially no effect on KCl toxicity when Na varied from 34 mg/L (low Na = Duluth 100; Supplemental Data, Table S2) to 150 mg/L (high Na; Supplemental Data, Table S1 and S2), with 96-h LC50s of 1226 and 1221 mg Cl/L, respectively (Table 1). Likewise, the mean LC50 for the 2 NaCl tests conducted at low K (3.9 mg/L) was 1032 mg Cl/L, whereas the LC50 at high K (15 mg/L) was 1012 mg Cl/L (Table 1). The lack of influence of Na on the toxicity of KCl contrasts with the marked ameliorative effect of Na on KCl toxicity reported for *C. dubia* (Mount et al. 2016), whereas the lack of influence of K on toxicity of NaCl is parallel with that found for *C. dubia*.

Ion activities

For all of the tests in the present study, we calculated LC50s and dilution water compositions in terms of activity (millimoles; Supplemental Data, Table S5) to account for the fact that, in more concentrated solutions, ions behave as though their concentrations are lower than their total concentrations (Snoeyink and Jenkins 1980). The importance of considering activity in expressing exposure to major ion salts was further affirmed in analyses for *C. dubia* (Mount et al. 2016). Determining specific causes of toxicity (e.g., anions, cations, osmolarity) in major ion salt tests was beyond the scope of the present study, but Erickson et al. (2016) suggested that the toxicities of K, Mg, and Ca to *C. dubia* appear to be attributable

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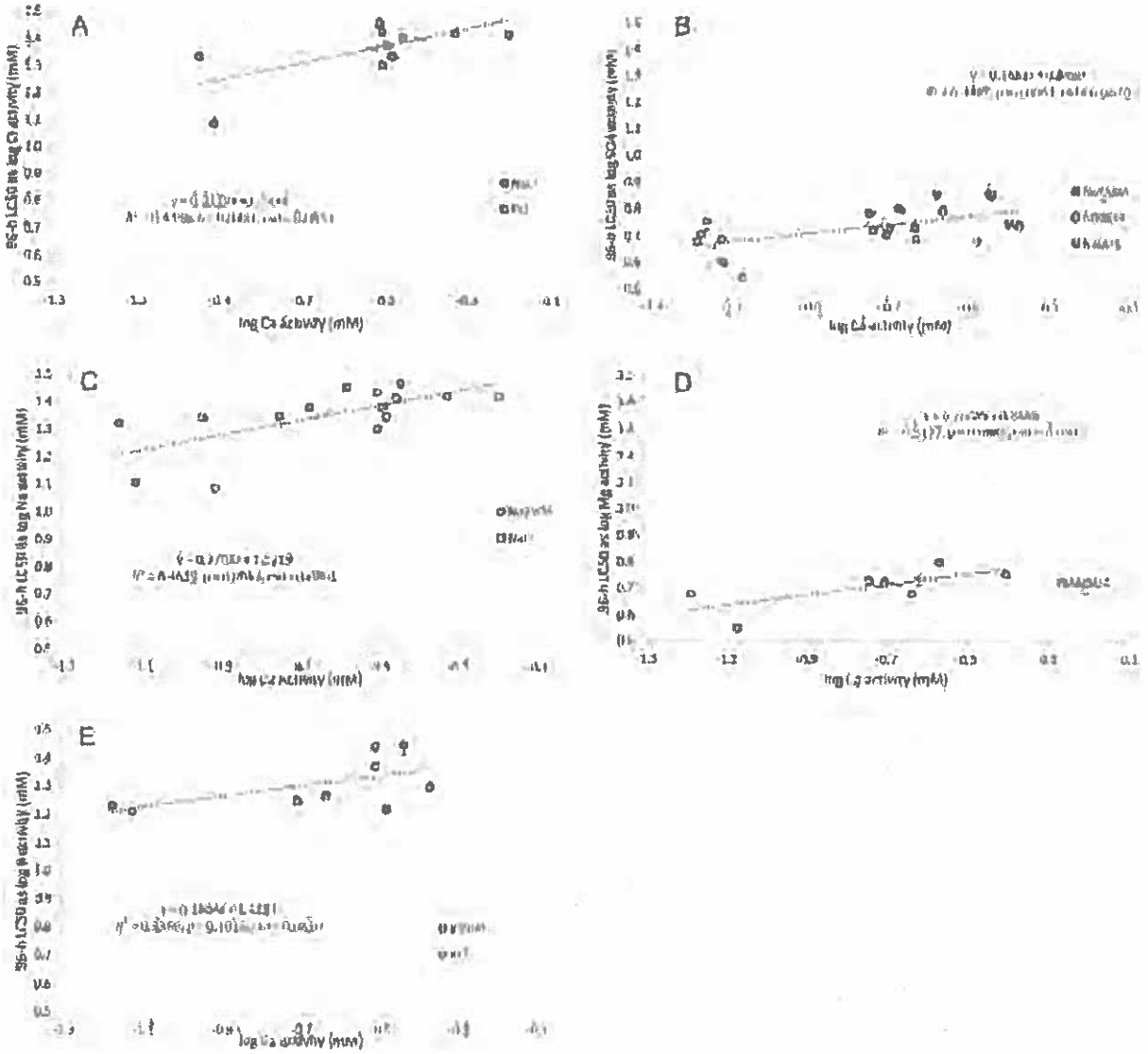


FIGURE 2: Influence of Ca activity on 96-h median lethal concentrations of various major ion salts for the mayfly *Neocloeon triangulifer* expressed as logs of (A) chloride activity, (B) sulfate activity, (C) sodium activity, (D) magnesium activity, and (E) potassium activity. LC50 = median lethal concentration; rsd = residual standard deviation.

to the cations rather than anions and that Na salt toxicity may be related to multiple ions or osmolarity (i.e., not necessarily the associated anion). We report toxicity data for the mayfly in terms of both anion and cation activities plotted against Ca activity because Ca was the most frequently manipulated major ion in dilution waters and was shown to be a primary influence on toxicity of Na and Mg salts to *C. dubia* (Mount et al. 2016).

As shown in Figure 2, the 96-h LC50s for Cl, SO_4, and Na were significantly positively correlated with Ca activity in the dilution water, whereas correlations for Mg and K with Ca were insignificant ($p > 0.05$). Although not statistically different from zero because of the inclusion of fewer tests, the slope for the Mg data was similar to those of the other ions and greater than the significantly positive slope for SO_4, which included more than double the number of tests. The chloride plot had the steepest slope, followed closely by Na. Mount et al. (2016) reported on the influence of Ca on Na salt toxicity (as Na activity) for *C. dubia* (Figure 3), but that study tested waters with substantially lower Ca concentrations than the present study did (as low as 0.04 mM compared to our lowest value of 0.2 mM). Much of the steepness in the curve in the *C. dubia* study (Mount et al. 2016) was below 0.2 mM Ca. Over the comparable range of Ca activities, the responses of the 2 organisms are similar; and if we had tested *N. triangulifer* in waters with even lower Ca concentrations, we might have observed a similarly stronger Ca dependence of Na toxicity. It is notable that in the case of the *C. dubia* data (Mount et al. 2016; Figure 3), there is distinct separation on the *y* axis between NaCl and Na_2SO_4; this was not observed for the mayfly.

Although the Ca slope for Mg activity was not statistically separable from zero, the Mg data for mayfly are generally consistent with the Ca slope found for *C. dubia* (Mount et al. 2016); and, as for the Na salts, the strongest effect of Ca on Mg salt toxicity

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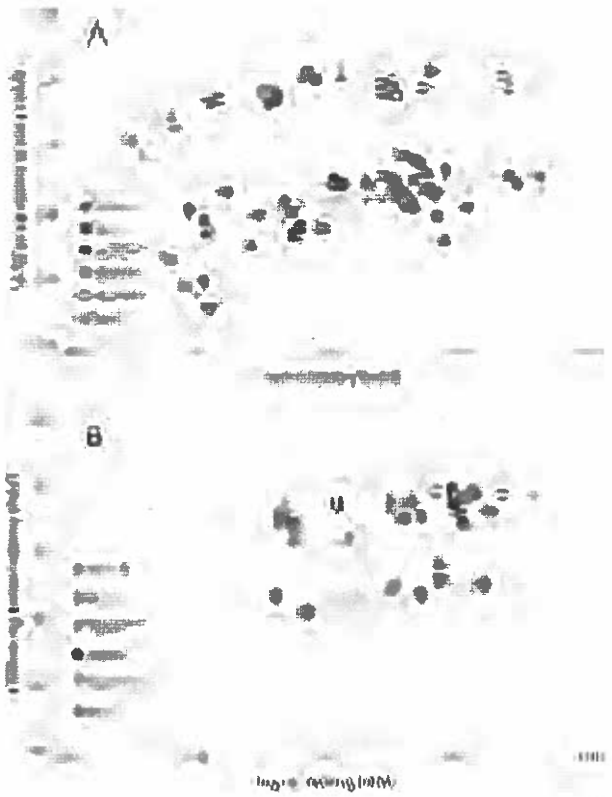


FIGURE 3: Influence of Ca activity on acute median lethal concentrations (LC50s) of various major ion salts for the (A) *Ceriodaphnia dubia* (from Mount et al. 2016) and (B) the mayfly *Neocloeon triangulifer*. All LC50s expressed in terms of cation activity for the given salt. Trendlines in (A) are linear fits for *C. dubia* data over the range of Ca activities tested with *Neocloeon*. The longer dashed yellow line fits Na_2SO_4 data, whereas the finer dotted line fits NaCl data. The same *C. dubia* trendlines are then superimposed with the *Neocloeon* data in (B).

for *C. dubia* occurred at Ca activities lower than those tested in the present study for mayfly (Figure 3). Another interesting trend apparent in Figure 3 is that the toxicities of Na and K are quite similar for *N. triangulifer* with Mg being substantially more toxic. This contrasts sharply with data for *C. dubia* and fathead minnows, for which K and Mg salts were substantially more toxic than Na salts (Mount et al. 1997, 2016). Unpublished data from C. Ivey et al. (2013, poster presented at Society of Environmental Toxicology and Chemistry) indicate an even greater disparity between Na and K toxicity to freshwater mussels, with KCl being on the order of 50-fold more toxic than NaCl on a millimolar basis.

Figure 4 in addition plots K salt LC50s against Na activity in dilution water for comparison with the finding of Mount et al. (2016) that Na regulates K salt toxicity to *C. dubia*. There is little slope evident in the data for the mayfly, further confirming our conclusion that in the case of this species Na appears to have little influence on K salt toxicity.

Sensitivity of N. triangulifer *relative to other organisms*

For the sodium salts, the range of LC50s we observed for *N. triangulifer* indicate that it is acutely sensitive relative to other

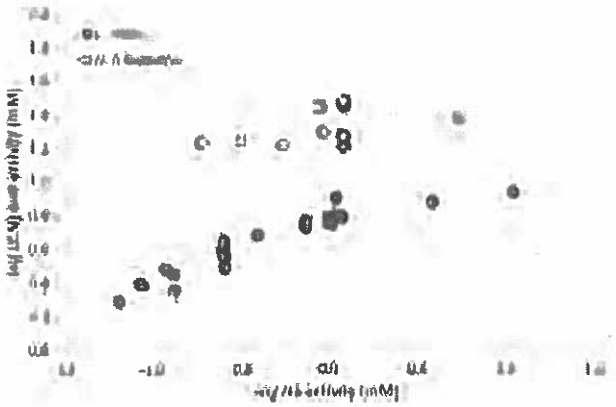


FIGURE 4: Potassium salt median lethal concentrations for the mayfly *Neocloeon triangulifer* and the cladoceran *Ceriodaphnia dubia* (from Mount et al. 2016) as a function of Na activity in dilution water. LC50 = median lethal concentration.

species. The acute toxicity of NaCl in waters of 80 to 100 mg/L hardness has been reported for many aquatic species. The chloride LC50 for *N. triangulifer* (837 mg Cl/L at nominal hardness of 90; Table 1) in the present study is lower than values for 11 other species tested in this hardness range including cladocerans (*C. dubia*, *Daphnia ambigua*, *D. magna*; Mount et al. 1997; Harmon et al. 2003; Elphicket al. 2011a; Soucek et al. 2011), a mussel (*L. siliquoidea*; Gillis 2011), a rotifer (*Brachionus calyciflorus*; Elphick et al. 2011a), an amphipod (*H. Azteca*; Elphick et al 2011a; Soucek et al. 2013), 2 worms (*Lumbriculus variegatus* and *Tubifex tubifex*; Elphick et al. 2011a; Soucek et al. 2011), an insect (*C. dilutes*; Elphick et al. 2011a), and 2 fish (*Pimephales promelas* and *Oncorhynchus mykiss*; Mount et al. 1997; Elphick et al. 2011a). Notably, the mayfly was more sensitive than *C. dubia*, for which there are a number of published LC50s in this hardness range (average LC50 ~1138 mg Cl/L; Mount et al. 1997, 2016; Harmon et al. 2003; Elphick et al. 2011a; Soucek et al. 2011). Struewing et al. (2015) and Stroud Water Research Center (J. Jackson, personal communication) have reported NaCl LC50s for *N. triangulifer* previously, but those tests were 48 h in duration compared to the 96-h tests in the present study, so comparisons of effect levels with our data are tenuous. In the present study, 48-h LC50s were consistently approximately double the corresponding 96-h LC50s (data not shown). The first molt for the organism occurs within this time frame and might account for the sharp difference in 48- and 96-h LC50s (D.J. Soucek, personal observation). The glochidia of 3 mussel species (*Lampsilis fasciola*, *Epioblasma torulosa*, and *Lampsilis cardium*) have been found to be more sensitive than *N. triangulifer* (LC50s ranging 179–817 mg Cl/L; Gillis 2011).

For Na_2SO_4, the LC50 for *N. triangulifer* at hardness 90 mg/L in the present study (1338 mg SO_4/L; Table 1) was lower than values for the 7 other species for which we found data at that approximate hardness: *H. azteca*, *Sphaerium simile*, *D. magna*, *P. promelas*, *C. dilutus*, *L. abrupta*, and *C. dubia* (Mount et al. 1997, 2016; Soucek and Kennedy 2005; Davies and Hall 2007; Soucek 2007; Wang et al. 2016). Reported LC50s for these species ranged from 1874 to 14 134 mg/L. Goetsch and Palmer (1997) generated an LC50 of 500 mg SO_4/L for the mayfly *Tricorythus* sp.

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at a lower hardness (~69 mg/L), confirming the sensitivity of mayflies to Na_2SO_4. There is a published data point at a similar hardness for *H. azteca* of 512 mg SO_4/L (Soucek and Kennedy 2005), but the dilution water for that toxicity test had a chloride concentration lower than that considered sufficient for optimal health for that species (Soucek et al. 2015). Thus, in general, *N. triangulifer* appears to be relatively sensitive to sodium salts, especially sodium sulfate. There have been several studies published on the chronic responses of *N. triangulifer* to NaCl and Na_2SO_4 in a range of dilution waters, and these were reviewed by Soucek and Dickinson (2015).

Compared with the sodium salts, far fewer published data are available on the acute toxicity of Mg and K salts to other species (Mount et al. 1997, 2016; Van Dam et al. 2010). The Mg salt toxicity data for *C. dubia*, *D. magna*, and *P. promelas* reported by Mount et al. (1997), with LC50s ranging from 224 to 569 mg Mg/L, are similar to those reported in the present study for the mayfly at a similar hardness (224–411 mg Mg/L at hardness ~90 mg/L; Table 1). Conversely, *N. triangulifer* was substantially less sensitive to K than the 3 species tested by Mount et al. (1997), the former having LC50s ranging from 785 to 1326 mg K/L at hardness ~90 mg/L (Table 1) and the latter having LC50s of <305 to 462 mg K/L. Van Dam et al. (2010) tested the responses of a variety of Australian freshwater species from an area with background water containing extremely low Ca to $MgSO_4$, with most having median effect concentrations between 4.4 and 63 mg Mg/L (the exception being *Chlorella* at 1215 mg Mg/L). The lower values from that study are approximately an order of magnitude lower than those reported in the present study (Table 1), but the dilution water in the Van Dam et al. (2010) study had very low Ca (<0.8 mg/L), which could account for the difference given the effect of Ca on Mg toxicity observed in the present study.

CONCLUSIONS

In summary, the mayfly was in general relatively sensitive to NaCl, $MgSO_4$, and especially Na_2SO_4 compared with other species reported in the literature but relatively less so to K salts. Sodium and magnesium salt toxicity decreased with increased hardness, whereas the K salt toxicity did not, consistent with findings for other species. However, in Ca to Mg manipulations, it is not clear whether Ca activity alone can account for all of the "hardness" effect. Over the range of Ca activity tested for the mayfly, the slopes of the Ca effect on toxicity of Na and Mg salts to mayfly were similar to those reported elsewhere for *C. dubia*, though it is unclear whether the steeper slopes reported for *C. dubia* and lower Ca activities would also occur for *N. triangulifer*. Two other key differences between these 2 species were 1) that K salt toxicity to *N. triangulifer* was not modified by Na in dilution water, and 2) that K toxicity to mayflies was very similar to Na toxicity on a millimolar basis, instead of the much greater toxicity of K observed for *C. dubia*.

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Data availability—Data are available from the corresponding author (soucek@illinois.edu).

REFERENCES

American Public Health Association, American Water Works Association and Water Environment Federation. 2005. *Standard Methods for the Examination of Water and Wastewater*, 21st ed. Washington DC.

ASTM International. 2014. Standard guide for conducting acute toxicity testing on test materials with fishes, macroinvertebrates, and amphibians. E729-96. In *Annual Book of ASTM Standards*, Vol 11.06. Philadelphia, PA, USA.

Boehme EA, Zipper CE, Schoenholtz SH, Soucek DJ, Timpano AJ. 2016. Temporal dynamics of benthic macroinvertebrate communities and their response to elevated specific conductance in Appalachian coalfield headwater streams. *Ecological Indicators* 64:171–180.

Clements WH, Kotalik C. 2016. Effects of major ions on natural benthic communities: An experimental assessment of the US Environmental Protection Agency aquatic life benchmark for conductivity. *Freshw Sci* 35:126–138.

Cormier SM, Suter GW, Zheng L. 2013. Derivation of a benchmark for freshwater ionic strength. *Environ Toxicol Chem* 32:263–271.

Corsi SR, Graczyk DJ, Geis SW, Booth NL, Richards KD. 2010. A fresh look at road salt: Aquatic toxicity and water-quality impacts on local, regional, and national scales. *Environ Sci Technol* 44:7376–7382.

Davies TD, Hall KJ. 2007. Importance of calcium in modifying the acute toxicity of sodium sulphate to *Hyalella azteca* and *Daphnia magna*. *Environ Toxicol Chem* 26:1243–1247.

Elphick JR, Bergh KD, Bailey HC. 2011a. Chronic toxicity of chloride to freshwater species: Effects of hardness and implications for water quality guidelines. *Environ Toxicol Chem* 30:239–246.

Elphick JR, Davies M, Gilron G, Canaria EC, Lo B, Bailey HC. 2011b. An aquatic toxicological evaluation of sulfate: The case for considering hardness as a modifying factor in setting water quality guidelines. *Environ Toxicol Chem* 30:247–253.

Erickson RJ, Mount DR, Highland TL, Hockett JR, Hoff DJ, Jenson CT, Norberg-King TJ, Peterson KN. 2016. The acute toxicity of major ion salts to *Ceriodaphnia dubia*. II. Empirical relationships in binary salt mixtures. *Environ Toxicol Chem* 36:1525–1537.

Gillis PL. 2011. Assessing the toxicity of sodium chloride to the glochidia of freshwater mussels: Implications for salinization of surface waters. *Environ Pollut* 159:1702–1708.

Goetsch PA, Palmer CG. 1997. Salinity tolerances of selected macroinvertebrates of the Sabie River, Kruger National Park, South Africa. *Arch Environ Con Tox* 32:32–41.

Goodfellow WL, Ausley LW, Burton DT, Denton DL, Dorn PB, Grothe DR, Heber MA, Norberg-King TJ, Rodgers JH Jr. 2000. Major ion toxicity in effluents: A review with permitting recommendations. *Environ Toxicol Chem* 19:175–182.

Hamilton MA, Russo RC, Thurston RV. 1977. Trimmed Spearman-Karber method for estimating lethal concentrations in toxicity bioassays. *Environ Sci Technol* 1:714–719.

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Harmon SM, Specht WL, Chandler GT. 2003. A comparison of the daphnids *Ceriodaphnia dubia* and *Daphnia ambigua* for the utilization in routine toxicity testing in the southeastern United States. *Arch Environ Con Tox* 45:79–85.

Hassell KL, Kefford BJ, Nugegoda D. 2006. Sub-lethal and chronic salinity tolerances of three freshwater insects: *Cloeon* sp. and *Centroptilum* sp. (Ephemeroptera: Baetidae) and *Chironomus* sp. (Diptera: Chironomidae). *J Exp Biol* 209:4024–4032.

Ivey CD, Consbrock RA, Kunz JL, Ingersoll CG, Wang N, Hammer C, Bauer CR, Auspurger T, Raimondo S, Barnhart C, Brumbaugh BG. 2013. Sensitivity of freshwater mussels at 2 life stages to acute or chronic effects of sodium chloride or potassium chloride. *Poster*, Society of Environmental Toxicology and Chemistry North America 34th Annual Meeting: Harmonizing Science Across Disciplines. Nashville, TN, USA, 17–21 November 2013, p 172.

Jacobus LM, Wiersema NA. 2014. The genera Anafroptilum Kluge, 2011 and Neocloeon Traver, 1932, reinstated status, in North America, with remarks about global composition of Centroptilum Eaton, 1869 (Ephemeroptera:Baetidae). *Zootaxa* 3814:385–391.

Johnson BR, Weaver PC, Nietch CT, Lazorchak JM, Struewing KA, Funk DH. 2015. Elevated major ion concentrations inhibit larval mayfly growth and development. *Environ Toxicol Chem* 34:167–172.

Kennedy AJ, Cherry DS, Currie RJ. 2004. Evaluation of ecologically relevant bioassays for a lotic system impacted by a coal-mine effluent, using *Isonychia*. *Environ Monit Assess* 95:37–55.

Kefford BJ, Papas PJ, Nugegoda D. 2003. Relative salinity tolerance of macroinvertebrates from the Barwon River, Victoria, Australia. *Mar Freshw Res* 54:755–765.

Kunz JL, Conley JM, Buchwalter DB, Norberg-King TJ, Kemble NE, Wang N, Ingersoll CG. 2013. Use of reconstituted waters to evaluate effects of elevated major ions associated with mountaintop coal mining on freshwater invertebrates. *Environ Toxicol Chem* 32:2826–2835.

Lasier PJ, Hardin IR. 2010. Observed and predicted reproduction of *Ceriodaphnia dubia* exposed to chloride, sulfate and bicarbonate. *Environ Toxicol Chem* 29:347–358.

McCafferty W, Waltz R. 1990. Revisionary synopsis of the Baetidae (Ephemeroptera) of North and Middle America. *Transactions of the American Entomological Society* 116:769–799.

McDunnough J. 1931. New species of North American Ephemeroptera. *Canadian Entomologist* 63:82–93.

Mount DR, Gulley DD, Hockett JR, Garrison TD, Evans JM. 1997. Statistical models to predict the toxicity of major ions to *Ceriodaphnia dubia*, *Daphnia magna*, and *Pimephales promelas* (fathead minnows). *Environ Toxicol Chem* 16:2009–2019.

Mount DR, Erickson RJ, Highland TL, Hockett JR, Hoff DJ, Jenson CT, Norberg-King TJ, Peterson KN, Polaske ZM, Wisniewski S. 2016. The acute toxicity of major ion salts to *Ceriodaphnia dubia*: I. Influence of background water chemistry. *Environ Toxicol Chem* 35:3039–3057.

Palmer MA, Bernhardt ES, Schlesinger WH, Eshleman KN, Foufoula-Georgiou E, Hendryx MS, Lemly AD, Likens GE, Loucks OL, Power ME, White PS, Wilcock PR. 2010. Mountaintop mining consequences. *Science* 327:148–149.

Pond GJ. 2010. Patterns of Ephemeroptera taxa loss in Appalachian headwater streams (Kentucky, USA). *Hydrobiologia* 641:185–201.

Pond GJ, Passmore ME, Borsuk FA, Reynolds L, Rose CJ. 2008. Downstream effects of mountaintop coal mining: Comparing biological conditions using family- and genus-level macroinvertebrate bioassessment tools. *J N Am Benthol Soc* 27:717–737.

Snoeyink VL, Jenkins D. 1980. *Water Chemistry*. John Wiley & Sons, New York, NY, USA.

Soucek DJ. 2007. Comparison of hardness- and chloride-regulated acute effects of sodium sulfate on two freshwater crustaceans. *Environ Toxicol Chem* 26:773–779.

Soucek DJ, Dickinson A. 2015. Full-life chronic toxicity of sodium salts to the mayfly *Neocloeon triangulifer* in tests with laboratory cultured food. *Environ Toxicol Chem* 34:2126–2137.

Soucek DJ, Dickinson A, Major KM, McEwen AR. 2013. Effect of test duration and feeding on relative sensitivity of genetically distinct clades of *Hyalella azteca*. *Ecotoxicology* 22:1359–1366.

Soucek DJ, Kennedy AJ. 2005. Effects of hardness, chloride, and acclimation on the acute toxicity of sulfate to freshwater invertebrates. *Environ Toxicol Chem* 24:1204–1210.

Soucek DJ, Linton TK, Tarr CD, Dickinson A, Wickramanayake N, Delos CG, Cruz LA. 2011. Influence of water hardness and sulfate on the acute toxicity of chloride to sensitive freshwater invertebrates. *Environ Toxicol Chem* 30:930–938.

Soucek DJ, Mount DR, Dickinson A, Hockett JR, McEwen AR. 2015. Contrasting effects of chloride on growth, reproduction, and toxicant sensitivity in two genetically distinct strains of *Hyalella azteca*. *Environ Toxicol Chem* 34:2354–2362.

Struewing KA, Lazorchak JM, Weaver PC, Johnson BR, Funk DH, Buchwalter DB. 2015. Part 2: Sensitivity comparisons of the mayfly *Centroptilum triangulifer* to *Ceriodaphnia* dubia and *Daphnia magna* using standard reference toxicants; NaCl, KCL and $CuSO_4$. *Chemosphere* 139:597–603.

Sweeney BW, Funk DH, Standley LJ. 1993. Use of the stream mayfly *Cloeon triangulifer* as a bioassay organism: Life history response and body burden following exposure to technical chlordane. *Environ Toxicol Chem* 12:115–125.

Timpano AJ, Schoenholtz SH, Soucek DJ, Zipper CE. 2015. Salinity as a limiting factor for biological condition in mining-influenced central Appalachian headwater streams. *J Am Water Resour As* 51:240–250.

Van Dam RA, Hogan AC, McCullough CD, Houston MA, Humphrey CL, Harford AJ. 2010. Aquatic toxicity of magnesium sulfate, and the influence of calcium, in very low ionic concentration water. *Environ Toxicol Chem* 29:410–421.

Wang N, Kunz JL, Ingersoll CG. 2015. Chronic effects of sodium chloride on a freshwater mussel (fatmucket *Lampsilis siliquoidea*) in 4- and 12-week water-only exposures. *Poster*, Society of Environmental Toxicology and Chemistry North America 36th Annual Meeting: Buzzing with Science: Cross-Pollination for Environmental Progress, Salt Lake City, UT, USA, 1–5 November 2015.

Wang N, Dorman RA, Ingersoll CG, Hardesty DK, Brumbaugh WG, Hammer EJ, Bauer CR, Mount DR. 2016. Acute and chronic toxicity of sodium sulfate to four freshwater organisms in water-only exposures. *Environ Toxicol Chem* 35:115–127.

Wang N, Kunz JL, Ingersoll CG. 2015. Chronic effects of sodium chloride on a freshwater mussel (fatmucket *Lampsilis siliquoidea*) in 4- and 12-week water-only exposures. Poster, Society of Environmental Toxicology and Chemistry North America 36th Annual Meeting: Buzzing with Science: Cross-Pollination for Environmental Progress, Salt Lake City, UT, USA, 1–5 November 2015.

Weaver PC, Lazorchak JM, Struewing KA, DeCelles SJ, Funk DH, Buchwalter DB, Johnson BR. 2015. Part 1: Laboratory culture of *Centroptilum triangulifer* (Ephemeroptera:Baetiae) using a defined diet of three diatoms. *Chemosphere* 139:589–596.

Zalizniak L, Kefford B, Nugegoda D. 2006. Is all salinity the same? I. The effect of ionic compositions on the salinity tolerance of five species of freshwater invertebrates. *Mar Freshw Res* 57:75–82.

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Calculation of Aquatic Life Criteria for Chloride

These calculations are based on "Summary of Data Concerning the Acute Toxicity of Sodium Chloride to Aquatic Animals" dated 1-15-09 and "Summary of Data Concerning the Chronic Toxicity of Sodium Chloride to Aquatic Animals" dated 1-15-09. Except as noted (for example, see footnote a), these calculations are consistent with the 1985 Guidelines. GMAVs and SMAVs are normalized to hardness = 300 mg/L and sulfate = 65 mg/L. GMAVs and SMAVs are expressed as mg chloride/L.

Rank*	GMAV	Genus	Species	SMAV	SMACR
	-----	Agria	Damselfly, Agria sp.	-----	
23	17161	Anquilla	American eel, Anquilla rostrata	17160.6	
	16203	Cambarus	Crayfish, Cambarus sp.	16203.2	
	14897	Fundulus	Plains killifish, Fundulus kansae	14897.1	
	14843	Libellulidae**	Dragonfly, Libellulidae	14843.4	
	13453	Gasterosteus	Threespine stickleback, Gasterosteus aculeatus	13452.6	
	-----	Carassius	Goldfish, Carassius auratus	-----	
	9933	Gambusia	Mosquitofish,	9933.4	

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		Gambusia affinis		
9157	Lepomis	Green sunfish, Lepomis cyanellus	9974.9	
		Bluegill, Lepomis macrochirus	8406.5e	
8971	Notropis	Red shiner, Notropis lutrensis	8971.1	
8043	Oncorhynchus	Rainbow trout, Oncorhynchus mykiss	8042.6	7.308
-----	Chironomus	Midge, Chironomus attenuatus	-----	
7442	Ameiurus	Black bullhead, Ameiurus melas	7442.4	
----	Erpobdella	Leech, Erpobdella punctata	----	
6515	Pimephales	Fathead minnow, Pimephales promelas	6515.3f	15.17h
6219	Tubifex	Tubificid worm, Tubifex tubifex	6218.6	
5078	Hyalella	Amphipod, Hyalella azteca	5077.7	
-----	Asellus	Isopod,	-----	

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		Asellus communis	
-----	Limnodrilus	Tubificid worm, Limnodrilus hoffmeisteri	-----
-----	Helisoma	Snail, Helisoma campanulata	-----
4686	Pseudacris	Chorus frog, Pseudacris sp.	4686.0
-----	Gammarus	Amphipod, Gammarus pseudolimnaeus	-----
-----	Crangonyx	Amphipod, Crangonyx sp.	-----
-----	Nemoura	Stonefly, Nemoura trispinosa	-----
-----	Lepidostoma	Caddisfly, Lepidostoma sp.	-----
-----	Parapsyche	Caddisfly, Parapsyche sp.	-----
3946	Diaptomus	Copepod, Diaptomus clavipes	3946.1
3891	Lirceus	Isopod, Lirceus fontinalis	3890.7
3728	Gyraulus	Snail,	-----

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			Gyraulus circumstriatus		
			Snail, Gyraulus parvus	3727.7	
	3350	Physa	Snail, Physa gyrina	3350.0	
			Snail, Physa heterostropha	-----	
	3086	Villosa	Mussel, Villosa delumbis	3821.1	
			Mussel, Villosa iris	2491.6	
4	2835	Lampsilis	Mussel, Lampsilis fasciola	2907.1	
			Mussel, Lampsilis siliquoidea	2764.4	
3	2326	Daphnia	Cladoceran, Daphnia ambigua	1649.7	4.148
			Cladoceran, Daphnia magna	3773.1d	1.974
			Cladoceran, Daphnia pulex	2020.5g	3.952
2	1542	Ceriodaphnia	Cladoceran,	1542.3c	>2.470i

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			Ceriodaphnia dubia	
1	1128	Sphaerium	Fingernail clam, Sphaerium simile	1127.9
			Fingernail clam, Sphaerium tenue	-----

* A "greater than" acute value for the brown trout (Salmo trutta) is not in this table because it is too low to be a useful "greater than" value.
** Name of family, not name of genus.

a. Section IV.1 of the 1985 Guidelines says: "For each species for which at least one acute value is available, the Species Mean Acute Value should be calculated as the geometric mean of the results of all flow-through tests in which the concentrations of test material were measured. For a species for which no such result is available, the SMAV should be calculated as the geometric mean of all available acute values, i.e., results of flow-through tests in which the concentrations were not measured and results of static and renewal tests based on initial concentrations (nominal concentrations are acceptable for most test materials if measured concentrations are not available) of test material." The guidance presented in section IV.1 of the 1985 Guidelines seems inappropriate for chloride because chloride is different from most pollutants for which aquatic life criteria are derived. Chloride is very soluble in water, does not oxidize or reduce, is not volatile, does not degrade, does not sorb to test chambers, test organisms, food, or waste products, is not complexed by materials that commonly occur in water, is not involved in a pH-dependent equilibrium in water, and does not precipitate in waters in which aquatic organisms commonly occur.
   i. For chloride, as long as the concentration of dissolved oxygen is sufficiently high, it seems appropriate to give static and renewal acute tests the same weight as flow-through acute tests in the derivation of the SMAV for a species.
   ii. For chloride, it seems inappropriate to give measured acute tests a weight of 1 and unmeasured acute tests a weight of 0 when both are available for the derivation of the SMAV for a species. For example, if there is a choice between one measured acute test on chloride and three unmeasured acute tests in three different laboratories, the three tests are probably preferable to the one test, but if the choice is between one measured acute test and two unmeasured acute tests in two different laboratories, the one test is probably preferable. Thus, for a species for which both measured and unmeasured acute tests are available for chloride, it seems appropriate to give measured acute tests a weight of 2.5 and unmeasured acute tests a weight of 1 when the SMAV is calculated.

   The conclusions described above concerning chloride were developed during discussions among Charles Delos, Charles Stephan, and Glen Thursby. For other pollutants, different conclusions concerning the relative merits of static, renewal, and flow-through acute toxicity tests and the relative merits of measured and unmeasured acute toxicity tests are likely to be more appropriate.

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b. For Ceriodaphnia dubia, the acute values from Hoke et al. (1992) are considered outliers. The geometric mean is 1468.1 for Mount et al. (1997), 1790.2 for U.S. EPA (1991), 1998.2 for WISLOH (2007), and 1457.3 for GLEC and INHS (2008).
SMAV = antilog ([log 1468.1 + log 1790.2 + log 1998.2 + log 1863.6 + 2.5(log 1311.1) + 2.5(log 1457.3)]/9) = 1542.3.

c. For Daphnia magna, the values of 3815.5 (Mount et al. 1997), <2785.1, (Anderson 1946), 2439.7 (Anderson 1948), and 3025.9 and 3357.4 (Biesinger and Christensen 1972) were not used. A geometric mean of 3906.7 was calculated from the limits given by Seymour et al. (1997). The geometric mean is 3208.8 for Hoke et al. (1992) and is 4054.2 for Davies and Hall (2007). The SMAV is 3773.1, which is the geometric mean of 3208.8, 5068.2, 3906.7, 2242.3, 4749.6, 3968.5, and 4054.2.

d. Bluegill: SMAV = antilog ([2.5(log 7702.3) + log 10461.6]/3.5) = 8406.5.

e. Fathead minnow: SMAV = antilog([log 2833.9 + 2.5(log 8665.1) + 2.5(log 8225.2) + log 5112.0 + log 5226.3]/8) = 6515.3.

f. Daphnia pulex: SMAV = antilog([2.5(log 1938.8) + log 2240.3]/3.5) = 2020.5.

g. Not used in calculations because, even though the acute and chronic tests were in the same document, different dilution waters were used in the tests.

h. The SMACR for Ceriodaphnia dubia is the geometric mean of 1.508, >3.841, and 2.601.

FAV = 1205 mg chloride/L

CMC = FAV/2 = 602.5 mg chloride/L

The five SMACRs (7.308, 4.148, 1.974, 3.952, and >2.438) that are available for use in calculations result in three GMACRs:

7.308	Oncorhynchus
3.187	Daphnia
>2.470	Ceriodaphnia

The 1985 Guidelines require ACRs for species in three different families, but Daphnia and Ceriodaphnia are in the same family. However, even though the ACR for the fathead minnow should not be used in calculations because the acute and chronic tests using the fathead minnow were

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performed in different dilution waters, the fathead minnow ACR can be considered a qualitative ACR and used to satisfy the MDRs because chloride is not likely to be complexed or sorbed or detoxified by organic or inorganic constituents of the dilution water.

The GMACRs for Oncorhynchus and Daphnia are consistent with the "greater than" GMACR for Ceriodaphnia and the GMACRs are within a factor of ten. Therefore, the Final ACR = 4.826, which is the geometric mean of the GMARCs for Oncorhynchus and Daphnia. This would give FCV = FAV/FACR = (1205 mg chloride/L)/4.826 = 249.7 mg chloride/L. However, this approach is contraindicated because the GMACRs (including the unused GMACR for Pimephales) indicate that the GMACR increases as the GMAV increases.

The GMACR for Daphnia is consistent with the "greater than" GMACR for Ceriodaphnia, so the GMACR for Daphnia can be used as the FACR. Therefore, FACR = 3.187 and FCV = FAV/FACR = (1205 mg chloride/L)/3.187 = 378.1 mg chloride/L.

CCC = FCV = 378.1 mg chloride/L.

The CMC and CCC given above are for hardness = 300 mg/L and sulfate = 65 mg/L. The equation that was used to normalize the acute values can be used to make the CMC and CCC dependent on hardness and sulfate. The resulting equations for the CMC and CCC are:

$$CMC = (602.5 \text{ mg chloride/L})\,(\text{hardness}/300)^{0.205797}\,(\text{sulfate}/65)^{-0.07452}$$
$$= (254.3 \text{ mg chloride/L})\,(\text{hardness})^{0.205797}\,(\text{sulfate})^{-0.07452}$$

At hardness = 300 mg/L and sulfate = 65 mg/L, CMC = 602.5 mg chloride/L.

$$CCC = (378.1 \text{ mg chloride/L})\,(\text{hardness}/300)^{0.205797}\,(\text{sulfate}/65)^{-0.07452}$$
$$= (159.6 \text{ mg chloride/L})\,(\text{hardness})^{0.205797}\,(\text{sulfate})^{-0.07452}$$

At hardness = 300 mg/L and sulfate = 65 mg/L, CCC = 378.1 mg chloride/L.

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Derivation of an Alternative FCV

Even though the above derivation of FCV = 378.1 mg chloride /L follows the procedure described in the 1985 Guidelines, there is an alternative approach that is justified on the basis of the "good science" clause in section XII.B of the 1985 Guidelines. This approach is based on the fact that the four low SMACRs for chloride were obtained with invertebrates, whereas the high SMACR was obtained with a vertebrate. This can be interpreted to mean that vertebrates have a higher ACR, on the average, than invertebrates, especially because the qualitative ACR for the fathead minnow is 15.17. Therefore, a vertebrate ACR and an invertebrate ACR can be used with the GMAVs to calculate a predicted Genus Mean Chronic Value for each genus, and then a FCV can be calculated directly from the predicted GMCVs. This approach calculates and uses a predicted chronic value for each genus for which an acute value is available and probably does a better job of taking into account the chronic sensitivities of both vertebrates and invertebrates to chloride. The relevant data and calculations are presented on the next few pages.

The FACR of 3.187 derived above was derived from all of the acceptable ACRs for invertebrates. The only acceptable ACR for a vertebrate is 7.308. A predicted GMCV can be calculated from each GMAV by using 3.187 as the invertebrate ACR and using 7.308 as the vertebrate ACR.

Table of predicted GMCVs for Chloride

(GMAVs and pGMCVs are expressed as mg chloride/L)
(ranked according to predicted GMCVs)

Rank	GMAV	Genus	Species	pGMCV
	-----	Agria	Damselfly, Agria sp.	-----
23	16203	Cambarus	Crayfish, Cambarus sp.	5084
	14843	Libellulidae*	Dragonfly, Libellulidae	4657

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17161	Anquilla	American eel, Anquilla rostrata	2348
6219	Tubifex	Tubificid worm, Tubifex tubifex	1951
-----	Chironomus	Midge, Chironomus attenuatus	-----
-----	Erpobdella	Leech, Erpobdella punctata	-----
13453	Gasterosteus	Threespine stickleback, Gasterosteus aculeatus	1841
14897	Fundulus	Plains killifish, Fundulus kansae	2038
-----	Carassius	Goldfish, Carassius auratus	-----
5078	Hyalella	Amphipod, Hyalella azteca	1593
----	Asellus	Isopod, Asellus communis	-----
-----	Limnodrilus	Tubificid worm, Limnodrilus hoffmeisteri	-----
-----	Helisoma	Snail, Helisoma campanulata	-----

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8043	Oncorhynchus	Rainbow trout, Oncorhynchus mykiss	1101
9933	Gambusia	Mosquitofish, Gambusia affinis	1359
-----	Gammarus	Amphipod, Gammarus pseudolimnaeus	-----
-----	Crangonyx	Amphipod, Crangonyx sp.	-----
-----	Nemoura	Stonefly, Nemoura trispinosa	-----
-----	Lepidostoma	Caddisfly, Lepidostoma sp.	-----
-----	Parapsyche	Caddisfly, Parapsyche sp.	-----
3891	Lirceus	Isopod, Lirceus fontinalis	1221
9157	Lepomis	Green sunfish, Lepomis cyanellus	1253
		Bluegill, Lepomis macrochirus	
3350	Physa	Snail, Physa heterostropha	1051

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		Snail, Physa gyrina	
3946	Diaptomus	Copepod, Diaptomus clavipes	1238
3086	Villosa	Mussel, Villosa delumbis	968.3
		Mussel, Villosa iris	
8971	Notropis	Red shiner, Notropis lutrensis	1228
3728	Gyraulus	Snail, Gyraulus circumstriatus	1170
		Snail, Guraulus parvus	
2835	Lampsilis	Mussel, Lampsilis fasciola	889.6
		Mussel, Lampsilis siliquoidea	
7442	Ameiurus	Black bullhead, Ameiurus melas	1018
6515	Pimephales	Fathead minnow, Pimephales promelas	891.5

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4	2326	Daphnia	Cladoceran, Daphnia ambigua Cladoceran, Daphnia magna Cladoceran, Daphnia pulex	729.8
3	4686	Pseudacris	Chorus frog, Pseudacris sp.	641.2
2	1542	Ceriodaphnia	Cladoceran, Ceriodaphnia dubia	483.8
1	1128	Sphaerium	Fingernail clam, Sphaerium simile Fingernail clam, Sphaerium tenue	353.9

* Name of family, not name of genus.

FCV based on predicted GMCVs = 382.7 mg chloride/L at hardness = 300 mg/L and sulfate = 65 mg/L.

$CCC = (382.7 \text{ mg chloride/L}) (\text{hardness}/300)^{0.205797} (\text{sulfate}/65)^{-0.07452}$
$= (161.5 \text{ mg chloride/L}) (\text{hardness})^{0.205797} (\text{sulfate})^{-0.07452}$

At hardness = 300 mg/L and sulfate = 65 mg/L, CCC = 382.7 mg chloride/L.

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09JanChlorideCronic.wpd DRAFT 1-15-09
C. Stephan

Summary of Data concerning the Chronic Toxicity of Sodium Chloride to Aquatic Animals

This summary is based on "Results of Literature Search concerning the Toxicity of Chloride to Aquatic Animals" dated 1-15-09. Except as noted, this summary is consistent with the 1985 Guidelines. All test results are expressed as mg chloride/L.

Fathead minnow

Birge et al. (1985) reported the results of a 33-day early life-stage test on sodium chloride in a stream water. The NOEC and LOEC were 252 and 352 mg/L, respectively, and the geometric mean was 298 mg/L. Birge et al. (1985) reported a 96-hr LC50 of 6570 mg/L, which would give an ACR of 22.05. However, it is not clear how the NOEC and LOEC were selected and the acute and chronic tests were performed in different dilution waters. The reported LOEC of 352 mg/L reduced survival by 9% compared to the control, whereas 533 mg/L reduced survival by 15%; neither concentration caused a substantial reduction in growth. It seems more appropriate to set the NOEC and LOEC at 352 and 533 mg/L, respectively, which gives a geometric mean of 433.1 mg/L. The ACR would be 15.17, but the acute and chronic tests were performed in different waters.

Diamond et al. (1992), Pickering et al. (1996) and the Wisconsin State Laboratory of Health (WISLOH 2007) performed 7-day tests on sodium chloride using the fathead minnow. Diamond et al. (1992) reported that the average geometric mean of the NOEC and LOEC was 1597 mg/L, whereas Pickering et al. (1996) reported a geometric mean subchronic value of 3458 mg/L. WISLOH (2007) reported a mean IC25 of 1752 mg/L. All three of these results are substantially higher than the geometric mean of 433.1 mg/L from Birge et al. (1985), which is not surprising because Table A19 in Birge et al. (1985) shows substantial mortality occurring between day 9 and day 33 in most of the treatments. Diamond et al. (1992) and Pickering et al. (1996) did not perform acute tests and so an ACR cannot be calculated; WISLOH (2007) obtained a mean 96-hr LC50 of 4143 mg/L, which would give an ACR of 2.365; this is substantially lower than the ACR of 15.17 from Birge et al. (1985). Although the 7-day test with the fathead minnow is not approved for use in the derivation of aquatic life criteria in the 1985 Guidelines, it could be used as a surrogate for the early life-stage test on a toxicant-specific basis if data demonstrated that the two tests give similar results. For sodium chloride, however, the data clearly indicate that the 7-day test misses much of the adverse effect observed in the 33-day early life-stage test. Because the early life-stage test is used as a surrogate for the life-cycle test, the comparison that is of most interest is a comparison of the 7-day test with the life-cycle test.

Rainbow trout

Birge et al. (1980) reported results of an early life-stage test on magnesium chloride.

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Spehar (1986) reported the results of an 8-week exposure to NaCl that began with eggs. The highest tested concentration of 3,917 mg/L did not reduce egg hatchability, but killed all of the early juvenile fish. The next highest concentration of 1,924 mg/L did not reduce survival, but did reduce growth. Spehar (1987) reported the results of an early life-stage test on NaCl. The highest tested concentration of 2,740 mg/L killed 100%, 1,324 mg/L killed 46%, and 643 mg/L (and lower concentrations) killed less than 4%. The geometric mean of 1324 and 643 is 922.7 mg/L. The 96-hr LC50 was 6,743 mg/L and the ACR was 7.308.

Ceriodaphnia dubia

Sarma et al. (2006) reported that, on the basis of toxicity tests that studied population dynamics, all ten tested zooplankton species were adversely affected by 910 to 1820 mg/L; their data indicate that C. dubia was the most sensitive of the ten species.

Cowgill and Milazzo (1990) reported results of a life-cycle test on sodium chloride. If the geometric mean of the EC50 and the NOEC is used as the chronic value, it would be 925 mg/L, and the ACR would be 1395/925 = 1.508.

Cowgill and Milazzo (1991b) tested concentrations of chloride (as NaCl) from 8 to 283 mg/L. They found that reproduction peaked at 102 mg/L and all tested concentrations up to the maximum of 283 mg/L gave more reproduction than the control treatment.

Cowgill and Milazzo (1990) used calcium chloride extracted from a brine well to study the effect of "hardness as calcium carbonate" on C. dubia, whereas Cowgill and Milazzo (1991b) used reagent-grade calcium chloride to study the effect of "hardness as calcium carbonate" on C. dubia.

Diamond et al. (1992) reported that the average geometric mean of the NOEC and LOEC was 235 mg/L.

Wisconsin State Laboratory of Hygiene (WISLOH 2007) reported, for tests in hard reconstituted water (hardness = 169.5 mg/L and sulfate = 162.7 mg/L), a mean IC25 of 385.2 mg/L and a mean acute LC50 of 1499 mg/L. A 25% reduction is too high for a chronic value, so in hard water the chronic value is <385.2 mg/L and the ACR is >3.891. For tests in moderately hard reconstituted water (hardness = 84.8 mg/L and sulfate = 81.4 mg/L), WISLOH reported a mean IC25 of 442.2 mg/L and a mean acute LC50 of 1677 mg/L. Because a 25% reduction is too high for a chronic value, in moderately hard water the chronic value is <442.2 mg/L and the ACR is >3.792. The geometric mean ACR is >3.841.

Lasier et al. (2004) reported an IC50 of 563 mg/L and an IC25 of 340 mg/L. A 25% reduction is too high for a chronic value, so the chronic value is <340 mg/L.

Lasier et al. (2006) reported that the chronic toxicity of chloride is reduced by hardness cations, but they did not give any quantitative information.

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From an interlaboratory study of the Ceriodaphnia dubia life-cycle test DeGraeve et al. (1992) reported that fifteen 7-day LC50s ranged from 170 to 1179 mg/L and sixteen IC50s based on reproduction ranged from 182 to 1153 mg/L. A 50% reduction is too much adverse effect to use LC50s or IC50s as chronic values, but they could be used as upper limits on chronic values.

Aragao and Pereira (2003) performed twelve 7-day life-cycle tests on NaCl; six were started with young from 16 to 24 hr old and six were started with young from 6 to 30 hr old. Of the twelve NOECs, based on reproduction, six were 303 mg/L, four were 152 mg/L, and two were <152 mg/L. The twelve 7-day IC50s based on reproduction ranged from 346 to 685 mg/L. If the geometric mean of the NOEC and the IC50 is used as the chronic value, the twelve chronic values would be:

NOEC	IC50	Chronic Value
303	685	456
303	558	411
152	455	263
303	582	420
303	667	450
303	594	424
<152	431	<256
152	412	250
152	346	229
<152	370	<237
152	437	258
303	406	351

The twelve chronic values range from <237 to 456 mg/L, and the geometric mean is <322 mg/L.

Cooney et al. (1992) performed 18 life-cycle tests on sodium chloride using C. dubia. For each of the 18 tests, the survival NOEC was 1092 mg/L and the survival LOEC was 1456 mg/L. The 18 reproduction NOECs ranged from <455 to 819 mg/L, whereas the 18 reproduction LOECs ranged from 455 to 1092 mg/L. If the geometric mean of the reproduction NOEC and the reproduction LOEC is used as the chronic value, the 18 chronic values would be:

NOEC	LOEC	Chronic Value
455	607	525
607	819	705
819	1092	946
819	1092	946
607	819	705
819	1092	946
455	607	525
819	1092	946

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455	607	525
<455	455	<455
<455	455	<455
<455	455	<455
607	819	705
607	819	705
607	819	705
<455	455	<455
455	607	525
455	607	525

The 18 chronic values range from <455 to 946 mg/L, and the geometric mean is <629 mg/L.

Harmon et al. (2003) reported results of a life-cycle test on sodium chloride. The chronic EC20 based on reproduction was 370.6 mg/L. The ACR is 964/370.6 = 2.601.

Daphnia ambigua

Harmon et al. (2003) reported results of a life-cycle test on sodium chloride. The chronic EC20 based on reproduction was 292.4 mg/L. The ACR is 1213/292.4 = 4.148.

Daphnia magna

Leblanc and Surprenant (1984) conducted a life-cycle test on one concentration of potassium chloride and Cowgill and Milazzo (1990) conducted a life-cycle test on calcium chloride extracted from brine wells.

Biesinger and Christensen (1972) reported that 1573 mg/L caused a 50% reduction in reproduction, whereas 1049 mg/L caused a 16% reduction in reproduction in a life-cycle test. If the chronic value is set at 1111 mg/L because this is the estimated EC20, the ACR would be 2.276 using the unfed acute test and 2.526 using the fed acute test, but this is not an acceptable chronic test because the concentrations of the toxicant in the test solutions were not measured.

NOTE: Many years ago when ASTM had a task group on life-cycle tests with Daphnia magna, most of the people on the task group were having a low percentage of successful chronic tests using the Biesinger methodology because survival was too low in the control treatment. The group met in Duluth to talk to Biesinger about his methodology. When it was explained that people were having a low success rate due to low survival in the control treatment, Biesinger said that his success rate was about 50%; he would start a test on a toxicant as often as necessary in order to eventually get a successful test on that toxicant. People complained to Biesinger that he did not say this in his publication (Biesinger and Christensen 1972), and Biesinger said that he would state the success rate in a subsequent publication concerning the development of the methodology; Biesinger never published a methodology paper. A variety of people tested a variety of foods and eventually found that the success rate could be greatly increased by using a food that was better than the one that Biesinger used. This leads me to think that the

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healthiness of the daphnids used by Biesinger and Christensen (1972) is suspect and that all of the acute and chronic data presented in Biesinger and Christensen (1972) are suspect; however, this does not mean that these test results are incorrect.

Cowgill and Milazzo (1990) reported results of a life-cycle test on sodium chloride; they reported an EC50 of 2597 mg/L and a NOEC of 2184 mg/L. If the geometric mean of the EC50 and the NOEC is used as the chronic value, it would be 2382 mg/L, and the ACR would be 4701/2382 = 1.974.

Cowgill and Milazzo (1991b) tested concentrations of chloride (as NaCl) from 8 to 283 mg/L. They found that reproduction peaked at 37 mg/L and all tested concentrations up to the maximum of 283 mg/L gave as much reproduction as the control treatment.

Cowgill and Milazzo (1990) used calcium chloride extracted from a brine well to study the effect of "hardness as calcium carbonate" on D. magna, whereas Cowgill and Milazzo (1991b) used reagent-grade calcium chloride to study the effect of "hardness as calcium carbonate" on D. magna.

Daphnia pulex

Birge et al. (1985) reported that the most sensitive adverse effect observed in a 21-day life-cycle test was a 27% reduction in reproduction at 441 mg/L, with no reduction at 314 mg/L. The chronic value was 372 mg/L (the geometric mean of 441 and 314 mg/L) and the ACR was 1470/372 = 3.952.

Stenonema modestum (a mayfly)

Diamond et al. (1992) reported that NOECs and LOECs based on survival and number of molts in 14-day tests ranged from 1213 to 4246 mg/L. These are not acceptable chronic tests, but they might be used to estimate an upper limit on the chronic value for this species.

Musculium securis (a clam)

The test results reported by Mackie (1978) are not acceptable because the treatments were prepared by adding sodium chloride to a mixture of soil, leaves, and deionized water.

Musculium transversum (a clam)

Anderson et al. (1978) reported results of chronic tests on KCl.

Rana sylvatica (a frog)

Sanzo and Hecnar (2006) reported that 625 mg/L caused a 62% reduction in the survival of wood frog tadpoles during a 90-day exposure, whereas 47 mg/L did not reduce survival. Although this is not an acceptable chronic test, 625 mg/L can be used as an upper limit on the chronic value for this species.

Gammarus pseudopinmaeus (an amphipod)

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Williams et al. (2000) reported that neither 1000 nor 2000 mg/L reduced survival in a two-month exposure in spring water, but this is not an acceptable chronic test.

Physa sp. (a snail)

Williams et al. (2000) reported that neither 1000 nor 2000 mg/L reduced survival in a two-month exposure in spring water, but this is not an acceptable chronic test.

Orconectes limosus (a crayfish)

Boutet and Chaisemartin (1973) reported the results of unacceptable chronic tests on potassium chloride and magnesium chloride.

The acceptable chronic values available for chloride are:

Fathead minnow	433.1 mg/L	Birge et al. 1985
Rainbow trout	922.7 mg/L	Spehar 1987
Ceriodaphnia dubia	925 mg/L	Cowgill and Milazzo 1990
Ceriodaphnia dubia	235 mg/L	Diamond et al. 1992
Ceriodaphnia dubia	<442.2 mg/L	WISLOH 2007 (mod. hard water)
Ceriodaphnia dubia	<385.2 mg/L	WISLOH 2007 (hard water)
Ceriodaphnia dubia	<340 mg/L	Lasier et al. 2004
Ceriodaphnia dubia	<322 mg/L	Aragao and Pereira 2003
Ceriodaphnia dubia	<629 mg/L	Cooney et al. 1992
Ceriodaphnia dubia	370.6 mg/L	Harmon et al. 2003
Daphnia ambigua	292.4 mg/L	Harmon et al. 2003
Daphnia magna	2382 mg/L	Cowgill and Milazzo 1990
Daphnia pulex	372 mg/L	Birge et al. 1985
Rana sylvatica	<625 mg/L	Sanzo and Hecnar 2006

These result in the following Genus Mean Chronic Values:

Pimephales	433.1 mg/L
Oncorhynchus	922.7 mg/L
Ceriodaphnia	<418.7 mg/L
Daphnia	637.5 mg/L
Rana	<625 mg/L

The acceptable ACRs available for chloride are:

Rainbow trout	7.308	Spehar 1987
Ceriodaphnia dubia	1.508	Cowgill and Milazzo 1990
Ceriodaphnia dubia	>3.841	WISLOH 2007
Ceriodaphnia dubia	2.601	Harmon et al. 2003
Daphnia ambigua	4.148	Harmon et al. 2003
Daphnia magna	1.974	Cowgill and Milazzo 1990
Daphnia pulex	3.952	Birge et al. 1985

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The following ACR is also available for chloride but it should not be used in calculations because the acute and chronic tests were performed in different waters:

Fathead minnow	15.17	Birge et al. 1985

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09JanChlorideAcute.wpd DRAFT 1-15-09
C. Stephan

Summary of Data Concerning the Acute Toxicity of Sodium Chloride to Aquatic Animals

This summary is based on "Results of Literature Search concerning the Toxicity of Chloride to Aquatic Animals" dated 1-15-09. Except as noted, this summary is consistent with the 1985 Guidelines.

Acute Values and Normalized Acute Values are expressed as mg chloride/L. Normalized Acute Values were calculated by normalizing the Acute Values to hardness = 300 mg/L and sulfate = 65 mg/L using the following equation:

$$NAV = (AV)\ (300/Hardness)^{0.205797}\ (65/Sulfate)^{-0.07452}$$

This equation is based on the equation presented in "Multiple Regression Equation for Chloride" dated 1-15-09. The hardness of 300 mg/L and the sulfate concentration of 65 mg/L are arbitrary; any other values for hardness and sulfate would have worked equally well. NAVs could not be calculated for all AVs because assumed values were not used for hardness or sulfate. Some of the values of hardness and sulfate are nominal, not measured, values.

Species	Method	Test Material	Hardness (mg/L)	Sulfate (mg/L)	Acute Value	Normalized Acute Value	Reference
Tubificid worm, Limnodrilus hoffmeisteri	S,U	Sodium chloride	100	----	3761	------	Wurtz and Bridges 1961
Tubificid worm, Tubifex tubifex	S,M	Sodium chloride	52 220	57.9 58.9	4278 6008	6083.2 6357.1	GLEC and INHS 2008
Leech, Erpobdella punctata	S,U	Sodium chloride	100	----	4550	------	Wurtz and Bridges 1961
Mussel, juvenile Villosa delumbis	S,M	Sodium chloride	169.5	162.7	3173	3821.1	Bringolf et al. 2007
Mussel, juvenile Villosa iris	R,M	Sodium chloride	169.5	162.7	2069	2491.6	Wang 2007

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Mussel, juvenile Lampsilis fasciola	S,M	Sodium chloride	169.5	162.7	2414	2907.1	Bringolf et al. 2007
Mussel, juvenile Lampsilis siliquoidea	R,M	Sodium chloride	169.5	162.7	1905	2294.1	Wang 2007
Mussel, juvenile Lampsilis siliquoidea	S,M	Sodium chloride	169.5	162.7	2766	3331.0	Bringolf et al. 2007
Fingernail clam, Sphaerium simile	S,M	Sodium chloride	51 192	59.9 61.7	740 1100	1059.2 1201.1	GLEC and INHS 2008
Fingernail clam, Sphaerium tenue	S,U	Sodium chloride	100 20	---- ----	667 698	------ ------	Wurtz and Bridges 1961
Snail, Physa gyrina	F,M	Sodium chloride	84.8	81.4	2540	3350.0	Birge et al. 1985
Snail, Physa heterostropha	S,U	Sodium chloride	100 100 100 20	---- ---- ---- ----	2123 3094 3761 2487	------ ------ ------ ------	Wurtz and Bridges 1961
Snail, Physa sp.	S,M	Sodium chloride	22	15	3247hp	4983.6	Clemens and Jones 1954
Snail, Physa sp.	S,U	Sodium chloride	----	----	>3000p	------	Williams et al. 2000
Snail, Gyraulus circumstriatus	S,U	Sodium chloride	100	----	1941	------	Wurtz and Bridges 1961
Snail,	S,M	Sodium	56	60.9	3078	4326.9	GLEC and INHS 2008

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Gyraulus parvus		chloride	212	59.7	3009	3211.4	
Snail, Helisoma campanulata	S,U	Sodium chloride	100	----	3731	------	Wurtz and Bridges 1961
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	84.8	81.4	1189brt 1042brt	1568.2 1374.3	Mount et al. 1997
Cladoceran, Ceriodaphnia dubia	R,U	Sodium chloride	74.1	----	1395	------	Cowgill and Milazzo 1990
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	39.2	4.6	507 447	632.7 557.8	Hoke et al. 1992
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	39.2 39.2 39.2 39.2 339.0	4.6 4.6 4.6 4.6 325.4	1395 1638 1274 1395 1698	1740.8 2044.1 1589.8 1740.8 1867.0	USEPA 1991
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	84.8 169.5	81.4 162.7	1677c 1499c	2211.8 1805.2	WISLOH 2007
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	84.8	81.4	1413e	1863.6	Valenti et al. 2007
Cladoceran, Ceriodaphnia dubia	S,M	Sodium chloride	67.1	64.4q	964	1311.1	Harmon et al. 2003
Cladoceran, Ceriodaphnia dubia	S,M	Sodium chloride	30 44 96 180	78.7 75.9 73.7 67.7	947 955 1130 1609	1542.9 1434.1 1442.1 1792.8	GLEC and INHS 2008

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			400	78.7	1491	1425.5	
			570	76.2	1907	1690.9	
			800	75.5	1764	1457.7	
			25	69.9	1007	1688.4	
			49	67.8	767	1117.1	
			95	70.3	1369	1744.7	
			194	69.9	1195	1314.3	
			375	68.9	1687	1618.3	
			560	68.3	1652	1458.2	
			792	70.9	1909	1573.5	
			280	28.1	1400	1334.0	
			280	59.6	1720	1733.4	
			280	117	1394	1477.2	
			280	239	1500	1676.5	
			280	482	1109	1306.0	
			280	729	1206	1464.7	
			279	22.9	1311	1231.2	
			276	49.7	1258	1254.4	
			283	107	1240	1302.5	
			281	229	1214	1351.5	
			290	461	1199	1397.2	
			278	694	1179	1428.8	
Cladoceran, Daphnia ambigua	S,M	Sodium chloride	67.1	64.4q	1213	1649.7	Harmon et al. 2003.
Cladoceran, Daphnia magna	S,U	Sodium chloride	84.8	81.4	2893brs	3815.5	Mount et al. 1997
Cladoceran, Daphnia magna	S,U	Sodium chloride	240	----	621	------	Khangarot and Ray 1989
Cladoceran,	S,U	Sodium	39.2	4.6	3038	3791.1	Hoke et al. 1992

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Daphnia magna		chloride	39.2 39.2	4.6 4.6	2726 2053	3401.8 2561.9	
Cladoceran, Daphnia magna	-,-	Sodium chloride	----	----	1008k 3319m	------ ------	Cowgill 1987
Cladoceran, Daphnia magna	S,U	Sodium chloride	108.7	13	<2548	<2785.1	Anderson 1946
Cladoceran, Daphnia magna	S,U	Sodium chloride	108.7	13	2232i	2439.7	Anderson 1948
Cladoceran, Daphnia magna	S,U	Sodium chloride	41.5	31.2	3563	5068.2	Dowden and Bennett 1965
Cladoceran, Daphnia magna	S,M	Sodium chloride	45.3	3.9v	2529a,f 2806b,f	3025.9 3357.4	Biesinger and Christensen 1972
Cladoceran, Daphnia magna	S,U	Sodium chloride	169.5	162.7	>2669 <3943d	>3214.2 <4748.4	Seymour et al. 1997
Cladoceran, Daphnia magna	S,U	Sodium chloride	46	3.9v	1880	2242.3	USEPA 1991
Cladoceran, Daphnia magna	S,U	Sodium chloride	169.5	162.7	3944c	4749.6	WISLOH 2007
Cladoceran, Daphnia magna	S,U	Sodium chloride	84.8	81.4	3009e	3968.5	Valenti et al. 2007
Cladoceran, Daphnia magna	S,U	Sodium chloride	106	102	3136 3222 3137	4017.4 4127.5 4018.6	Davies and Hall 2007

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Cladoceran, Daphnia pulex	S,M	Sodium chloride	84.8	81.4	1470	1938.8	Birge et al. 1985
Cladoceran, Daphnia pulex	S,U	Sodium chloride	84.8 84.8 84.8 84.8	81.4 81.4 81.4 81.4	1159 1775 1805 2242	1528.6 2341.0 2380.6 2956.9	Palmer et al. 2004
Copepod, Diaptomus clavipes	S,M	Sodium chloride	22	15	2571h	3946.1	Clemens and Jones 1954
Isopod, Asellus communis	S,U	Sodium chloride	100 20	---- ----	5004 3094	------ ------	Wurtz and Bridges 1961
Isopod, Lirceus fontinalis	F,M	Sodium chloride	84.8	81.4	2950	3890.7	Birge et al. 1985
Amphipod, Hyalella azteca	S,U	Sodium chloride	102.5	98.4	3947	5077.7	Lasier et al. 1997
Amphipod, Gammarus pseudolimnaeus	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Amphipod, Crangonyx sp.	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Crayfish, Cambarus sp.	S,M	Sodium chloride	22	15	10557h	16203.2	Clemens and Jones 1954
Dragonfly, Libellulidae	S,M	Sodium chloride	22	15	9671h	14843.4	Clemens and Jones 1954
Damselfly,	S,U	Sodium	100	----	14558	------	Wurtz and Bridges 1961

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Agria sp.		chloride	20	----	13952	------	
Stonefly, Nemoura trispinosa	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Caddisfly, Lepidostoma sp.	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Caddisfly, Parapsyche sp.	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Midge, Chironomus attenuatus	S,U	Sodium chloride	----	----	4850	------	Thornton and Sauer 1972
American eel, Anquilla rostrata	S,U	Sodium chloride	42.4	40.7	10846	15667.3	Hinton and Eversole 1978
American eel, Anquilla rostrata	S,U	Sodium chloride	42.4	40.7	13012	18796.2	Hinton and Eversole 1979
Goldfish, Carassius auratus	S,M	Sodium chloride	148.8	----	9465	------	Threader and Houston 1983
Red shiner, Notropis lutrensis	S,M	Sodium chloride	22	15	5771g 5920g	8857.5 9086.2	Clemens and Jones 1954
Fathead minnow, Pimephales promelas	S,U	Sodium chloride	39.2 39.2 339.0	4.6 4.6 325.4	2790 2123 2244	3481.7 2649.3 2467.3	USEPA 1991
Fathead minnow, Pimephales promelas	F,M	Sodium chloride	84.8	81.4	6570	8665.1	Birge et al. 1985

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Fathead minnow, Pimephales promelas	S,M	Sodium chloride	22	15	5288g 5431g	8116.2 8335.7	Clemens and Jones 1954
Fathead minnow, Pimephales promelas	S,U	Sodium chloride	84.8	81.4	3876br	5112.0	Mount et al. 1997
Fathead minnow, Pimephales promelas	S,U	Sodium chloride	84.8 169.5	81.4 162.7	4167c 4127c	5495.8 4970.0	WISLOH 2007
Black bullhead, Ameiurus melas	S,M	Sodium chloride	22	15	4849g	7442.4	Clemens and Jones 1954
Rainbow trout, Oncorhynchus mykiss	S,U	Sodium chloride	22.4	----	>485j	------	Camargo and Tarazona 1991
Rainbow trout, Oncorhynchus mykiss	F,M	Sodium chloride	46	3.9v	6743	8042.6	Spehar 1986,1987
Rainbow trout, Oncorhynchus mykiss	R,U	Sodium chloride	284	----	12363	------	Vosyliene et al. 2006
Brown trout, Salmo trutta	S,U	Sodium chloride	22.4	----	>607j	------	Camargo and Tarazona 1991
Plains killifish, Fundulus kansae	S,M	Sodium chloride	22	15	9706g	14897.1	Clemens and Jones 1954
Mosquitofish, Gambusia affinis	S,M	Sodium chloride	22	15	6472g	9933.4	Clemens and Jones 1954
Mosquitofish, Gambusia affinis	S,U	Sodium chloride	----	14.9	9099	------	Al-Daham and Bhatti 1977

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Threespine stickleback, Gasterosteus aculeatus	R,M	Sodium chloride	84.8	81.4	10200b	13452.6	Garibay and Hall 2004
Green sunfish, Lepomis cyanellus	S,M	Sodium chloride	22	15	6499g	9974.9	Clemens and Jones 1954
Bluegill, Lepomis macrochirus	F,M	Sodium chloride	84.8	81.4	5840	7702.3	Birge et al. 1985
Bluegill (3.7 g), Lepomis macrochirus	S,U	Sodium chloride	44.3	15.5	7853	10461.6	Academy of Natural Sciences 1960; Patrick et al. 1968; Trama 1954
Chorus frog, Pseudacris sp.	R,M	Sodium chloride	84.8	81.4	3553	4686.0	Garibay and Hall 2004

a = not fed. (All tests not marked "a" or "b" were unfed tests.)
b = fed.
c = mean of at least 15 LC50s.
d = range of several toxicity tests.
e = mean of 32 tests.
f = not used because there is reason to suspect that the daphnids might have been unhealthy.
g = tables 4, 7, and 9, except for tests at 28C in table 4.
h = tables 8 and 11; Daphnia pulex tests were not used because test duration was 96 hr.
i = test duration was 64 hr.
j = no deaths in 196 hr.
k = selenium deficient.
m = selenium sufficient.
p = not used in calculation of GMAV because the species is unknown and so it is not known how to combine this acute value with the acute values for which the species are known.
q = calculated using the formula for reconstituted water and the reported average measured hardness.
r = concentrations were measured in stock solutions.
s = not acclimated to the dilution water.

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t = might not have been acclimated to the dilution water.
v = based on analyses of samples of Lake Superior water taken in the spring and fall of 2008.

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Supplementary information concerning the results of toxicity tests on chloride

1. The atomic weights used are those given on the website of the National Institute of Standards and Technology:
   - Calcium = 40.078
   - Carbon = 12.011
   - Chlorine = 35.453
   - Hydrogen = 1.008
   - Iron = 55.845
   - Magnesium = 24.305
   - Nitrogen = 14.007
   - Oxygen = 15.999
   - Potassium = 39.098
   - Sodium = 22.990
   - Sulfur = 32.065

2. The molecular weights used are:
   - $CaCl_2$ = 110.984 (63.89 % chloride) (36.11 % calcium) (Cl/Ca = 1.769)
   - $CaCl_2 \cdot 2H_2O$ = 147.014 (27.26 % calcium) (48.23 % chloride)
   - $CaCO_3$ = 100.086 (40.04 % calcium)
   - CaO = 56.077 (71.47 % calcium)
   - $Ca(NO_3)_2$ = 164.086 (24.42 % calcium)
   - $Ca(NO_3)_2 \cdot 4H_2O$ = 236.146 (16.97 % calcium)
   - $CaSO_4$ = 136.139 (70.56 % sulfate)
   - $CaSO_4 \cdot 2H_2O$ = 172.169 (55.79 % sulfate) (23.28 % calcium) (20.93 % water)
   - $FeCl_3 \cdot 6H_2O$ = 270.294 (39.35 % chloride)
   - H_2O = 18.015
   - KCl = 74.551 (47.56 % chloride) (52.44 % potassium) (Cl/K = 0.9068)
   - K_2SO_4 = 174.257 (55.13 % sulfate)
   - $MgCl_2$ = 95.211 (74.47 % chloride) (25.53 % magnesium) (Cl/Mg = 2.917)
   - $MgSO_4$ = 120.366 (79.81 % sulfate) (20.19 % magnesium)
   - $MgSO_4 \cdot 7H_2O$ = 246.471 (38.97 % sulfate) (9.86 % magnesium)
   - NaCl = 58.443 (60.66 % chloride) (39.34 % sodium) (Cl/Na = 1.542)
   - Na_2SO_4 = 142.041 (67.63 % sulfate)

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$Na_2SO_4 \cdot 10H_2O = 322.191$ (29.81 % sulfate)
$SO_4 = 96.061$

3. Hardness (as $CaCO_3$) = (100.086/40.078)(Ca) + (100.086/24.305)(Mg) = 2.497(Ca) + 4.118(Mg)

4. Trama (1954), Cairns and Scheier (1959), Academy of Natural Sciences (1960), and Patrick et al. (1968) all reported results of toxicity tests that were performed at the Academy of Natural Sciences of Philadelphia with the bluegill in dilution waters that were very similar:

	mg/L
KCl	20
Na_2SiO_3	20
$NaHCO_3$	40
$MgSO_4 \cdot 7H_2O$	40
$Ca(NO_3)_2$	30*
$CaCO_3$	10
K_2HPO_4	10 or 2
Fe^{+++} (as ferric citrate)	4 or 0.4

Ca = 11.3 mg/L
Mg = 3.9 mg/L
Hardness = 44.3 mg/L as $CaCO_3$
Chloride = 9.5 mg/L
Sulfate = 15.5 mg/L

*Long after the tests of concern were performed, this was reported to be 40 mg/L of $Ca(NO_3)_2 \cdot 4H_2O$.

5. Freeman (1953), Freeman and Fowler (1953), Fairchild (1955), Dowden (1960), Dowden (1962), and Dowden and Bennett (1965) all contained information regarding toxicity tests performed at Louisiana State University in Baton Rouge, but several different dilution waters were used. Dowden and Bennett (1965) tried to clarify the most important dilution waters used, but the citations given for the waters on page 1310 need to be clarified. Reference 4 is the correct citation for "Standard Reference Water" (SRW), but the correct citation for "Reference Dilution Water" (RDW) is reference 6 (not reference 3) and reference 3 should be cited for "glass-wool filtered University Lake Water (ULW). ULW is considered an unacceptable dilution water because it is from "a small drainpipe-fed lake on the campus of Louisiana State University" (Dowden 1960). The compositions of SRW and RDW are:

SRW	mg/L
$MgSO_4 \cdot 7H_2O$	71.

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K_2SO_4	6.5
$MnSO_4 \cdot 4H_2O$	0.2
$CaCl_2 \cdot 2H_2O$	18.6
$NaHCO_3$	25.
NH_4NO_3	3.
$K_2HPO_4 \cdot 3H_2O$	1.1
CaO	32.2
$Na_2SiO_3 \cdot 9H_2O$	62.6
$FeCl_3 \cdot 6H_2O$	1.2

Ca = 23.0 mg/L
Mg = 7.0 mg/L
Hardness = 86.2 mg/L as $CaCO_3$
Chloride = 9.4 mg/L
Sulfate = 31.2 mg/L

RDW	mg/L
$CaCl_2$	110
$NaHCO_3$	110
NaCl	100
$MgSO_4 \cdot 7H_2O$	60
KCl	20

Ca = 39.7 mg/L
Mg = 5.9 mg/L
Hardness = 123.4 mg/L as $CaCO_3$
Chloride = 140.4 mg/L
Sulfate = 23.4 mg/L

6. When known, the concentration of chloride in dilution water was negligible in tests on chloride.

7. Karraker (2007) says that "road salt" contains sodium chloride, sodium ferrocyanide, heavy metals, and often sand or cinder. Results of toxicity tests on "road salt" were not used.

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8. Hyalella azteca appears to be especially sensitive to some pollutants when the concentration of chloride is low, e.g., lower than 25 mg/L. This should not affect the sensitivity of this species to chloride.

9. Mount et al. (1997) reported that the toxicities of sodium and calcium salts to C. dubia, D. magna, and the fathead minnow are primarily attributable to the corresponding anion.

10. Some data presented in Table 1 of USEPA (1988) have been changed:
    a. Several values differ because of roundoff differences.
    b. USEPA (1988) used results of short acute tests for the reasons given on pages 2 and 3 (see also Lowell et al. 1995), but results of short tests are not used here because short acute tests sometimes give higher LC50s than standard tests.
    c. Data from Dowden (1961, which should be 1960) and Kostecki and Jones (1983) are not used here because of the dilution water used in the tests.
    d. The test results from Trama (1954) are also given in Academy of Natural Sciences (1960) and Patrick et al. (1968).
    e. Hamilton et al. (1975) did not adequately acclimate the midges.
    f. Fed acute tests were not used in USEPA (1988), but fed acute tests are used here and are given preference over unfed acute tests when the test organisms are cladocerans.

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C. Stephan

Description of the Review of Results of Toxicity Tests on Chloride

Sections II.B, II.C, II.D, II.E, II.F, IV.B, IV.C, IV.D, IV.E, IV.H, VI.B, VI.C, VI.D, and VI.E of the 1985 Guidelines give reasons why some results of toxicity tests should not be used, should be rejected, or should not be used in calculations, whereas sections II.G, X, XI.C, XII.A.14, and XII.B allow the use of "questionable data" and "other data" in some situations. An easy-to-understand way of explaining the material given in the sections listed above is to say that sections II.B, II.C, II.D, II.E, II.F, IV.B, IV.C, IV.D, IV.E, IV.H, VI.B, VI.C, VI.D, and VI.E give reasons why some results of toxicity tests using aquatic animals should not be directly used in the derivation of a FAV or a FCV, whereas sections II.G, X, XI.C, XII.A.14, and XII.B describe other possible uses of test results with aquatic animals that should not be directly used in the derivation of a FAV or a FCV.

The 1985 Guidelines say the following concerning the use of results of toxicity tests using aquatic animals:

1. General guidance
   a. All data should be available in typed, dated, and signed hard copy (publication, manuscript, letter, memorandum, etc.) with enough supporting information to indicate that acceptable test procedures were used and that the results are probably reliable. (see section II.B)
   b. Information that is confidential or privileged or otherwise not available for distribution should not be used. (see section II.B)
   c. Questionable data, whether published or unpublished, should not be used. For example, a test result should usually be rejected if it is from:
      i. a test that did not contain a control treatment.
      ii. a test in which too many organisms in the control treatment died or showed signs of stress or disease.
      iii. a test in which distilled or deionized water was used as the dilution water without addition of appropriate salts.

      (see section II.C)
   d. A result of a test on technical-grade material may be used if appropriate, but a result of a test on a formulated mixture or an emulsifiable concentrate of the test material should not be used. (see section II.D)
   e. For some highly volatile, hydrolyzable, or degradable materials it is probably appropriate to use only results of flow-through tests in which the concentrations of test material in the test solutions were measured often enough using acceptable analytical methods. (see section II.E)
   f. Data should be rejected if they were obtained using:
      i. Brine shrimp
      ii. A species that does not have a reproducing wild population in North America.

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iii. Organisms that were previously exposed to substantial concentrations of the test material or other contaminants.

(see section II.F)

2. Guidance specifically regarding results of acute tests
   g. Acute toxicity tests should have been conducted using acceptable procedures. (see section IV.B)
   h. Except for tests using saltwater annelids and mysids, results of acute tests during which the test organisms were fed should not be used, unless data indicate that the food did not affect the toxicity of the test material. (see section II.C)
   i. Results of acute tests conducted in unusual dilution water, e.g., dilution water in which total organic carbon or particulate matter exceeded 5 mg/L, should not be used, unless a relationship is developed between acute toxicity and organic carbon or particulate matter or unless data show that organic carbon, particulate matter, etc., do not affect toxicity. (see section IV.D)
   j. Acute values should be based on endpoints which reflect the total severe acute adverse impact of the test material on the organisms used in the test. Therefore, only the following kinds of data on acute toxicity to aquatic animals should be used:
      1. Tests with daphnids and other cladocerans should be started with organisms less than 24 hours old and tests with midges should be started with second- or third-instar larvae. The result should be the 48-hr EC50 based on percentage of organisms immobilized plus percentage of organisms killed. If such an EC50 is not available from a test, the 48-hr LC50 should be used in place of the desired 48-hr EC50. An EC50 or LC50 of longer than 48 hr can be used as long as the animals were not fed and the control animals were acceptable at the end of the test.
      2. The result of a test with embryos and larvae of barnacles, bivalve molluscs (clams, mussels, oysters, and scallops), sea urchins, lobsters, crabs, shrimp, and abalones should be the 96-hr EC50 based on the percentage of organisms with incompletely developed shells plus the percentage of organisms killed. If such an EC50 is not available from a test, the lower of the 96-hr EC50 based on the percentage of organisms with incompletely developed shells and the 96-hr LC50 should be used in place of the desired 96-hr EC50. If the duration of the test was between 48 and 96-hr, the EC50 or LC50 at the end of the test should be used.
      3. The acute values from tests with all other freshwater and saltwater animal species and older life stages of barnacles, bivalve molluscs, sea urchins, lobsters, crabs, shrimps, and abalones should be the 96-hr EC50 based on the percentage of organisms exhibiting loss of equilibrium plus the percentage of organisms immobilized plus the percentage of organisms killed. If such an EC50 is not available from a test, the 96-hr LC50 should be used in place of the desired 96-hr EC50.
      4. Tests with single-celled organisms are not considered acute tests, even if the duration was 96 hours or less.
      5. If the tests were conducted properly, acute values reported as "greater than" values and those which are above the solubility of the test material should be used,

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because rejection of such acute values would unnecessarily lower the Final Acute Value by eliminating acute values for resistant species.
(see section IV.E)

k. The agreement of the data within and between species should be considered. Acute values that appear to be questionable in comparison with other acute and chronic data for the same species and for other species in the same genus probably should not be used in the calculation of a SMAV. For example, if the acute values available for a species or genus differ by more than a factor of 10, some or all of the values probably should not be used in calculations. (see section IV.H)

3. Guidance specifically regarding results of chronic tests
   l. Chronic values should be based on results of flow-through (except renewal is acceptable for daphnids) chronic tests in which the concentrations of test material in the test solutions were properly measured at appropriate times during the test. (see section VI.B)
   m. Results of chronic tests in which survival, growth, or reproduction in the control treatment was unacceptably low should not be used. The limits of acceptability will depend on the species. (see section VI.C)
   n. Results of chronic tests conducted in unusual dilution water, e.g., dilution water in which total organic carbon or particulate matter exceeded 5 mg/L, should not be used, unless a relationship is developed between chronic toxicity and organic carbon or particulate matter or unless data show that organic carbon, particulate matter, etc., do not affect toxicity. (see section VI.D)
   o. Chronic values should be based on endpoints and lengths of exposure appropriate to the species. Therefore, only data on chronic toxicity to aquatic animals that satisfy the species-specific requirements given in sections VI.E.1, VI.E.2, and VI.E.3 should be used.
4. Guidance regarding other possible uses of results of toxicity tests using aquatic animals
   p. Questionable data, data on formulated mixtures and emulsifiable concentrates, and data obtained with non-resident species or previously exposed organisms may be used to provide auxiliary information but should not be used in the derivation of criteria. (see section II.F)
   q. Pertinent information that could not be used in earlier sections might be available concerning adverse effects on aquatic organisms and their uses. The most important of these are data on cumulative and delayed toxicity, flavor impairment, reduction in survival, growth, or reproduction, or any other adverse effect that has been shown to be biologically important. Especially important are data for species for which no other data are available. Data from behavioral, biochemical, physiological, microcosm, and field studies might also be available. Data might be available from tests conducted in unusual dilution water, from chronic tests in which the concentrations were not measured, from tests with previously exposed organisms, and from tests on formulated mixtures or emulsifiable concentrates. Such data might affect a criterion if the data were obtained with an important species, the test concentrations were measured, and the endpoint was biologically important. (see section X)

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r. The CCC is equal to the lowest of the FCV, FPV, and FRV, unless other data show that a lower value should be used. (see section XI.C)
s. Are any of the other data important? (see section XII.A.14)
t. On the basis of all available pertinent laboratory and field information, determine if the criterion is consistent with sound scientific information. If it is not, another criterion, either higher or lower, should be derived using appropriate modifications of these Guidelines. (see section XII.B)

In addition, the following aquatic life criteria documents published by U.S. EPA in 1985, 1986, 1987, and 1988 gave a variety of reasons for classifying specific test results as "unused":

U.S. EPA. 1985. Ambient Water Quality Criteria for Cadmium - 1984. EPA 440/5-84-032. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1985. Ambient Water Quality Criteria for Chlorine - 1984. EPA 440/5-84-030. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1985. Ambient Water Quality Criteria for Copper - 1984. EPA 440/5-84-031. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1985. Ambient Water Quality Criteria for Lead - 1984. EPA 440/5-84-027. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1985. Ambient Water Quality Criteria for Mercury - 1984. EPA 440/5-84-026. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1986. Ambient Water Quality Criteria for Chlorpyrifos - 1986. EPA 440/5-86-005. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1986. Ambient Water Quality Criteria for Parathion - 1986. EPA 440/5-86-007. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1986. Ambient Water Quality Criteria for Pentachlorophenol - 1986. EPA 440/5-86-009. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1986. Ambient Water Quality Criteria for Toxaphene - 1986. EPA 440/5-86-006. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1987. Ambient Water Quality Criteria for Selenium - 1987. EPA 440/5-87-006. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1987. Ambient Water Quality Criteria for Zinc - 1987. EPA 440/5-87-003. U.S. Environmental Protection Agency, Washington, DC.

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U.S. EPA. 1988. Ambient Water Quality Criteria for Chloride - 1988. EPA 440/5-88-001. U.S. Environmental Protection Agency, Washington, DC.

The following is a compilation of the reasons, although some have been paraphrased. Most of these reasons can be considered to be based on items a through o listed above.

1. The document is a secondary publication of the test result.
2. The test procedures, test material, dilution water, and/or results were not adequately described.
3. The test species is not resident in North America.
4. The test species was not obtained in North America and was not identified well enough to determine whether it is resident in North America.
5. The test organisms were not identified beyond, for example, "crayfish" or "minnows."
6. There is reason to believe that the test organisms were possibly stressed by disease or parasites.
7. The test organisms were exposed to elevated concentrations of the test material before the test and/or the control organisms contained high concentrations of the test material.
8. The test organisms were obtained from a sewage oxidation pond.
9. By the end of the test, the test organisms had not been fed for too long a period of time.
10. The water quality varied too much during the test.
11. The test was conducted with brine shrimp, which species are from a unique saltwater environment.
12. The exposed biological material was an enzyme, excised or homogenized tissue, tissue extract, plasma, or cell culture.
13. The test organisms were not acclimated to the dilution water for a sufficiently long time.
14. The test organisms were exposed to the test material via gavage, injection, or food.
15. There is reason to believe that the test organisms were probably crowded during the test.
16. The test organisms reproduced during an acute test and the young could not be distinguished from the old at the end of the test.
17. The test material was a component of a mixture, effluent, fly ash, sediment, drilling mud, sludge, or formulation.
18. In a test on zinc, the dilution water contained a phosphate buffer.
19. The test material was chlorine and it was not measured acceptably during the test.
20. The test chamber contained sediment.
21. The test was conducted in plastic test chambers without measurement of the test material.
22. The test was a field study and the concentration of test material was not measured adequately.
23. A known volume of stock solution was placed on a wall of the test chamber and evaporated and then dilution water was placed in the test chamber; the investigators assumed that all of the test material dissolved in the dilution water, but the concentrations of the test material in the test solutions were not measured.
24. The test only studied metabolism of the test material.
25. The only effects studied were biochemical, histological, and/or physiological.
26. The data concerned the selection, adaptation, or acclimation of organisms for increased resistance to the test material.

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27. The percent survival in the control treatment was too low.
28. The concentration of solvent in some or all of the test solutions was too high.
29. The study was a microcosm study.
30. The concentration of test material fluctuated too much during the exposure.
31. Too few test organisms were used in the test.
32. The dilution factor was ten.
33. There was no control treatment.
34. The pH was below 6.5.
35. The dilution water was chlorinated or "tap" water.
36. The dilution water contained an excessive amount of a chelating agent such as EDTA or other organic matter.
37. The acceptability of the dilution water is questionable because of its origin or content.
38. The dilution water was distilled or deionized water without addition of appropriate salts.
39. The measured test temperature fluctuated too much.
40. Neither raw data nor a clearly defined endpoint was reported.
41. The results were not adequately presented or could not be interpreted.
42. The results were only presented graphically.
43. The test was a chronic test and the concentration of test material was not measured.

Nevertheless, the things that the 1985 Guidelines say regarding other possible uses of test results with aquatic animals that should not be directly used in the derivation of a FAV or a FCV makes it clear that "unused" test results can be used in a criteria document, if appropriate. They should not be directly used in the derivation of a FAV or a FCV, but they can be used in other ways in some situations.

Further, several additional considerations were taken into account when results of aquatic toxicity tests on chloride were reviewed:

a. Review of results of toxicity tests on such pollutants as chloride should take additional considerations into account because chloride is different from most pollutants for which aquatic life criteria are derived. Chloride is very soluble in water, does not oxidize or reduce, is not volatile, does not degrade, does not sorb to test chambers, test organisms, food, or waste products, is not complexed by materials that commonly occur in water, is not involved in a pH-dependent equilibrium in water, and does not precipitate in waters in which aquatic organisms commonly occur. Toxicity tests on most pollutants are subject to one or more of these potential complications and so it is more important to be concerned about test methodology when considering other pollutants.
b. Section IV.C of the 1985 Guidelines says: "Except for tests with saltwater annelids and mysids, results of acute tests during which the test organisms were fed should not be used, unless data indicate that the food did not affect the toxicity of the test material." Section XII.B of the 1985 Guidelines says: "On the basis of all available pertinent laboratory and field information, determine if the criterion is consistent with sound scientific evidence. If it is not, another criterion, either higher or lower, should be derived using appropriate modifications of these Guidelines." Appendix 1 below demonstrates that (i) results of acute toxicity tests on chloride should not be rejected just because the test organisms were fed

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during the tests and (ii) results of fed acute tests should be given preference over results of unfed acute tests when the test organisms are cladocerans.

c. If tests in a document using some species had acceptable control mortalities but other tests in the same document using other species had unacceptable control mortalities, the tests using species with unacceptable control mortalities were not used. The general policy is that tests in a document using different species should be evaluated on a species-by-species basis, not on a document-by-document basis.

d. Results of 96-hr toxicity tests using juvenile freshwater mussels were used if the methodology, etc., were acceptable, but results of tests using glochidia of freshwater mussels were not used. Acute (e.g., 96-h) toxicity tests using juvenile freshwater mussels are rather standard acute toxicity tests and can be evaluated using, for example, ASTM Standard E729. In contrast, acute toxicity tests using glochidia of freshwater mussels require special consideration because free-living glochidia must attach to a host in order to survive, and they typically attach within seconds to days. In addition, for a specific species and a specific toxicant, the glochidia 6-h EC50 might be substantially higher than the glochidia 24-h EC50. It is known that free-living glochidia of several species can remain viable for up to about ten days, depending on the species and on the percent viability that is considered acceptable. However, it is not known how fast glochidia of individual species usually attach to a host, and this is important because the glochidia EC50 for some toxicants and species is quite dependent on the duration of the toxicity test. Thus, a very important question is "What species-specific toxicity-test duration is ecologically relevant for glochidia?"

e. USEPA is tending more toward a weight-of-evidence approach to the derivation of aquatic life criteria than when the 1985 Guidelines were written. The 1985 Guidelines provided very little guidance concerning a variety of issues regarding the review of test results and a weight-of-evidence approach benefits from the consideration of more data; early rejection of test results is not a good idea when a weight-of-evidence approach is used.

f. When a potential problem is identified regarding the quality of the result of a toxicity test, it usually means that the test result is questionable, not that it is incorrect. It is certainly appropriate to note test results that are questionable, but is not necessarily appropriate to immediately reject a test result that is questionable.

g. There is uncertainty regarding the results of all scientific studies. Even detailed reports of the results of toxicity tests do not necessarily allow the identification of all potential problems, as demonstrated by the range of results that is sometimes found in round-robin tests. For example, the quality of food is usually unknown, regardless of what information is given regarding the food used. (Even humans occasionally receive unhealthy food from grocery stores and restaurants.)

h. The most important issue regarding the quality of the result of a toxicity test is replication. Questions concerning the validity of a test result are best addressed by repeating the test, especially if the test is repeated in a different laboratory.

i. Test results should be rejected only for sound scientific reasons, not merely on the basis of suspicions or concerns.

j. If a test result is rejected, there is little impetus for anybody to repeat the test.

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Appendix 1: Fed and Unfed Acute Tests on Chloride Salts

The table on the last page of this attachment compares the results of fed and unfed acute toxicity tests on NaCl, $CaCl_2$, $MgCl_2$, and KCl. The table contains all of the sets of data from each document that contained comparable acute toxicity data regarding three or more of the four salts listed above.

It is quite possible that different ions, especially chloride and potassium, have different modes of action, have different relative toxicities to different species, and possibly are affected differently by an increase in hardness, calcium, and/or magnesium. (It is possible to obtain an LC50 for NaCl or KCl in soft water, but it is not possible to obtain an LC50 for $CaCl_2$ or $MgCl_2$ in soft water because the test material increases hardness.)

The Mount et al. fed tests with C. dubia and D. magna are at the top of the table with the Biesinger and Christensen D. magna fed tests. The two fed tests with D. magna agree very well for NaCl and for $MgCl_2$ and are almost within a factor of two for $CaCl_2$ and KCl. For all four salts the B&C fed tests gave lower values than the Mount et al. fed tests. Also for all four salts, the B&C unfed tests gave lower results than the B&C fed tests. This might indicate that Mount et al. used a better food than B&C.

For all four salts C. dubia was more sensitive than D. magna in the Mount et al. fed tests. The five ratios are similar for C. dubia and D. magna, but the C. dubia ratio is always equal to or higher than the D. magna ratio. The ratios from the Mount et al. fed tests with C. dubia and D. magna are similar to the ratios from fed and unfed tests using the three species of fish at the bottom of the table:

Ca/Na (n=5): from 0.57 to 0.98 (High/Low = 1.7)
Mg/Na (n = 3): from 0.34 to 0.55 (H/L = 1.6)
K/Na (n = 5): from 0.11 to 0.25 (H/L = 2.3)
Ca/K (n = 5): from >2.19 to 7.12 (H/L = <3.25)
Ca/Mg (n = 3): from 1.78 to 1.87 (H/L = 1.1)

It is interesting that the five ratios are very similar for cladocerans and fishes. It is also interesting that there is no overlap among the Ca/Na, Mg/Na, and K/Na ratios and there is no overlap among the Ca/Na, Ca/K, and Ca/Mg ratios. The apparent toxicity of chloride depends on the other ions that are in the test solutions in a quite reproducible manner.

These data clearly indicate that results of fed tests on these four salts should not be rejected just because the test organisms were fed during the tests. In addition, the best data regarding D. magna are probably from the Mount et al. fed tests. The fed-unfed comparisons by Biesinger and Christensen and Mount et al. demonstrate that either better foods should be developed for cladocerans and/or cladocerans should be fed during all acute tests. If cladocerans are fed during acute toxicity tests, it is possible that the duration of the tests could be increased from 48 hr to 96 hr.

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There are several considerations regarding the feeding of cladocerans during acute toxicity tests on NaCl, $CaCl_2$, $MgCl_2$, and KCl:

1. The better the food used, the more healthy the organisms will be at the beginning of the test.
2. Feeding during the test will reduce the possibility of stress due to lack of food.
3. Lower quality organisms and stressed organisms might be more sensitive to these four salts.
4. Because these four salts are not very toxic, the concentrations used in toxicity tests are so high that contamination by one or more heavy metals might be sufficient to stress or kill cladocerans during acute toxicity tests. If contamination by one or more metals causes stress or death, food might sorb or complex the metals and reduce their toxicities.
   a. Cladocerans are more sensitive to some metals than fathead minnows, bluegills, and mosquitofish.
   b. EDTA will complex and detoxify several heavy metals.
5. If food affects the results of acute toxicity tests, it also affects the acute-chronic ratio.
6. All species are fed during chronic toxicity tests.
7. Chloride is not likely to be sorbed or complexed by food.

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	Acute Value (mg chloride/L)				Ratio of Acute Values				
	NaCl	CaCl2	MgCl2	KCl	Ca/Na	Mg/Na	K/Na	Ca/K	Ca/Mg
C. dubia Mount fed	1189	1169	655	300	0.98	0.55	0.25	3.90	1.78
D. magna Mount fed	2893	1770	990	314	0.61	0.34	0.11	5.64	1.78
D. magna B&C fed	2806	821	939	150	0.29	0.33	0.05	5.47	0.87
D. magna B&C unfed	2529	92	408	84	0.04	0.16	0.03	1.10	0.23
D. magna* K&R unfed	621	679		128	1.09		0.21	5.30	
D. magna Anderson unfed (64-hr tests)	2232	588	551	205	0.26	0.25	0.09	2.87	1.07
D. magna D&B unfed	3563	1920	2755		0.54	0.77			0.70
T. tubifex** Khangarot	1204	497		737	0.41		0.61	0.67	
Fathead minnow Mount fed	3876	2958	1579	418	0.76	0.41	0.11	7.08	1.87
Mosquitofish A&B unfed	9099	5196		<2378	0.57		<0.26	>2.19	
Bluegill Trama unfed	7853	6804		956	0.87		0.12	7.12	

* This acute value for NaCl is unusually low compared to the other acute values for D. magna.

** These results were considered not acceptable because test temperature was high and the acute value for D. magna in the same water was unusually low.

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09JanChlorideAcute.wpd DRAFT 1-15-09
C. Stephan

Summary of Data Concerning the Acute Toxicity of Sodium Chloride to Aquatic Animals

This summary is based on "Results of Literature Search concerning the Toxicity of Chloride to Aquatic Animals" dated 1-15-09. Except as noted, this summary is consistent with the 1985 Guidelines.

Acute Values and Normalized Acute Values are expressed as mg chloride/L. Normalized Acute Values were calculated by normalizing the Acute Values to hardness = 300 mg/L and sulfate = 65 mg/L using the following equation:

$$NAV = (AV)\ (300/Hardness)^{0.205797}\ (65/Sulfate)^{-0.07452}$$

This equation is based on the equation presented in "Multiple Regression Equation for Chloride" dated 1-15-09. The hardness of 300 mg/L and the sulfate concentration of 65 mg/L are arbitrary; any other values for hardness and sulfate would have worked equally well. NAVs could not be calculated for all AVs because assumed values were not used for hardness or sulfate. Some of the values of hardness and sulfate are nominal, not measured, values.

Species	Method	Test Material	Hardness (mg/L)	Sulfate (mg/L)	Acute Value	Normalized Acute Value	Reference
Tubificid worm, Limnodrilus hoffmeisteri	S,U	Sodium chloride	100	----	3761	------	Wurtz and Bridges 1961
Tubificid worm, Tubifex tubifex	S,M	Sodium chloride	52 220	57.9 58.9	4278 6008	6083.2 6357.1	GLEC and INHS 2008
Leech, Erpobdella punctata	S,U	Sodium chloride	100	----	4550	------	Wurtz and Bridges 1961
Mussel, juvenile Villosa delumbis	S,M	Sodium chloride	169.5	162.7	3173	3821.1	Bringolf et al. 2007
Mussel, juvenile Villosa iris	R,M	Sodium chloride	169.5	162.7	2069	2491.6	Wang 2007

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Mussel, juvenile Lampsilis fasciola	S,M	Sodium chloride	169.5	162.7	2414	2907.1	Bringolf et al. 2007
Mussel, juvenile Lampsilis siliquoidea	R,M	Sodium chloride	169.5	162.7	1905	2294.1	Wang 2007
Mussel, juvenile Lampsilis siliquoidea	S,M	Sodium chloride	169.5	162.7	2766	3331.0	Bringolf et al. 2007
Fingernail clam, Sphaerium simile	S,M	Sodium chloride	51 192	59.9 61.7	740 1100	1059.2 1201.1	GLEC and INHS 2008
Fingernail clam, Sphaerium tenue	S,U	Sodium chloride	100 20	---- ----	667 698	------ ------	Wurtz and Bridges 1961
Snail, Physa gyrina	F,M	Sodium chloride	84.8	81.4	2540	3350.0	Birge et al. 1985
Snail, Physa heterostropha	S,U	Sodium chloride	100 100 100 20	---- ---- ---- ----	2123 3094 3761 2487	------ ------ ------ ------	Wurtz and Bridges 1961
Snail, Physa sp.	S,M	Sodium chloride	22	15	3247hp	4983.6	Clemens and Jones 1954
Snail, Physa sp.	S,U	Sodium chloride	----	----	>3000p	------	Williams et al. 2000
Snail, Gyraulus circumstriatus	S,U	Sodium chloride	100	----	1941	------	Wurtz and Bridges 1961
Snail,	S,M	Sodium	56	60.9	3078	4326.9	GLEC and INHS 2008

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Gyraulus parvus		chloride	212	59.7	3009	3211.4	
Snail, Helisoma campanulata	S,U	Sodium chloride	100	----	3731	------	Wurtz and Bridges 1961
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	84.8	81.4	1189brt 1042brt	1568.2 1374.3	Mount et al. 1997
Cladoceran, Ceriodaphnia dubia	R,U	Sodium chloride	74.1	----	1395	------	Cowgill and Milazzo 1990
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	39.2	4.6	507 447	632.7 557.8	Hoke et al. 1992
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	39.2 39.2 39.2 39.2 339.0	4.6 4.6 4.6 4.6 325.4	1395 1638 1274 1395 1698	1740.8 2044.1 1589.8 1740.8 1867.0	USEPA 1991
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	84.8 169.5	81.4 162.7	1677c 1499c	2211.8 1805.2	WISLOH 2007
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	84.8	81.4	1413e	1863.6	Valenti et al. 2007
Cladoceran, Ceriodaphnia dubia	S,M	Sodium chloride	67.1	64.4q	964	1311.1	Harmon et al. 2003
Cladoceran, Ceriodaphnia dubia	S,M	Sodium chloride	30 44 96 180	78.7 75.9 73.7 67.7	947 955 1130 1609	1542.9 1434.1 1442.1 1792.8	GLEC and INHS 2008

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			400	78.7	1491	1425.5	
			570	76.2	1907	1690.9	
			800	75.5	1764	1457.7	
			25	69.9	1007	1688.4	
			49	67.8	767	1117.1	
			95	70.3	1369	1744.7	
			194	69.9	1195	1314.3	
			375	68.9	1687	1618.3	
			560	68.3	1652	1458.2	
			792	70.9	1909	1573.5	
			280	28.1	1400	1334.0	
			280	59.6	1720	1733.4	
			280	117	1394	1477.2	
			280	239	1500	1676.5	
			280	482	1109	1306.0	
			280	729	1206	1464.7	
			279	22.9	1311	1231.2	
			276	49.7	1258	1254.4	
			283	107	1240	1302.5	
			281	229	1214	1351.5	
			290	461	1199	1397.2	
			278	694	1179	1428.8	
Cladoceran, Daphnia ambigua	S,M	Sodium chloride	67.1	64.4q	1213	1649.7	Harmon et al. 2003.
Cladoceran, Daphnia magna	S,U	Sodium chloride	84.8	81.4	2893brs	3815.5	Mount et al. 1997
Cladoceran, Daphnia magna	S,U	Sodium chloride	240	----	621	------	Khangarot and Ray 1989
Cladoceran,	S,U	Sodium	39.2	4.6	3038	3791.1	Hoke et al. 1992

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Daphnia magna		chloride	39.2 39.2	4.6 4.6	2726 2053	3401.8 2561.9	
Cladoceran, Daphnia magna	-,-	Sodium chloride	---	---	1008k 3319m	------ ------	Cowgill 1987
Cladoceran, Daphnia magna	S,U	Sodium chloride	108.7	13	<2548	<2785.1	Anderson 1946
Cladoceran, Daphnia magna	S,U	Sodium chloride	108.7	13	2232i	2439.7	Anderson 1948
Cladoceran, Daphnia magna	S,U	Sodium chloride	41.5	31.2	3563	5068.2	Dowden and Bennett 1965
Cladoceran, Daphnia magna	S,M	Sodium chloride	45.3	3.9v	2529a,f 2806b,f	3025.9 3357.4	Biesinger and Christensen 1972
Cladoceran, Daphnia magna	S,U	Sodium chloride	169.5	162.7	>2669 <3943d	>3214.2 <4748.4	Seymour et al. 1997
Cladoceran, Daphnia magna	S,U	Sodium chloride	46	3.9v	1880	2242.3	USEPA 1991
Cladoceran, Daphnia magna	S,U	Sodium chloride	169.5	162.7	3944c	4749.6	WISLOH 2007
Cladoceran, Daphnia magna	S,U	Sodium chloride	84.8	81.4	3009e	3968.5	Valenti et al. 2007
Cladoceran, Daphnia magna	S,U	Sodium chloride	106	102	3136 3222 3137	4017.4 4127.5 4018.6	Davies and Hall 2007

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Cladoceran, Daphnia pulex	S,M	Sodium chloride	84.8	81.4	1470	1938.8	Birge et al. 1985
Cladoceran, Daphnia pulex	S,U	Sodium chloride	84.8 84.8 84.8 84.8	81.4 81.4 81.4 81.4	1159 1775 1805 2242	1528.6 2341.0 2380.6 2956.9	Palmer et al. 2004
Copepod, Diaptomus clavipes	S,M	Sodium chloride	22	15	2571h	3946.1	Clemens and Jones 1954
Isopod, Asellus communis	S,U	Sodium chloride	100 20	---- ----	5004 3094	------ ------	Wurtz and Bridges 1961
Isopod, Lirceus fontinalis	F,M	Sodium chloride	84.8	81.4	2950	3890.7	Birge et al. 1985
Amphipod, Hyalella azteca	S,U	Sodium chloride	102.5	98.4	3947	5077.7	Lasier et al. 1997
Amphipod, Gammarus pseudolimnaeus	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Amphipod, Crangonyx sp.	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Crayfish, Cambarus sp.	S,M	Sodium chloride	22	15	10557h	16203.2	Clemens and Jones 1954
Dragonfly, Libellulidae	S,M	Sodium chloride	22	15	9671h	14843.4	Clemens and Jones 1954
Damselfly,	S,U	Sodium	100	----	14558	------	Wurtz and Bridges 1961

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Agria sp.		chloride	20	----	13952	------	
Stonefly, Nemoura trispinosa	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Caddisfly, Lepidostoma sp.	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Caddisfly, Parapsyche sp.	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Midge, Chironomus attenuatus	S,U	Sodium chloride	----	----	4850	------	Thornton and Sauer 1972
American eel, Anquilla rostrata	S,U	Sodium chloride	42.4	40.7	10846	15667.3	Hinton and Eversole 1978
American eel, Anquilla rostrata	S,U	Sodium chloride	42.4	40.7	13012	18796.2	Hinton and Eversole 1979
Goldfish, Carassius auratus	S,M	Sodium chloride	148.8	----	9465	------	Threader and Houston 1983
Red shiner, Notropis lutrensis	S,M	Sodium chloride	22	15	5771g 5920g	8857.5 9086.2	Clemens and Jones 1954
Fathead minnow, Pimephales promelas	S,U	Sodium chloride	39.2 39.2 339.0	4.6 4.6 325.4	2790 2123 2244	3481.7 2649.3 2467.3	USEPA 1991
Fathead minnow, Pimephales promelas	F,M	Sodium chloride	84.8	81.4	6570	8665.1	Birge et al. 1985

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Fathead minnow, Pimephales promelas	S,M	Sodium chloride	22	15	5288g 5431g	8116.2 8335.7	Clemens and Jones 1954
Fathead minnow, Pimephales promelas	S,U	Sodium chloride	84.8	81.4	3876br	5112.0	Mount et al. 1997
Fathead minnow, Pimephales promelas	S,U	Sodium chloride	84.8 169.5	81.4 162.7	4167c 4127c	5495.8 4970.0	WISLOH 2007
Black bullhead, Ameiurus melas	S,M	Sodium chloride	22	15	4849g	7442.4	Clemens and Jones 1954
Rainbow trout, Oncorhynchus mykiss	S,U	Sodium chloride	22.4	----	>485j	------	Camargo and Tarazona 1991
Rainbow trout, Oncorhynchus mykiss	F,M	Sodium chloride	46	3.9v	6743	8042.6	Spehar 1986,1987
Rainbow trout, Oncorhynchus mykiss	R,U	Sodium chloride	284	----	12363	------	Vosyliene et al. 2006
Brown trout, Salmo trutta	S,U	Sodium chloride	22.4	----	>607j	------	Camargo and Tarazona 1991
Plains killifish, Fundulus kansae	S,M	Sodium chloride	22	15	9706g	14897.1	Clemens and Jones 1954
Mosquitofish, Gambusia affinis	S,M	Sodium chloride	22	15	6472g	9933.4	Clemens and Jones 1954
Mosquitofish, Gambusia affinis	S,U	Sodium chloride	----	14.9	9099	------	Al-Daham and Bhatti 1977

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Threespine stickleback, Gasterosteus aculeatus	R,M	Sodium chloride	84.8	81.4	10200b	13452.6	Garibay and Hall 2004
Green sunfish, Lepomis cyanellus	S,M	Sodium chloride	22	15	6499g	9974.9	Clemens and Jones 1954
Bluegill, Lepomis macrochirus	F,M	Sodium chloride	84.8	81.4	5840	7702.3	Birge et al. 1985
Bluegill (3.7 g), Lepomis macrochirus	S,U	Sodium chloride	44.3	15.5	7853	10461.6	Academy of Natural Sciences 1960; Patrick et al. 1968; Trama 1954
Chorus frog, Pseudacris sp.	R,M	Sodium chloride	84.8	81.4	3553	4686.0	Garibay and Hall 2004

a = not fed. (All tests not marked "a" or "b" were unfed tests.)
b = fed.
c = mean of at least 15 LC50s.
d = range of several toxicity tests.
e = mean of 32 tests.
f = not used because there is reason to suspect that the daphnids might have been unhealthy.
g = tables 4, 7, and 9, except for tests at 28C in table 4.
h = tables 8 and 11; Daphnia pulex tests were not used because test duration was 96 hr.
i = test duration was 64 hr.
j = no deaths in 196 hr.
k = selenium deficient.
m = selenium sufficient.
p = not used in calculation of GMAV because the species is unknown and so it is not known how to combine this acute value with the acute values for which the species are known.
q = calculated using the formula for reconstituted water and the reported average measured hardness.
r = concentrations were measured in stock solutions.
s = not acclimated to the dilution water.

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t = might not have been acclimated to the dilution water.
v = based on analyses of samples of Lake Superior water taken in the spring and fall of 2008.

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Supplementary information concerning the results of toxicity tests on chloride

1. The atomic weights used are those given on the website of the National Institute of Standards and Technology:
   - Calcium = 40.078
   - Carbon = 12.011
   - Chlorine = 35.453
   - Hydrogen = 1.008
   - Iron = 55.845
   - Magnesium = 24.305
   - Nitrogen = 14.007
   - Oxygen = 15.999
   - Potassium = 39.098
   - Sodium = 22.990
   - Sulfur = 32.065

2. The molecular weights used are:
   - $CaCl_2$ = 110.984 (63.89 % chloride) (36.11 % calcium) (Cl/Ca = 1.769)
   - $CaCl_2 \cdot 2H_2O$ = 147.014 (27.26 % calcium) (48.23 % chloride)
   - $CaCO_3$ = 100.086 (40.04 % calcium)
   - CaO = 56.077 (71.47 % calcium)
   - $Ca(NO_3)_2$ = 164.086 (24.42 % calcium)
   - $Ca(NO_3)_2 \cdot 4H_2O$ = 236.146 (16.97 % calcium)
   - $CaSO_3$ = 136.139 (70.56 % sulfate)
   - $CaSO_4 \cdot 2H_2O$ = 172.169 (55.79 % sulfate) (23.28 % calcium) (20.93 % water)
   - $FeCl_3 \cdot 6H_2O$ = 270.294 (39.35 % chloride)
   - H_2O = 18.015
   - KCl = 74.551 (47.56 % chloride) (52.44 % potassium) (Cl/K = 0.9068)
   - K_2SO_4 = 174.257 (55.13 % sulfate)
   - $MgCl_2$ = 95.211 (74.47 % chloride) (25.53 % magnesium) (Cl/Mg = 2.917)
   - $MgSO_4$ = 120.366 (79.81 % sulfate) (20.19 % magnesium)
   - $MgSO_4 \cdot 7H_2O$ = 246.471 (38.97 % sulfate) (9.86 % magnesium)
   - NaCl = 58.443 (60.66 % chloride) (39.34 % sodium) (Cl/Na = 1.542)
   - Na_2SO_4 = 142.041 (67.63 % sulfate)

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$Na_2SO_4 \cdot 10H_2O = 322.191$ (29.81 % sulfate)
$SO_4 = 96.061$

3. Hardness (as $CaCO_3$) = (100.086/40.078)(Ca) + (100.086/24.305)(Mg) = 2.497(Ca) + 4.118(Mg)

4. Trama (1954), Cairns and Scheier (1959), Academy of Natural Sciences (1960), and Patrick et al. (1968) all reported results of toxicity tests that were performed at the Academy of Natural Sciences of Philadelphia with the bluegill in dilution waters that were very similar:

	mg/L
KCl	20
Na_2SiO_3	20
$NaHCO_3$	40
$MgSO_4 \cdot 7H_2O$	40
$Ca(NO_3)_2$	30*
$CaCO_3$	10
K_2HPO_4	10 or 2
Fe^{+++} (as ferric citrate)	4 or 0.4

Ca = 11.3 mg/L
Mg = 3.9 mg/L
Hardness = 44.3 mg/L as $CaCO_3$
Chloride = 9.5 mg/L
Sulfate = 15.5 mg/L

*Long after the tests of concern were performed, this was reported to be 40 mg/L of $Ca(NO_3)_2 \cdot 4H_20$.

5. Freeman (1953), Freeman and Fowler (1953), Fairchild (1955), Dowden (1960), Dowden (1962), and Dowden and Bennett (1965) all contained information regarding toxicity tests performed at Louisiana State University in Baton Rouge, but several different dilution waters were used. Dowden and Bennett (1965) tried to clarify the most important dilution waters used, but the citations given for the waters on page 1310 need to be clarified. Reference 4 is the correct citation for "Standard Reference Water" (SRW), but the correct citation for "Reference Dilution Water" (RDW) is reference 6 (not reference 3) and reference 3 should be cited for "glass-wool filtered University Lake Water (ULW). ULW is considered an unacceptable dilution water because it is from "a small drainpipe-fed lake on the campus of Louisiana State University" (Dowden 1960). The compositions of SRW and RDW are:

SRW	mg/L
$MgSO_4 \cdot 7H_2O$	71.

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K_2SO_4	6.5
$MnSO_4 \cdot 4H_2O$	0.2
$CaCl_2 \cdot 2H_2O$	18.6
$NaHCO_3$	25.
NH_4NO_3	3.
$K_2HPO_4 \cdot 3H_2O$	1.1
CaO	32.2
$Na_2SiO_3 \cdot 9H_2O$	62.6
$FeCl_3 \cdot 6H_2O$	1.2

Ca = 23.0 mg/L
Mg = 7.0 mg/L
Hardness = 86.2 mg/L as $CaCO_3$
Chloride = 9.4 mg/L
Sulfate = 31.2 mg/L

RDW	mg/L
$CaCl_2$	110
$NaHCO_3$	110
NaCl	100
$MgSO_4 \cdot 7H_2O$	60
KCl	20

Ca = 39.7 mg/L
Mg = 5.9 mg/L
Hardness = 123.4 mg/L as $CaCO_3$
Chloride = 140.4 mg/L
Sulfate = 23.4 mg/L

6. When known, the concentration of chloride in dilution water was negligible in tests on chloride.

7. Karraker (2007) says that "road salt" contains sodium chloride, sodium ferrocyanide, heavy metals, and often sand or cinder. Results of toxicity tests on "road salt" were not used.

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8. Hyalella azteca appears to be especially sensitive to some pollutants when the concentration of chloride is low, e.g., lower than 25 mg/L. This should not affect the sensitivity of this species to chloride.

9. Mount et al. (1997) reported that the toxicities of sodium and calcium salts to C. dubia, D. magna, and the fathead minnow are primarily attributable to the corresponding anion.

10. Some data presented in Table 1 of USEPA (1988) have been changed:
    a. Several values differ because of roundoff differences.
    b. USEPA (1988) used results of short acute tests for the reasons given on pages 2 and 3 (see also Lowell et al. 1995), but results of short tests are not used here because short acute tests sometimes give higher LC50s than standard tests.
    c. Data from Dowden (1961, which should be 1960) and Kostecki and Jones (1983) are not used here because of the dilution water used in the tests.
    d. The test results from Trama (1954) are also given in Academy of Natural Sciences (1960) and Patrick et al. (1968).
    e. Hamilton et al. (1975) did not adequately acclimate the midges.
    f. Fed acute tests were not used in USEPA (1988), but fed acute tests are used here and are given preference over unfed acute tests when the test organisms are cladocerans.

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C. Stephan

Multiple Regression Equation for Chloride

Grizzle and Mauldin (1995; 24-hr tests using striped bass) and Lasier et al. (2006; 7-day survival tests using Ceriodaphnia dubia) reported that calcium and/or magnesium reduced the toxicity of chloride, whereas MacGregor et al. (1986) reported that the toxicity of NaCl was not significantly affected by hardness. Davies and Hall (2007) reported that the Ca-Mg ratio did not affect the toxicity of either NaCl or KCl to D. magna. Because of these incomplete and potentially conflicting reports, U.S. EPA hired the Great Lakes Environmental Center (GLEC) and the Illinois Natural History Survey (INHS) to perform toxicity tests concerning the effect of hardness and sulfate on the toxicity of chloride to selected aquatic animals.

The equations presented in Figures 1 through 7 of the GLEC and INHS (2008) report can be used to make the aquatic life criterion for chloride dependent on both hardness and sulfate. However, although the LC50s used in Figures 1 through 7 are based on measured concentrations of chloride, the hardnesses and the concentrations of sulfate are nominal, not measured, values. Nevertheless, for Ceriodaphnia dubia Figure 3 shows that a log-log plot gives a straighter line than the plots given in Figures 1 and 2. A straight line fits the sulfate data in Figures 4, 5, and 6 equally well. Because a log-log plot will be used for the hardness data, a log-log plot will be used for the sulfate data.

Figure 7 gives log-log hardness equations for three other species, based on nominal hardnesses. The intercepts of the four log-log hardness equations differ because the species have different sensitivities. For the purpose of making a chloride criterion dependent on hardness, the important differences between the four equations are the exponents.

C. dubia	0.2144
S. simile	0.286
G. parvus	-0.0164
T. tubifex	0.245

The exponent for C. dubia is based on seven LC50s from GLEC and seven LC50s from INHS, whereas each of the other exponents is based on two LC50s from one laboratory. In addition, the exponent for C. dubia is close to the mean of the other three exponents. Therefore, it seems reasonable to set the chloride hardness exponent equal to the chloride hardness exponent obtained with C. dubia.

Multiple regression was performed on the data presented on pages 29 and 36 of GLEC and INHS (2008) concerning the effects of hardness and sulfate on the toxicity of chloride to C. dubia. The analysis was performed using the natural logs of the hardnesses, concentrations of sulfate, and LC50s and using the assumption that the effects of hardness and sulfate on the toxicity of chloride are proportional effects, not additive effects. The following hardnesses, concentrations of sulfate, and LC50s were used:

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Hardness	Sulfate	LC50
30	78.7	947
44	75.9	955
96	73.7	1130
180	67.7	1609
400	78.7	1491
570	76.2	1907
800	75.5	1764
25	69.9	1007
49	67.8	767
95	70.3	1369
194	69.9	1195
375	68.9	1687
560	68.3	1652
792	70.9	1909
280	28.1	1400
280	59.6	1720
280	117	1394
280	239	1500
280	482	1109
280	729	1206
279	22.9	1311
276	49.7	1258
283	107	1240
281	229	1214
290	461	1199
278	694	1179

The resulting equation for C. dubia is:

$$LC50 = (616.67 \text{ mg chloride/L})(\text{hardness})^{0.205797}(\text{sulfate})^{0.07452}$$

where the units are:

LC50: mg chloride/L
hardness: mg $CaCO_3$/L
sulfate: mg sulfate/L.

As noted above, the C. dubia data concerning the effect of hardness on the chloride LC50 are supported by data in GLEC and INHS (2008) for three other species: a fingernail clam (Sphaerium simile), a tubificid worm (Tubifex tubifex), and a snail (Gryaulus parvus). However, no data for other species were presented in GLEC and INHS (2008) supporting the C. dubia data concerning the effect of sulfate on the chloride LC50.

WISLOH (2007) and USEPA (1991) present the following chloride LC50s in low-hardness, low-sulfate dilution water and in high-hardness, high-sulfate dilution water for C. dubia and for the fathead minnow (see "Summary of Data concerning the Acute Toxicity of Sodium Chloride to Aquatic Animals" dated 1-15-09):

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Species	Hardness (mg/L)	Sulfate (mg/L)	Acute Value (mg Cl/L)	Reference
Cladoceran	39.2	4.6	1395	USEPA 1991
C. dubia	39.2	4.6	1638	
	39.2	4.6	1274	
	39.2	4.6	1395	
	339.0	325.4	1698	
Cladoceran	84.8	81.4	1677	WISLOH 2007
C. dubia	169.5	162.7	1499	
Fathead minnow	39.2	4.6	2790	USEPA 1991
P. promelas	39.2	4.6	2123	
	339.0	325.4	2244	
Fathead minnow	84.8	81.4	4167	WISLOH 2007
P. promelas	169.5	162.7	4127	

To facilitate use of these data, geometric mean LC50s were calculated from replicate LC50s.

If the multiple-regression equation based on the C. dubia data in GLEC and INHS (2008) is used to adjust the low-hardness, low-sulfate LC50 to the corresponding high hardness and high concentration of sulfate, the results are:

	Predicted LC50	Measured LC50	M - P*	Percent Difference**
C. dubia				
WISLOH (2007):	1837	1499	-338	-20.3%
USEPA (1991):	1612	1698	+ 86	5.2%
Fathead minnow				
WISLOH (2007):	4563	4127	-436	-10.0%
USEPA (1991):	2762	2244	-518	-20.7%

* M - P = (Measured LC50) - (Predicted LC50)

** Percent Difference = 100 (Measured - Predicted)/([Measured + Predicted]/2)

Each predicted LC50 is within a factor of two of the corresponding measured LC50 and so all four differences could be due to experimental variation. However, three of the four differences are in the same direction and the difference in the other direction is smaller.

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There is a more direct way to relate the WISLOH (2007) and USEPA (1991) data for C. dubia and the fathead minnow to the multiple-regression equation. The relationship regarding the effect of hardness on the chloride LC50 is supported by data for four species, so it is reasonable to use this relationship to adjust the low-hardness LC50 to the high hardness. Because the low-hardness LC50 is at low sulfate, the predicted high-hardness LC50 is also at low sulfate. Therefore, the predicted high hardness, low sulfate LC50 and the measured high hardness, high sulfate LC50 can be used to calculate an exponent for sulfate. (An exponent in an arithmetic equation is a slope in a log-log plot.) The resulting sulfate exponents are:

C. dubia
WISLOH (2007): sulfate exponent = -0.368
USEPA (1991): sulfate exponent = -0.062

Fathead minnow
WISLOH (2007): sulfate exponent = -0.220
USEPA (1991): sulfate exponent = -0.123

The sulfate exponent from the multiple-regression analysis of the GLEC and INHS (2008) C. dubia data was -0.07452. This is in the range of the new C. dubia exponents, but is substantially lower than one of the new C. dubia exponents and is lower than both of the new fathead minnow exponents; the mean of the four new exponents is -0.193. Charlie Delos and Chuck Stephan interpret these exponents to mean that WISLOH (2007) and USEPA (1991) provide data for both C. dubia and the fathead minnow that support the concepts that (i) 0.205797 is a reasonable value for the hardness exponent, (ii) an increase in the concentration of sulfate causes a decrease in the chloride LC50 and (iii) the sulfate exponent might be more negative than indicated by the GLEC and INHS (2008) data.

The above calculations use multiple regression; covariance analysis is not used for several reasons. Data are available for C. dubia from two labs whereas data are available for the other three species from only one lab. Covariance analysis would do a good job of weighting the data by species, but it is not clear that it would do a good job of taking into account the fact that data for C. dubia are available from two labs. Also, many more data points are available for C. dubia than for all of the other species combined, so covariance analysis would give much more weight to C. dubia than to the other three species, which is what the above calculations do. Further, the exponent for C. dubia is close to the mean of the exponents for the other three species. For these reasons it is likely that covariance analysis would give a pooled exponent that is close to the exponent for C. dubia. In addition, data concerning sulfate are available only for C. dubia, so it seems desirable to do multiple regression of the C. dubia data rather than doing covariance analysis of the hardness data and then trying to find a way to integrate the sulfate exponent with the hardness exponent. It is possible that multiple regression and covariance analysis could be used together, but a better approach might be to use GLM or GLiM. However, it is possible that the available data do not satisfy the assumptions of any of these techniques.

Calculation of Aquatic Life Criteria for Chloride

These calculations are based on "Summary of Data Concerning the Acute Toxicity of Sodium Chloride to Aquatic Animals" dated 1-15-09 and "Summary of Data Concerning the Chronic Toxicity of Sodium Chloride to Aquatic Animals" dated 1-15-09. Except as noted (for example, see footnote a), these calculations are consistent with the 1985 Guidelines. GMAVs and SMAVs are normalized to hardness = 300 mg/L and sulfate = 65 mg/L. GMAVs and SMAVs are expressed as mg chloride/L.

Rank*	GMAV	Genus	Species	SMAV	SMACR
	-----	Agria	Damselfly, Agria sp.	-----	
23	17161	Anquilla	American eel, Anquilla rostrata	17160.6	
	16203	Cambarus	Crayfish, Cambarus sp.	16203.2	
	14897	Fundulus	Plains killifish, Fundulus kansae	14897.1	
	14843	Libellulidae**	Dragonfly, Libellulidae	14843.4	
	13453	Gasterosteus	Threespine stickleback, Gasterosteus aculeatus	13452.6	
	-----	Carassius	Goldfish, Carassius auratus	-----	
	9933	Gambusia	Mosquitofish,	9933.4	

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		Gambusia affinis		
9157	Lepomis	Green sunfish, Lepomis cyanellus	9974.9	
		Bluegill, Lepomis macrochirus	8406.5c	
8971	Notropis	Red shiner, Notropis lutrensis	8971.1	
8043	Oncorhynchus	Rainbow trout, Oncorhynchus mykiss	8042.6	7.308
-----	Chironomus	Midge, Chironomus attenuatus	-----	
7442	Ameiurus	Black bullhead, Ameiurus melas	7442.4	
-----	Erpobdella	Leech, Erpobdella punctata	----	
6515	Pimephales	Fathead minnow, Pimephales promelas	6515.3f	15.17h
6219	Tubifex	Tubificid worm, Tubifex tubifex	6218.6	
5078	Hyalella	Amphipod, Hyalella azteca	5077.7	
-----	Asellus	Isopod,	-----	

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		Asellus communis	
-----	Limnodrilus	Tubificid worm, Limnodrilus hoffmeisteri	-----
-----	Helisoma	Snail, Helisoma campanulata	-----
4686	Pseudacris	Chorus frog, Pseudacris sp.	4686.0
-----	Gammarus	Amphipod, Gammarus pseudolimnaeus	-----
-----	Crangonyx	Amphipod, Crangonyx sp.	-----
-----	Nemoura	Stonefly, Nemoura trispinosa	-----
-----	Lepidostoma	Caddisfly, Lepidostoma sp.	-----
-----	Parapsyche	Caddisfly, Parapsyche sp.	-----
3946	Diaptomus	Copepod, Diaptomus clavipes	3946.1
3891	Lirceus	Isopod, Lirceus fontinalis	3890.7
3728	Gyraulus	Snail,	-----

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			Gyraulus circumstriatus		
			Snail, Gyraulus parvus	3727.7	
	3350	Physa	Snail, Physa gyrina	3350.0	
			Snail, Physa heterostropha	-----	
	3086	Villosa	Mussel, Villosa delumbis	3821.1	
			Mussel, Villosa iris	2491.6	
4	2835	Lampsilis	Mussel, Lampsilis fasciola	2907.1	
			Mussel, Lampsilis siliquoidea	2764.4	
3	2326	Daphnia	Cladoceran, Daphnia ambigua	1649.7	4.148
			Cladoceran, Daphnia magna	3773.1d	1.974
			Cladoceran, Daphnia pulex	2020.5g	3.952
2	1542	Ceriodaphnia	Cladoceran,	1542.3c	>2.470i

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			Ceriodaphnia dubia	
1	1128	Sphaerium	Fingernail clam, Sphaerium simile	1127.9
			Fingernail clam, Sphaerium tenue	-----

* A "greater than" acute value for the brown trout (Salmo trutta) is not in this table because it is too low to be a useful "greater than" value.
** Name of family, not name of genus.

a. Section IV.I of the 1985 Guidelines says: "For each species for which at least one acute value is available, the Species Mean Acute Value should be calculated as the geometric mean of the results of all flow-through tests in which the concentrations of test material were measured. For a species for which no such result is available, the SMAV should be calculated as the geometric mean of all available acute values, i.e., results of flow-through tests in which the concentrations were not measured and results of static and renewal tests based on initial concentrations (nominal concentrations are acceptable for most test materials if measured concentrations are not available) of test material." The guidance presented in section IV.I of the 1985 Guidelines seems inappropriate for chloride because chloride is different from most pollutants for which aquatic life criteria are derived. Chloride is very soluble in water, does not oxidize or reduce, is not volatile, does not degrade, does not sorb to test chambers, test organisms, food, or waste products, is not complexed by materials that commonly occur in water, is not involved in a pH-dependent equilibrium in water, and does not precipitate in waters in which aquatic organisms commonly occur.
   i. For chloride, as long as the concentration of dissolved oxygen is sufficiently high, it seems appropriate to give static and renewal acute tests the same weight as flow-through acute tests in the derivation of the SMAV for a species.
   ii. For chloride, it seems inappropriate to give measured acute tests a weight of 1 and unmeasured acute tests a weight of 0 when both are available for the derivation of the SMAV for a species. For example, if there is a choice between one measured acute test on chloride and three unmeasured acute tests in three different laboratories, the three tests are probably preferable to the one test, but if the choice is between one measured acute test and two unmeasured acute tests in two different laboratories, the one test is probably preferable. Thus, for a species for which both measured and unmeasured acute tests are available for chloride, it seems appropriate to give measured acute tests a weight of 2.5 and unmeasured acute tests a weight of 1 when the SMAV is calculated.

   The conclusions described above concerning chloride were developed during discussions among Charles Delos, Charles Stephan, and Glen Thursby. For other pollutants, different conclusions concerning the relative merits of static, renewal, and flow-through acute toxicity tests and the relative merits of measured and unmeasured acute toxicity tests are likely to be more appropriate.

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b. For Ceriodaphnia dubia, the acute values from Hoke et al. (1992) are considered outliers. The geometric mean is 1468.1 for Mount et al. (1997), 1790.2 for U.S. EPA (1991), 1998.2 for WISLOH (2007), and 1457.3 for GLEC and INHS (2008).
SMAV = antilog ([log 1468.1 + log 1790.2 + log 1998.2 + log 1863.6 + 2.5(log 1311.1) + 2.5(log 1457.3)]/9) = 1542.3.

c. For Daphnia magna, the values of 3815.5 (Mount et al. 1997), <2785.1, (Anderson 1946), 2439.7 (Anderson 1948), and 3025.9 and 3357.4 (Biesinger and Christensen 1972) were not used. A geometric mean of 3906.7 was calculated from the limits given by Seymour et al. (1997). The geometric mean is 3208.8 for Hoke et al. (1992) and is 4054.2 for Davies and Hall (2007). The SMAV is 3773.1, which is the geometric mean of 3208.8, 5068.2, 3906.7, 2242.3, 4749.6, 3968.5, and 4054.2.

d. Bluegill: SMAV = antilog ([2.5(log 7702.3) + log 10461.6]/3.5) = 8406.5.

e. Fathead minnow: SMAV = antilog([log 2833.9 + 2.5(log 8665.1) + 2.5(log 8225.2) + log 5112.0 + log 5226.3]/8) = 6515.3.

f. Daphnia pulex: SMAV = antilog([2.5(log 1938.8) + log 2240.3]/3.5) = 2020.5.

g. Not used in calculations because, even though the acute and chronic tests were in the same document, different dilution waters were used in the tests.

h. The SMACR for Ceriodaphnia dubia is the geometric mean of 1.508, >3.841, and 2.601.

FAV = 1205 mg chloride/L

CMC = FAV/2 = 602.5 mg chloride/L

The five SMACRs (7.308, 4.148, 1.974, 3.952, and >2.438) that are available for use in calculations result in three GMACRs:

7.308	Oncorhynchus
3.187	Daphnia
>2.470	Ceriodaphnia

The 1985 Guidelines require ACRs for species in three different families, but Daphnia and Ceriodaphnia are in the same family. However, even though the ACR for the fathead minnow should not be used in calculations because the acute and chronic tests using the fathead minnow were

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performed in different dilution waters, the fathead minnow ACR can be considered a qualitative ACR and used to satisfy the MDRs because chloride is not likely to be complexed or sorbed or detoxified by organic or inorganic constituents of the dilution water.

The GMACRs for Oncorhynchus and Daphnia are consistent with the "greater than" GMACR for Ceriodaphnia and the GMACRs are within a factor of ten. Therefore, the Final ACR = 4.826, which is the geometric mean of the GMARCs for Oncorhynchus and Daphnia. This would give FCV = FAV/FACR = (1205 mg chloride/L)/4.826 = 249.7 mg chloride/L. However, this approach is contraindicated because the GMACRs (including the unused GMACR for Pimephales) indicate that the GMACR increases as the GMAV increases.

The GMACR for Daphnia is consistent with the "greater than" GMACR for Ceriodaphnia, so the GMACR for Daphnia can be used as the FACR. Therefore, FACR = 3.187 and FCV = FAV/FACR = (1205 mg chloride/L)/3.187 = 378.1 mg chloride/L.

CCC = FCV = 378.1 mg chloride/L.

The CMC and CCC given above are for hardness = 300 mg/L and sulfate = 65 mg/L. The equation that was used to normalize the acute values can be used to make the CMC and CCC dependent on hardness and sulfate. The resulting equations for the CMC and CCC are:

$$CMC = (602.5 \text{ mg chloride/L})\,(\text{hardness}/300)^{0.205797}\,(\text{sulfate}/65)^{-0.07452}$$
$$= (254.3 \text{ mg chloride/L})\,(\text{hardness})^{0.205797}\,(\text{sulfate})^{-0.07452}$$

At hardness = 300 mg/L and sulfate = 65 mg/L, CMC = 602.5 mg chloride/L.

$$CCC = (378.1 \text{ mg chloride/L})\,(\text{hardness}/300)^{0.205797}\,(\text{sulfate}/65)^{-0.07452}$$
$$= (159.6 \text{ mg chloride/L})\,(\text{hardness})^{0.205797}\,(\text{sulfate})^{-0.07452}$$

At hardness = 300 mg/L and sulfate = 65 mg/L, CCC = 378.1 mg chloride/L.

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Derivation of an Alternative FCV

Even though the above derivation of FCV = 378.1 mg chloride /L follows the procedure described in the 1985 Guidelines, there is an alternative approach that is justified on the basis of the "good science" clause in section XII.B of the 1985 Guidelines. This approach is based on the fact that the four low SMACRs for chloride were obtained with invertebrates, whereas the high SMACR was obtained with a vertebrate. This can be interpreted to mean that vertebrates have a higher ACR, on the average, than invertebrates, especially because the qualitative ACR for the fathead minnow is 15.17. Therefore, a vertebrate ACR and an invertebrate ACR can be used with the GMAVs to calculate a predicted Genus Mean Chronic Value for each genus, and then a FCV can be calculated directly from the predicted GMCVs. This approach calculates and uses a predicted chronic value for each genus for which an acute value is available and probably does a better job of taking into account the chronic sensitivities of both vertebrates and invertebrates to chloride. The relevant data and calculations are presented on the next few pages.

The FACR of 3.187 derived above was derived from all of the acceptable ACRs for invertebrates. The only acceptable ACR for a vertebrate is 7.308. A predicted GMCV can be calculated from each GMAV by using 3.187 as the invertebrate ACR and using 7.308 as the vertebrate ACR.

Table of predicted GMCVs for Chloride

(GMAVs and pGMCVs are expressed as mg chloride/L)
(ranked according to predicted GMCVs)

Rank	GMAV	Genus	Species	pGMCV
	-----	Agria	Damselfly, Agria sp.	-----
23	16203	Cambarus	Crayfish, Cambarus sp.	5084
	14843	Libellulidae*	Dragonfly, Libellulidae	4657

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17161	Anquilla	American eel, Anquilla rostrata	2348
6219	Tubifex	Tubificid worm, Tubifex tubifex	1951
-----	Chironomus	Midge, Chironomus attenuatus	-----
-----	Erpobdella	Leech, Erpobdella punctata	-----
13453	Gasterosteus	Threespine stickleback, Gasterosteus aculeatus	1841
14897	Fundulus	Plains killifish, Fundulus kansae	2038
-----	Carassius	Goldfish, Carassius auratus	-----
5078	Hyalella	Amphipod, Hyalella azteca	1593
----	Asellus	Isopod, Asellus communis	-----
-----	Limnodrilus	Tubificid worm, Limnodrilus hoffmeisteri	-----
-----	Helisoma	Snail, Helisoma campanulata	-----

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8043	Oncorhynchus	Rainbow trout, Oncorhynchus mykiss	1101
9933	Gambusia	Mosquitofish, Gambusia affinis	1359
-----	Gammarus	Amphipod, Gammarus pseudolimnaeus	-----
-----	Crangonyx	Amphipod, Crangonyx sp.	-----
-----	Nemoura	Stonefly, Nemoura trispinosa	-----
-----	Lepidostoma	Caddisfly, Lepidostoma sp.	-----
-----	Parapsyche	Caddisfly, Parapsyche sp.	-----
3891	Lirceus	Isopod, Lirceus fontinalis	1221
9157	Lepomis	Green sunfish, Lepomis cyanellus	1253
		Bluegill, Lepomis macrochirus	
3350	Physa	Snail, Physa heterostropha	1051

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		Snail, Physa gyrina	
3946	Diaptomus	Copepod, Diaptomus clavipes	1238
3086	Villosa	Mussel, Villosa delumbis	968.3
		Mussel, Villosa iris	
8971	Notropis	Red shiner, Notropis lutrensis	1228
3728	Gyraulus	Snail, Gyraulus circumstriatus	1170
		Snail, Guraulus parvus	
2835	Lampsilis	Mussel, Lampsilis fasciola	889.6
		Mussel, Lampsilis siliquoidea	
7442	Ameiurus	Black bullhead, Ameiurus melas	1018
6515	Pimephales	Fathead minnow, Pimephales promelas	891.5

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4	2326	Daphnia	Cladoceran, Daphnia ambigua Cladoceran, Daphnia magna Cladoceran, Daphnia pulex	729.8
3	4686	Pseudacris	Chorus frog, Pseudacris sp.	641.2
2	1542	Ceriodaphnia	Cladoceran, Ceriodaphnia dubia	483.8
1	1128	Sphaerium	Fingernail clam, Sphaerium simile Fingernail clam, Sphaerium tenue	353.9

* Name of family, not name of genus.

FCV based on predicted GMCVs = 382.7 mg chloride/L at hardness = 300 mg/L and sulfate = 65 mg/L.

$$CCC = (382.7 \text{ mg chloride/L}) (\text{hardness}/300)^{0.205797} (\text{sulfate}/65)^{-0.07452}$$
$$= (161.5 \text{ mg chloride/L}) (\text{hardness})^{0.205797} (\text{sulfate})^{-0.07452}$$

At hardness = 300 mg/L and sulfate = 65 mg/L, CCC = 382.7 mg chloride/L.

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Environmental Toxicology

Acute toxicity of sodium chloride and potassium chloride to a unionid mussel (*Lampsilis siliquoidea*) in water exposures

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Cited by: 3

Abstract

Freshwater mussels (order Unionoida) are one of the most imperiled groups of animals in the world. However, many ambient water quality criteria and other environmental guideline values do not include data for freshwater mussels, in part because mussel toxicity test methods are comparatively new and data may not have been available when criteria and guidelines were derived. The objectives of the present study were to evaluate the acute toxicity of sodium chloride (NaCl) and potassium chloride (KCl) to larvae (glochidia) and/or juveniles of a unionid mussel (fatmucket, *Lampsilis siliquoidea*) and to determine the potential influences of water hardness (50, 100, 200, and 300 mg/L as $CaCO_3$) and other major ions (Ca, K, SO_4, or HCO_3) on the acute toxicity of NaCl to the mussels. From the KCl test, the 50% effect concentration (EC50) for fatmucket glochidia was 30 mg K/L, similar to or slightly lower than the EC50s for juvenile fatmucket (37–46 mg K/L) tested previously in our laboratory. From the NaCl tests, the EC50s for glochidia increased from 441 to 1597 mg Cl/L and the EC50s for juvenile mussels increased from 911 to 3092 mg Cl/L with increasing water hardness from 50 to 300 mg/L. Increasing K from 0.4 to 1.9 mg/L, SO_4 from 13 to 40 mg/L, or HCO_3 from 44 to 200 mg/L in the 50 mg/L hardness water did not substantially change the NaCl EC50s for juvenile mussels, whereas increasing Ca from 9.9 to 42 mg/L increased the EC50s by a factor of 2. The overall results indicate that glochidia were equally or more sensitive to NaCl and KCl compared with juvenile mussels and that the increased water hardness ameliorated the acute toxicity of NaCl to glochidia and juveniles. These responses rank fatmucket among the most acutely sensitive freshwater organisms to NaCl and KCl. *Environ Toxicol Chem* 2018;37:3041–3049. © 2018 SETAC. This article is a US government work and, as such, is in thepublic domain in the United States of America.

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Citing Literature

Number of times cited according to CrossRef: 3

John K. Jackson and David H. Funk, Temperature affects acute mayfly responses to elevated salinity: implications for toxicity of road de-icing salts, *Philosophical Transactions of the Royal Society B: Biological Sciences*, 10.1098/rstb.2018.0081, **374**, 1764, (20180081), (2018).
Crossref

Ning Wang, James L. Kunz, Rebecca A. Dorman, Christopher G. Ingersoll, Jeffery A. Steevens, Edward J. Hammer and Candice R. Bauer, Evaluation of chronic toxicity of sodium chloride or potassium chloride to a unionid mussel (Lampsilis siliquoidea) in water exposures using standard and refined toxicity testing methods, *Environmental Toxicology and Chemistry*, **37**, 12, (3050-3062), (2018).
Wiley Online Library

Ning Wang, James L. Kunz, Danielle Cleveland, Jeffery A. Steevens and Isabelle M. Cozzarelli, Biological Effects of Elevated Major Ions in Surface Water Contaminated by a Produced Water from Oil Production, *Archives of Environmental Contamination and Toxicology*, 10.1007/s00244-019-00610-3, (2019).
Crossref

Supporting Information

This article includes online-only Supplemental Data.

Filename	Description
etc4206-sup-0001-SuppData-S1.docx 69.2 KB	Supporting Data S1.

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Environmental Toxicology and Chemistry

Supplemental Data

EVALUATING CHRONIC TOXICITY OF SODIUM CHLORIDE OR POTASSIUM CHLORIDE TO A UNIONID MUSSEL (*LAMPSILIS SILIQUOIDEA*) IN WATER EXPOSURES USING STANDARD AND REFINED TOXICITY TESTING METHODS

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Table S1. Summary of test conditions for conducting chronic toxicity tests with fatmucket (*Lampsilis siliquoidea*) in basic accordance with ASTM (2017)

Parameter	Conditions
Test chemical	KCl or NaCl
Test type	Flow through
Test Duration	4, 8, or 12 weeks
Temperature	20°C (2012 NaCl test only) or 23°C (see text)
Light	Ambient laboratory light; about 500 lux; 16L:8D
Test chamber	300-ml beaker with 200 mL of water (5 ml of sand in exposures with sand; see text)
Water renewal	125 ml of additional water/4 h
Age of test organism	About 1-week, 1-month, or 2-month-old juveniles (see text)
Organisms/chamber	10
Replicates/conc.	4 or 8
Feeding	2 mL of algal mixture 2 to 6 times daily (see text)
Dilution water	Diluted well water (see text)
Test concentrations	5 concentrations plus control; 50% serial dilution (see text)
Chemical analyses	Water samples for Cl or K analyses at the beginning and end of the test and once every week (Cl) or once every 2 weeks (K)
Water quality	Dissolved oxygen, pH, conductivity, hardness, and alkalinity measured weekly in the control, medium, and/or high exposure concentrations. Major cations and anions in control waters measured periodically (see text)
Endpoint	Survival, length, dry weight, biomass
Test acceptability criteria	≥ 80% control survival

Table S2. Mean measured water quality characteristics (standard deviation in parenthesis)[a] in a chronic 4-week KCl test and 4 chronic 4- to 12-week NaCl toxicity tests with different ages of juvenile fatmucket (*Lampsilis siliquoidea*), feeding, and with or without a sand substrate

			Water quality						Major cations and anions (mg/L)						
Test	Test duration (week)	Sand	Number of samples	Dissolved oxygen (mg/L)	pH	Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)	Total ammonia (mg N/L)	Number of samples	Ca	K	Mg	Na	Cl	SO_4
2012 NaCl exposure started with 2-month-old juveniles and fed 2 mL of algal mixture 2 times daily															
Cl-1a[b]	4	No	24-30	8.9 (0.5)	8.2 (0.1)	105 (1.7)	91 (2.3)	0.05 (0.03)	2-3	26 (0.1)	1.1 (0.0)	9.3 (0.0)	13 (0.1)	11 (0.3)	18 (0.4)
Cl-1b[b]	4	Yes													
2013 KCl exposure started with 2-month-old juveniles and fed 2 mL of algal mixture 2 times daily															
K-1a[b]	4	No	17	8.1 (0.3)	8.3 (0.2)	105 (3.5)	94 (2.9)	0.07 (0.03)	1-3	26 (0.8)	1.1 (0.1)	9.2 (0.4)	10 (0.7)	12	18
K-1b[b]	4	Yes													
2014 NaCl exposure started with 2-month-old juveniles and fed 2 mL of algal mixture 6 times daily[c]															
Cl-2a	4	Yes	24-60	8.0 (0.5)	8.1 (0.2)	103 (2.7)	93 (2.6)	0.07 (0.05)	2-10	25 (0.1)	1.1 (0.1)	9.1 (0.1)	12 (0.1)	15 (1.1)	21 (0.0)
Cl-2b	8	Yes	39-108	7.8 (0.5)	8.1 (0.2)	103 (3.7)	95 (3.7)	0.09 (0.05)	4-18	25 (0.2)	1.1 (0.1)	9.0 (0.1)	12 (0.3)	15 (1.2)	20 (0.4)
Cl-2c	12	Yes	63-132	7.8 (0.5)	8.0 (0.2)	104 (4.6)	96 (3.5)	0.09 (0.05)	6-22	26 (0.3)	1.1 (0.1)	9.0 (0.1)	12 (0.4)	15 (1.2)	20 (0.9)
2015 NaCl exposure started with 1-month-old juveniles and fed 2 mL of algal mixture 6 times daily															
Cl-3	4	Yes	4-12	7.8 (0.1)	8.1 (0.1)	98 (1.6)	97 (2.5)	0.10 (0.02)	1	25	1.1	9.0	12	12	19
2015 NaCl exposure started with 1-week-old juveniles and fed 2 mL of algal mixture 6 times daily[c]															
Cl-4a	4	Yes	28-36	7.9 (0.2)	8.1 (0.1)	105 (4.3)	97 (4.5)	0.06 (0.02)	1-5	26	1.1	9.1	12	11 (0.9)	18
Cl-4b	12	Yes	65-79	7.8 (0.3)	8.0 (0.2)	103 (3.5)	96 (4.3)	0.08 (0.03)	2-12	25 (0.3)	1.1 (0.1)	9.0 (0.1)	12 (0.4)	15 (1.8)	18 (0.0)

[a] Water quality was measured in the control, medium, and high exposure concentrations. Major ions measured in the control water.

[b] Composite samples from replicate beakers with or without sand.

[c] Feeding rate was increased by 50% every 4 weeks.

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Table S3. Measured potassium concentrations, mean survival (standard deviation in parentheses), and 50% effect concentration (EC50) during the first 4 days of the 4-week KCl toxicity exposure started with 2-month-old juvenile fatmucket (*Lampsilis siliquoidea*)

Nominal (mg K/L)	Measured (mg K/L)	Survival (%; n=4)
Control	1.0	100 (0)
6.3	3.9	100 (0)
13	12	100 (0)
25	24	100 (0)
50	45	15 (5.8)
100	105	0 (0)
EC50 (95% confidence limits)		37 (34-40)[a]

[a] The data did not meet the requirements of the Gaussian distribution model (at least 2 partial responses) in the Toxicity Relationship Analysis Program (version 1.30a, Erickson 2015), Spearman-Karber method was used to determine the EC50 following the flowchart recommended by the USEPA (2002) using TOXSTAT® software (version 3.5, Western EcoSystems Technology).

References:

Erickson RJ. 2015. Toxicity Relationship Analysis Program (TRAP), Ver 1.30a. EPA/600/C-11/002. U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency. 2002. Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms, 5th ed. EPA-821-R-02-012. Office of Water, Washington, DC.

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Table S4. Mean measured water quality characteristics[a] (standard deviation in parenthesis) during the first 4 days of the chronic 4-week KCl toxicity test started with 2-month-old juvenile fatmucket (*Lampsilis siliquoidea*)[a]

Dissolved oxygen	pH	Hardness	Alkalinity	Major cation and anion (mg/L; n=1)					
(mg/L; n=6)	(n=6)	(mg/L as $CaCO_3$; n=6)		Ca	K	Mg	Na	Cl	SO_4
8.0 (0.1)	8.4 (0.1)	104 (2.6)	93 (1.0)	25	1.0	8.7	9	12	18

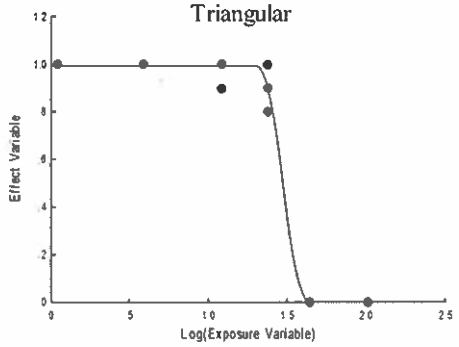
[a] Water quality was measured in the control, medium, and high exposure concentrations at the beginning and end of tests. Major ions were measured in the control water at the beginning of the test.

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Figure S1. Regressions of estimating 20% effect concentrations (EC20s; mg K/L) and 95% confidence limits for the responses of fatmucket (*Lampsilis siliquoidea*) in 4-week KCl water exposures with or without sand substrate in 2013. Each circle indicates the measured response in each of the 4 replicates, and the line represents the nonlinear regression fit. The EC20 and regression line are highlighted in red when insufficient data were available to support adequate analysis by Toxicity Relationship Analysis Program

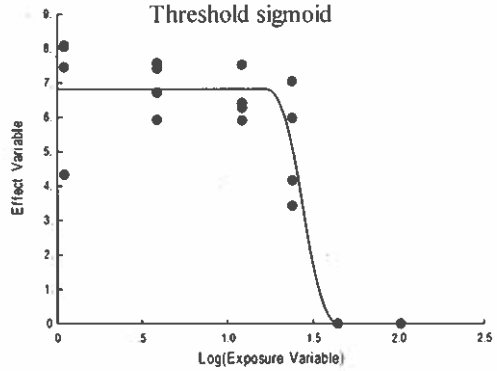
Exposure without sand

EC20 based on survival: 26 (no CL)



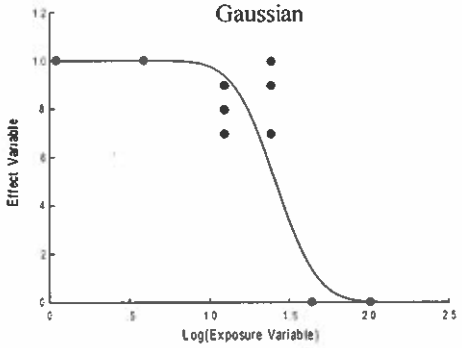
EC20 based on dry weight: NE
do not meet the conditions of any regression models.

EC20 based on biomass: 23 (21-26)

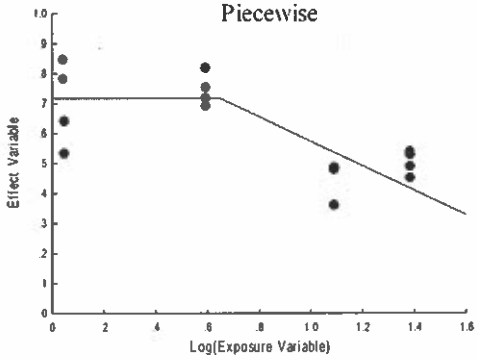


Exposure with sand

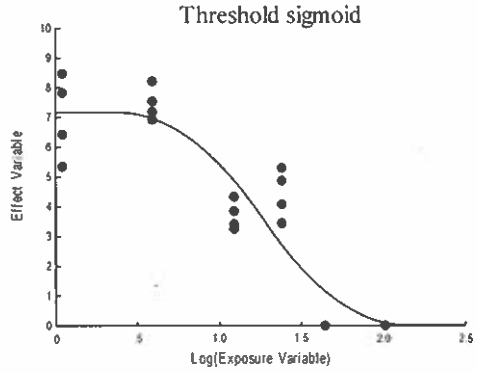
EC20 based on survival: 17 (16-18)



EC20 based on dry weight: 10 (3.9-25)



EC20 based on biomass: 8.7 (4.3-18)

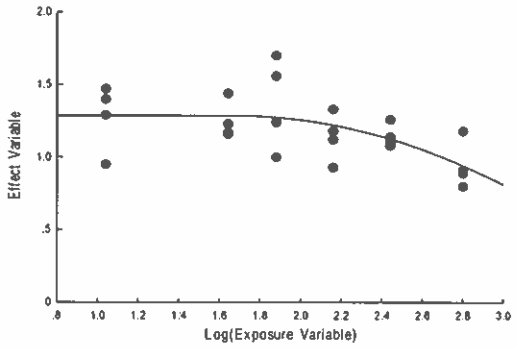


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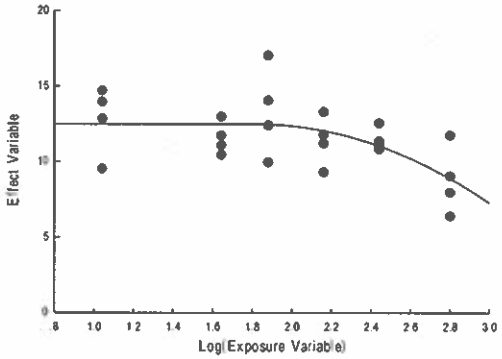
Figure S2. Regressions of estimating 20% effect concentrations (EC20s; mg Cl/L) and 95% confidence limits for the responses of fatmucket (*Lampsilis siliquoidea*) in 4-week NaCl test started with 2-month-old juveniles in water exposure with or without sand substrate in 2012. Each circle indicates the measured response in each of the 4 replicates, and the line represents the nonlinear regression (threshold sigmoidal) fit

Exposure without sand

EC20 based on dry weight: 445 (202-979)

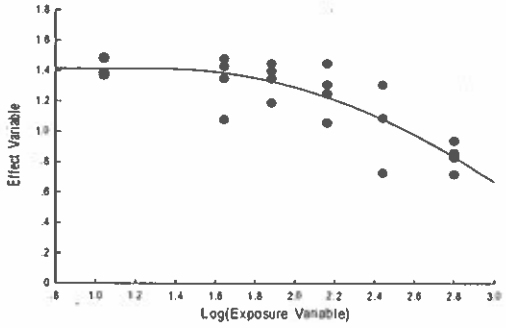


EC20 based on biomass: 437 (221-862)

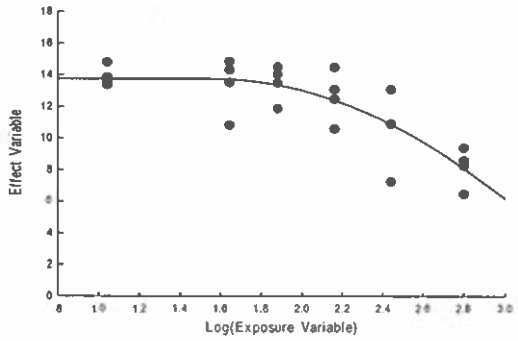


Exposure with sand

EC20 based on dry weight: 227 (117-442)



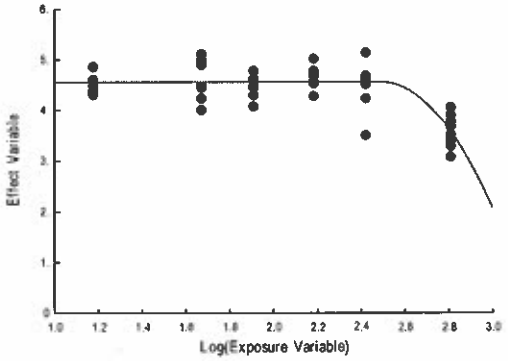
EC20 based on biomass: 264 (151-461)



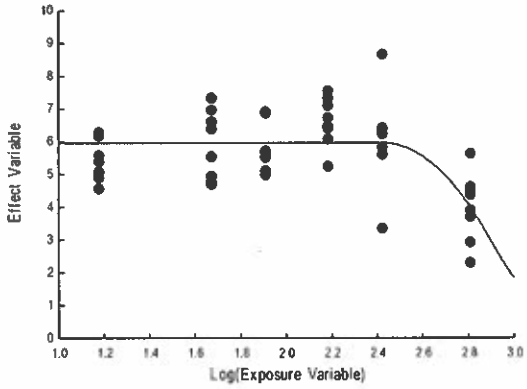
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Figure S3. Regressions of estimating 20% effect concentrations (EC20s; mg Cl/L) and 95% confidence limits for the responses of fatmucket (*Lampsilis siliquoidea*) in 12-week NaCl test started with 2-month-old juveniles in water exposure with sand substrate in 2014. Each circle indicates the measured response in each of the 8 replicates, and the line represents the nonlinear regression (threshold sigmoidal) fit. The EC20 and regression line are highlighted in red when insufficient data were available to support adequate analysis by Toxicity Relationship Analysis Program

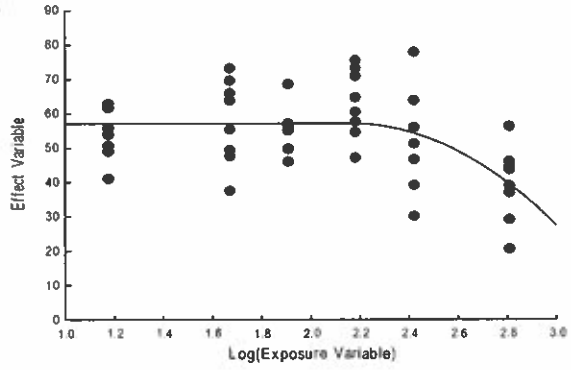
EC20 based on length: 628 (no CL)



EC20 based on dry weight: 527 (no CL)



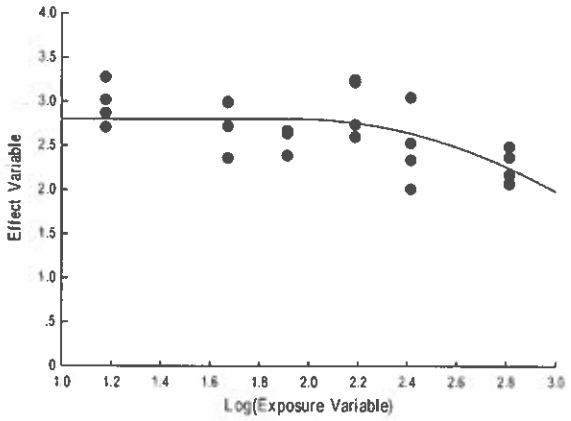
EC20 based on biomass: 482 (320-724)



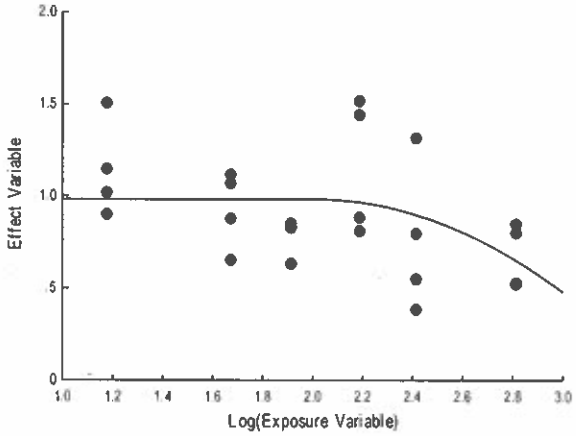
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Figure S4. Regressions of estimating 20% effect concentrations (EC20s; mg Cl/L) and 95% confidence limits for the responses of fatmucket (*Lampsilis siliquoidea*) in chronic 4-week NaCl test started with 1-month-old juveniles in water exposures with sand substrate in 2015. Each circle indicates the measured response in each of the 4 replicates, and the line represents the nonlinear regression (threshold sigmoidal) fit. The EC20 and regression line are displayed in red if insufficient data were available to support adequate analysis by Toxicity Relationship Analysis Program

EC20 based on length: 656 (348-1238)



EC20 based on dry weight: 425 (147-1231)



EC20 based on biomass: 403 (142-1145)

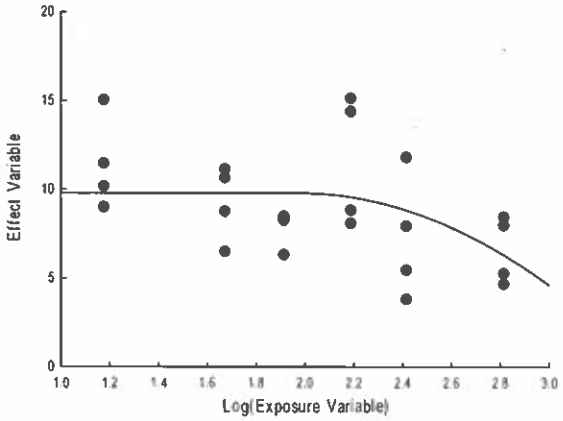
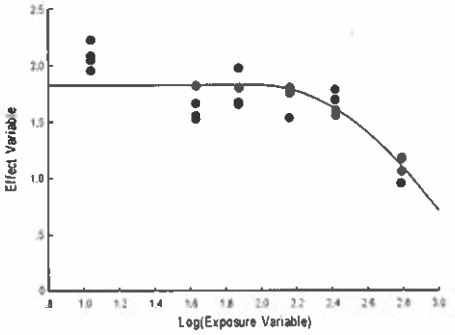


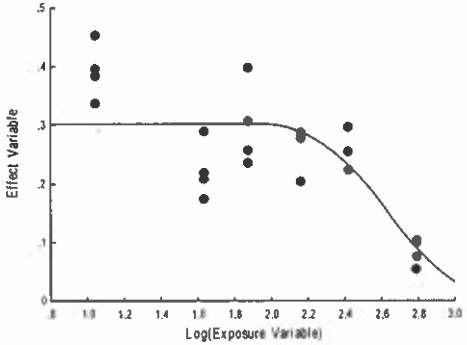
Figure S5. Regressions of estimating 20% effect concentrations (EC20s; mgCl/L) and 95% confidence limits for the responses of fatmucket (*Lampsilis siliquoidea*) in chronic in 4- and 12-week NaCl test started with 1-week-old juveniles in water exposure with sand substrate in 2015. Each circle indicates the measured response in each of the 4 replicates, and the line represents the nonlinear regression (threshold sigmoidal) fit

4-week responses

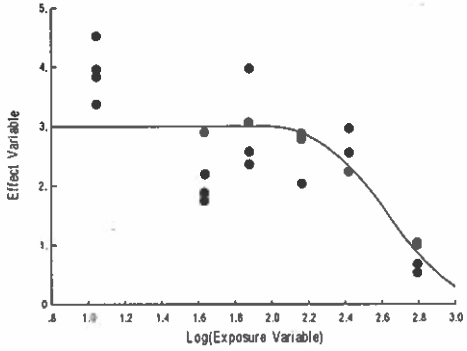
EC20 based on length: 358 (257-499)



EC20 based on dry weight:244 (137-436)

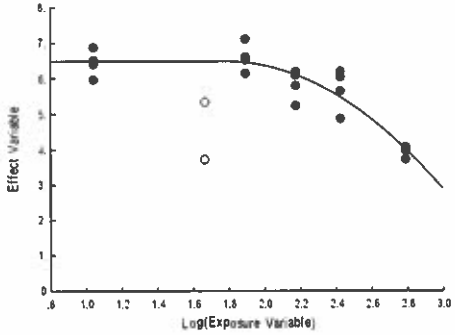


EC20 based on biomass: 251 (140-449)

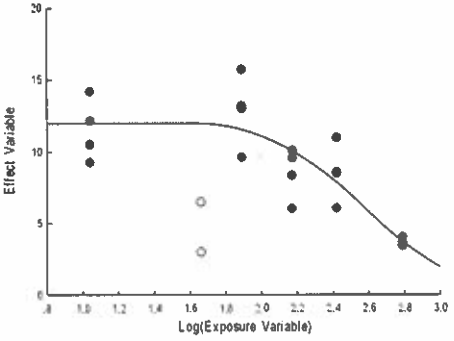


12-week responses

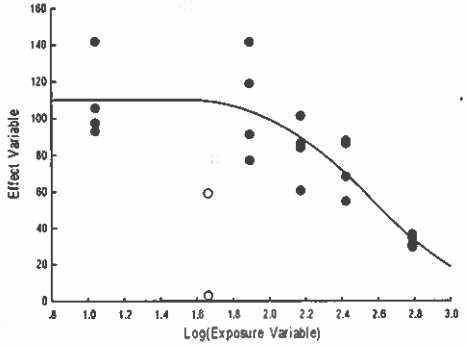
EC20 based on length: 323 (234-444)



EC20 based on dry weight: 173 (87-345)



EC20 based on biomass: 158 (78-321)

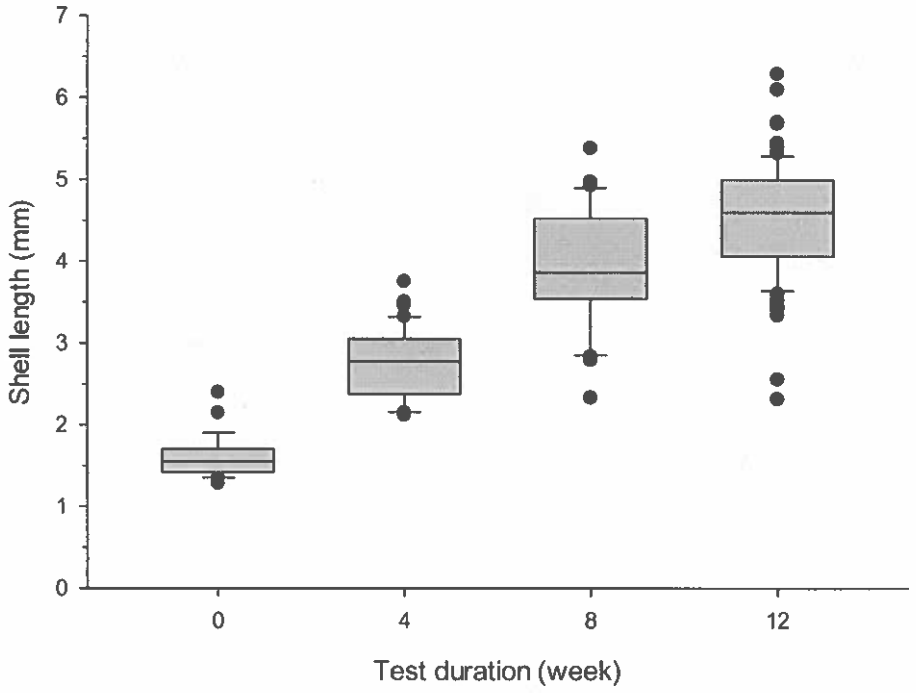


* The growth values with open circles were not included for the analyses due to the high mortality, including 2 replicates with 100% mortality, in the treatment.

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Figure S6. The variability in shell lengths of juvenile fatmucket (*Lampsilis siliquoidea*) at the beginning of the test and at weeks 4, 8, and 12 in the control treatment of the 2014 4- to 12-week NaCl toxicity test. The boundary of the box indicates the 25th and 75th percentiles, a line within the box shows the median, and the error bars indicate 10th and 90th percentiles (n=40).



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Supplemental Data, Section S1

REFINING METHODS FOR CONDUCTING CHRONIC TOXICITY TESTS WITH FRESHWATER MUSSELS IN WATER EXPOSURES

BACKGROUND

The ASTM International standard for conducting chronic toxicity testing with mussels was first published in 2005 (ASTM 2017) and is in need of refinement (Wang et al. 2011). Although the survival of mussels in controls in previous chronic tests typically exceeded the test acceptability criterion of ≥80% survival (ASTM 2017), the growth of the control mussels has been inconsistent among chronic toxicity tests (Ingersoll et al. 2015). Further studies are necessary to optimize feeding and other test conditions for assessing the mussel growth endpoint (Wang et al. 2011, Ingersoll et al. 2015). The objective of the present study was to evaluate survival and growth of juvenile mussels (Fatmucket, *Lampsilis siliquoidea*) in 4- to 12 week water exposures under control conditions (1) with and without a sand substrate, (2) with or without sand and test chamber replacement every 2 weeks, (3) with different feeding levels and frequencies of algal mixture, or with an addition of food to algal mixture, and (4) with different water renewal types (static renewal vs flow through). The results of this study are useful to refine test conditions to maximize control survival and growth of juvenile mussels in long-term exposures and to revise the ASTM (2017) methods for conducting chronic water-only toxicity tests with juvenile mussels.

MATERIALS AND METHODS

Brooding female fatmucket were collected in February 2014 from the Silver Fork of Perche Creek (Boone County, MO) and shipped to Missouri State University, Springfield, MO for production of juvenile mussels. Newly metamorphosed juveniles (<5 d old) were shipped overnight to the Columbia Environmental Research Center (CERC), Columbia, MO and cultured for 2 months in a recirculating mussel culture system (Barnhart 2006) before the feeding study. The mussels were fed once every hour automatically with an algal mixture to maintain a concentration of 2 nL cell volume/mL in the culture system (see the algal source, food preparation, and other details in main text of this manuscript). The culture water was the same water used in the feeding treatments and prepared by diluting the CERC well water (a hardness of ~300 mg/L as $CaCO_3$) with deionized water to a hardness of 100 mg/L as $CaCO_3$. Water

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temperature of 23±1°C and ambient laboratory light of 500 lux with 16:8 h light:dark photoperiod were maintained during the mussel culture and feeding treatments.

The feeding study started in July 2014 with 13 treatments for a test duration of 4 weeks, and 6 treatments for 12 weeks (Session 1-Table 1). Specific details are provided below.

Effects of beaker replacement and sand substrate under flow-through conditions. A previous 12-week NaCl toxicity test conducted in our laboratory failed because the control survival in exposures were below 80% after 8 weeks (unpublished data). A difficulty during chronic toxicity testing with mussels was cleaning debris in water-only beakers. Unconsumed food, mussel excreta, and, sometimes, fungi or algae accumulated and stuck on test beakers and mussel shells. Recent studies in our laboratory (unpublished data) have shown that periodic beaker replacement or placing a thin layer of silica sand in the beaker appeared to enhance hygiene (less fungi or algae growing on mussel shells). Four treatments were designed to confirm the effects of beaker replacement and sand substrate on survival and growth of juvenile fatmucket under the flow-through condition with a routine feeding level of 2 ml of algal mixture, which was prepared daily before morning feeding by adding 1 mL of Nanno 3600® and 2 mL of Shellfish Diet 1800® into 1.8 L of test water (algal concentration ~510 nl cell volume/ml; Wang et al. 2007):

Treatment 1: No substrate and no beaker replacement: This treatment was the same as that used in our previous chronic toxicity tests with juvenile mussels (e.g., Wang et al. 2007, 2010, 2011; Besser et al. 2013) and was considered as a control to determine the amount of improvement of mussel survival and growth in other treatments. Test duration was 4 weeks.

Treatment 2: No substrate but beaker replacement: Test beakers were replaced every 2 weeks. For the beaker replacement, the mussels in each replicate beaker were rinsed into a 200-mL glass dish with test water for survival determination. Surviving mussels (see details below) were transferred into new beakers. Test durations were 4 and 12 weeks.

Treatment 3: Sand substrate addition but no beaker replacement: 5 mL of silica sand (~100 to 400-µm particles; Granusil #5010, Unimin Corporation, New Canaan, CT, USA), which had been held in control water for 24 h prior to the treatment, was added to each replicate beaker at the beginning of the treatment. Test duration was 4 weeks.

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Treatment 4: Beaker and sand replacement: Sand was placed in beakers at the beginning of the treatments. The sand and beakers were replaced every 2 weeks. Test durations were 4 and 12 weeks.

Effects of feeding under flow-through condition. The routine feeding rate of 2 ml of algal mixture twice daily used in our previous studies (Wang et al. 2007, 2010, 2011) was based on a mussel feeding study in water-only (no substrate) beakers at 20°C (Wang et al. 2007). Recent studies have indicated that juvenile fatmucket grew faster at 23°C than 20°C in the culture and testing (J.M. Kunz; C.M. Barnhart of Missouri State University, unpublished data). In addition to the routine feeding (2 mL of algal mixture twice daily in Treatment 4), 4 treatments were designed to determine the optimum feeding levels of algal mixtures for the growth of juvenile fatmucket at 23°C in test beakers containing sand substrate and with beaker and sand replacement once every other week:

Treatment 5: 3 mL of algal mixture twice daily manually in the early morning and late afternoon. Test durations were 4 and 12 weeks.

Treatment 6: 2 mL of algal mixture 3 times daily manually in the early morning, noon, and late afternoon. Test durations were 4 and 12 weeks.

Treatment 7: 1 mL of algal mixture 6 times daily. The food was delivered by a Hamilton syringe pump automatically every 4 hours. Test durations were 4 and 12 weeks.

Treatment 8: 2 mL of algal mixture 6 times daily. The food was delivered by a Hamilton syringe pumps automatically every 4 hours. Test durations were 4 and 12 weeks.

Effects of the addition of other food to algal mixture under flow-through condition. Klaine et al (1997) reported that a diet with alga *Selenastrum capricornutum* and combined yeast-cerophyl-trout chow (YCT) was the best food among several potential diets for the growth of juvenile mussels (*Utterbackia imbecillis*). However, yeast globules formed on mussel shells and could not be rinsed or removed without potentially damaging the juvenile shell (Klaine et al. 1997). Our design with sand substrate under flow-through conditions might help reduce globule formation. In addition, Eybe et al. (2013) found that including a protein-containing additive (crushed red bloodworms) with the algae improved survival and growth of juvenile freshwater pearl mussel

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(*Margaritifera margaritifera*). A commercially available food Oyster-feast® (Reed Mariculture, Campbell, CA) was used for the present study. Oyster-feast® is a food mixture of oyster eggs and ovarian tissue for the culture of corals, other invertebrates, and fish, and contains high protein and omega-3 fatty acids (http://reefnutrition.com/oyster_feast.php). Three treatments were designed to evaluate the effects of the addition of YCT or Oyster-feast® to the algal mixture on survival and growth of juvenile fatmucket at 23°C in test beakers containing sand substrate and with beaker and sand replacement once every other week:

Treatment 9: 2 mL of algal mixture twice daily + 0.25 mL of YCT (1,800 mg/L stock; USEPA 2000) once daily. Test duration was 4 weeks.

Treatment 10: 2 mL of algal mixture twice daily + 0.5 mL of YCT once daily. Test duration was 4 weeks.

Treatment 11: 2 mL of algal mixture twice daily + 5 µL concentrate of Oyster-Feast® once daily (1/2 of the maximum amount recommended by the food provider). Test duration was 4 weeks.

Effects of feeding under static-renewal conditions. Limited chronic toxicity tests with juvenile mussels have been conducted under static-renewal conditions in our laboratory unpublished data, James Kunz) and previous studies (Bringolf et al. 2007). A static-renewal test may be useful when a flow-through system (e.g. diluter) is not available or the volume of test solution is limited for a flow-through test (e.g., effluent). A recent 28-d static-renewal effluent test with juvenile fatmucket indicated frequent beaker replacement (once every week) improved survival and growth (unpublished data, James Kunz). The present study further determined the optimum feeding rate under static-renewal conditions. All test conditions were the same as Treatment 4 in flow-through conditions, except that the treatments were conducted for 4 weeks and about 70% of the water was renewed on Mondays, Wednesdays, and Fridays, and beakers and sand were replaced once every week. Two feeding levels of algal mixture were used:

Treatment 12: 2 mL of algal mixture twice daily in the early morning and late afternoon. Test duration was 4 weeks.

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Treatment 13: 3 mL of algal mixture twice daily in the early morning and late afternoon. Test duration was 4 weeks.

All experiments were conducted concurrently in 3 intermittent flow-through proportional diluter systems modified from Mount and Brungs (1967, Wang et al. 2007). For the treatments with a 4-week test duration, 4 replicate glass beakers per treatment were placed in a water bath of the diluter. For the treatments with the 4- and 12-week test durations, 8 replicate beakers were placed in the bath (4 replicates for sampling survival and growth data at week 4, and 4 replicates for sampling at week 12). Test water was maintained at 23±1°C. Each beaker (300 mL) had a 2.5-cm hole in the side covered with 50-mesh (279-µm width opening) stainless-steel screen and held 200 ml of water. For the experiments under flow-through condition, the diluter provided 125 ml of water to each replicate beaker every 4 h (3.6 water volume additions per day). At the start of the experiments, 10 juvenile mussels (starting age ~60 d old) exhibiting foot movement were impartially transferred into each beaker. Additionally, 4 replicates of 10 mussels per replicate were preserved in 70% ethanol for the measurements of initial length and dry weight. Algal mixture was prepared daily before morning feeding by adding 1 mL of Nanno 3600® and 2 mL of Shellfish Diet 1800® (Reed Mariculture, Campbell, CA) into 1.8 L of test water (algal concentration ~510 nl cell volume/ml; Wang et al. 2007) and kept in a refrigerator at <4°C for the feeding in the rest of the day. For the auto-feeding treatments, a stock of the algal mixture was maintained in an aerated cooler with ice packs and changed daily, and 3 syringe pumps (Hamilton, Reno, NV, USA) automatically delivered the targeted amount of algal mixture to exposure mixing chambers of the diluter right before each water cycling (Wang et al. 2011). In the treatments with a longer-term duration of 12 weeks, feeding levels were increased 50% every 4 weeks.

Water quality (dissolved oxygen, pH, conductivity, hardness, alkalinity, and ammonia) were determined using standard methods (Eaton et al. 2005) on composite water samples collected from the replicates at least every 2 weeks. At the end of the 4- or 12-week study, mussels in each replicate beaker was examined for survival under a dissecting microscope. Mussels with an empty shell or with a gaped shell containing decomposed tissue were classified as dead. Surviving mussels in each replicate were counted and preserved in 70% ethanol for subsequent dry weight measurements. Dry weight of pooled mussels per replicate was determined by drying

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the mussels at 60°C for 48 h. The differences in mean weight increases (calculated as final weight/starting weight) among each of the 4 4-week treatment groups and among the 6 12-week treatments were determined using ANOVA and Duncan's multiple range test using SAS/STAT version 9.4, SAS Institute). The level of statistical significance was set at $p \leq 0.05$.

RESULTS AND DISCUSSION

Water quality

Measured water quality characteristics are summarized in Session S1-Table 2. Mean measured concentrations of dissolved oxygen were ≥ 7.6 mg/L. Mean measured concentrations of total ammonia nitrogen ranged from 0.04 to 0.08 mg N/L in Treatments 1 to 11 under flow-through conditions and were 0.10 and 0.16 mg N/L in Treatments 12 and 13 under static-renewal conditions. Mean measured conductivity, pH, hardness, and alkalinity were similar within a treatment and among different treatments (conductivity 253 to 265 µS/cm, pH 8.0 to 8.3, alkalinity 91 to 102 mg/L as $CaCO_3$, hardness 101 to 106 mg/L as $CaCO_3$; Session S1-Table 2).

4-week treatments

Mean survival was similar among the 13 treatments, ranging from 95 to 100% (Session S1-Table 1). Under flow-through conditions, the mean weight increase in Treatment 1 conducted under traditional conditions (i.e., no sand and no beaker replacement, fed 2 mL algal mixture 2 times daily; ASTM 2017) was about 3 fold of the starting weight, whereas the other 10 treatments exhibited about 5- to 13-fold weight increase (Session S1-Figure 1ABC). Specifically, under the same feeding of 2 mL algal mixture 2 times daily, Treatments 2 (with beaker replacement every 2 weeks), Treatment 3 (with sand addition but no beaker and sand replacement), and Treatment 4 (with sand addition plus sand and beaker replacement every 2 weeks) had significantly greater weight increase than Treatment 1(Session S1-Figure 1A). The results indicate that replacing beakers every 2 weeks or adding sand substrate improved mussel growth.

Among Treatments 4 to 8, all with sand and beaker replacement but at different feeding rates and frequencies of algal mixture, Treatment 8 with the auto-feeding 6 times 2 mL algal mixture had significantly greater weight increase than the other 4 treatments (Session S1-Figure 1B). The weight increases among the 3 treatments with manual feeding (Treatments 4, 5, and 6) were not

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significantly different although Treatment 6 with the 3 times 2 mL algal mixture showed a slightly higher weight increase with less variability than Treatment 4 (2 times 2 mL) and Treatment 5 (2 times 3 mL; Session S1-Figure 1B). The weight increase in Treatment 7 with the auto-feeding 6 times 1 mL algal mixture was relatively low although the daily total amount of food was designed to be equal to or more than the 3 manual feeding treatments. It is likely that a portion of food had been lost when the diluter delivered the water (mixed with the food) to replicate beakers and the excess water, and potentially food, flowed out through the side screen. Therefore, the increased feeding rate and frequency of the auto-feeding 6 times 2 mL algal mixture supports the best growth.

The mean weight increases of mussels fed algae plus the 2 levels of YCT (Treatments 9 and 10) and fed algae plus Oyster-feast® were similar; however, the variation among replicates in Treatment 10 (algae plus high YCT treatment was much lower (Session S1-Figure 1C). The growth of mussels in these 3 treatments with additional food to the algal mixture were not significantly different from the growth of mussels only fed algal mixture 2 times daily in Treatment 4 (Session S1-Figure 1C). Notably, the mean weight increase in Treatment 10 with the additional 0.5 mL YCT was 27% greater than the weight increase in the algal feeding-only treatment, indicating the mussels may have benefited some from the YCT. Further studies need to confirm the effect of YCT on mussel growth. However, increasing YCT amount may likely cause elevated ammonia (e.g., Wang et al. 2013, to which juvenile mussels are highly sensitive (Wang et al. 2007, 2011).

Under static-renewal conditions, the weight increases in Treatments 12 and 13 with 2 different feeding rates were not significantly different (Session S1-Figure 1D). Surprisingly, the mussels under static-renewal conditions grew much faster (>70%) than the mussels fed similarly under flow-through conditions (Treatments 4 and 5). A possible reason was higher food availability in the static-renewal treatments, where the water in test chambers was renewed once Mondays, Wednesdays, and Fridays, compared to the flow-through condition, where each water addition every 4 h flushed away some remaining food in test chambers. This speculation appeared to be supported by the fact that increasing food availability by auto-feeding with each water addition in the flow-through Treatment 8 (Session S1-Figure 1B) substantially improved the growth of mussels, and the mussels grew as fast as those under static-renewal conditions (Session S1-

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Figure 1D). The high survival and growth of mussels in the static-renewal treatments indicated that chronic toxicity tests with juvenile mussels can be successfully completed under static-renewal conditions, with a minimum water renewal on Mondays, Wednesdays, and Fridays, and sand and beaker replacement every week. The static-renewal test is useful when a flow-through system is not available or there is limited solution (e.g., effluent) for testing. However, mean concentrations of ammonia of 0.10 and 0.16 mg N/L in the 2 static-renewal treatments (Treatments 12 and 13) were 2- or 3-fold higher than those with similar feeding rates but under flow-through conditions (Treatments 4 and 5; Table Session S1-Table 2), indicating the potential problem of water quality. In a previous 4-week ammonia toxicity test with test water and pH (8.2) similar to those in the present study, the lowest effect concentration to juvenile fatmucket was as low as 0.26 mg N/L (Wang et al. 2011). Increasing water renewal (e.g., once daily, rather than once on Mondays, Wednesdays, and Fridays in the present study) may keep the ammonia below 0.1 mg N/L at a feeding rate that results in good growth of the mussels.

12-week treatments

Mean survival ranged from 78 to 98% at the end of the 6 12-week treatments (Session S1-Table 1). In Treatments 5, 6, and 7, one replicate had much lower survival (40 or 50%) compared to the other 3 replicates (typically 90 or 100%). This replicate effect has been found in previous chronic 4-week toxicity testing (e.g., Wang et al. 2016) and more often in our longer-term (e.g., 2 months) mussel culture (unpublished data). The mean weight increase ranged from 31 to 60 fold among the 6 12-week treatments, and, as observed in the 4-week study, the growth in Treatment 8 with the auto-feeding 6 times 2 mL algal mixture was significantly greater than the growth in the other 5 treatments (Session S1-Figure 2). Although the growth rates among the 5 treatments were not significantly different, the mussels in Treatment 6 with the 3 times 2 mL algal mixture had the highest weight increase (Session S1-Figure 2), which was consistent with the results obtained in the 4-week study (Session S1-Figure 1B). The results indicate that a long-term 12-week toxicity test can be successfully completed starting with 2-month-old juvenile mussels under flow-through condition with beaker replacement every 2 weeks. Adding a sand substrate may have kept food more dispersed and limited the growth of fungi or algae on the mussel shell. Increasing feeding frequency improved the mussel growth. The results of the overall feeding

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study can be useful for the revision of the ASTM standard for conducting chronic toxicity test with juvenile mussels (ASTM 2017).

REFERENCES

ASTM International. 2017. Standard guide for conducting laboratory toxicity tests with freshwater mussels (E2455-06 (2013)). Annual Book of ASTM Standards, Volume 11.06. ASTM International, West Conshohocken, PA.

Barnhart MC. 2006. Bucket of muckets: A compact recirculating system for rearing juvenile freshwater mussels. Aquaculture 254:227-233.

Besser JM, Brumbaugh WG, Ingersoll CG, Ivey CD, Kunz JL, Kemble NE, Schlekat CE, Rogevich-Garman E. 2013. Chronic toxicity of nickel-spiked freshwater sediments: Variation in toxicity among eight invertebrate taxa and eight sediments. *Environ Toxicol Chem* 32:2495-2506.

Bringolf, R.B., Cope, W.G., Barnhart, M.C., Mosher, S., Lazaro, P.R., Shea, D., 2007.Acute and chronic toxicity of pesticide formulations (atrazine, chlorpyrifos and permethrin) to glochidia and juveniles of *Lampsilis siliquoidea*. *Environ Toxicol Chem* 26, 2086-2093.

Eaton AD, Clesceri LS, Rice EW, Greenberg AE. 2005. Standard Methods for the Examination of Water and Wastewater, 21st ed.: Washington, D.C., American Public Health Association, Water Environment Federation, American Water Works Association, 1,368 p.

Eybe TF, Bohn TT, Sures B. 2013. The first millimetre – rearing juvenile freshwater pearl mussels (*Margaritifera margaritifera* L.) in plastic boxes. *Aquatic Conserv* 23: 964–975.

Ingersoll CG, Kunz JL, Hughes JP, Wang N, Ireland DS, Mount DR, Hockett JR, Valenti TW. 2015. Relative sensitivity of an amphipod *Hyalella azteca*, a midge *Chironomus dilutus*, and a unionid mussel *Lampsilis siliquoidea* to a toxic sediment. *Environ Toxicol Chem* 34:1134–1144.

Klaine SJ, Warren LW, Summers JM, 1997. The use of juvenile mussels (*Utterbackia imbecillis*, SAY) as a standardized toxicity testing organism. Final report to US Environmental Protection Agency, Athens, GA.

Electronic Filing: Received, Clerk's Office 3/14/2019

Kunz JL, Ingersoll CG, Smalling KL, Elskus AA, Kuivila KM. 2017. Chronic toxicity of azoxystrobin to freshwater amphipods, midges, cladocerans, and mussels in water-only exposures. *Environ Toxicol Chem* 36:2308-2315.

Mount DI, Brungs WA. 1967. A simplified dosing apparatus for fish toxicology studies. *Water Res.* 1:21-29.

US Environmental Protection Agency. 2000. Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates, second edition, EPA/600/R-99/064, Washington, DC.

Wang N, Ingersoll CG, Greer IE, Hardesty DK, Ivey CD, Kunz JL, Brumbaugh WG, Dwyer FJ, Roberts AD, Augspurger T, Kane CM, Neves RJ, Barnhart MC. 2007. Chronic toxicity of copper and ammonia to juvenile freshwater mussels (Unionidae). *Environ Toxicol Chem* 26:2048-2056.

Wang N, Ingersoll CG, Ivey CD, Hardesty DK, May TW, Augspurger T, Roberts AD, van Genderen E, Barnhart MC. 2010. Sensitivity of early life stages of freshwater mussels (Unionidae) to acute and chronic toxicity of lead, cadmium, and zinc in water. *Environ Toxicol Chem* 29:2053-2063.

Wang N, Consbrock R, Ingersoll CG, Barnhart MC. 2011. Evaluation of influence of sediment on the sensitivity of a unionid mussel (*Lampsilis siliquoidea*) to ammonia in 28-day water exposures. *Environ Toxicol Chem* 30:2270-2276.

Wang N, Ingersoll CG, Kunz JL, Brumbaugh WG, Kane CM, Evans RB, Alexander S, Walker C, Bakaletz S. 2013. Toxicity of sediments potentially contaminated by coal mining and natural gas extraction to unionid mussels and commonly tested benthic invertebrates. *Environ Toxicol Chem* 32: 207-221.

Wang N, Dorman RA, Ingersoll CG, Hardest DK, Brumbaugh WG, Hammer EJ, Bauer CR, Mount DR. 2016. Acute and chronic toxicity of sodium sulfate to four freshwater organisms in water-only exposures. *Environ Toxicol Chem* 35:115-127.

Session S1-Table 1. Summary of 13 treatments with different feeding and holding conditions and mean survival (n=4; standard deviation in parentheses) in the 4- or 12-week study conducted at 23°C in 2014

Study goal	Treat.[a]	Description[b]	Survival (%)	
			4 weeks	12 weeks
Effects of sand presence or sand and beaker replacement under flow-through condition, with a routine feeding of algal mixture (Wang et al. 2007)	1	2X2 mL algal mixture, no substrate, and no beaker replacement as recommended in ASTM (2017). The treatment served as a control to evaluate the improvement of mussel growth in other treatments	98 (5.0)	NA
	2*	2X2 mL algal mixture, no substrate, with beaker replacement after 2 weeks	100 (0)	95 (10)
	3	2X2 mL algal mixture, no beaker replacement, with 5 mL of sand	98 (5.0)	NA
	4*	2X2 mL algal mixture, with sand and beaker replacement after 2 weeks	98 (5.0)	88 (5.0)
Effects of feeding levels under flow-through condition, with sand and beaker replacement	5*	2X3 mL algal mixture (one in the morning and another in the afternoon)	100 (0)	83 (29)
	6*	3X2 mL algal mixture (morning, noon, and afternoon)	100 (0)	78 (22)
	7*	6X1 mL algal mixture (once every 4 h automatically; see text)	100 (0)	88 (25)
	8*	6X2 mL algal mixture (once every 4 h automatically; see text)	100 (0)	98 (5.0)
Effects of a food addition to algae under flow-through condition, with sand and beaker replacement	9	2X2 mL algal mixture + 1X0.25 mL of yeast-cerophyl-trout chow	100 (0)	NA
	10	2X2 mL algal mixture + 1X0.50 mL of yeast-cerophyl-trout chow	95 (5.8)	NA
	11	2X2 mL algal mixture + 1X5 µL concentrate of Oyster-Feast® (1/2 of the maximum amount recommended by the food provider)	98 (5.0)	NA
Effects of feeding under static-renewal condition	12	2X2 mL algal mixture, sand and beaker replacement once per week	98 (5.0)	NA
	13	2X3 mL algal mixture, sand and beaker replacement once per week	100 (0)	NA

[a] All 13 treatments were conducted for 4 weeks, of which 6 treatments indicated with an asterisk (*) had additional replicates for an extended study period to 12 weeks.

[b] 2X, 3X, or 6X indicates 2, 3, or 6 time feeding per day, respectively.

NA = Not applicable.

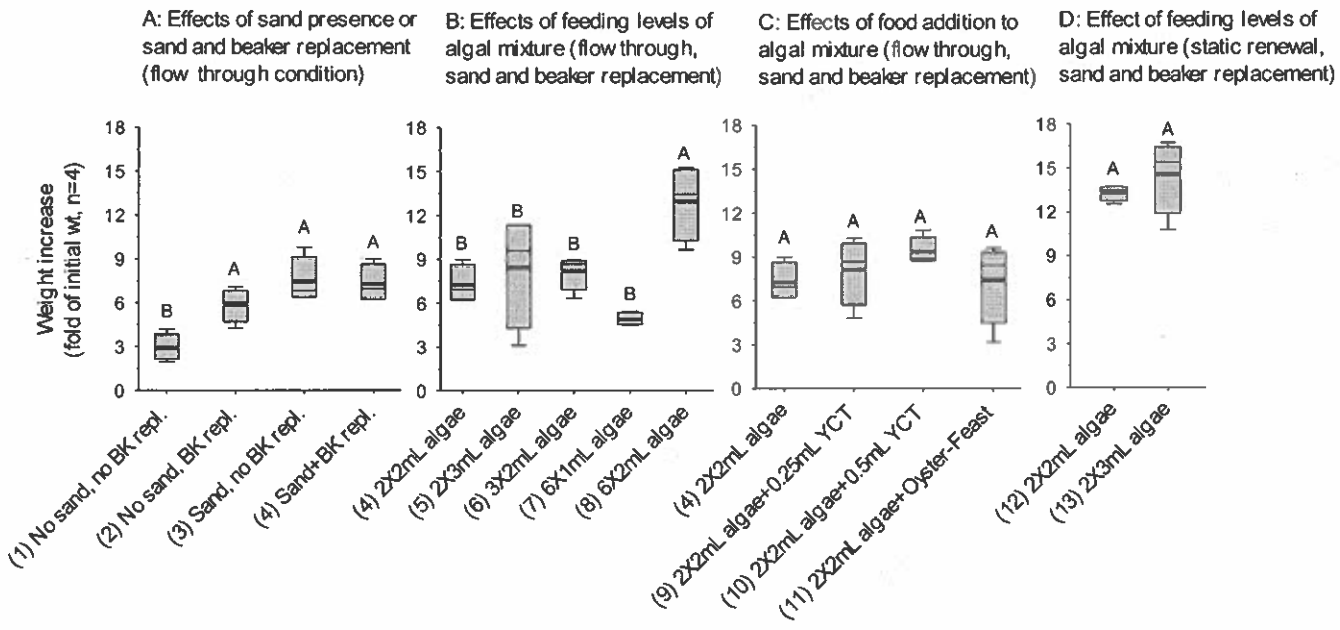
R04712

Session S1-Table 2. Mean measured water quality characteristics in the feeding study with juvenile fatmucket (*Lampsilis siliquoidea*) in 2014. See Session S1-Table 1 for the description of treatments

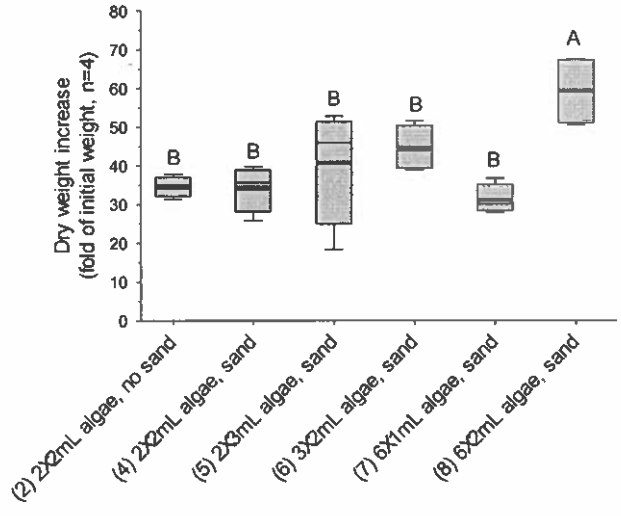
	Dissolved oxygen (mg/L)		Conductivity (µS/cm, 25 °C)		pH		Hardness (mg/L as $CaCO_3$)		Alkalinity (mg/L as $CaCO_3$)		Total ammonia (mg TN/L)	
Treatment	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
4-week study (n=3-6)												
1	8.0	0.6	254	8.3	8.2	0.2	101	1.2	91	6.1	0.05	0.02
2	7.9	0.6	254	7.9	8.2	0.1	104	4.0	92	3.5	0.05	0.02
3	8.0	0.6	253	8.5	8.2	0.1	103	2.3	93	3.1	0.05	0.02
4	8.2	0.5	255	5.5	8.2	0.1	103	2.3	93	2.3	0.04	0.01
5	8.0	0.6	255	7.2	8.1	0.1	101	2.3	92	3.5	0.05	0.02
6	8.0	0.6	256	7.0	8.1	0.1	102	3.5	102	16	0.05	0.01
7	8.0	0.6	259	9.4	8.0	0.1	101	3.1	95	6.1	0.05	0.01
8	7.9	0.4	258	4.4	8.1	0.1	103	4.6	92	3.5	0.06	0.01
9	8.0	0.5	254	6.5	8.3	0.3	103	2.3	93	3.1	0.06	0.02
10	8.0	0.5	255	5.9	8.2	0.1	101	2.3	91	4.2	0.07	0.04
11	8.1	0.7	254	7.7	8.2	0.2	101	1.2	92	3.5	0.04	0.02
12	7.9	0.4	265	7.5	8.1	0.1	102	2.0	99	11	0.10	0.05
13	7.6	0.4	264	5.9	8.1	0.1	101	1.2	94	3.5	0.16	0.12
12-week study (n=6-14)												
2	7.8	0.6	258	6.7	8.2	0.1	106	5.2	92	2.8	0.07	0.04
4	7.9	0.7	258	5.8	8.2	0.1	105	2.8	93	3.0	0.05	0.03
5	7.8	0.7	258	5.8	8.1	0.1	105	3.6	92	2.7	0.06	0.02
6	7.8	0.7	259	6.4	8.2	0.1	103	2.8	96	11	0.06	0.03
7	7.8	0.7	262	8.1	8.1	0.1	103	4.1	93	4.3	0.05	0.02
8	7.7	0.6	264	8.5	8.1	0.1	105	3.9	93	2.7	0.08	0.03

R04713

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Session S1-Figure 1. The fold increases in dry weight of juvenile fatmucket (*Lampsilis siliquoidea*) in 13 treatments with different feeding and holding conditions over a 4-week period. The boundary of the box indicates the 25th and 75th percentiles, and the error bars indicate 10th and 90th percentiles (n=4). A thin black line within the box marks the median and a thick red line shows a mean. Means with a same letter above the bars within each of 4 treatment groups (panel A, B, C, and D) are not significantly different (Duncan's multiple range test, $p>0.05$).



Session S1-Figure 2. The fold increases in dry weight of juvenile fatmucket (*Lampsilis siliquoidea*) in 6 treatments with different feeding over a 12-week period. The boundary of the box indicates the 25th and 75th percentiles, and the error bars indicate 10th and 90th percentiles (n=4). A thin black line within the box marks the median and a thick red line shows a mean. Means with a same letter above the bars are not significantly different (Duncan's multiple range test, $p>0.05$). Note that feeding rates were increased 50% every 4 weeks.

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ATTACHMENT 2

CHLORIDE IMPAIRED STREAMS IN ILLINOIS

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Order	Priority	Hydrologic Unit Code	Water Name	Assessment ID	Water Size	Designated Use	Cause
1299	Medium	714010604	Akin Creek	IL_NHG-02	3.24	Aquatic Life	Chloride
1363	Medium	714010603	Casey Fork	IL_NJ-07	17.88	Aquatic Life	Chloride
802	Medium	712000403	Des Plaines River	IL_G-07	10.78	Aquatic Life	Chloride
150	Medium	712000405	Des Plaines River	IL_G-15	3.52	Aquatic Life	Chloride
158	Medium	712000405	Des Plaines River	IL_G-22	4.31	Aquatic Life	Chloride
168	Medium	712000405	Des Plaines River	IL_G-28	9.02	Aquatic Life	Chloride
174	Medium	712000405	Des Plaines River	IL_G-30	5.19	Aquatic Life	Chloride
181	Medium	712000405	Des Plaines River	IL_G-32	6.18	Aquatic Life	Chloride
323	Medium	712000407	Des Plaines River	IL_G-03	8.41	Aquatic Life	Chloride
331	Medium	712000407	Des Plaines River	IL_G-11	9.05	Aquatic Life	Chloride
343	Medium	712000407	Des Plaines River	IL_G-39	11.25	Aquatic Life	Chloride
2781	Low	713001003	Drowning Fork	IL_DGLC-01	18.83	Aquatic Life	Chloride
2665	Low	712000408	Du Page River	IL_GB-11	10.07	Aquatic Life	Chloride
556	Medium	712000611	Fiddle Creek	IL_DTRA-W-C1	2.04	Aquatic Life	Chloride
547	Medium	712000611	Fox River	IL_DT-22	7.86	Aquatic Life	Chloride
931	Medium	712000406	Hickory Creek	IL_GG-04	8.11	Aquatic Life	Chloride
935	Medium	712000406	Hickory Creek	IL_GG-06	12.63	Aquatic Life	Chloride
938	Medium	712000406	Hickory Creek	IL_GG-22	2.25	Aquatic Life	Chloride
1000	Medium	709000602	Huntley Ditch	IL_PQIB-H-C1	0.6	Aquatic Life	Chloride
679	Medium	712000701	Indian Creek	IL_DTZK	7.86	Aquatic Life	Chloride
2121	Medium	712000410	Lacey Creek	IL_GBLC	3.69	Aquatic Life	Chloride
2768	Low	714020101	Lake Fork	IL_OW-01	9.72	Aquatic Life	Chloride
2770	Low	714020101	Lake Fork	IL_OW-02	4.91	Aquatic Life	Chloride
748	Medium	712000304	Little Calumet River South	IL_HB-01	8.68	Aquatic Life	Chloride
2740	Low	713000103	Little Vermilion River	IL_DR-01	3.79	Aquatic Life	Chloride
1089	Medium	712000409	Manhattan Creek	IL_GCA-M-A1	2.53	Aquatic Life	Chloride
1290	Medium	714010604	Middle Fork Big Muddy River	IL_NH-06	12.49	Aquatic Life	Chloride
1293	Medium	714010604	Middle Fork Big Muddy River	IL_NH-07	19.74	Aquatic Life	Chloride
2653	Low	712000301	Middle Fork North Branch Chicago River	IL_HCCC-02	18.57	Aquatic Life	Chloride
2656	Low	712000301	Middle Fork North Branch Chicago River	IL_HCCC-04	3.51	Aquatic Life	Chloride
2647	Low	712000301	North Branch Chicago River	IL_HCC-07	11.9	Aquatic Life	Chloride
1320	Medium	514020404	North Fork Saline River	IL_ATF-05	7.95	Aquatic Life	Chloride
1323	Medium	514020404	North Fork Saline River	IL_ATF-07	5.62	Aquatic Life	Chloride
2717	Low	714010605	Pond Creek	IL_NG-02	23.53	Aquatic Life	Chloride
1117	Medium	712000612	Poplar Creek	IL_DTG-02	15.01	Aquatic Life	Chloride
1175	Medium	512011114	Robinson Creek	IL_BFC-11	0.92	Aquatic Life	Chloride
1783	Medium	512010903	Salt Fork Vermilion River	IL_BPJ-07	3.12	Aquatic Life	Chloride
1589	Medium	713000608	Sangamon River	IL_E-05	13.58	Aquatic Life	Chloride
112	Medium	712000301	Skokie River	IL_HCCD-01	13.47	Aquatic Life	Chloride
117	Medium	712000301	Skokie River	IL_HCCD-09	1.76	Aquatic Life	Chloride
1007	Medium	709000602	South Branch Kishwaukee River-East	IL_PQI-H-C5	4.29	Aquatic Life	Chloride
278	Medium	712000408	Spring Brook	IL_GBKA	1.74	Aquatic Life	Chloride
1168	Medium	512011114	Sugar Creek	IL_BF-01	4.84	Aquatic Life	Chloride
2630	Low	712000302	Thorn Creek	IL_HBD-04	4.32	Aquatic Life	Chloride
859	Medium	712000302	Thorn Creek	IL_HBD-06	2.21	Aquatic Life	Chloride
951	Medium	712000406	Union Ditch	IL_GGC-FN-C1	1.23	Aquatic Life	Chloride
2650	Low	712000301	West Fork North Branch Chicago River	IL_HCCB-05	14.48	Aquatic Life	Chloride

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ATTACHMENT 3

LIST OF ORGANIZATIONS CONTACTED

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ATTACHMENT 4-LIST OF ORGANIZATIONS CONTACTED REGARDING THE COLD TEMPERATURE COLD RESEARCH

Abbott Laboratories
AbbVie
Akzo Nobel Surface Chemistry LLC
American Commercial Lines
Citgo Petroleum Corporation
City of Aurora
City of Batavia
City of Chicago
City of Chicago Dept. of Law
City of Crystal Lake
City of Elmhurst
City of Geneva
City of Joliet
City of St. Charles
ComEd
Cook County Dept of Env. Control
DeKalb Sanitary District
Downers Grove Public Works
Downers Grove Sanitary District
DuPage County DOT
DuPage County Public Works
Elk Grove Village
ExxonMobil Joliet Refinery
Fairmount Santrol
Fox Metro Water Reclamation District
Fox River Water Reclamation District
Illinois Department of Transportation
Illinois State Toll Highway Authority
IMTT Illinois
Ingredion
Ingrediron
Kane County Dept. of Environmental Mgmt.
Kane County DOT
KASteel Chemicals Inc.
Lake County Division of Transportation
McHenry County Highway Dept.
MWRDGC
Noramco Chicago
NRG Energy
Salt Institute
Seaways, Inc.

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Thompson Coburn LLP
Village of Antioch
Village of Barrington
Village of Bartlett
Village of Bensenville
Village of Carol Stream
Village of Cary
Village of Deerfield
Village of Glen Ellyn
Village of Glenview
Village of Grayslake
Village of Hinsdale
Village of Homer Glen
Village of LaGrange
Village of Lake Barrington
Village of Lake in the Hills
Village of Libertyville
Village of Lisle
Village of Lombard
Village of Maywood
Village of Mokena
Village of Montgomery
Village of Morton Grove
Village of New Lenox
Village of Northbrook
Village of Oak Brook
Village of Orland Park
Village of Romeoville
Village of Round Lake Beach
Village of Skokie
Village of Tinley Park
Village of Villa Park
Village of Wauconda
Village of Westchester
Village of Western Springs
Village of Wheeling
Village of Willowbrook
Village of Wilmette
Village of Winnetka
Village of Woodridge
Will County Division of Transportation

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ATTACHMENT 4

SORSI ARTICLE

R04721

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journal homepage: www.elsevier.com/locate/scitotenv

River chloride trends in snow-affected urban watersheds: increasing concentrations outpace urban growth rate and are common among all seasons

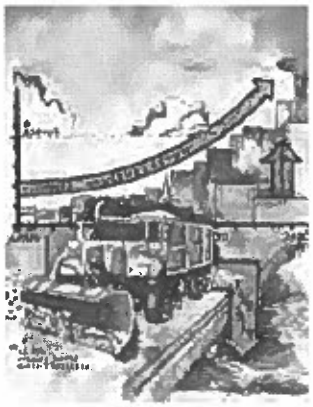
Steven R. Corsi [a,*], Laura A. De Cicco [a], Michelle A. Lutz [a], Robert M. Hirsch [b]

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HIGHLIGHTS

- Chloride trends in northern U.S. urban streams are computed.
- The rate of chloride concentration increase outpaced urbanization from 1990 to 2011.
- The greatest chloride concentration increase was during the winter.
- Increasing chloride concentration trends were observed in all seasons.
- Chronic water quality criteria for chloride were exceeded for extended durations.

GRAPHICAL ABSTRACT



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ABSTRACT

Chloride concentrations in northern U.S. included in this study have increased substantially over time with average concentrations approximately doubling from 1990 to 2011, outpacing the rate of urbanization in the northern U.S. Historical data were examined for 30 monitoring sites on 19 streams that had chloride concentration and flow records of 18 to 49 years. Chloride concentrations in most studied streams increased in all seasons (13 of 19 in all seasons; 16 of 19 during winter); maximum concentrations occurred during winter. Increasing concentrations during non-deicing periods suggest that chloride was stored in hydrologic reservoirs, such as the shallow groundwater system, during the winter and slowly released in baseflow throughout the year. Streamflow dependency was also observed with chloride concentrations increasing as streamflow decreased, a result of dilution during rainfall- and snowmelt-induced high-flow periods. The influence of chloride on aquatic life increased with time; 29% of sites studied exceeded the concentration for the USEPA chronic water quality criteria of 230 mg/L by an average of more than 100 individual days per year during 2006–2011. The rapid rate of chloride concentration increase in these streams is likely due to a combination of possible increased road salt application rates, increased baseline concentrations, and greater snowfall in the Midwestern U.S. during the latter portion of the study period.

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1. Introduction

The impact of road salt on aquatic ecosystems continues to increase as urban development and subsequent road salt applications increase with time. Substantial application of road salt in the U.S. began in the 1940s increasing to an annual average of 9.6 million metric tons/yr of NaCl-based road salt in the 1980s and 19.5 million metric tons/yr in the last 5 years reported, ending in 2011 (Kelly and Matos, 2013). Increasing trends in chloride concentrations have been observed in water bodies of the U.S. and attributed, at least in part, to road salt influence. These trends have included rivers (Godwin et al., 2003; Interlandi and Crockett, 2003; Thunqvist, 2004; Kaushal et al., 2005; Kelly et al., 2012a), groundwater (Reisch and Toran, 2013; Kelly, 2008; Perera et al., 2009; Cassanelli and Robbins, 2013), inland lakes (Ramstack et al., 2004; Novotny and Stefan, 2010; Müller and Gächter, 2012), and even water bodies as large as the Laurentian Great Lakes (Chapra et al., 2009, 2012).

Elevated salt concentrations in surface waters can exert an adverse effect on aquatic organisms (Cañedo-Argüelles et al., 2013). The U.S. Environmental Protection Agency (USEPA) ambient water quality criteria for chloride (when associated with sodium) defines the chronic criterion as a 4-day average concentration exceeding 230 mg/L and the acute criterion as a 1-h average concentration exceeding 860 mg/L (U.S. Environmental Protection Agency, 1988). Given the sensitivity of freshwater organisms to chloride, exceedances of these criteria have the potential to affect a substantial number of species (U.S. Environmental Protection Agency, 1988). In a thorough assessment of the environmental impacts of road salt, Environment Canada estimated that 5% of aquatic species would be affected at chloride concentrations of 210 mg/L and 10% of aquatic species would be affected at chloride concentrations of 240 mg/L for chronic exposures (Environment Canada, 2001). Multiple studies have observed chloride concentrations greater than these benchmark concentrations in streams as a result of road salt runoff. These studies have included local (Ruth, 2003; Trowbridge et al., 2010; Allert et al., 2012; Morgan et al., 2012), regional (Kelly et al., 2012b), and national geographic scopes (Corsi et al., 2010).

Urban land cover in the U.S. has also increased over time from an estimated 61,000 km^2 in 1945 to 247,000 km^2 in 2007 (Nickerson et al., 2011). With urban land cover projected to continue increasing (Alig et al., 2004), applications of road salt for deicing impervious surfaces are also likely to increase. Adding to the current and past water quality issues resulting from the salinization of streams, including road salt runoff, an analysis of water quality in the northeastern U.S. predicted that many surface waters in that area of the country would not be potable for human consumption and would become toxic to freshwater life within the next century (Kaushal et al., 2005).

The primary objectives of this study were to define temporal trends in chloride concentrations in the context of chloride dependency on streamflow rates, compare temporal chloride trends among seasons, and compare these trends to changes in urban land cover, aquatic life criteria, and road salt sales patterns. Trend analysis was done using the modern water quality trend modeling technique that controlled for streamflow rate and season to help avoid confounding results due to natural variability (Hirsch et al., 2010).

2. Methods

2.1. Site selection

An initial focus for 14 sites on 3 streams in the Milwaukee metropolitan area was conducted. To assess the broader geographic impact, 11 additional streams in urban areas of the northern U.S. were studied, 4 streams in northern areas with little urban impact were studied, and one stream in an urban area of the southern U.S. was studied as a warm-climate reference.

Sites were initially chosen based on proximity to areas of urban influence in the northern U.S. (Fig. 1, Table 1). Three sites with a low degree of urbanization in northeast Wisconsin and one site in Oregon were included to evaluate non-urban influence, and the Trinity River in Texas was also examined as a non-deicing reference site in an urban area. Second, adequate data availability for modeling was necessary. Most sites had 200 or more chloride observations and 20 or more years of record with no significant gaps in data collection (i.e., larger than 5 years), and sample representation during all seasons throughout the water quality record (Table S1). The exceptions include five sites that had between 151 and 194 observations, and one site that had a 6-yr gap. These sites were included to maintain adequate geographic representation of sites (Table S1). Sites located within or just downstream from large lakes or impoundments were omitted. A continuous record of streamflow data concurrent with the chloride record was required at the selected site or at a nearby site on the same stream. Sites selected in the Milwaukee metropolitan area were chosen from a dense network of available sites in an effort to adequately represent changes in the Milwaukee, Menomonee, and Kinnickinnic Rivers.

2.2. Data sources

Chloride data were obtained from the Milwaukee Metropolitan Sewerage District (MMSD), the Wisconsin Department of Natural Resources (WDNR), and the Water Quality Portal (WQ portal; http://www.waterqualitydata.us/), which includes data from the USGS National Water Information System (NWIS) and EPA STOrage and RETrieval Data Warehouse (STORET). Coordinate bounding boxes were used to query the WQ Portal to locate streams in metropolitan areas of primarily the northern U.S. with sufficient data (Fig. 1). Where data from different sources overlapped at common sites, data were combined except for one site where data from one of the sources were not considered valuable due to many duplicate data points and data differences that called into question analytical results.

If available, streamflow data from the USGS National Water Information System (http://waterdata.usgs.gov/nwis) were retrieved from the same location where chloride samples were collected; otherwise, data from a nearby location(s) on the same stream were scaled by drainage area to estimate streamflow at the chloride sampling location. In two cases, there were data gaps in streamflow that were estimated using an ordinary least squares regression with streamflow data from a nearby site (Meno 70th, $R^2 = 0.65$; Milw Cedarburg, $R^2 = 0.95$).

Road salt sales data were compiled from an annual reporting of Historical Statistics for Mineral and Material Commodities in the United States (Kelly and Matos, 2013) and used as a proxy for assessing overall road salt applications in the studied watersheds. Road salt sales were used in place of actual application numbers due to the complicated nature of gathering road salt application data from all municipalities and private applicators on the scale of this study.

Daily snowfall data for eight weather stations in the U.S. were retrieved from the National Climate Data Center (http://www.ncdc.noaa.gov/cdo-web/) for evaluation of snowfall changes throughout the study period (Table S2). Stations were chosen based on proximity of chloride study sites and availability of data during the study period.

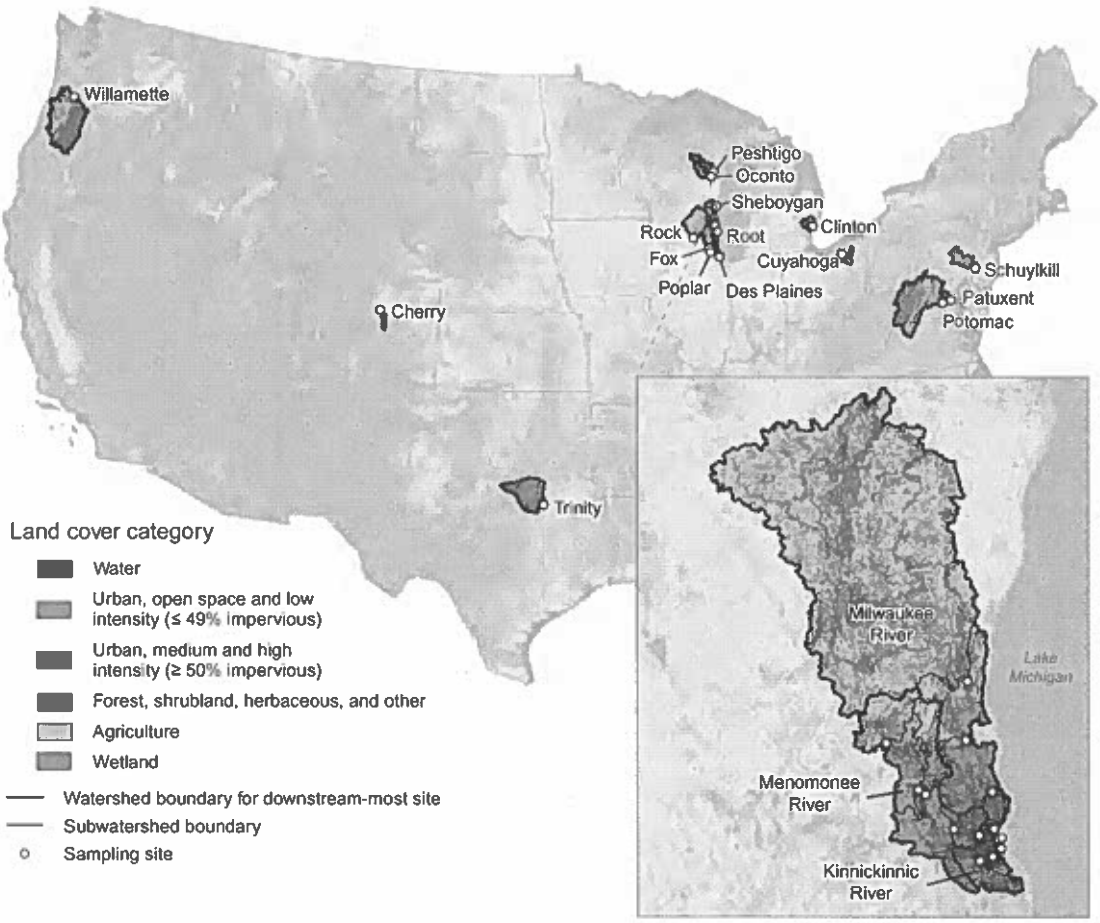
Land cover composition and other watershed characteristics were determined from several published GIS datasets and provided in Table 1, and methods are described in Supplemental Information.

2.3. Data analysis

Data analysis included water quality trend modeling, graphical analysis of trends, and exploration of modeling results in comparison to land use, the USEPA water quality criterion, and road salt sales in the U.S.

R04723

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Base composited from Instituto Nacional de Estadística Geografía e Informática, The Atlas of Canada, and U.S. Geological Survey North American Atlas - Political Boundaries, 1:10,000,000, 2006; U.S. Geological Survey National Land Cover Database 2006, 30-meter resolution, 2011; U.S. Environmental Protection Agency and U.S. Geological Survey National Hydrography Dataset Plus (modified), 1:100,000, 2005. Albers Equal Area Conic USGS CONUS Projection, referenced to North American Datum of 1983.

Fig. 1. Study site locations and watershed characteristics.

2.3.1. Rationale for water quality modeling technique

Chloride concentrations in streams have the potential to vary depending on several factors that all arise from the nature of the contamination sources, transport characteristics, and hydrologic characteristics of a given watershed. Considerations when attempting to understand these influential factors are very similar to those outlined previously describing potentially influential factors in stream nutrient concentrations and fluxes (Hirsch et al., 2010). The primary considerations are as follows: As urban development continues, sources of nonpoint pollution such as road salt application tend to increase as well, so it is logical to expect chloride concentrations in streams to change with time. Given that road salt is applied only during cold-weather periods, seasonal differences in chloride concentrations are also expected. The nature of road salt transport to surface waters causes chloride concentrations to change with streamflow. For example, when road salt melts ice and snow during periods of low streamflow, stream chloride concentrations can become very high, but when road salt runoff periods are coincident with high-streamflow periods resulting from snowmelt or rainfall events, chloride concentrations are likely to be lower due to the larger amounts of water available to dilute the road salt.

Long-term changes in chloride concentrations from road salt can follow a variety of temporal patterns responding to factors such as: the rate of urban development, changes in road salt application practices, long-term storage and release processes from large water bodies and groundwater, and changing climate conditions. Other major sources include treated wastewater as well as fertilizer and livestock, with other minor sources also contributing (Kelly et al., 2012b). These influences led to the use of WRTDS, a data analysis technique that can describe long-term change in a flexible manner (not simply as linear or quadratic time trends) and account for the seasonal- and streamflow-related dependencies which may, themselves, be changing over a period of many years or decades (Hirsch et al., 2010). The WRTDS analysis used here is implemented within the EGRET package (Hirsch and De Cicco, 2014) in the R statistical language (R Development Core Team, 2008).

2.3.2. Modeling water quality changes

The WRTDS method is based on weighted linear regression to estimate daily concentration throughout time, discharge (streamflow), and seasonal dimensions of the data used to calibrate the model. For any given estimation point in the data domain (where the point is defined by year, season and streamflow) the model gives increased weight to values similar in time, streamflow, and season to the estimation point. For example, concentrations of samples collected in year two of a sample period will have little influence on model estimates for year 10, concentrations of samples collected during low flow periods will have little influence on model estimates for high flow, and concentrations of samples collected during summer will have little influence on model estimates for winter periods. Weighting for proximity of the estimation point to the observed data by time (the time distance),

R04724

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Table 1
Watershed characteristics of study sites.

Site name	Metropolitan			Drainage	Percent land cover in 2006				Percent land cover in 1992[c]		
	State	Area	Short Name	area (km^2)	Urban[a]	Agricultural[a]	Forest/ other[a]	% Impervious[b]	Urban	Agricultural	Forest/ other
Milwaukee River at Pioneer Rd near Cedarburg	WI	Milwaukee	Milw Cedarburg	1555	11.0	56.2	32.8	2.9	9.6	58.5	31.9
Milwaukee River at Brown Deer Rd	WI	Milwaukee	Milw Brown Deer	1674	12.7	54.9	32.4	3.4	11.1	57.4	31.5
Milwaukee River at Estabrook Park	WI	Milwaukee	Milw	1785	17.5	51.4	31.0	5.6	16.0	53.9	30.1
Milwaukee River at Wells St	WI	Milwaukee	Milw Wells	1808	18.5	50.8	30.7	6.3	17.0	53.3	29.8
Milwaukee River at Jones Island at Mouth at Milwaukee	WI	Milwaukee	Milw Jones	2240	29.2	43.8	27.0	11.3	27.1	46.7	26.2
Menomonee River at County Line Road	WI	Milwaukee	Meno County	79	30.1	46.2	23.7	10.0	24.5	53.0	22.4
Menomonee River at 127th St	WI	Milwaukee	Meno 127th	153	52.0	28.5	19.4	17.8	43.0	37.7	19.3
Menomonee River at Hampton Ave	WI	Milwaukee	Meno Hampton	211	51.0	29.6	19.4	18.6	43.3	37.7	19.0
Menomonee River at 70th St Bridge at Wauwatosa	WI	Milwaukee	Meno 70th	318	65.1	20.0	14.9	24.7	59.4	26.1	14.5
Menomonee River at 25th St	WI	Milwaukee	Meno 25th	355	68.6	17.9	13.5	27.9	63.5	23.4	13.1
Kinnickinnic River at S 27th St	WI	Milwaukee	KK 27th	45	99.0	0.0	1.0	49.8	98.8	0.4	0.8
Kinnickinnic River at S 7th St	WI	Milwaukee	KK 7th	53	98.2	0.0	1.8	50.3	98.1	0.4	1.5
Kinnickinnic River at 1st St	WI	Milwaukee	KK 1st	63	98.5	0.0	1.5	50.5	98.4	0.3	1.3
Kinnickinnic River at Jones Island Ferry	WI	Milwaukee	KK Jones	69	98.0	0.0	2.0	51.6	97.8	0.3	1.9
Root River at Racine, WI	WI	Racine	Root	480	29.8	52.7	17.4	10.0	26.0	52.8	21.2
Peshtigo River at Peshtigo, WI	WI	Rural	Peshtigo	2872	4.3	15.5	80.3	0.4	4.6	14.3	81.1
Oconto River near Oconto, WI	WI	Rural	Oconto	2473	4.9	21.8	73.4	0.5	5.2	21.2	73.6
Sheboygan River at Sheboygan, WI	WI	Rural	Sheboygan	1103	8.1	64.7	27.2	2.2	7.7	66.6	25.7
Rock River at Afton, WI	WI	Janesville	Rock	8661	11.3	65.6	23.1	3.2	10.0	66.7	23.3
Willamette River at Portland, OR	OR	Rural	Willamette	28,967	7.3	20.4	72.2	2.6	6.9	20.6	72.4
Des Plaines River at Riverside, IL	IL	Chicago	Des Plaines	1643	63.8	18.8	17.4	27.5	60.0	22.0	18.0
Fox River at Algonquin, IL	IL	Chicago	Fox	3601	24.8	45.2	30.0	7.0	21.8	47.3	31.0
Poplar Creek at Elgin, IL	IL	Chicago	Poplar	92	67.9	7.5	24.6	26.5	62.0	15.0	22.9
Cherry Creek at Denver, CO	CO	Denver	Cherry	1063	21.7	0.6	77.7	6.9	15.9	0.7	83.4
Clinton River at Moravian Drive at Mt. Clemens, MI	MI	Detroit	Clinton	1937	52.3	19.9	27.8	20.0	49.7	23.0	27.3
Cuyahoga River at Independence, OH	OH	Cleveland	Cuyahoga	1836	39.8	17.4	42.8	10.9	34.1	20.7	45.3
Schuylkill River at Philadelphia, PA	PA	Philadelphia	Schuylkill	4888	24.2	29.7	46.1	6.4	18.6	39.1	42.3
Patuxent River near Bowie, MD	MD	Columbia	Patuxent	906	31.9	26.4	41.8	8.7	20.0	44.1	35.9
Potomac River at Chain Bridge, at Washington, DC	DC	Washington, DC	Potomac	29,967	10.1	29.6	60.3	2.1	8.3	32.1	59.6
Trinity River below Dallas, TX	TX	Dallas	Trinity	16,224	22.3	14.4	63.3	7.9	19.3	15.8	64.9

[a] Watershed urban, agriculture, and forest/other percentages for 2006 were determined from the National Land Cover Database 2006 Land Cover dataset (Fry et al., 2011).
[b] Watershed impervious percentages for 2006 were determined from the National Land Cover Database 2006 Percent Developed Imperviousness dataset (Fry et al., 2011).
[c] Watershed urban, agriculture, and forest/other percentages for 1992 were determined from the National Land Cover Database 1992/2001 Retrofit Land Cover Change dataset (Fry et al., 2009).

streamflow (the discharge distance), and season (the seasonal distance) are assigned using a tricube weight function with half-window widths of 10 years, 2 natural log units, and 0.5 years in the time, streamflow, and seasonal dimensions respectively. These values were chosen after experimentation of the smallest values that did not cause unrealistic oscillations. The overall weight on any given observation is the product of the three weights. Estimation by the WRTDS model was performed using measured chloride and corresponding daily streamflow values. This tool has not previously been used to examine chloride trends, but applications using WRTDS have primarily been used for examination of nutrients (Hirsch et al., 2010; Medalie et al., 2012; Green et al., 2014).

2.3.3. Examination of water quality changes

One type of output produced using WRTDS for each of the study locations was graphics showing estimated concentrations for three levels of streamflow (the 10, 50, and 90 percentile points on the daily streamflow frequency distribution), four seasons of the year (centered on February 15 [winter], May 15 [spring], August 15 [summer], and November 15 [fall]), and each year of the period of record. Another type of output is a contour plot of the differences in estimated chloride concentration between the years 1981 and 2010 as a function of time-of-year and streamflow. WRTDS was also used to compute flow-normalized annual chloride concentrations over the period of record. Flow-normalization is a technique that removes the effect of year-to-year variations in streamflow (but not seasonal variations) on average chloride concentrations (Hirsch et al., 2010).

Linear regression was used to explore the response of flow-normalized annual chloride concentrations as well as the number of individual days that these concentrations exceeded the USEPA water quality (exceedance days) to the percent of urban land cover in the watershed. Linear temporal regression was also used to compare the change in national road salt sales in the U.S. to the change in urban land cover in the northern U.S. to coincide with the location of most road salt sales in the U.S. The calculation of expected number of exceedance days was determined using logistic regression based on the output of the WRTDS model for the two periods 1990–1994 and 2006–2010. These dates were chosen based on the inclusion of at least 20 years, while minimizing the number of sites that had to be excluded due to missing data. The non-deicing reference site (Trinity River) and seiche-affected sites (Milw Jones, KK 1st, KK Jones) were not used in these analyses. The period of record did not have sufficient data between 1990 and 2011 for the Clinton, Cuyahoga, and Fox River, so these sites were not included in these analyses. Dates for the Schuylkill and Des Plaines Rivers did not match perfectly, but were near enough to provide an estimate for the later time period. The WRTDS method has been extended here to estimate the daily probability of exceedance of a threshold. Because the WRTDS model provides a conditional mean and conditional variance of concentration for each day as a function of streamflow, time of year, and year (trend) it is possible to compute a conditional probability of

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exceedance of the threshold under the assumption that the conditional distribution of concentration is log-normal. Using these results from all of the sites, logistic regressions were fit for each of the two 5-year time periods. These logistic regression models estimate the daily probability of exceedance at a site as a function the square root of the percent of the watershed that was urbanized during that time period. The number of predicted exceedances per year was then determined by summing these probabilities for the year. These calculations were implemented in R using the betareg function. Pseudo R-squared values for both models were approximately 0.83.

3. Results

Three major watersheds cover the bulk of the Milwaukee metropolitan area: the Milwaukee River, the Menomonee River, and the Kinnickinnic River. These three watersheds have all experienced increased chloride concentrations from 1980 to 2010 during winter, spring, summer, and fall (Fig. 2). The greatest increases in chloride concentrations were in watersheds with the greatest urban land cover percentage. Concentrations for the Milwaukee study sites were greatest in the Kinnickinnic River followed by the Menomonee River and then the Milwaukee River (drainage areas of 45, 355, and 1808 km^2, with 99, 68.6, and 18.5% urban land cover respectively).

In addition, chloride concentrations increased with decreasing streamflow for all three of these watersheds in each of the four seasons. The mean chloride concentration in the Milwaukee River exceeded 140 mg/L during winter low flow periods and was approaching 100 mg/L during summer low-flow periods toward the end of the study period. Mean chloride concentrations in the Menomonee and Kinnickinnic Rivers exceeded the USEPA chronic water quality criteria of 230 mg/L during the winter and spring at all three flow rates in the latter years of the study, and exceeded 100 mg/L during summer and fall periods at all three streamflow rates toward the end of the study duration.

Similar four-season graphs illustrating streamflow dependency for all remaining study sites except those impacted by backwater influences from Lake Michigan (hereafter referred to as seiche) are provided in the supporting information (Figs. S1–S25). Chloride concentrations also increased over all four seasons and decreased with streamflow at all of these additional sites except three with a few notable exceptions: Chloride concentrations at the Peshtigo River had increasing trends over the course of the study period, but concentrations did not increase with decreasing flow; concentrations were relatively constant in the Willamette River. Both of these sites have primarily forested land cover and little urban influence. With these watershed conditions, there is likely to be low road salt application and this is confirmed by very low chloride concentrations (less than 10 mg/L). Chloride concentrations in the Kinnickinnic River at 7th St. did not vary substantially with flow, but did have a slightly increasing relation with increasing streamflow during winter due to samples with high concentrations during high flow periods in the winter. Changes in concentrations with respect to streamflow at the southern urban reference site (Trinity River) were not consistent through the study period.

The change in concentration over time at three different locations within the Milwaukee River watershed is another illustration of increasing road salt effect with urban land cover. These three monitoring sites increased in downstream order from 11% to 17.5% to 18.5% urban land cover (Fig. 3, top to bottom panels, respectively; NLCD 2006 (Fry et al., 2011)). Even with these relatively minor differences in urban land cover, the effect on chloride concentration changes from 1981 to 2010 is apparent in the Milwaukee River with the Wells St. results indicating higher concentrations during winter than the two upstream sites. The greatest increase in chloride concentrations occurred during winter low-flow periods at all three sites, with greater changes as urban influence in the watershed increased. Although the greatest concentration increase was seen during these low flow winter events, substantial increases in chloride concentration also occurred during higher flow periods and extended throughout the year.

Flow-normalized concentrations estimated from 1980 to 2010 for 30 selected sites on 19 streams indicated that concentrations increased for the majority of the sites (Fig. 4). For the more urban watersheds, increases in concentration were greatest in winter periods, but summer periods also experienced increasing chloride concentrations. For the less urban watersheds, there were increasing trends over time (winter and summer slopes were similar) and the concentrations during winter were greater than or similar to concentrations during the summer. The magnitude of chloride concentrations as well as the slope of concentration change increased as the impervious land cover in the watershed increased. For example, the highest chloride concentrations and the greatest change (increase) in chloride concentration over this time period were sites with the highest degree of impervious area including those in Milwaukee, Chicago, Detroit, Cleveland, and Racine metropolitan areas (Fig. 4, top three rows, Table 1). Chloride concentrations generally decreased with decreasing impervious area in the bottom four rows of Fig. 4. The two exceptions are the sites in Portland (Willamette River) and Dallas (Trinity River) which show little or no trend in chloride concentration over the study period. Land cover in the Willamette River had 72% forest and natural area in the watershed, road salt was not commonly used in Oregon during the study period, and the climate

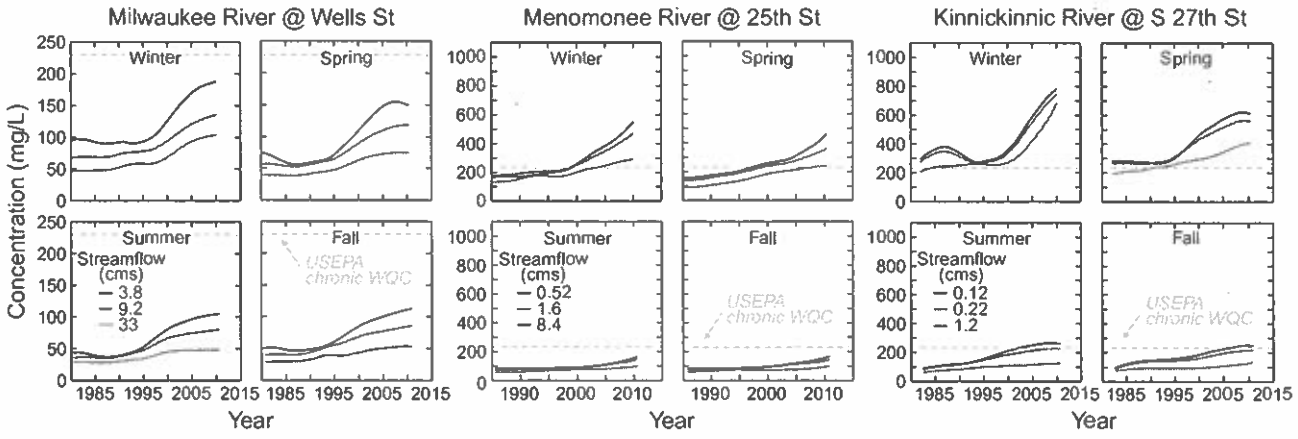


Fig. 2. Chloride concentration estimates at 10, 50, and 90 percentile flow rates from the WRTDS model over time and grouped by season for three Milwaukee streams. Graphs are presented in order of decreasing watershed size and increasing urban land cover from left to right. Streamflow is expressed in cubic meters per second (cms). Dashed line for USEPA chronic water quality criteria represents 230 mg/L.

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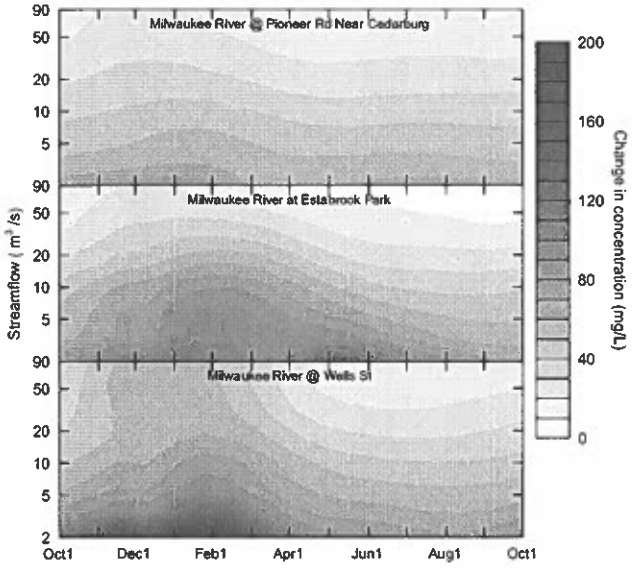


Fig. 3. Contour map of the change in chloride concentration by streamflow and time of year between 1981 and 2010 on the Milwaukee River. Sites are ordered from top to bottom with increasing urban land cover in the watershed. The color legend indicates change in concentration in mg/L.

in the Trinity River is warm enough that road salt application is not common.

Notable differences were observed among sites with low watershed imperviousness in the Midwest U.S. (Rock River; Milwaukee River at Cedarburg, which is upstream from the Milwaukee metropolitan area; and the Sheboygan River) versus those outside of the Midwest (Potomac and Willamette Rivers).

Sites with low imperviousness in the Midwest have higher chloride concentrations, when compared with sites in other areas of the country. Sites with low imperviousness in these different regions also show notable differences in non-urban land cover types; whereas the Midwest sites have large proportions of agricultural land, sites in other regions were dominated by forest and natural areas (Table 1). Concentrations at seiche-affected sites on the Milwaukee and Kinnickinnic Rivers also increased, but the magnitude of these trends was typically muted in comparison with upstream, non-seiche affected sites. Chloride concentrations were lower at study sites with the lowest percent impervious watersheds (less than 0.5%), but increasing trends were still apparent in winter and summer seasons.

Flow-normalized chloride concentration estimates from the WRTDS model were compared with urban land cover in the contributing watershed as 5-yr means for 1990–1994 and 2006–2010 (Fig. 5-A). There was a linear relation between mean concentration and percent urban land cover for both time periods, but regression slopes indicated a change in this relation over time with slopes for these regression equations indicating an increase in chloride concentration of 2.9 and 5.8 mg/L/% urban land cover for the 1990–94 and 2006–10 time periods respectively. Concentrations from 2006 to 2010 were approximately double the concentrations for 1990–1994 for the same percentage of urban land cover.

The logistic models for the probability of water quality criteria exceedance as a function of the square root of the percent of urban land cover in the watershed were significantly different ($p < 0.001$) between the two periods (1990–1994 and 2006–2010; Fig. 5-B). For a watershed with 25% urban area, the expected number of days exceeding 230 mg/L per year increased from 5 to 14, and for a watershed with 90% urban area, it increased from 95 to 231 days per year. An expected value of 17 days exceeding 230 mg/L per year decreased from 50% to 29% urban land cover, and an expected value of 95 exceedance days per year decreased from 95% to 63% urban land cover. About 29% of sites studied exceeded the concentration for the USEPA chronic water quality criteria of 230 mg/L by an average of more than 100 individual days per year during 2006–2011. All regression slopes in Fig. 5 were significant with $p < 0.001$, and R^2 values for all regressions ranged between 0.83 and 0.99. Slopes were significantly different in each of the analyses represented in Fig. 5 ($p < 0.001$ for panels A and B and $p < 0.05$ for panel C).

Beginning in 1987 and ending in 2010, road salt sales in the U.S. increased at an average rate of 3.9%/yr, and urban land cover in the northern part of the U.S. increased at a rate of 2.8%/yr (Fig. 5-C). These trends indicate that road salt usage increased at a rate 40% greater than the increase in urban land cover in the northern U.S. during this period.

4. Discussion

4.1. Temporal trends and relation with land use

Results of the present research indicate that chloride concentrations increased with time in most streams studied in the northern U.S. throughout the study period. While there were trends present in streams with watersheds dominated by urban, agriculture, and forest/natural areas alike, there was a clear increase in concentration as urban land cover (and impervious surfaces) in the watershed increased.

The concentration increase in watersheds with relatively small amounts of urban land use may be influenced by road salt, but may also be a result of other sources such as agricultural runoff which is another potentially important source of chlorides in rural watersheds (Mullaney et al., 2009). Still, the greater winter concentrations suggest that road salt was an important factor in observed trends in the rural watersheds. In contrast with the Midwest sites, which are more highly developed for agriculture, requiring a more extensive road network, the Potomac and Willamette River watersheds have larger percent forest and natural areas (60% and 72% respectively). A detailed watershed-specific investigation would be needed to better understand relative contributions in these rural sites.

The rate of chloride concentration increase outpaced that of urbanization for this study, so urban land cover information alone cannot account for these chloride trends. This changing relation of chloride with urban land cover over time (Fig. 5-A) may be attributed to several potential factors. First, it is possible that more salt was applied per unit urban area during the latter portion of the study period than during the early portion. This appears likely given that road salt sales in the northern U.S. outpaced the rate of increase in urban land cover by 40% during the study period (Fig. 5-C). More salt could be applied per unit area due to three primary reasons: 1) the application rate could have increased as an attempt to maintain more ice-free conditions; 2) the density of impervious area per unit urban area could have increased, thereby increasing the need for road salt, or 3) the difference in weather conditions between the early and latter portions of the study could have warranted different application rates.

Second, the baseline concentrations have been increasing over time due to continued road salt input to the shallow groundwater system and inability of the system to recover to true background concentrations before the next deicing season begins. The result is an increase in baseline concentrations from shallow groundwater discharge to the stream during low flow, as indicated by increasing summer concentrations. Since baseline concentrations increased with time over the course of the study, less additional road salt runoff was needed to reach concentrations of concern in the later years of the study than in the early years, effectively changing the slope of the chloride to urban land cover relation. With baseline concentrations governed by groundwater discharges in many instances, this finding is consistent with other research that has observed elevated chloride concentrations in groundwater which has caused elevated stream concentrations (Kelly, 2008; Eyles et al., 2013).

To explore the possibility of changing weather patterns as potential explanation of increased salt application, snowfall data were examined

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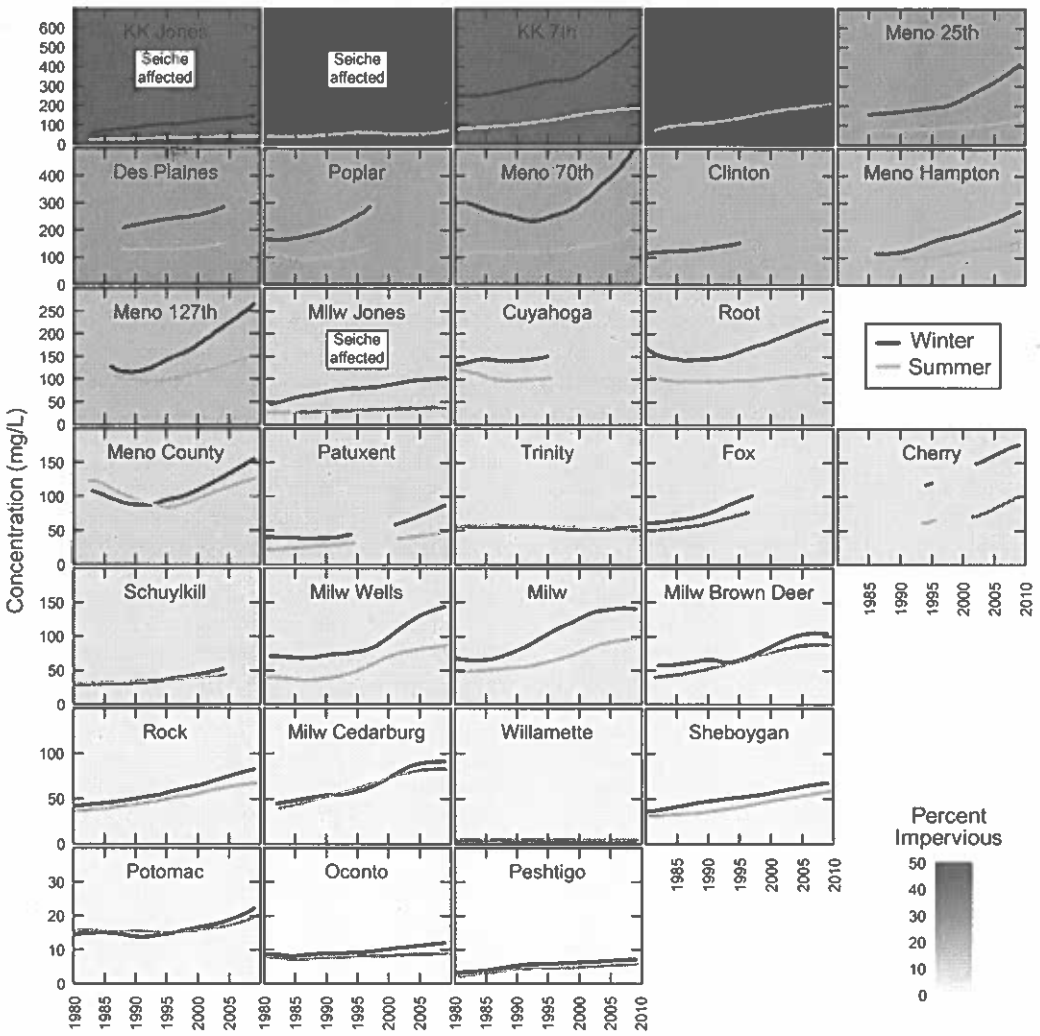


Fig. 4. Winter (black line) and summer (gray line) flow-normalized chloride concentration trends for 30 sites in 19 streams across the United States. The background color represents watershed percent imperviousness as determined using the National Land Cover Database from 2006 (Fry et al., 2011). Sites are ordered by percent imperviousness. Seiche affected is defined by backwater influence from Lake Michigan.

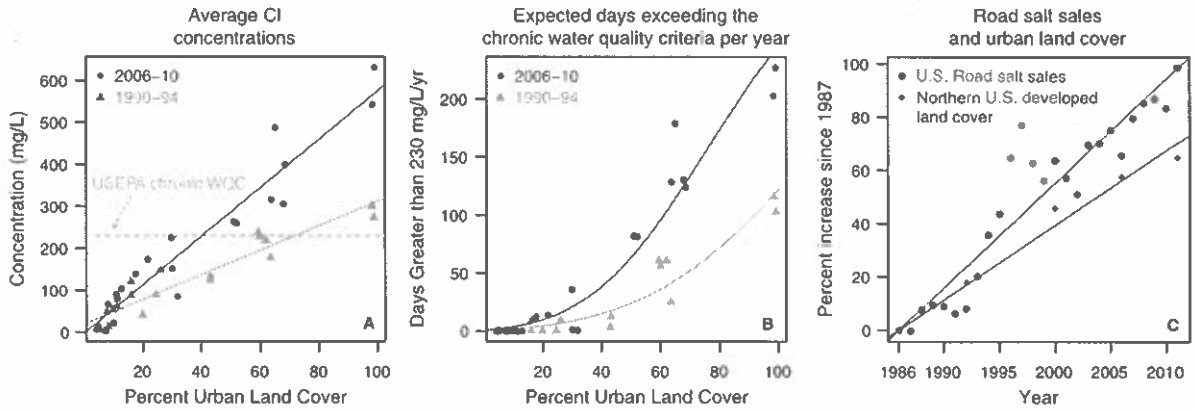


Fig. 5. Average chloride concentration (A) and expected number of individual days per year with concentration exceeding the USEPA chronic water quality criteria of 230 mg/L (B) from modeling results compared to urban land cover percentage in the contributing watershed, and the percent increase in U.S. annual road salt sales compared to the percent increase in urban land cover in the northern U.S. since 1987 (C). Lines (A and C) represent ordinary least squares regression models and curves (B) are based on results of logistic regressions of the probability of daily exceedance as a function of urban land cover. In panel C, U.S. road salt sales are presented as a 5-yr moving average. Dashed line for USEPA chronic water quality criteria represents 230 mg/L (A).

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for nine National Weather Service monitoring stations ranging geographically from Washington, D.C., to Denver, Colorado (Table S2, supporting information). For each station, the average total annual snowfall and the average annual number of individual days with snow exceeding 20 mm were computed as a measure of potential for road salt application. An increase in the annual number of days with snow exceeding 20 mm was observed at five stations, and a decrease was observed at four stations. An increase in annual snowfall was observed at six stations, and a decrease was observed at three stations. These data indicated a potentially mixed influence of weather on road salt applications among chloride monitoring sites. Given that 23 of the 30 stream sites were located in the Midwest, the result that data from all four weather stations in the Midwest had increased annual snowfall (average increase of 16%) and days with greater than 20 mm of snow (average increase of 13%) indicated a potential for road salt application increase due to snowfall conditions. In contrast, two of four weather stations in the eastern part of the country had decreased annual snowfall (average overall decrease of 11%) and three of four weather stations had decreased days with greater than 20 mm of snow (average overall decrease of 23%) indicating a potential for road salt application decrease due to snowfall conditions. Snowfall (annual depth and days with greater than 20 mm) in Denver, Colorado decreased by more than 40%. Despite the mixed trends in snow records, stream chloride concentrations increased in each of these three areas of the country, suggesting that increasing baseline concentrations and possible increasing application rates due to factors other than snow cover contribute to the changing relation of chloride with urban land cover over time. Since weather patterns and road salt application methods are locally variable, it would be valuable to extend this study in future research by examining the overall concentrations and the baseline concentrations with respect to precipitation and total salt application on an individual watershed basis.

Given the increasing road salt sales per unit area of urban land cover in the U.S., the increasing baseline chloride concentrations during summer periods, and the difference in snow conditions, it appears multiple factors could plausibly be contributors to the changing relation between average chloride concentrations and urban land cover within the watershed.

4.2. Seasonality

Increasing chloride trends were present all year, including seasons that do not require deicer application; however, the highest concentrations occurred during winter periods. A similar year-round influence has been noted multiple times in previous research (Williams et al., 2000; Kelly, 2008; Perera et al., 2013). This non-deicing season effect has been attributed to salt infiltrating into the shallow groundwater system thereby serving as a "reservoir" of salt that is slowly discharged into streams as baseflow. Relatively slow travel times in the shallow groundwater system could account for the time lag between deicer applications and eventual discharge into the stream.

4.3. Streamflow dependency

Chloride concentrations commonly increased with decreasing streamflow throughout all seasons of the year in most streams studied. The same relation has previously been observed in streams of Illinois (Kelly et al., 2010) and Toronto (Meriano et al., 2009). This behavior can be explained primarily by the factors that govern hydrology throughout the year. During cold-weather months, road salt applications occur during many types of precipitation events. These include a gradient of precipitation forms ranging from purely snowfall events to mixed rainfall and snowfall events to purely rainfall events when freezing temperatures are expected. Precipitation with very little or no liquid precipitation provide little dilution of road salt as it melts snow and ice and eventually drains to nearby streams. These are also low-flow periods, so the stream itself provides little dilution. The combination of these two factors results in high chloride concentrations in the streams. Conversely, during deicing events with greater quantities of liquid precipitation, more dilution of the road salt is provided directly from the precipitation. In addition, when snow is present on the ground, melting is enhanced by contact with rainfall, streamflow is elevated, and dilution potential in the stream is greater. These high-dilution events still have elevated chloride concentrations, but not as high as the low-dilution events.

During non-deicing months, chloride concentrations also decreased with increasing streamflow. Precipitation events again serve to dilute chloride concentrations more than those during low-flow periods that are dominated by groundwater discharge, which is a substantial source of chloride during the non-deicing months.

4.4. Comparison to aquatic toxicity benchmarks

Elevated chloride concentrations resulting from road salt application and runoff in watersheds have potential impacts on aquatic organisms (U.S. Environmental Protection Agency, 1988; Environment Canada, 2001). Increasing trends over time have resulted in increasing exceedances of concentrations that are likely to be harmful to aquatic life. The current research indicates that the relation between urban land cover and the number of daily exceedances of the USEPA chronic water quality criteria concentration of 230 mg/L has changed during the study period (Fig. 5). The number of exceedances for a particular percent of urban land cover was greater during the latter portion of the study as compared to the early portion of the study. As described above for increasing concentrations, an increase in road salt application rates over time, an increase in the baseline concentrations as indicated by summer chloride trends, and changes in snowfall are likely causes of the increased water quality criterion exceedance rate.

Previous research has indicated that degradation of biological integrity is evident beginning below 1% impervious area (Stepenuck et al., 2002; Cuffney et al., 2010; King et al., 2010). Results from the present research are consistent with these findings as chloride concentrations began to increase as soon as urban land cover was present, and concentrations exceeded the chronic water quality criterion beginning at approximately 10% impervious area (approximately 25% urban land cover; Table 1, Fig. 5). A review of road salt effects conducted by Environment Canada concluded that high concentrations of chloride may have immediate or long-term effects on ecosystem populations and that lower concentrations may have adverse effects on community structure, diversity, and productivity (Environment Canada, 2001). Studies reviewed for this Environment Canada effort found that some of the biological components affected included densities of bacteria and algae, drift of stream benthic invertebrates, as well as diversity and community structure of aquatic invertebrates (Evans and Frick, 2001). Other work has determined that elevated chloride concentrations can also influence reproduction of aquatic organisms (Beggel and Geist, 2015). All of this information is primarily based on direct influence from chloride exposures, but indirect exposures caused by mobilization of heavy metals may also have impacts on aquatic organisms (Amrhein et al., 1992; Bäckström et al., 2004; Nelson et al., 2009). These chloride influences are yet another stressor in addition to those commonly thought to impact biological integrity of urban streams such as hydraulic and hydrologic factors, degraded water quality from point and non-point source runoff, and altered habitat and stream channels (Walsh et al., 2005; Steuer et al., 2010).

The multi-season impacts presented in this research suggest the possibility of extended-duration, high-concentration exposure to chloride in urban streams of the northern U.S. This possibility appears credible given that extended-duration (multiple months), high-concentration exposures to chlorides have previously been documented in urban streams receiving road salt runoff (Corsi et al., 2010; Baldwin et al., 2012; Kelly et al., 2012b). Further work to define concentration–duration relations is warranted given that the current USEPA chronic water quality criterion is designed for a 4-day exposure period, and it appears that exposures have

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potential to be much longer than 4 days. Longer-duration exposures may result in additional impacts on the full life-cycle of aquatic organisms that may not be evident with common evaluation methods.

4.5. Salt management and alternatives

The nature of salt presence in environmental waters makes this issue very difficult to address with common stormwater management practices that rely most commonly on settling or filtration of particulate matter (Waschbusch, 1999; Greb et al., 2000; Horwatich et al., 2011). Since salt dissolves readily in water, these types of management practices will not remove salt from runoff. The only reliable way to reduce the impact of road salt on receiving streams is to reduce applications. There are a host of techniques that have been identified and documented for reduction of road salt application. For example, many municipalities have salt management plans that include a strategy for minimizing road salt usage. Some of these practices include training programs for most effective use, pre-wetting of granular salt to maximize salt retention on paved surfaces, applicators that are calibrated and vary by groundspeed, anti-icing that reduces bonding between snow and pavement and makes plowing more effective, and more efficient predictions of icing conditions to inform deicing activities (Kramberger and Zerovnik, 2008; Fay et al., 2013). In addition, there are a number of alternative chemicals that have been used. These alternative chemicals commonly include other chloride-containing salts such as magnesium chloride or calcium chloride, organic salts such as calcium magnesium acetate, potassium acetate, or sodium acetate, different variations of salt brines, and organic deicers such as glycols. Unfortunately, none of these options are without potential environmental impact as well. All of these alternative deicers have varying degrees of associated aquatic toxicity (Environment Canada, 2001). In addition, organic chemicals used as deicers have an additional impact from increased biochemical oxygen demand (Corsi et al., 2012) and excessive biofilm growth (Mericas et al., 2014). Still, road salt is more common than the alternatives due to the performance effectiveness and relatively low cost compared to alternatives.

5. Conclusions

The U.S. is an urbanizing nation, and with increasing development, previous data and results from this research indicate that road salt applications, chloride concentrations, and resulting adverse impacts on aquatic organisms in streams are likely to increase along with urban development. This research indicates that chloride concentrations in urban streams of the northern U.S. and resulting water quality criteria exceedances have increased at a greater rate than the rate of urban development. In addition, elevated chloride concentrations in these streams through all seasons have implications on long-term exposures to chloride for aquatic organisms. Results of this research provide verification that chloride concentrations in urban streams continue to increase, influencing the potential for aquatic life in affected streams.

Acknowledgments

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Appendix A. Supplementary data

Methods for the determination of land cover and other watershed characteristics, characteristics of water quality and associated streamflow sites (Table S1), snowfall information at nine National Weather Service Stations (Table S2), WRTDS modeling results during the periods from 1990 to 1994 and 2006 to 2010 for winter and summer periods (Table S3). This material is available free of charge via the Internet at STOTEN TO http://dx.doi.org/10.1016/j.scitotenv.2014.12.012.

References

Alig, R.J., Kline, J.D., Lichtenstein, M., 2004. Urbanization on the US landscape: looking ahead in the 21st century. Landsc. Urban Plan. 69 (2–3), 219–234 (Aug 15).
Allert, A.L., Cole-Neal, C.L., Fairchild, J.F., 2012. Toxicity of chloride under winter low-flow conditions in an urban watershed in central Missouri, USA. Bull. Environ. Contam. Toxicol. 89 (2), 296–301 (Aug).
Amrhein, C., Strong, J.E., Mosher, P.A., 1992. Effect of deicing salts on metal and organic matter mobilization in roadside soils. Environ. Sci. Technol. 26 (4), 703–709 (Apr 1).
Bäckström, M., Karlsson, S., Bäckman, L., Folkeson, L., Lind, B., 2004. Mobilisation of heavy metals by deicing salts in a roadside environment. Water Res. 38 (3), 720–732 (Feb).
Baldwin, A.K., Graczyk, D.J., Robertson, D.M., Saad, D.A., Magruder, C.J., 2012. Use of Real-Time Monitoring to Predict Concentrations of Select Constituents in the Menomonee River Drainage Basin, Southeast Wisconsin, 2008–9. (Internet), U.S. Geological Survey, Reston, VA, p. 129 (Report No.: 2012–5064. Available from: http://pubs.usgs.gov/sir/2012/5064/pdf/sir2012-5064_web.pdf).
Beggel, S., Geist, J., 2015. Acute effects of salinity exposure on glochidia viability and host infection of the freshwater mussel *Anodonta anatina* (Linnaeus, 1758). Sci. Total Environ. 502, 659–665 (Jan 1).
Cañedo-Argüelles, M., Kefford, B.J., Piscart, C., Prat, N., Schäfer, R.B., Schulz, C.-J., 2013. Salinisation of rivers: an urgent ecological issue. Environ. Pollut. 173, 157–167 (Feb).
Cassanelli, J.P., Robbins, G.A., 2013. Effects of road salt on Connecticut's groundwater: a statewide centennial perspective. J. Environ. Qual. 42 (3), 737.
Chapra, S.C., Dove, A., Rockwell, D.C., 2009. Great Lakes chloride trends: long-term mass balance and loading analysis. J. Great Lakes Res. 35 (2), 272–284 (Jun).
Chapra, S.C., Dove, A., Warren, G.J., 2012. Long-term trends of Great Lakes major ion chemistry. J. Great Lakes Res. 38 (3), 550–560 (Sep).
Corsi, S.R., Graczyk, D.J., Geis, S.W., Booth, N.L., Richards, K.D., 2010. A fresh look at road salt: aquatic toxicity and water-quality impacts on local, regional, and national scales. Environ. Sci. Technol. 44 (19), 7376–7382.
Corsi, S.R., Mericas, D., Bowman, G.T., 2012. Oxygen demand of aircraft and airfield pavement deicers and alternative freezing point depressants. Water Air Soil Pollut. 223 (5), 2447–2461 (Jun 1).
Cuffney, T.F., Brightbill, R.A., May, J.T., Waite, I.R., 2010. Responses of benthic macroinvertebrates to environmental changes associated with urbanization in nine metropolitan areas. Ecol. Appl. 20 (5), 1384–1401 (Jun 22).
Environment Canada, 2001. Priority Substances List Assessment Report Road Salts. (Internet), Environment Canada, Canada (Report No.: 0-662-31018-7. Available from: http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/contaminants/psl2-lsp2/road_salt_sels_voirie/road_salt_sels_voirie-eng.pdf).
Evans, M., Frick, C., 2001. The Effects of Road Salts on Aquatic Ecosystems. (Internet), Environment Canada, Burlington, Ontario, Canada, p. 298 (Report No.: National Water Resources Institute Series No. 02–308. Available from: http://brage.bibsys.no/xmlui/bitstream/id/201102/the_effects_road_salts.pdf).
Eyles, N., Meriano, M., Chow-Fraser, P., 2013. Impacts of European settlement (1840–present) in a Great Lake watershed and lagoon: Frenchman's Bay, Lake Ontario, Canada. Environ. Earth Sci. 68 (8), 2211–2228 (Apr 1).
Fay, L., Shi, X., Huang, J., 2013. Strategies to mitigate the impacts of chloride roadway deicers on the natural environment. (Internet), National Cooperative Highway Research Program, Transportation Research Board, National Research Council, Washington D.C. (Available from: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_449.pdf).
Fry, J.A., Coan, M.J., Homer, C.G., Meyer, D.K., Wickham, J.D., 2009. Completion of the National Land Cover Database (NLCD) 1992–2001 Land Cover Change Retrofit product. (Internet), U.S. Geological Survey, Reston, VA, p. 18 (Report No.: 2008–1379. Available from: http://pubs.usgs.gov/of/2008/1379/pdf/ofr2008-1379.pdf).
Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., et al., 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States. Photogramm. Eng. Remote Sens. 77 (9), 858–864.
Godwin, K.S., Hafner, S.D., Buff, M.F., 2003. Long-term trends in sodium and chloride in the Mohawk River, New York: the effect of fifty years of road-salt application. Environ. Pollut. 124 (2), 273–281 (Jul).
Greb, S., Bannerman, R., Corsi, S., Pitt, R., 2000. Evaluation of the multichambered treatment train, a retrofit water-quality management practice. Water Environ. Res. 72 (2), 207–216 (Apr.).
Green, C.T., Bekins, B.A., Kalkhoff, S.J., Hirsch, R.M., Liao, L., Barnes, K.K., 2014. Decadal surface water quality trends under variable climate, land use, and hydrogeochemical setting in Iowa, USA. Water Resour. Res. 50 (3), 2425–2443 (Mar 1).
Hirsch, R.M., De Cicco, L.A., 2014. U.S. Department of the Interior U.S. Geological Survey User Guide to Exploration and Graphics for RivEr Trends (EGRET) and dataRetrieval: R Packages for Hydrologic Data. (Internet), U. S. Geological Survey, Reston, VA, p. 95 (Oct. Report No.: 4-A10. Available from: http://pubs.usgs.gov/tm/04/a10/).

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Hirsch, R.M., Moyer, D.L., Archfield, S.A., 2010. Weighted regressions on time, discharge, and season (WRTDS), with an application to Chesapeake Bay river inputs 1. J. Am. Water Resour. Assoc. 46 (5), 857–880.

Horwatich, J.A., Bannerman, R.T., Pearson, R., 2011. Highway-runoff quality, and treatment efficiencies of a hydrodynamic-settling device and a stormwater-filtration device in Milwaukee, Wisconsin. (Internet), United States Geological Survey, p. 76 (Report No.: SIR - 2010–5160. Available from: http://pubs.usgs.gov/sir/2010/5160/).

Interlandi, S.J., Crockett, C.S., 2003. Recent water quality trends in the Schuylkill River, Pennsylvania, USA: a preliminary assessment of the relative influences of climate, river discharge and suburban development. Water Res. 37 (8), 1737–1748 (Apr).

Kaushal, S.S., Groffman, P.M., Likens, G.E., Belt, K.T., Stack, W.P., Kelly, V.R., et al., 2005. Increased salinization of fresh water in the northeastern United States. Proc. Natl. Acad. Sci. U. S. A. 102 (38), 13517–13520 (Sep 20).

Kelly, W.R., 2008. Long-term trends in chloride concentrations in shallow aquifers near chicago. Ground Water 46 (5), 772–781.

Kelly, T.D., Matos, G.R., 2013. Historical Statistics for Mineral and Material Commodities in the United States. (Internet), U.S. Geological Survey, Reston, VA (Report No.: 140. Available from: http://pubs.usgs.gov/ds/2005/140/).

Kelly, W.R., Panno, S.V., Hackley, K.C., Hwang, H.-H., Martinsek, A.T., Markus, M., 2010. Using chloride and other ions to trace sewage and road salt in the Illinois Waterway. Appl. Geochem. 25 (5), 661–673 (May).

Kelly, W.R., Panno, S.V., Hackley, K.C., 2012a. Impacts of road salt runoff on water quality of the Chicago, Illinois, Region. Environ. Eng. Geosci. 18 (1), 65–81 (Feb 1).

Kelly, W.R., Panno, S.V., Hackley, K.C., 2012b. The Sources, Distribution, and Trends of Chloride in the Waters of Illinois. Illinois State Water Survey, Prarie Research Institute, Champaign, Illinois, p. 67 (Mar, Report No.: B-74).

King, R.S., Baker, M.E., Kazyak, P.F., Weller, D.E., 2010. How novel is too novel? Stream community thresholds at exceptionally low levels of catchment urbanization. Ecol. Appl. 21 (5), 1659–1678 (Dec 9).

Kramberger, T., Zerovnik, J., 2008. A contribution to environmentally friendly winter road maintenance: optimizing road de-icing. Transp. Res. D 13 (5), 340–346.

Medalie, L., Hirsch, R.M., Archfield, S.A., 2012. Use of flow-normalization to evaluate nutrient concentration and flux changes in Lake Champlain tributaries, 1990–2009. Lake Champlain 2010. 38 (Supplement 1(0)), 58–67.

Meriano, M., Eyles, N., Howard, K.W.F., 2009. Hydrogeological impacts of road salt from Canada's busiest highway on a Lake Ontario watershed (Frenchman's Bay) and lagoon, City of Pickering, J. Contam. Hydrol. 107 (1–2), 66–81 (Jun 26).

Mericas, D., Sturman, P., Lutz, M., Cieciek, C., Boltz, J., Morgenroth, E., 2014. Understanding Microbial Biofilms in Receiving Waters Impacted by Airport Deicing Activities. Airport Cooperative Research Program. Transportation Research Board of the National Academies, Washington, D.C. (Report No.: ACRP 115).

Morgan, R.P., Kline, K.M., Kline, M.J., Cushman, S.F., Sell, M.T., Weitzell, R.E., et al., 2012. Stream conductivity: relationships to land use, chloride, and fishes in Maryland streams. N. Am. J. Fish Manag. 32 (5), 941–952.

Mullaney, J.R., Lorenz, D.L., Arntson, A.D., 2009. Chloride in Groundwater and Surface Water in Areas Underlain by the Glacial Aquifer System, Northern United States. (Internet), U.S. Geological Survey, Reston, VA (Available from: http://pubs.usgs.gov/sir/2009/5086/pdf/sir2009-5086.pdf).

Müller, B., Gächter, R., 2012. Increasing chloride concentrations in Lake Constance: characterization of sources and estimation of loads. Aquat. Sci. 74 (1), 101–112 (Jan).

Nelson, S., Yonge, D., Barber, M., 2009. Effects of road salts on heavy metal mobility in two eastern Washington soils. J. Environ. Eng. 135 (7), 505–510.

Nickerson, C., Ebel, R., Borchers, A., Fernando, C., 2011. Major Uses of Land in the United States, 2007. (Internet), (Dec. Report No.: EIB-89. Available from: http://www.ers.usda.gov/publications/eib-economic-information-bulletin/eib89.aspx#.UwJT37RFq5Q).

Novotny, E.V., Stefan, H.G., 2010. Projections of chloride concentrations in urban lakes receiving road de-icing salt. Water Air Soil Pollut. 211 (1–4), 261–271 (Sep 1).

Perera, N., Gharabaghi, B., Noehammer, P., 2009. Stream chloride monitoring program of city of Toronto: implications of road salt application. Water Qual. Res. J. Can. 44 (2) ([Internet], [cited 2014 Feb 14]. Available from: http://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=12013080&AN=46795597&h=WPgK%2FLCKKtMnebn0SXAMxtDkIT62qAAuYGy2WvL3M9V4vY2e37CQ9AxX%2BiTrljzdhixJAkFBSuiU70R2ECGgOg%3D%3D&crl=c).

Perera, N., Gharabaghi, B., Howard, K., 2013. Groundwater chloride response in the Highland Creek watershed due to road salt application: a re-assessment after 20 years. J. Hydrol. 479, 159–168 (Feb 4).

R Development Core Team, 2008. R: A Language and Environment for Statistical Computing. (Internet), R Foundation for Statistical Computing, Vienna, Austria (Available from: http://www.R-project.org).

Ramstack, J.M., Fritz, S.C., Engstrom, D.R., 2004. Twentieth century water quality trends in Minnesota lakes compared with presettlement variability. Can. J. Fish. Aquat. Sci. 61 (4), 561–576 (Apr 1).

Reisch, C.E., Toran, L., 2013. Characterizing snowmelt anomalies in hydrochemographs of a karst spring, Cumberland Valley, Pennsylvania (USA): evidence for multiple recharge pathways. Environ. Earth Sci. 1–12.

Ruth, O., 2003. The effects of de-icing in Helsinki urban streams, Southern Finland. Water Sci. Technol. 48 (9), 33–43.

Stepenuck, K.F., Crunkilton, R.L., Wang, L., 2002. Impacts of urban landuse on macroinvertebrate communities in southeastern Wisconsin streams 1. J. Am. Water Resour. Assoc. 38 (4), 1041–1051 (Aug 1).

Steuer, J.J., Stensvold, K.A., Gregory, M.B., 2010. Determination of biologically significant hydrologic condition metrics in urbanizing watersheds: an empirical analysis over a range of environmental settings. Hydrobiologia 654 (1), 27–55 (Oct 1).

Thunqvist, E.-L., 2004. Regional increase of mean chloride concentration in water due to the application of deicing salt. Sci. Total Environ. 325 (1–3), 29–37 (Jun 5).

Trowbridge, P.R., Kahl, J.S., Sassan, D.A., Heath, D.L., Walsh, E.M., 2010. Relating road salt to exceedances of the water quality standard for chloride in New Hampshire streams. Environ. Sci. Technol. 44 (13), 4903–4909 (Jul 1).

U.S. Environmental Protection Agency, 1988. Ambient Water Quality Criteria for Chloride—1988. (Internet), (Washington, DC. Available from: http://www.epa.gov/waterscience/pc/ambientwqc/chloride1988.pdf).

Walsh, C.J., Roy, A.H., Feminella, J.W., Cottingham, P.D., Groffman, P.M., Morgan II, R.P., 2005. The urban stream syndrome: current knowledge and the search for a cure. J. N. Am. Benthol. Soc. 24 (3), 706–723.

Waschbusch, R.J., 1999. Evaluation of the effectiveness of an urban stormwater treatment unit in Madison, Wisconsin, 1996–97. (Internet), United States Geological Survey (Report No.: WRI - 99–4195. Available from: http://pubs.water.usgs.gov/wri994195).

Williams, D.D., Williams, N.E., Cao, Y., 2000. Road salt contamination of groundwater in a major metropolitan area and development of a biological index to monitor its impact. Water Res. 34 (1), 127–138.

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ATTACHMENT 5

TOLLWAY OFFSET PROGRAM

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Wood Dale Chloride Offset

INTERGOVERNMENTAL AGREEMENT BETWEEN
THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY
AND
THE CITY OF WOOD DALE
FOR
CHLORIDE OFFSET PROGRAM

This INTERGOVERNMENTAL AGREEMENT ("AGREEMENT") is entered into this 13TH day of JUNE, 2017, by and between The Illinois State Toll Highway Authority, an instrumentality and administrative agency of the State of Illinois, hereinafter called the "ILLINOIS TOLLWAY", and The City of Wood Dale, a municipal corporation of the State of Illinois, hereinafter called the "CITY", individually referred to as "PARTY", and collectively referred to as "PARTIES".

WITNESSETH:

WHEREAS, the ILLINOIS TOLLWAY in order to facilitate the free flow of traffic and ensure safety to the motoring public, intends to improve the existing Elgin O'Hare Expressway, extend the expressway from its eastern terminus at Rohlwing Road (Illinois Route 53) to O'Hare International Airport (ORD) to be known entirely as Illinois Route 390, and construct the Western Access connecting the Jane Addams Memorial Tollway (I-90) with the Tri-State Tollway (I-294) (hereinafter sometimes referred to as the Elgin O'Hare Western Access "EOWA"), and included in multiple ILLINOIS TOLLWAY construction contracts. The ILLINOIS TOLLWAY will implement, operate and maintain the mainline improvements as tolled facilities (hereinafter sometimes referred to as "Toll Highway"); and

WHEREAS, highway de-icing practices during winter months commonly use de-icing salts to provide for safe vehicular travel and winter maintenance for the EOWA will require the use of chlorides; and

WHEREAS, studies acknowledged the potential for the addition of chloride concentrations in area streams and as the EOWA project is advancing in implementation, permits for Section 404 and Section 401 of the Clean Water Act (CWA) have been secured from the United States Army Corp of Engineers (USACE) and the Illinois Environmental Protection Agency (IEPA); and

WHEREAS, conditions established within the ILLINOIS TOLLWAY's CWA Section 401 permit require the implementation of a "Chloride Offset Program" (hereinafter called the "PROGRAM") to mitigate for increased chloride loading in the Total Maximum Daily Loading (TMDL) watersheds throughout the EOWA project area; and

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WHEREAS, a Memorandum of Understanding (MOU) between the ILLINOIS TOLLWAY and DuPage River Salt Creek Workgroup (DRSCW) was executed October 31, 2013 to outline the PROGRAM, which is attached hereto as "Exhibit A" and incorporated by reference; and

WHEREAS, per the MOU, it was agreed that the entirety of the offset will occur within the impacted areas and be tailored to individual receiving stream segments to the maximum extent possible. As such, local watershed communities and agencies participating in the PROGRAM will be responsible for winter operations on the land surfaces that drain to those segments and are herein referred to as "TIER 1 COMMUNITY" or "TIER 1 COMMUNITIES"; and

WHEREAS, the CITY has been identified as a TIER 1 COMMUNITY and has, in coordination with the DRSCW, conducted a review of their snow and ice operations in an effort to identify areas of operational improvements relating to efficiency gains in winter chloride usage, and per the CITY'S review, it is believed that an effective reduction in chloride usage can be attained, as part of the PROGRAM through the upgrading of equipment utilized for winter operations by the CITY; and

WHEREAS, the PARTIES mutually agree to review winter operation policies and procedures and work in coordination with the DRSCW to monitor the administration and progress of the PROGRAM; and

WHEREAS, the ILLINOIS TOLLWAY by virtue of its powers as set forth in the "Toll Highway Act," 605 ILCS 10/1 *et seq.* is authorized to enter into this AGREEMENT; and

WHEREAS, the CITY by virtue of its powers as set forth in the "Illinois Municipal Code," 65 ILCS 5/1-1-1 *et seq.* is authorized to enter into this AGREEMENT; and

WHEREAS, a cooperative Intergovernmental Agreement is appropriate and such an Agreement is authorized by Article VII, Section 10 of the Illinois Constitution and the "Intergovernmental Cooperation Act", 5 ILCS 220/1 *et seq.*

WHEREAS for recording purposes this AGREEMENT shall be known as #004685.

NOW, THEREFORE, in consideration of the aforementioned recitals and the mutual covenants contained herein, the PARTIES hereto agree to the following summary of the responsibilities and participation of each PARTY in the implementation of the PROGRAM.

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I. PURPOSE and SCOPE

A. The PROGRAM established a projected increase over existing conditions or baseline for the EOWA of 3,888 tons of salt per year, per a baseline 39.7 tons/lane mile/year application rate. The goal of the offset program will be to reduce salt usage in roadway applications in the project related watersheds by the amount of the increase (3,888 tons per year) plus a margin of safety of 25 percent or a total reduction of 4,860 tons per year.

B. The ILLINOIS TOLLWAY, as part of the PROGRAM, has established a rate reduction goal of 20% from the EOWA's established baseline salt application rate of 39.7 tons/lane mile/year, thereby accounting for 972 tons per year of the 4,860 tons per year of salt required to be reduced, as part of the PROGRAM.

C. The CITY, as part of the PROGRAM and per this AGREEMENT, has established a rate reduction goal of 17.5% from its established baseline application salt application rate of 12.3 tons/lane mile/year, thereby accounting for 204 tons per year of the 4,860 tons per year of salt required to be reduced, as part of the PROGRAM.

D. Both structural and non-structural practices will comprise the PROGRAM to provide the needed improvements in water quality but it is understood that offset reductions can only be accounted for through non-structural practices.

II. STRUCTURAL BEST MANAGEMENT PRACTICES

A. Grass swales, bio-swales, infiltration basins, and other designs will be incorporated by the ILLINOIS TOLLWAY into the EOWA projects in order to minimize the effects of roadway runoff and improve the quality of roadway runoff discharged to receiving waters and/or nearby wetlands.

III. NON-STRUCTURAL BEST MANAGEMENT PRACTICES

A. A salt reduction goal has been established by the ILLINOIS TOLLWAY and DRSCW for the PROGRAM through the analysis of existing conditions, existing practices in the affected watersheds, and planned highway improvements. Offsets will include both the adoption of salt reduction strategies implemented by the ILLINOIS TOLLWAY and providing salt application data to DRSCW, including but not limited to their application rates for each lane mile, as well as financial and other support to other mutually agreed upon partners.

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B. The ILLINOIS TOLLWAY recognizes that meeting the objectives of the Total Maximum Daily Loads ("TMDL's") will require reductions in area chloride loading above those set out in the PROGRAM and agrees to review its practices at an agency wide scale and to actively partner with the DRSCW, its members or successors, in working for PROGRAM area chloride reductions beyond the life of the PROGRAM with the goal of meeting the applicable water quality standard.

IV. RESPONSIBILITIES

A. Pursuant to EXHIBIT A, a guideline for monitoring and reporting chloride offsets has been established. Both PARTIES agree that the requirements embodied in Clean Water Act Section 401 certification(s) or Section 404 or NPDES permit(s), are the sole responsibility of the ILLINOIS TOLLWAY, and that the CITY is not responsible in any way for the ILLINOIS TOLLWAY's failure to comply with such requirements.

B. The CITY shall provide the ILLINOIS TOLLWAY a summary raw data report that includes the following data for the most recent winter season for a minimum of five consecutive winter seasons, post equipment purchase and installation; 1) total lane miles maintained, 2) actual road salt usage in tons per lane mile, 3) baseline road salt usage in tons per lane mile, 4) target road salt usage in tons per lane mile, 5) total winter season precipitation events requiring deicing efforts, 6) average precipitation in inches of snow, ice and liquid form of winter season precipitation per precipitation event, 7) duration of each operator deicing efficiency training session and number of operators attending, 8) new equipment installation and new practices implemented and identification and practices planned and 9) the completed DRSCW's Winter Public Agency Deicing Questionnaire.

C. The PARTIES agree that the PROGRAM may require several years of monitoring and reporting from PROGRAM partners.

D. The PARTIES will develop and maintain a guidance document for the PROGRAM which will at minimum detail the methods for calculating the build scenario non-PROGRAM increase, the needed offset, BMP's the monitoring PROGRAM and reporting baseline requirements. The document will be updated by agreement between the PARTIES as the PROGRAM advances.

V. DELIVERABLES

A. The deliverables will be transmitted to the ILLINOIS TOLLWAY, by the CITY and include written reports documenting, as defined in Article IV, Paragraph B. of this AGREEMENT by June 1st pertaining to the preceding winter season.

B. The ILLINOIS TOLLWAY maintains its responsibility to remain compliant with the "Clean Water Act" as determined and administered by the IEPA.

VI. FINANCIAL

A. The ILLINOIS TOLLWAY as sponsor of the PROGRAM will compensate the CITY as outlined in this AGREEMENT and included in the CITY's Request for Equipment and Training "PROPOSAL".

B. The purchase of equipment identified within the CITY's PROPOSAL, as part of the PROGRAM shall be reimbursed by the ILLINOIS TOLLWAY to the CITY.

C. The CITY will be paid based upon its invoice(s) which shall include detailed receipts of purchased items in substantial conformance with the Budget included in the CITY's PROPOSAL.

D. The CITY shall certify in writing, upon presentation of each invoice hereunder, that items as invoiced have been actually purchased and installed and that the CITY is in fact complying with all other provisions of this AGREEMENT. Invoicing shall be sufficiently itemized to permit the ILLINOIS TOLLWAY or its consultant(s) or cooperating governmental unit(s) to verify performance of the work so invoiced.

E. It is mutually agreed that the estimated cost to the ILLINOIS TOLLWAY shall not exceed $139,500 for the term of this AGREEMENT through five consecutive winter seasons, beginning with the first winter season in which purchased equipment has been utilized and use data has been provided to the ILLINOIS TOLLWAY.

VII. GENERAL PROVISIONS

A. It is understood and agreed that this is an AGREEMENT between the City of Wood Dale and the Illinois State Toll Highway Authority.

B. All equipment proposed for purchase and installation, shall be done so prior to the 2018/2019 winter season but efforts will be made for purchases and installations to occur prior to the 2017/2018 winter season.

C. The term of this AGREEMENT shall extend through five consecutive winter seasons in which purchased equipment has been utilized and use data has been provided to the ILLINOIS TOLLWAY.

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D. PARTIES agree to collaborate in effort to fulfill applicable goals of the PROGRAM as established in Section IV. of EXHIBIT A. Should the PARTIES mutually agree that the CITY did not operate in a manner demonstrating intent achieve the goal reduction of 17.5% in a PROGRAM year, the ILLINOIS TOLLWAY shall provide written notice to the CITY identifying delinquencies of agreed upon practices. Should the PARTIES mutually agree that the CITY did not operate in a manner in which to achieve the goal reduction of 17.5% for a second year during the term of this AGREEMENT, the ILLINOIS TOLLWAY and shall provide written notice to the CITY identifying delinquencies of agreed upon practices and the CITY shall provide reimbursement to the ILLINOIS TOLLWAY for all payments made by the ILLINOIS TOLLWAY associated with this agreement within 90 days of CITY's receipt of the notice.

E. Equipment purchased under this AGREEMENT by the ILLINOIS TOLLWAY on behalf of the CITY becomes the property and responsibility of the CITY and the CITY shall indemnify, hold harmless and defend the ILLINOIS TOLLWAY, its officials, directors, officers, employees, and agents from and against all liability, claims, suits, demands, proceedings and action, including costs, fees and expense of defense, arising from, growing out of, or related to, any loss, damage, injury, death, or loss or damage to property resulting from, or connected with, the CITY's negligent or willful acts, errors or omissions in its performance under this AGREEMENT, including, but not limited to, use of the equipment described herein. The CITY expressly acknowledges that the ILLINOIS TOLLWAY, through provision of funding, training, and certification under this AGREEMENT, is not intended to be a joint employer of the CITY's employees and agents and does not excerpt control over such persons in their use of the equipment that is the subject of this AGREEMENT.

F. It is understood and agreed that this AGREEMENT constitutes the complete and exclusive statement of the agreement of the PARTIES relative to the subject matter hereof and supersedes all previous oral and written proposals, negotiations, representations or understandings concerning such subject matter.

G. This AGREEMENT may be executed in two (2) or more counterparts, each of which shall be deemed an original and all of which shall be deemed one and the same instrument.

H. Under penalties of perjury, the CITY certifies that its correct Federal Tax Identification number is 36-6008547 and it is doing business as a governmental entity, whose mailing address is The City of Wood Dale, 404 North Wood Dale Road, Wood Dale, Illinois 60143.

I. The PARTIES agree to maintain books and records related to the performance of this AGREEMENT and necessary to support amounts charged to the ILLINOIS TOLLWAY and/or any of the PARTIES under the AGREEMENT for a minimum of five (5) years from the last action on the AGREEMENT. The PARTIES

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further agree to cooperate fully with any audit and to make its books and records, and books and records within its custody or control available to the Illinois Attorney General, the Illinois Auditor General, the ILLINOIS TOLLWAY Inspector General, the ILLINOIS TOLLWAY Department of Internal Audit, the ILLINOIS TOLLWAY or any other governmental agency or agent thereof that is authorized to audit or inspect such books and records.

J. The introductory recitals included at the beginning of this AGREEMENT are agreed to and incorporated into this AGREEMENT.

(This section intentionally left blank.)

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MEMORANDUM OF UNDERSTANDING
BETWEEN
THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY
AND
THE DUPAGE RIVER SALT CREEK WORKGROUP
FOR
CHLORIDE OFFSET PROGRAM

This MEMORANDUM OF UNDERSTANDING (hereinafter referred to as the "MOU") is entered into this 31st day of October AD, 2013, by and between THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY, an instrumentality and administrative agency of the State of Illinois, hereinafter called the "TOLLWAY", and THE DUPAGE RIVER SALT CREEK WORKGROUP, a group of local watershed stakeholders which include sanitary districts, municipalities, counties, forest preserve districts, state and federal agencies, and private environmental organizations of the State of Illinois, hereinafter called the "DRSCW", individually referred to as "PARTY", and collectively referred to as "PARTIES".

WITNESSETH:

WHEREAS, the TOLLWAY recently approved a 15 year Capitol Program, "Move Illinois; *The Illinois Tollway Driving the Future,*" which includes improving the Jane Addams Memorial Tollway (I-90) (hereinafter sometimes referred to as the "Toll Highway"), by reconstructing and widening from the John F. Kennedy Expressway to Interstate Route 39. The contemplated improvements are substantially included in multiple TOLLWAY construction contracts; and

WHEREAS, the TOLLWAY intends to improve the Elgin O'Hare Expressway, extending the expressway from its eastern terminus at Rohlwing Road (Illinois Route 53) to O'Hare International Airport (ORD) and constructing the Western Access connecting the Jane Addams Memorial Tollway (I-90) with the Tri-State Tollway (I-294) (hereinafter sometimes referred to as the Elgin O'Hare Western Access "EOWA"), and included in multiple TOLLWAY construction contract(s). The TOLLWAY will implement, operate and maintain the mainline improvements as tolled facilities (hereinafter sometimes referred to as the "Toll Highway"); and

WHEREAS, because the projects are in such close proximity, strategies for some aspects of environmental mitigation (i.e., water quality enhancements) are being considered collectively by the PARTIES, where feasible and practicable; and

WHEREAS, highway de-icing practices during winter months commonly use de-icing salts to provide for safe vehicular travel and winter maintenance for I-90 and the EOWA will require the use of salts; and

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WHEREAS, studies acknowledged the potential for the addition of chloride concentrations in area streams and as the I-90 and EOWA projects are advancing to implementation, applications for Section 404 and Section 401 permits have been submitted to the United States Army Corp of Engineers (USACE) and the Illinois Environmental Protection Agency (IEPA); and

WHEREAS, the enhancement of water quality has been the focus of the DRSCW for many years, and the TOLLWAY in an effort to have the "Cleanest and Greenest" program possible is requesting that a partnership be developed between the PARTIES hereto, and a collaboration with permitting agencies, to achieve chloride offsets and reductions to enhance the water quality throughout the DRSCW's water-sheds affected by I-90 and the EOWA; and

WHEREAS, the waterways receiving storm water and snowmelt runoff from the I-90 and EOWA are on the IEPA's Section 303D List of impaired waters and thus require at a minimum no net increase in chlorides as defined in the "Clean Water Act"; and

WHEREAS, this MOU, for recording purposes shall be known as 002013-22, executed in duplicate, and has been prepared to outline the general understanding between the DRSCW and the TOLLWAY with regard to determine and establish their respective responsibilities toward a proposed "Chloride Offset Program" (hereinafter referred to as the "PROGRAM") and also serve as a basis for developing Intergovernmental Agreements with local watershed communities and agencies in the impacted area; and

WHEREAS the PARTIES agree that the entirety of the offset will occur with the impacted areas and be tailored to individual receiving stream segments to the maximum extent possible. As such local watershed communities and agencies participating in the PROGRAM will be responsible for winter operations on the land surfaces that drain to those segments and are herein referred to as "Tier 1 Communities";

NOW, THEREFORE, in consideration of the aforementioned recitals and the mutual covenants contained herein, the PARTIES hereto agree to the following summary of the responsibilities and participation of each PARTY in the implementation of the PROGRAM.

I. GOAL

A. The goal of the PROGRAM is to offset the increased chloride loadings from I-90 and the EOWA by affecting reductions in the use of winter de-icing salts from existing conditions. The TOLLWAY will reduce chloride applications in a quantifiable manner in support of the 401 Water Quality Certification process for I-90 and the EOWA projects and of local municipalities National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System ("NPDES MS4") permit requirements.

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B. The intent is to establish a partnership between the TOLLWAY and governmental bodies to achieve the chloride loading offset.

C. The partners will endeavor to achieve the offsets in communities straddling and or upstream of the I-90 and EOWA, but the TOLLWAY will expand beyond that area if needed to achieve the offset amounts.

D. Both structural and non-structural practices will comprise the PROGRAM to provide the needed improvements in water quality.

II. STRUCTURAL BEST MANAGEMENT PRACTICES

A. Grass swales, bio-swales, infiltration basins, etc. will be incorporated by TOLLWAY into the I-90 and EOWA projects in order to minimize the effects of roadway runoff and improve the quality of roadway runoff discharged to receiving waters and/or nearby wetlands.

III. NON-STRUCTURAL BEST MANAGEMENT PRACTICES

A. A salt reduction goal will be established by the TOLLWAY and DRSCW for the PROGRAM through further analysis of existing conditions, existing practices in the affected watersheds, and planned highway improvements. Offsets will include the adoption of salt reduction strategies (enhanced training, improved materials use, equipment upgrades), implemented by both the TOLLWAY and the Tier I communities. All participants will provide documentation on their salt application rates per lane mile, application totals, calibration logs and details on financial and other support to other mutually agreed upon partners.

B. The TOLLWAY recognizes that meeting the objectives of the Total Maximum Daily Loads ("TMDL's") will require reductions in area chloride loading above those set out in the PROGRAM and agrees to review its practices at an agency wide scale and to actively partner with the DRSCW, its members or successors, in working for PROGRAM area chloride reductions beyond the life of the PROGRAM with the goal of meeting the applicable water quality standard.

IV. TOLLWAY AND DRSCW RESPONSIBILITIES

A. Both PARTIES agree that the requirements embodied in Clean Water Act Section 401 certification(s) or Section 404 or NPDES permit(s), are the sole responsibility of the TOLLWAY, and that the DRSCW or participating agencies cannot be held liable in any way for failure to comply with such requirements.

B. The DRSCW will endeavor to unify stakeholders in the project areas with the common goal of improving chloride water quality. It is recognized that participating communities are voluntary agents and neither they nor the DRSCW can be held liable in any way for failure to collaborate in the plan.

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C. The DRSCW will determine the baseline conditions through appropriate studies with stakeholders and other environmental evaluation which shall include sampling and analyses, as well as flow evaluation.

D. The DRSCW will determine the opportunities for improving de-icing practices through surveys and interviews with stakeholders.

E. The DRSCW and the TOLLWAY will set priorities, tracking offset progress, and the timeframe for achievement with concurrence from the IEPA.

F. The TOLLWAY will provide ongoing financial assistance supporting capital investments of alternative de-icing methods potentially for municipalities and agencies that are participating in the PROGRAM until such time as the PROGRAM objectives are met.

G. The TOLLWAY with the DRSCW's technical assistance will establish training and certifications for operators that would enhance awareness of best practices for snow and ice management operations.

H. The TOLLWAY with the DRSCW will establish data sites/sources for weather data and other information helpful in managing roadway de-icing.

I. The DRSCW with the support of the TOLLWAY will conduct long term monitoring that records salt usage and stream conditions. Evaluation of future operating conditions will be compared to baseline conditions.

J. The TOLLWAY and the DRSCW will report annually by July 1st to the IEPA the resulting efforts and success of the PROGRAM on an annual basis beginning in July of 2014. Success will be measured primarily by the application rate and totals reported with consideration given to the ambient monitoring system.

K. The TOLLWAY and the DRSCW will collaborate to put in place an ambient monitoring system that will be part of the PROGRAM monitoring and evaluation, and will document pre and post PROGRAM chloride conditions in the receiving streams. A monitoring plan will be developed through input from both PARTIES with the intent of conducting stream monitoring on Addison Creek, Salt Creek mainstem, Spring Brook, Meacham Creek and West Branch mainstem. The pre and post conditions will be synthesized in a report and submitted to IEPA on an annual basis along with other reporting data. The system would assist in evaluating the success of the PROGRAM in meeting the TMLD's goals and will be funded wholly by the TOLLWAY.

L. The PARTIES agree that the PROGRAM may require several years of monitoring and reporting from PROGRAM partners.

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M. The PARTIES will develop and maintain a guidance document for the PROGRAM which will at minimum detail the methods for calculating the build scenario non-PROGRAM increase, the needed offset, BMP's the monitoring PROGRAM and reporting baseline requirements. The document will be updated by agreement between the PARTIES as the PROGRAM advances.

V. INTERGOVERNMENTAL AGREEMENTS

A. The TOLLWAY shall use its best efforts to enter into Intergovernmental Agreements prepared by the TOLLWAY and Tier 1 communities based upon this MOU to further determine and establish respective responsibilities toward financial partnerships, information sharing, and training.

B. These Intergovernmental Agreements shall not relieve the TOLLWAY of their responsibility to comply with the "Clean Water Act" as determined and enforced by the IEPA.

VI. FINANCIAL

A. The TOLLWAY will support financial partnerships through an Intergovernmental Agreement requiring cost sharing with a local partner as defined by the PROGRAM.

B. Project requests to the TOLLWAY will be subject to DRSCW and TOLLWAY approvals, to cost effectively promote salt usage reduction.

VII. TERMS OF THE MOU

A. The term of this MOU shall extend until such time that the PROGRAM offset has been achieved reductions have been demonstrated for a minimum of three (3) years. Either PARTY shall have the right to terminate this MOU at any time by providing at least ninety (90) days written notice to the other party in the event either PARTY breaches the terms and conditions of this MOU. At the end of the agreement period this document may be renewed by the mutual consent of the PARTIES.

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IN WITNESS THEREOF, the PARTIES have entered into this MOU as of the date written below.

THE DUPAGE RIVER SALT CREEK WORKGROUP

By: _____
David Gorman, President

Date: 10-30-13

Attest: _____
10-30-13
(Please Print Name)

THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY

By: _____
Kristi Lafleur, Executive Director

Date: 10/31/13

Approved as to Form and Constitutionality

_____ 10/31/13
Tiffany I. Bohn, Assistant Attorney General, State of Illinois

JMR_MOU_DuPage River Salt Creek Workgroup_I-90 & EOWA

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The Illinois Tollway
2700 Ogden Avenue
Downers Grove, Illinois 60515-1703
Phone: 630/241-6800
Fax: 630/241-6100
TTY: 630/241-6898

November 4, 2013

Mr. Stephen McCracken
DuPage River Salt Creek Workgroup
The Conservation Foundation
10 S. 404 Knoch Knolls
Naperville, IL 60565

Re: Memorandum of Understanding between the The Illinois State Toll Highway Authority and the DuPage River Salt Creek Workgroup for Chloride Offset Program.

Dear Mr. McCracken:

Enclosed please find one (1) fully executed Memorandum of Understanding between the Illinois State Toll Highway Authority and The DuPage River Salt Creek Workgroup for Chloride Offset Program on I-90 and the Elgin O'Hare Western Access.

Very truly yours,

Tiffany I. Bohn

Tiffany I. Bohn
Assistant Attorney General

TIB:mw
Enclosure

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THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY

TO: Eileen Cosgriff, CIS

FROM: Tiffany I. Bohn, Assistant Attorney General

DATE: November 4, 2013

SUBJECT: ***Memorandum of Understanding between The DuPage River Salt Creek Workgroup and The Illinois State Toll Highway Authority for Chloride Offset Program.***

Attached please find one (1) fully executed original Memorandum of Understanding between the DuPage River Salt Creek Workgroup and the Illinois State Toll Highway Authority Chloride Offset Program.

This document is transmitted to your attention for the Department's records.

This Memorandum of Understanding does not require a Board Resolution.

TIB:mw
Attachment

cc:
V. Avila
T. Bohn
K. Kell
P. Kovacs
D. Manetti
M. Molliconi
P. Pearn
J. Romano
S. Talaber
B. Wagner
V. Yee
G. Zimmer
R. Zucchero

Activity	Description	Municipal Estimated Grant Cost	Wood Dale Match	Estimated chloride reduction	Schedule
Staff Training	Concentrated small group training on interpreting weather forecasts, developing site specific storm management plans, and reconfiguring operations plans from updated forecasts.		$8,000.00	Cumulative 17.5%	Budgeted Item: Would be implemented this winter.
Purchase of 2.5 Ton Dump with sling host for v-box and anti-icing	This will allow the City to expand it's anti-icing program to cover the entire City and the V-Box would serve the industrial thus decreasing current number of passes required for salting creating less waste.	$139,500.00	170,500.00	Cumulative 17.5%	Budgeted Item for FY 18: Truck would be ordered as soon as confirmation of grant is received.
Total		$139,500.00	$178,500	Cumulative 17.5%	

This process is inter-dependent; one missing link will stop the effectiveness that the organizations involved are looking to accomplish.

Request $139,500.00; City investment $178,500.00

In the event that costs for equipment and training exceed the funds granted the City of Wood Dale, the City of Wood Dale will offset costs to the extent that City funds have available.

Average total salt use (2013-2014 to 2015-2016) 1,166 tons.
Average annual use per street mile (1,166 /95 = 12.3 tons per lane mile annual
Estimated Average Total Reduction is 17.5% or 204 tons

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Basin	Lane Miles	Annual Load	17.5% reduction	Basin reduction Target
Salt Creek Main Stem	52.2	642.06	112.3605	667.2
Addison Creek	9.4	115.62	20.2335	207.2
Bensenville Ditch	18.2	223.86	39.1755	228.8
Willow Creek	15.2	186.96	32.718	980

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05/25/17 6.3/2

RESOLUTION NO. 21286

Background

It is in the best interest of the Illinois State Toll Highway Authority (the "Tollway") to enter into an Intergovernmental Agreement with the City of Wood Dale in connection with the construction of Illinois Route 390. In order to remain compliant with guidelines established by the Illinois Environmental Protection Agency, the Tollway and the DuPage River Salt Creek Workgroup (DRSCW) established a Chloride Offset Program to minimize chloride usage and enhance water quality throughout the DRSCW's water-sheds affected by Illinois Route 390. The Program is being implemented through partnerships with municipalities within the impacted areas by providing training to identify potential operational improvements, and the upgrading of equipment utilized for winter operations. The City of Wood Dale is an impacted municipality and requests the Illinois Tollway participate in the cost of providing training and purchasing upgraded equipment. The total estimated cost to the Tollway is not to exceed $139,500.

Resolution

The Chief Engineering Officer and the Acting General Counsel are authorized to negotiate and prepare an Intergovernmental Agreement between the Illinois State Tollway Highway Authority and the City of Wood Dale in substantially the form attached to this Resolution. The Chairman or the Executive Director is authorized to execute said agreement and the Chief Financial Officer is authorized to issue warrants in payment thereof.

Approved by: _____
Chairman

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Bensenville Chloride Offset

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**INTERGOVERNMENTAL AGREEMENT BETWEEN
THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY
AND
THE VILLAGE OF BENSENVILLE
FOR
CHLORIDE OFFSET PROGRAM**

This INTERGOVERNMENTAL AGREEMENT ("AGREEMENT") is entered into this 26TH day of JUNE, 2017, by and between The Illinois State Toll Highway Authority, an instrumentality and administrative agency of the State of Illinois, hereinafter called the "ILLINOIS TOLLWAY", and The Village of Bensenville, a municipal corporation of the State of Illinois, hereinafter called the "VILLAGE", individually referred to as "PARTY", and collectively referred to as "PARTIES".

WITNESSETH:

WHEREAS, the ILLINOIS TOLLWAY in order to facilitate the free flow of traffic and ensure safety to the motoring public, intends to improve the existing Elgin O'Hare Expressway, extend the expressway from its eastern terminus at Rohlwing Road (Illinois Route 53) to O'Hare International Airport (ORD) to be known entirely as Illinois Route 390, and construct the Western Access connecting the Jane Addams Memorial Tollway (I-90) with the Tri-State Tollway (I-294) (hereinafter sometimes referred to as the Elgin O'Hare Western Access "EOWA"), and included in multiple ILLINOIS TOLLWAY construction contracts. The ILLINOIS TOLLWAY will implement, operate and maintain the mainline improvements as tolled facilities (hereinafter sometimes referred to as "Toll Highway"); and

WHEREAS, highway de-icing practices during winter months commonly use de-icing salts to provide for safe vehicular travel and winter maintenance for the EOWA will require the use of chlorides; and

WHEREAS, studies acknowledged the potential for the addition of chloride concentrations in area streams and as the EOWA project is advancing in implementation, permits for Section 404 and Section 401 of the Clean Water Act (CWA) have been secured from the United States Army Corp of Engineers (USACE) and the Illinois Environmental Protection Agency (IEPA); and

WHEREAS, conditions established within the ILLINOIS TOLLWAY's CWA Section 401 permit require the implementation of a "Chloride Offset Program" (hereinafter called the "PROGRAM") to mitigate for increased chloride loading in the Total Maximum Daily Loading (TMDL) watersheds throughout the EOWA project area; and

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WHEREAS, a Memorandum of Understanding (MOU) between the ILLINOIS TOLLWAY and DuPage River Salt Creek Workgroup (DRSCW) was executed October 31, 2013 to outline the PROGRAM, which is attached hereto as "Exhibit A" and incorporated by reference; and

WHEREAS, per the MOU, it was agreed that the entirety of the offset will occur within the impacted areas and be tailored to individual receiving stream segments to the maximum extent possible. As such, local watershed communities and agencies participating in the PROGRAM will be responsible for winter operations on the land surfaces that drain to those segments and are herein referred to as "TIER 1 COMMUNITY" or "TIER 1 COMMUNITIES"; and

WHEREAS, the VILLAGE has been identified as a TIER 1 COMMUNITY and has, in coordination with the DRSCW, conducted a review of their snow and ice operations in an effort to identify areas of operational improvements relating to efficiency gains in winter chloride usage, and per the VILLAGE'S review, it is believed that an effective reduction in chloride usage can be attained, as part of the PROGRAM through the upgrading of equipment utilized for winter operations by the VILLAGE; and

WHEREAS, the PARTIES mutually agree to review winter operation policies and procedures and work in coordination with the DRSCW to monitor the administration and progress of the PROGRAM; and

WHEREAS, the ILLINOIS TOLLWAY by virtue of its powers as set forth in the "Toll Highway Act," 605 ILCS 10/1 *et seq.* is authorized to enter into this AGREEMENT; and

WHEREAS, the VILLAGE by virtue of its powers as set forth in the "Illinois Municipal Code," 65 ILCS 5/1-1-1 *et seq.* is authorized to enter into this AGREEMENT; and

WHEREAS, a cooperative Intergovernmental Agreement is appropriate and such an Agreement is authorized by Article VII, Section 10 of the Illinois Constitution and the "Intergovernmental Cooperation Act", 5 ILCS 220/1 *et seq.*

WHEREAS for recording purposes this AGREEMENT shall be known as #004686.

NOW, THEREFORE, in consideration of the aforementioned recitals and the mutual covenants contained herein, the PARTIES hereto agree to the following summary of the responsibilities and participation of each PARTY in the implementation of the PROGRAM.

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I. PURPOSE and SCOPE

A. The PROGRAM established a projected increase over existing conditions or baseline for the EOWA of 3,888 tons of salt per year, per a baseline 39.7 tons/lane mile/year application rate. The goal of the offset program will be to reduce salt usage in roadway applications in the project related watersheds by the amount of the increase (3,888 tons per year) plus a margin of safety of 25 percent or a total reduction of 4,860 tons per year.

B. The ILLINOIS TOLLWAY, as part of the PROGRAM, has established a rate reduction goal of 20% from the EOWA's established baseline salt application rate of 39.7 tons/lane mile/year, thereby accounting for 972 tons per year of the 4,860 tons per year of salt required to be reduced, as part of the PROGRAM.

C. The VILLAGE, as part of the PROGRAM and per this AGREEMENT, has established a rate reduction goal of 17.5% from its established baseline application salt application rate of 12.3 tons/lane mile/year, thereby accounting for 204 tons per year of the 4,860 tons per year of salt required to be reduced, as part of the PROGRAM.

D. Both structural and non-structural practices will comprise the PROGRAM to provide the needed improvements in water quality but it is understood that offset reductions can only be accounted for through non-structural practices.

II. STRUCTURAL BEST MANAGEMENT PRACTICES

A. Grass swales, bio-swales, infiltration basins, and other designs will be incorporated by the ILLINOIS TOLLWAY into the EOWA projects in order to minimize the effects of roadway runoff and improve the quality of roadway runoff discharged to receiving waters and/or nearby wetlands.

III. NON-STRUCTURAL BEST MANAGEMENT PRACTICES

A. A salt reduction goal has been established by the ILLINOIS TOLLWAY and DRSCW for the PROGRAM through the analysis of existing conditions, existing practices in the affected watersheds, and planned highway improvements. Offsets will include both the adoption of salt reduction strategies implemented by the ILLINOIS TOLLWAY and providing salt application data to DRSCW, including but not limited to their application rates for each lane mile, as well as financial and other support to other mutually agreed upon partners.

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B. The ILLINOIS TOLLWAY recognizes that meeting the objectives of the Total Maximum Daily Loads ("TMDL's") will require reductions in area chloride loading above those set out in the PROGRAM and agrees to review its practices at an agency wide scale and to actively partner with the DRSCW, its members or successors, in working for PROGRAM area chloride reductions beyond the life of the PROGRAM with the goal of meeting the applicable water quality standard.

IV. RESPONSIBILITIES

A. Pursuant to EXHIBIT A, a guideline for monitoring and reporting chloride offsets has been established. Both PARTIES agree that the requirements embodied in Clean Water Act Section 401 certification(s) or Section 404 or NPDES permit(s), are the sole responsibility of the ILLINOIS TOLLWAY, and that the VILLAGE is not responsible in any way for the ILLINOIS TOLLWAY's failure to comply with such requirements.

B. The VILLAGE shall provide the ILLINOIS TOLLWAY a summary raw data report that includes the following data for the most recent winter season for a minimum of five consecutive winter seasons, post equipment purchase and installation; 1) total lane miles maintained, 2) actual road salt usage in tons per lane mile, 3) baseline road salt usage in tons per lane mile, 4) target road salt usage in tons per lane mile, 5) total winter season precipitation events requiring deicing efforts, 6) average precipitation in inches of snow, ice and liquid form of winter season precipitation per precipitation event, 7) duration of each operator deicing efficiency training session and number of operators attending, 8) new equipment installation and new practices implemented and identification and practices planned and 9) the completed DRSCW's Winter Public Agency Deicing Questionnaire.

C. The PARTIES agree that the PROGRAM may require several years of monitoring and reporting from PROGRAM partners.

D. The PARTIES will develop and maintain a guidance document for the PROGRAM which will at minimum detail the methods for calculating the build scenario non-PROGRAM increase, the needed offset, BMP's the monitoring PROGRAM and reporting baseline requirements. The document will be updated by agreement between the PARTIES as the PROGRAM advances.

V. DELIVERABLES

A. The deliverables will be transmitted to the ILLINOIS TOLLWAY, by the VILLAGE and include written reports documenting, as defined in Article IV,

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Paragraph B. of this AGREEMENT by June 1st pertaining to the preceding winter season.

B. The ILLINOIS TOLLWAY maintains its responsibility to remain compliant with the "Clean Water Act" as determined and administered by the IEPA.

VI. FINANCIAL

A. The ILLINOIS TOLLWAY as sponsor of the PROGRAM will compensate the VILLAGE as outlined in this AGREEMENT and included in the VILLAGE's Request for Equipment and Training "PROPOSAL".

B. The purchase of equipment identified within the VILLAGE's PROPOSAL, as part of the PROGRAM shall be reimbursed by the ILLINOIS TOLLWAY to the VILLAGE.

C. The VILLAGE will be paid based upon its invoice(s) which shall include detailed receipts of purchased items in substantial conformance with the Budget included in the VILLAGE's PROPOSAL.

D. The VILLAGE shall certify in writing, upon presentation of each invoice hereunder, that items as invoiced have been actually purchased and installed and that the VILLAGE is in fact complying with all other provisions of this AGREEMENT. Invoicing shall be sufficiently itemized to permit the ILLINOIS TOLLWAY or its consultant(s) or cooperating governmental unit(s) to verify performance of the work so invoiced.

E. It is mutually agreed that the estimated cost to the ILLINOIS TOLLWAY shall not exceed $367,000 for the term of this AGREEMENT through five consecutive winter seasons, beginning with the first winter season in which purchased equipment has been utilized and use data has been provided to the ILLINOIS TOLLWAY.

VII. GENERAL PROVISIONS

A. It is understood and agreed that this is an AGREEMENT between the VILLAGE of Bensenville and the Illinois State Toll Highway Authority.

B. All equipment proposed for purchase and installation, shall be done so prior to the 2018/2019 winter season but efforts will be made for purchases and installations to occur prior to the 2017/2018 winter season.

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C. The term of this AGREEMENT shall extend through five consecutive winter seasons in which purchased equipment has been utilized and use data has been provided to the ILLINOIS TOLLWAY.

D. PARTIES agree to collaborate in effort to fulfill applicable goals of the PROGRAM as established in Section IV. of EXHIBIT A. Should the PARTIES mutually agree that the VILLAGE did not operate in a manner demonstrating intent achieve the goal reduction of 17.5% in a PROGRAM year, the ILLINOIS TOLLWAY shall provide written notice to the VILLAGE identifying delinquencies of agreed upon practices. Should the PARTIES mutually agree that the VILLAGE did not operate in a manner in which to achieve the goal reduction of 17.5% for a second year during the term of this AGREEMENT, the ILLINOIS TOLLWAY and shall provide written notice to the VILLAGE identifying delinquencies of agreed upon practices and the VILLAGE shall provide reimbursement to the ILLINOIS TOLLWAY for all payments made by the ILLINOIS TOLLWAY associated with this agreement within 90 days of VILLAGE's receipt of the notice.

E. Equipment purchased under this AGREEMENT by the ILLINOIS TOLLWAY on behalf of the VILLAGE becomes the property and responsibility of the VILLAGE and the VILLAGE shall indemnify, hold harmless and defend the ILLINOIS TOLLWAY, its officials, directors, officers, employees, and agents from and against all liability, claims, suits, demands, proceedings and action, including costs, fees and expense of defense, arising from, growing out of, or related to, any loss, damage, injury, death, or loss or damage to property resulting from, or connected with, the VILLAGE's negligent or willful acts, errors or omissions in its performance under this AGREEMENT, including, but not limited to, use of the equipment described herein. The VILLAGE expressly acknowledges that the ILLINOIS TOLLWAY, through provision of funding, training, and certification under this AGREEMENT, is not intended to be a joint employer of the VILLAGE's employees and agents and does not excerpt control over such persons in their use of the equipment that is the subject of this AGREEMENT.

F. It is understood and agreed that this AGREEMENT constitutes the complete and exclusive statement of the agreement of the PARTIES relative to the subject matter hereof and supersedes all previous oral and written proposals, negotiations, representations or understandings concerning such subject matter.

G. This AGREEMENT may be executed in two (2) or more counterparts, each of which shall be deemed an original and all of which shall be deemed one and the same instrument.

H. Under penalties of perjury, the VILLAGE certifies that its correct Federal Tax Identification number is 36-6005794 and it is doing business as a governmental

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entity, whose mailing address is The Village of Bensenville, 12 S. Center Street, Bensenville, Illinois 60106.

I. The PARTIES agree to maintain books and records related to the performance of this AGREEMENT and necessary to support amounts charged to the ILLINOIS TOLLWAY and/or any of the PARTIES under the AGREEMENT for a minimum of five (5) years from the last action on the AGREEMENT. The PARTIES further agree to cooperate fully with any audit and to make its books and records, and books and records within its custody or control available to the Illinois Attorney General, the Illinois Auditor General, the ILLINOIS TOLLWAY Inspector General, the ILLINOIS TOLLWAY Department of Internal Audit, the ILLINOIS TOLLWAY or any other governmental agency or agent thereof that is authorized to audit or inspect such books and records.

J. The introductory recitals included at the beginning of this AGREEMENT are agreed to and incorporated into this AGREEMENT.

(This section intentionally left blank)

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[illegible]

THE VILLAGE OF [illegible]

By: [illegible]
[illegible]
Village [illegible]

Attest: [illegible]
[illegible]
[illegible]

Attest: [illegible]

THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY

By: [illegible]
[illegible]
Executive Director

Date: [illegible]

By: [illegible]
[illegible]
Chief Engineer

[illegible]

By: [illegible]
[illegible]
[illegible]

Date: [illegible]

Approved as to Form and Constitutionality:

[illegible]
[illegible]
Attorney General, State of Illinois

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05/25/17 6.3/3

RESOLUTION NO. 21287

Background

It is in the best interest of the Illinois State Toll Highway Authority (the "Tollway") to enter into an Intergovernmental Agreement with the Village of Bensenville in connection with the construction of Illinois Route 390. In order to remain compliant with guidelines established by the Illinois Environmental Protection Agency, the Tollway and the DuPage River Salt Creek Workgroup (DRSCW) established a Chloride Offset Program to minimize chloride usage and enhance water quality throughout the DRSCW's water-sheds affected by Illinois Route 390. The Program is being implemented through partnerships with municipalities within the impacted areas by providing training to identify potential operational improvements, and the upgrading of equipment utilized for winter operations. The Village of Bensenville is an impacted municipality and requests the Illinois Tollway participate in the cost of providing training and purchasing upgraded equipment. The total estimated cost to the Tollway is not to exceed $367,000.

Resolution

The Chief Engineering Officer and the Acting General Counsel are authorized to negotiate and prepare an Intergovernmental Agreement between the Illinois State Tollway Highway Authority and the Village of Bensenville in substantially the form attached to this Resolution. The Chairman or the Executive Director is authorized to execute said agreement and the Chief Financial Officer is authorized to issue warrants in payment thereof.

Approved by: _____
Chairman

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Framework for Chloride Mitigation

Electronic Filing: Received, Clerk's Office 3/14/2019

MEMORANDUM

Elgin O'Hare Western Access and I-90 East Widening and Reconstruction: A Framework for Chloride Mitigation

PREPARED FOR: Bryan Wagner/Illinois Tollway

PREPARED BY: Larry Martin/CH2M HILL
Mark Mittag/CH2M HILL
Jim Huff/Huff and Huff

DATE: March 10, 2014

The Elgin O'Hare Western Access (EOWA) and I-90 East Widening and Reconstruction projects (Projects) are major transportation investments in the Chicagoland area located generally west of O'Hare Airport. The projects span various watersheds (see Exhibit 1). Most all the watersheds have water quality impairments ranging from low dissolved oxygen to elevated levels of total suspended solids (TSS), heavy metals, and chlorides from winter road and parking lot deicing operations. Many streams do not meet the Illinois chloride water quality standard of 500 mg/L. Because the chloride standard is exceeded in several locations, the Illinois Environmental Protection Agency (IEPA) has established Total Maximum Daily Loads (TMDLs) for the West Branch DuPage River, Salt Creek, and Addison Creek. Higgins Creek has a TMDL study underway. The allowable chloride loads require that measures be implemented to achieve the load reductions, which will be realized with more efficient winter deicing practices.

In December 2012 and February 2013, the Illinois Tollway submitted applications for Section 404 and Section 401 permits to the U.S. Army Corps of Engineers (USACE) and IEPA for the Projects. During the planning phases of the Projects, and more recently during the permitting processes, water quality has been a topic repeatedly emphasized by regulatory agencies, environmental groups, and individuals. In recent meetings with the IEPA, the agency acknowledged that the planned stormwater best management practices (BMPs) for the Projects would adequately manage the quality of the roadway runoff for TSS and heavy metals. For streams impaired for chlorides, however, IEPA indicated that there will be no net increase in chlorides with the projects to ensure compliance with the applicable regulations.

Program Organization

In response to IEPA's directives, the Illinois Tollway has developed a program for salt reduction in the EOWA project area. The Illinois Tollway has resolved that for this program to be viable it requires collaboration and participation beyond the boundaries of the Illinois Tollway organization. The framework of this program involves a strategic alliance with the DuPage River Salt Creek Workgroup (DRSCW), other strategic watershed groups, and local units of government for advancing salt reduction in streams affected by the project. Moving forward, the Illinois Tollway will administer and manage the overall salt reduction program for the project with guidance and support from the DRSCW. The partnership with the DRSCW will be formalized with a Memorandum of Understanding (MOU). Working arrangements with local units of government will be formalized with the use of an Intergovernmental Agreement (IGA). IGA's will be established with communities that are directly adjacent to the EOWA project and would include Hanover Park, Schaumburg, Roselle, Itasca, Elk Grove Village, Wood Dale, Bensenville, Des Plaines, Mount Prospect, Franklin Park, City of Chicago, North Lake, and Elmhurst. IGA's would also be established with DuPage and Cook counties, and local townships.

It is anticipated that the program duration will be permanent and will be a condition of the 401 Water Quality Certification. The program will be implemented in steps. The initial step involves developing the overall program, which is currently underway with the Illinois Tollway and the DRSCW planning the framework of the program that includes the following elements:

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- Establishing baseline conditions (the starting point),
- Developing salt reduction goals, enlisting the municipal partners,
- Aligning the salt reducing practices that best fit community needs,
- Establishing funding needs,
- Developing training workshops, and
- Developing a monitoring and reporting program to measure progress toward stated goals.

The MOU with the DRSCW is be finalized by summer 2013. The IGA process with municipal partners will commence in the fall of 2013 and be completed by mid-2014. Funding levels required to finance the program are currently being developed. Program funding will come from a combination of Illinois Tollway, local communities, and other sources. It is anticipated that the Illlinois Tollway would contribute the majority share. Funding put forth by the Illinois Tollway would be distributed to the local units of government for equipment upgrades and would be administered through the IGA's.

The major Investment in new salt reducing practices is expected in the early years of the program to maximize benefits to water quality. The goal is to have salt reducing practices in place in the east-west corridor (~10 mile section between Gary Avenue on the west to York Road on the east) prior to the opening of new pavement in late 2015. The completion of the east-west corridor is schedule for 2018, and the completion of the Western Access is scheduled for 2025.

Program reporting will occur on an annual basis. Information will be collected on an annual basis to compare usage under the program with the current baseline conditions. Salt usage will be expressed in tons of salt applied in a deicing season per lane-mile. An end-of-season meeting of the communities and the Illinois Tollway may be sponsored to share lessons learned and consider adjustments prior to the next deicing season. Results below expectation will be assessed and adjustment made to the program approach.

Program Work Scope

The salt reduction scope of work is comprised of work tasks that are designed to achieve a "no net increase" in chloride with an added buffer of no less than 25 percent. Based on an assessment of current practices and future requirements, the program objective will be to achieve an annual reduction of 4,860 tons in watersheds affected by the EOWA project. The program consists of two elements:

- Improving current Illinois Tollway deicing practices.
- Expanding salt reduction practices to local communities within the EOWA drainage areas.

Improving Current Illinois Tollway Deicing Practices

An internal review of the Illinois Tollway's deicing practices was initiated in early 2013. In addition to the Illinois Tollway's internal staff expertise, the agency retained the services of an internationally known deicing expert, Dr. Wilfred Nixon, a professor and researcher on highway maintenance and ice engineering at the University of Iowa.

In 2013, Illinois Tollway staff and Dr. Nixon initiated a review of current Tollway winter maintenance practices and policies with the purpose of identifying the potential for more efficient ice control chemicals usage (e.g., salt and others) in winter maintenance activities, while maintaining a very high level of service and safety.

The review of current practices and policies focused on six principle areas of winter maintenance, including:

- Levels of service

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- Performance measurement and continuous improvement
- Materials usage
- Equipment selection and operations
- Strategic operations
- Tactical operations

In the review of these practice areas, current salt loadings were obtained, detailed interviews were conducted with Illinois Tollway staff, and salt yard operations and equipment were examined. The following draft recommendations were formulated from the data, interviews, and observations:

- Pre-wetting salt solids on the truck – yields up to a 25 percent reduction in salt use.
- Use salt brine for pre-wetting regularly with periodic strategic use of calcium chloride brine.
- Optimizing salt application rates by considering pavement temperature and weather types may be able to reduce application rates from 500, 300 and 200 pounds per lane-mile to 375, 225, and 150 pounds per lane-mile. Reduction in salt application may require pilot testing to confirm application rate efficiency.
- Use direct liquid application prior to a storm to prevent bonding between the snow/ice and the pavement and reduce total chemical required during a storm event (anti-icing) – yields up to a 75 percent reduction in salt use during these events.
- Other practices that produce effective, but smaller reductions in salt use are the application of tow plows, new plow cutting edges, and communicating reduction methods with other agencies.

The implementation of these practices would be preceded by a review, evaluation, and approval process within the Illinois Tollway organization. As a first step, practices such as pre-wetting salt, using salt brine, adjusting salt application rates, and using direct liquid applications would be evaluated and screened based on performance, compatibility with current practice, etc. Practices that advance from the screening phase would be pilot-tested. Pilot projects would be conducted for at least one winter season, and would be pilot-tested in the region of one maintenance yard. The effectiveness, cost-savings, and comparative performance of each method would be assessed for system-wide usage. Initial pilot-testing is planned for the winter 2013-2014. The practice(s) selected for implementation and their associated reduction of salt in the project area will count towards meeting the goal of not increasing chloride discharge with the project.

Expanding Salt Reducing Practices to Local Communities - Chloride Off-Set Program

The Illinois Tollway and DRSCW have developed the Chloride Off-Set program to a concept level. It program concept provides the clarity necessary to obtain concurrence from their respective organizations to advance to program implementation. The scope of the program is described as follows.

- **Program facilitation and management.** The Illinois Tollway will manage the implementation of the salt reduction program, and be responsible to the regulatory agencies (i.e., IEPA and USACE) for compliance with the terms and conditions of the Section 404 and 401 permits. The use of IGAs would be used to formalize working arrangements with the DRSCW and local municipalities. The DRSCW will serve as a principal in the development and implementation of the program. Whereas, the DRSCW has long-term established relationships with the stakeholder communities and have been entrusted to provide guidance related to water quality issues, the DRSCW will facilitate the overall integration of the project area's salt reduction program into the water quality initiatives of the stakeholder community.

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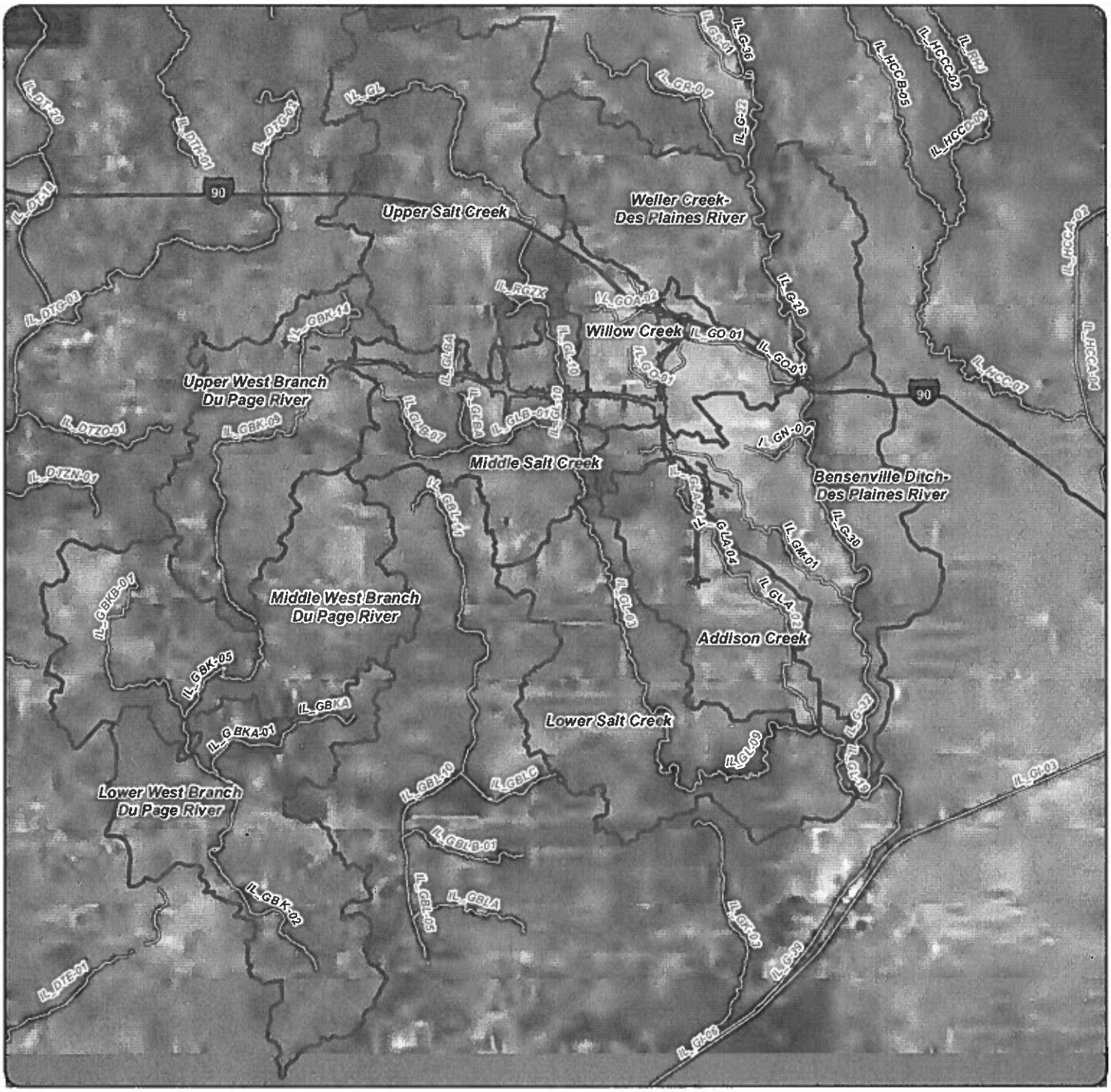
- **Program funding.** The funding for the program is currently under review. Funding would be directed to training, promotion of alternative deicing practices, and equipment upgrades that would provide greater efficiencies in salt usage. Funding will come from a combination of Illinois Tollway, local municipalities, and other sources. The use of IGAs will be the mechanism to enable partnership of the local communities and the funding arrangements that will affect salt reducing practices. Likely funding scenarios include the Illinois Tollway contributing the majority share, and the local communities and other sources (i.e., state and federal grant monies) comprising the remainder.
- **Assess existing practices.** Surveys and interviews are routinely conducted by the DRSCW with communities in the project area to determine current deicing practices. An additional survey will be conducted as part of this initiative to accurately define current community salt usage. This data will be used to tailor the types of salt reduction practices that would provide the best results for each community.
- **Establish baseline conditions.** The community surveys and interviews will also be used to establish baseline conditions for each potential partner. As an initial task, baseline estimates will be compiled from current practices and records, and in the absence of detailed records, a comparison to peer communities will be estimated. As a follow-on task, the collection of accurate application rates per lane-mile using existing practices will occur in Year One of the program. Standard procedures will be established to determine application rates for each community. Baseline conditions will be recorded as the rate of salt usage per lane-mile (pounds per lane-mile) under standard conditions, and total tons of salt used during the deicing season.
- **Finalize program goals and salt reduction targets.** Based on an assessment of current practices and future requirements, the program objective will be to achieve an annual reduction in tons of salt across the project area. Each partner community will be assigned a target goal wherein the combined targets of the individual communities will add to the program wide target. Individual community targets will be determined based on current practices and reasonably achievable reductions with the use of salt reducing practices.
- **Identify alternative practices best-suited to local communities.** The winter deicing practice surveys and interviews will be used to identify the types of deicing technology needed within each community for additional salt usage efficiency. The current practices will shape the menu of practices recommended for each community. Actual implementation of the new deicing practices would begin implementation in Year Two of the program.
- **Initiate training for more efficient deicing practices.** The DRSCW routinely provides training, workshops, and seminars concerning water quality practices. The organization in conjunction with the Illlinois Tollway will update training for achieving greater efficiencies in deicing practices. Appropriate training on best available deicing technologies and best practices will be shared across the partnering communities. The intent is to provide the best available information to the communities in the project area that result in salt reducing practices. Training would be initiated in Year One of the program.
- **Establish data sites (weather-related information) for managing roadway deicing.** The Illinois Tollway has a system of pavement temperature sensors and subscribes to instantaneous weather data. Data sharing with the municipal partner is contemplated and would aid local communities in making winter storm management decisions.
- **Monitor/report.** Salt use reporting will be a requirement of the program. The Tollway and each community will provide annual usage expressed as tons of salt applied per lane-mile annually. This usage rate combined with the miles of roads in the community will be used to compare progress in salt reduction and overall salt use efficiency. An end-of-season meeting will be hosted by the Illinois Tollway to share lessons learned and consider program adjustments for the next deicing season. Instreaming monitoring is planned to demonstrate that the reduction in salt use is reducing chloride

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concentrations in receiving waters. The sampling locations and frequency of sampling is in the planning stages.

- **Reassess program objectives.** An annual assessment of the program will be conducted by the Illinois Tollway and the DRSCW. The program metrics will be evaluated to study trends, and salt reducing practices will be review to determine actual effectiveness compared to theoretical. The assessment will be documented as a report and submitted to regulatory agencies upon request. Results that are below expectations will be addressed with the necessary program revisions that produce the needed outcome

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LEGEND

- Full-Build 2040 Footprint
- Watershed Boundary
- River/Stream

Elgin O'Hare Western Access

0 1.5 3 6
Miles

Exhibit 1
Watersheds

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Liquid Deicing Options and Evaluation

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MEMORANDUM

Liquid Deicing Options and Evaluation for the Elgin O'Hare Western Access Project

PREPARED FOR: Bryan Wagner/Illinois Tollway

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Mark Mittag/CH2M HILL

COPY TO: Reed Panther/Illinois Tollway
Steve McCracken/DRSCW
Illinois Environmental Protection Agency
Jim Huff/Huff and Huff
Larry Martin/CH2M HILL

DATE: July 16, 2013

As part of a chloride offset program for the Elgin O'Hare Western Access (EOWA) project, winter deicing efficiencies have been evaluated for Illinois Tollway and partnering communities. Technology experts have indicated a move towards using more liquid deicers provides efficiency in salt use. Improved efficiency results in less rock salt use. This memorandum summarizes the technology options most readily applicable to Illinois Tollway and local communities with the goal of estimating salt reduction with the implementation of more widespread use of liquid deicer.

The use of liquid brine through pre-wetting and anti-icing practices was investigated for the EOWA project. Pre-wetting involves applying salt brine directly to the surface of bulk salt solids prior to conventional deicing. The pre-wetting rapidly activates the salt melting process and reduces the degree of bounce-and-scatter of salt off the roadway surface. Anti-icing involves the application of brines or organic products to the roadway surface prior to a snow or ice event to prevent or weaken the bond between the snow or ice and the pavement surface. Preventing a bond to the pavement allows for easier and more efficient snow removal. Both practices provide considerable benefit to snow and ice management agencies.

Types of Brine

Pre-wetting and anti-icing liquid agents can be salt brines, organic agents or byproducts, or combinations of both. The focus of this general investigation involves only the use of salt brine created from bulk rock salt (sodium chloride) and water. It is assumes that brines are 23.3 percent salt by weight. Other common pre-wetting and anti-icing brines include those created from magnesium chloride and calcium chloride salts. Each salt has benefits and drawbacks and is typically appropriate for specific environmental and road conditions; however, rock salt brine is the most widely used and most affordable deicing agent. The Illinois Tollway or local communities may want to augment sodium chloride brines with calcium chloride or other liquids or mixtures based upon weather and travel conditions.

Advantages of Brine for Pre-wetting and Anti-Icing

The advantages of using brine for pre-wetting and anti-icing are listed below and are adapted from the Iowa Department of Transportation's Systems Operation Bureau, Office of Maintenance.

Pre-wetting

- Rock salt can be spread more uniformly and less is wasted on shoulders and ditches, reducing the impact to the environment.
- Materials adhere to the surface because the salt and brine mixture has a thicker consistency.
- Melting begins faster since a liquid has been introduced to the salt. It is important for salt to be in liquid form to prevent snow and ice bonding to pavement.
- Since the brine begins working and diluting as it hits the surface, it will dry much more rapidly, returning the roadway to normal winter driving conditions much sooner.

- Spreading speeds can be increased because more material stays on the roadway.
- Residual salt may remain on the road that will immediately begin working with the next storm.
- When dry materials are pre-wet with brine, the dry material application rate can actually be cut back 20 to 30 percent because more of the material remains on the roadway. In addition, the additional brine speeds the melting action.
- Can be used as a deicer on very thin layers of frost or black ice, but with caution. Salt brine is not recommended for snow pack unless it is treated regularly and frequently with a sufficient quantity of salt brine and or salt brine and rock salt. Brine alone will rapidly dilute and if an insufficient concentration is maintained and may refreeze before it can burrow through the snow or ice pack.

Anti-icing

- Application prior to a storm can help prevent snow and ice from bonding to the pavement and can help keep the roadway wet longer into a storm (or throughout the storm, if a very light precipitation event).
- Makes clean-up quicker and returns roads to normal driving conditions more rapidly.
- Reduces labor hours.
- Reduces wear on ice blades and underbody plows.

For additional information, the Iowa DOT winter maintenance website serves as a comprehensive resource and can be accessed at http://www.iowadot.gov/maintenance/materials.html.

Findings of the Nixon Report

The Illinois Tollway consulted with Dr. Nixon from the University of Iowa on a review of deicing procedures and efficiency opportunities. Dr. Nixon's report explained that approximately 30 percent of the salt spread on the road by conventional deicing methods can be expected to leave the road surface. The pre-wetting of road salt prior to spreading has shown to result in only a 4 percent loss of salt when spread on the center lane of a three lane road at vehicle speeds of 30 to 40 mph, application rates of 400 lb per lane mile, and at pre-wetting rates of 6 gallons per ton of salt applied.

As a result, a potential reduction in salt application by approximately 25 percent can be reasonably expected, meanwhile still maintaining the same level of service. Similar potential salt reductions between 20 and 30 percent have been supported by the Wisconsin Transportation Information Center, the Salt Institute's *Snowfighters Handbook*, the Iowa DOT, and the New Hampshire Department of Environmental Services. Anti-icing reductions were not explicitly stated in the Nixon Report.

Anti-icing efforts are typically more dependent on environmental conditions, road surface conditions, and on the timing of application prior to a storm or ice event. Therefore, salt savings when using anti-icing can vary but can be optimized with extensive operational experience. The *Chloride Reduction Implementation Plan for Dinsmore Brook Watershed, Windham, NH* (February 2011) from the New Hampshire Department of Environmental Services indicates that salt reductions between 10 and 30 percent can be expected when anti-icing.

Estimate of Current Salt Use and Planned Reductions with Pre-Wetting/Anti-Icing Strategies

Pre-wetting and anti-icing options were considered for communities that span the EOWA corridor. Tier 1 communities were designated as those located within the EOWA project footprint or within the USGS watersheds bordering the project footprint. Additional analysis has continued to evaluate the potential salt reduction in each community. These Tier 1 communities are located in watersheds of interest to the DuPage River Salt Creek Workgroup (DRSCW), as well as Des Plaines River watersheds, due to their proximity to the project footprint. Several communities span several watersheds. Consequently, the community salt reduction potential considers all reductions available as long as they are within the DRSCW or Des Plaines River watersheds.

The effectiveness of pre-wetting and anti-icing in the reduction of salt quantities were determined based on total lane miles present within the Tier 1 communities and typical per-lane-mile salt application rates. Total lane miles within Tier 1 communities are summarized in Table 1. Refer to Exhibits 1 and 2, which identify roadways within Tier 1 communities and watershed boundaries.

TABLE 1
Lane Miles per Jurisdiction Spanning EOWA Project Footprint

Jurisdiction[a]	DRSCW Watershed Lane Miles	Des Plaines Watershed Lane Miles	Total Lane Miles	Estimated Salt Usage, ton/yr[b]
Locally-Maintained				
Addison Township	25.4	7.2	32.6	457
Bensenville	57.6	49.2	106.7	1,494
Berkeley	21.7	0.0	21.7	304
Bloomingdale Township	7.2	0.0	7.2	101
Chicago	0.0	208.3	208.3	2,916
Elk Grove Township	14.6	6.5	21.0	295
Elk Grove Village	143.8	110.5	254.3	3,561
Elmhurst	289.1	0.0	289.1	4,047
Franklin Park	0.0	105.7	105.7	1,480
Hanover Park	137.0	0.0	137.0	1,918
Itasca	61.7	0.0	61.7	864
Leyden Township	1.6	44.9	46.6	652
Medinah (Unincorporated)	34.8	0.0	34.8	488
Northlake	57.7	12.3	69.9	979
Roselle	126.6	0.0	126.6	1,773
Schaumburg	246.4	0.0	246.4	3,450
Schaumburg Township	17.9	0.0	17.9	250
Wood Dale	46.9	37.1	84.0	1,176
Locally-Maintained Subtotal	1,289.9	581.6	1,871.5	26,202
DuPage County-Maintained	91.5	27.7	119.1	1,668
Cook County-Maintained	113.7	24.8	138.5	1,939
Total	**1,494**	**634**	**2,129**	**29,808**

[a] IDOT-maintained lane miles are excluded from these quantities. Includes locally-, DuPage Co.-, and Cook Co.-maintained lane miles.

[b] Assumed application rate: 14 tons/lane mile/year.

Note: IDOT-maintained lane miles are excluded from these quantities. Includes locally-, DuPage Co.-, and Cook Co.-maintained lane miles.

Roadway lane mile totals were based on a 2011 (latest available) Illinois Department of Transportation Roadway Data Layer GIS files (http://gis.dot.illinois.gov/gist2/), which also included jurisdictional information. The baseline road salt application rate assumed was 14 tons/lane mile/year, based on a 2007 survey conducted by the DRSCW on the average annual salt application reported by respondents located in within the Salt Creek watershed.

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Table 2 indicates the lane miles and an estimate of added salt usage with the Initial Construction Plan (ICP) and the Full-Build phase of the Elgin O'Hare Western Access Project. Freeway/Toll road lane miles were assigned an average road salt application rate of 39.7 ton/lane mile/year based on IDOT and Illinois Tollway system-wide application rates during the 2000/2001 through 2010/2011 winter seasons. As shown in Table 2, the increase over existing conditions or baseline with the ICP is 3,888 tons per year. The goal of the offset program will be to reduce salt usage on roadway in the project related watersheds by the amount of the increase (3.888 tons per year) plus a margin of safety (MOS) of 25 percent or a total reduction of 4,860 tons per year.

TABLE 2
Salt Application Summary for EOWA Project Limits
Estimated Annual Salt Application Rates

Project Stage	Lane miles [a]	Salt Applied, ton/yr [b]	Increase from Baseline Condition, ton/yr
Existing (Baseline) Condition	159	3,959	N/A
Initial Construction Plan (ICP)	264	7,847	3,888
2040 Full Build	293	8,969	5,010

[a] Lane miles include arterial/collector and freeway lane miles located within the project limits.
[b] Considers two different salt application rates depending on the roadway class. Arterial/collector roads are loaded at 14 ton/lane mile/year. Freeways are loaded at 39.7 ton/lane mile/year.

Table 3 expands on the data provided in Table 1 and shows estimates of potential salt reductions with the use of pre-wetting or anti-icing management techniques. Overall, the use of pre-wetting and anti-icing has the potential to reduce salt use in the project watersheds by up to 40 percent or a reduction of approximately 11,900 tons per year. The combined potential of these practices to reduce salt use in the project related watersheds is far greater than the offset target of 4,860 tons per year. While unlikely, if additional offsets are needed, communities further upstream (Tier 2 communities) or downstream (Tier 3 communities) in these watersheds could be approached to achieve further reductions in salt application.

Table 4 is a breakdown of the salt reduction target (4,860 tons per year) distributed by watershed in the project area (see Exhibit 3). The breakdown is proportional to the additional miles of roadway added within each watershed.

TABLE 3
Salt Application Summary by USGS Watershed for Tier 1 Communities
Estimated Annual Salt Application Rates and Potential Reductions With Best Management Practices

USGS Watershed	Lane Miles	Salt Applied, ton/yr	Salt Reduction with Pre-Wetting, ton/yr [a]	Salt Reduction with Anti-Icing, ton/yr [b]	Potential Total Salt Reduction, ton/yr
Des Plaines River Watershed					
Addison Creek	319	4,462	1,116	669	1,785
Bensenville Ditch-Des Plaines River	435	6,085	1,521	913	2,434
Willow Creek	198	2,768	692	415	1,107
Des Plaines River Watershed Sub-total	*952*	*13,315*	*3,329*	*1,997*	*5,326*

TABLE 3

Salt Application Summary by USGS Watershed for Tier 1 Communities

Estimated Annual Salt Application Rates and Potential Reductions With Best Management Practices

USGS Watershed	Lane Miles	Salt Applied, ton/yr	Salt Reduction with Pre-Wetting, ton/yr [a]	Salt Reduction with Anti-Icing, ton/yr [b]	Potential Total Salt Reduction, ton/yr
DRSCW Watershed					
Middle Salt Creek	436	6,106	1,527	916	2,442
Upper West Branch DuPage River	329	4,603	1,151	690	1,841
DRSCW Watershed Sub-total	*756*	*10,709*	*2,678*	*1,606*	*4,283*
Grand Total	**1,717**	**24,024**	**6,007**	**3,603**	**9,609**

Note: IDOT-maintained lane miles are excluded from these quantities. Includes locally-, DuPage Co.-, and Cook Co.-maintained lane miles. Reductions were directly applied to the total annual salt usage based on an application rate of 14 tons salt/lane mile/year.

[a] Expected salt reduction attributed to pre-wetting is between 20 and 30 percent. Reduction assumed: 25 percent

[b] Expected salt reduction attributed to anti-icing is between 10 and 30 percent. Reduction assumed: 15 percent

TABLE 4

Summary by USGS Watershed for the Initial Construction Plan (ICP) EOWA Project

Estimated Annual Salt Application Rates and Increases from Existing Conditions

USGS Watershed	Reduction from Baseline Condition, ton/yr	Target Reduction with MOS, ton/yr [a]	Comparison to Local Offset Potential, ton/yr
Des Plaines River Watershed			
Addison Creek	259	324	1,785
Bensenville Ditch-Des Plaines River	645	806	2,434
Willow Creek	1,761	2,201	1,107
Des Plaines River Watershed Sub-total	*2,665*	*3,331*	*5,326*
DRSCW Watershed			
Middle Salt Creek	1,191	1,489	2,442
Upper West Branch DuPage River	32	40	1,841
DRSCW Watershed Sub-total	*1,223*	*1,529*	*4,283*
Grand Total	**3,888**	**4,860**	**9,609**

[a] Includes a margin of safety (MOS) to have 125 percent of the salt application increase for the Initial Construction Plan (ICP) condition.

Based on the estimate of current salt use in the watershed areas, the ability to offset the increased salt usage for the ICP is clearly achievable with the use of pre-wetting and anti-icing practices. With the project, the overall reduction in salt needed to achieve no net increase as well as the 25 percent margin of safety is 4,860 tons/year. The opportunity within local communities for pre-wetting and anti-icing practices to reduce salt use is far greater than the estimated offset requirement (approximately 10,000 tons/year).

Offsets will be made through a combination of Illinois Tollway reductions and partnership with local communities. For the Des Plaines River and DRSCW watersheds, the offsets available through local communities easily exceed the offset totals needed. If necessary, additional offsets can be achieved from further reductions upstream, from other Illinois Tollway operations not part of the EOWA project, other potential partners, or combinations of these options.

To track improvements in salt usage, both annual tons of salt applied and a typical storm application rate will be tracked to take into account variation in winter conditions from year to year. The implementation of these practices will be applicable to both the Illinois Tollway and local communities. The actual mix of these practices will be determined individually for each entity with the objective of tailoring salt reducing practices that best fit the community needs and yields a substantive reduction in salt use.

Major Equipment Requirements

Equipment options for pre-wetting and anti-icing operations using sodium chloride brine include:

Anti-icing

- Salt storage
- Brine production equipment (if produced onsite)
- Brine storage tank (whether purchased as bulk product or produced onsite)
- Truck-mounted brine storage, trailer brine storage, or combination storage
- Brine applicator

Pre-wetting

- Salt storage
- Brine production equipment (if produced onsite)
- Brine storage tank (whether purchased as bulk product or produced onsite)
- Truck-mounted brine and salt storage
- Brine applicator to salt

References such as the Iowa DOT Systems Operation Bureau, Office of Maintenance have additional information available on typical equipment needs. This source provides a comprehensive description of the equipment requirements and options available for anti-icing or pre-wetting programs.

Additional Ice/Snow Management Items

In addition to retrofitting fleet vehicles and constructing or purchasing brine production equipment to accommodate either anti-icing or pre-wetting practices, the following are recommendations that will further improve ice and snow removal efficiency.

- **Education and training of ice and snow management staff.** Education and training could include a one-day annual conference prior to the winter season to discuss proper operation and maintenance of ice and snow removal technologies, standards of practice, past observations, and potential solutions. This meeting would include regional ice and snow management staff.
- **Information sharing amongst members of the ice and snow management community.** This could include monthly meetings, webinars, or forums during the winter season for members to engage other municipalities or townships on the success of their deicing programs.
- **Equipment calibration program and training.** The offsets program will require that equipment is calibrated regularly and calibration documentation is provided to ensure proper and accurate salt application rates are reported annually.

References

DuPage River Salt Creek Workgroup and CDM. *Chloride Education and Reduction Program, 2010 Deicing Program Survey.* April 2011.

Environmental Impact Statement, Section 3.10: Water Resources and Aquatic Habitats.

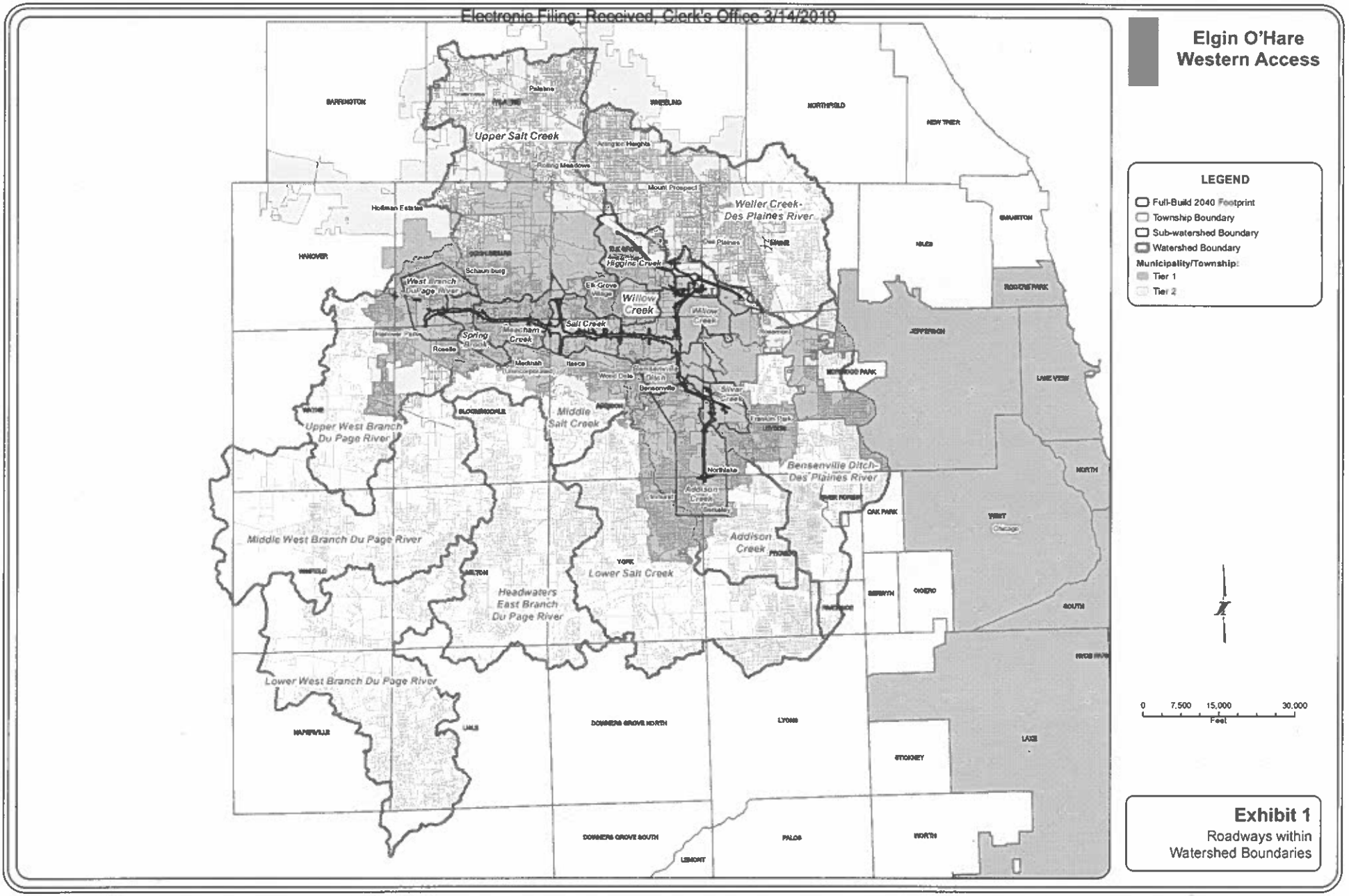
Iowa Department of Transportation Office of Maintenance. *Brine Production.* http://www.iowadot.gov/maintenance/materials.html

New Hampshire Department of Environmental Services, Watershed Management Bureau. *Chloride Reduction Implementation Plan for Dinsmore Brook Watershed.* Windham, NH. Feb. 2011.

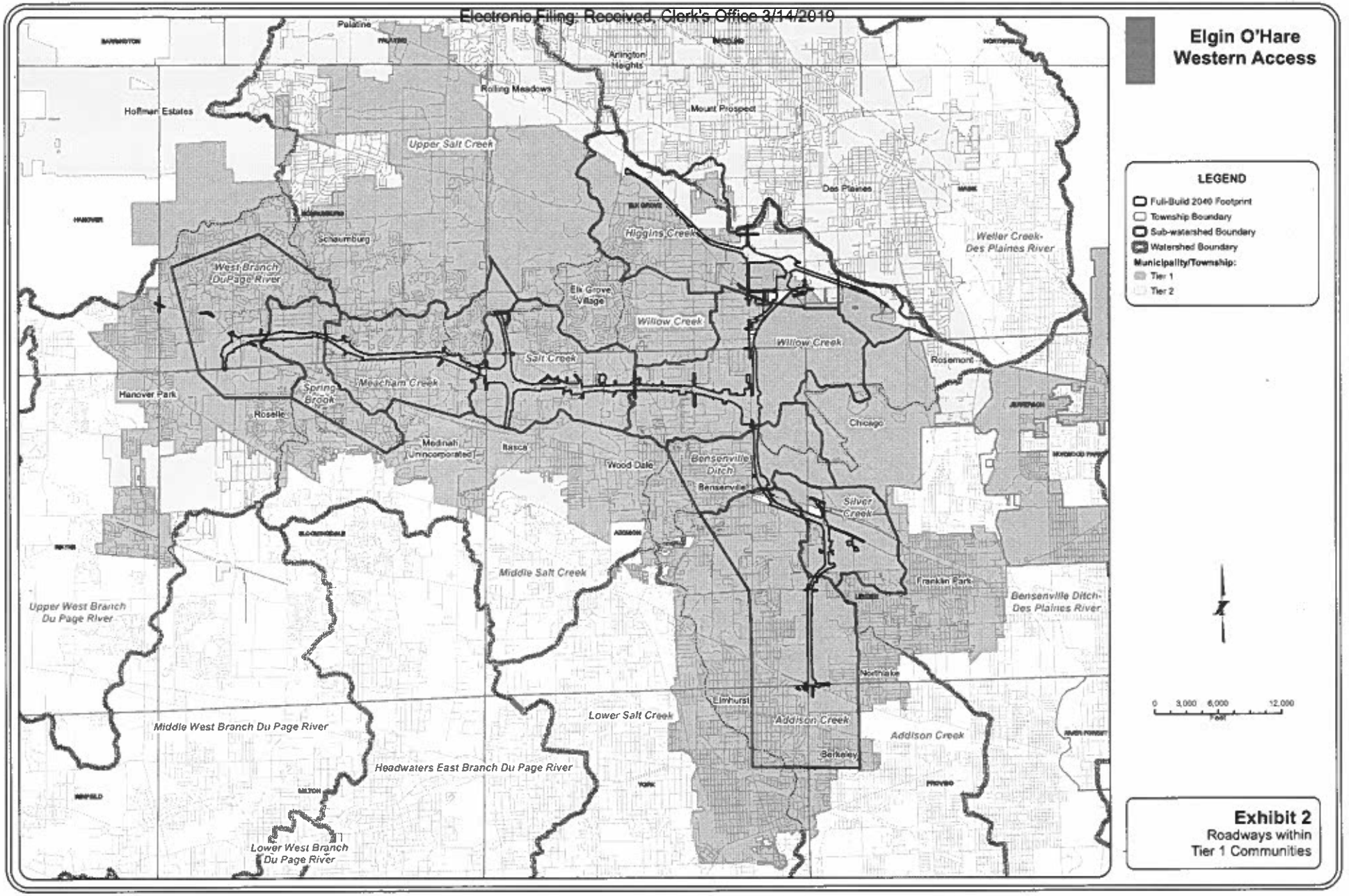
Salt Institute. *The Snowfighters Handbook*, 40th Ed. Alexandria, VA. 2007.

Wisconsin Transportation Information Center. *Wisconsin Transportation Bulletin No. 22*. Madison, WI. Dec. 2005.

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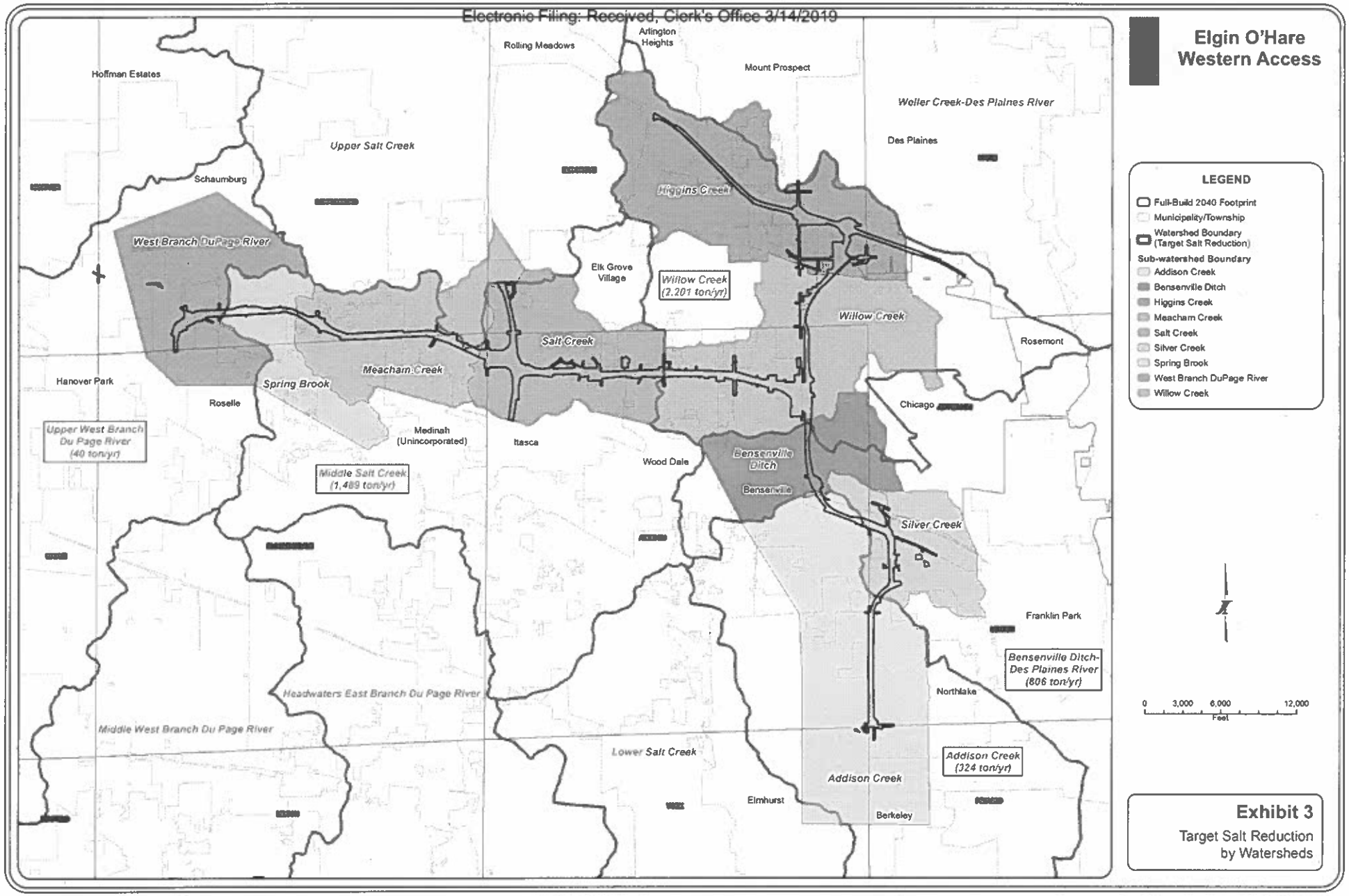


R04777


Elgin O'Hare
Western Access
LEGEND
Full-Build 2040 Footprint
Township Boundary
Sub-watershed Boundary
Watershed Boundary
Municipality/Township:
Tier 1
Tier 2
Palatine
Arlington Heights
Rolling Meadows
Hoffman Estates
Mount Prospect
Des Plaines
Upper Salt Creek
Schaumburg
Higgins Creek
Weller Creek-
Des Plaines River
West Branch
DuPage River
Elk Grove
Village
Willow Creek
Willow Creek
Salt Creek
Rosemont
Meacham Creek
Spring
Brook
Hanover Park
Roselle
Chicago
Medinah
(Unincorporated)
Itasca
Wood Dale
Bensenville
Ditch
Bensenville
Silver
Creek
Middle Salt Creek
Franklin Park
Bensenville Ditch-
Des Plaines River
Upper West Branch
Du Page River
Northlake
Lower Salt Creek
Addison Creek
Addison Creek
Middle West Branch Du Page River
Headwaters East Branch Du Page River
Lower West Branch
Du Page River
0 3,000 6,000 12,000
Feet
Exhibit 2
Roadways within
Tier 1 Communities

R04778

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DuPage River Salt Creek Workgroup
Chloride Offset Program

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MEMORANDUM OF UNDERSTANDING
BETWEEN
THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY
AND
THE DUPAGE RIVER SALT CREEK WORKGROUP
FOR
CHLORIDE OFFSET PROGRAM

This MEMORANDUM OF UNDERSTANDING (hereinafter referred to as the "MOU") is entered into this 31st day of October AD, 2013, by and between THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY, an instrumentality and administrative agency of the State of Illinois, hereinafter called the "TOLLWAY", and THE DUPAGE RIVER SALT CREEK WORKGROUP, a group of local watershed stakeholders which include sanitary districts, municipalities, counties, forest preserve districts, state and federal agencies, and private environmental organizations of the State of Illinois, hereinafter called the "DRSCW", individually referred to as "PARTY", and collectively referred to as "PARTIES".

WITNESSETH:

WHEREAS, the TOLLWAY recently approved a 15 year Capitol Program, "Move Illinois; *The Illinois Tollway Driving the Future,*" which includes improving the Jane Addams Memorial Tollway (I-90) (hereinafter sometimes referred to as the "Toll Highway"), by reconstructing and widening from the John F. Kennedy Expressway to Interstate Route 39. The contemplated improvements are substantially included in multiple TOLLWAY construction contracts; and

WHEREAS, the TOLLWAY intends to improve the Elgin O'Hare Expressway, extending the expressway from its eastern terminus at Rohlwing Road (Illinois Route 53) to O'Hare International Airport (ORD) and constructing the Western Access connecting the Jane Addams Memorial Tollway (I-90) with the Tri-State Tollway (I-294) (hereinafter sometimes referred to as the Elgin O'Hare Western Access "EOWA"), and included in multiple TOLLWAY construction contract(s). The TOLLWAY will implement, operate and maintain the mainline improvements as tolled facilities (hereinafter sometimes referred to as the "Toll Highway"); and

WHEREAS, because the projects are in such close proximity, strategies for some aspects of environmental mitigation (i.e., water quality enhancements) are being considered collectively by the PARTIES, where feasible and practicable; and

WHEREAS, highway de-icing practices during winter months commonly use de-icing salts to provide for safe vehicular travel and winter maintenance for I-90 and the EOWA will require the use of salts; and

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WHEREAS, studies acknowledged the potential for the addition of chloride concentrations in area streams and as the I-90 and EOWA projects are advancing to implementation, applications for Section 404 and Section 401 permits have been submitted to the United States Army Corp of Engineers (USACE) and the Illinois Environmental Protection Agency (IEPA); and

WHEREAS, the enhancement of water quality has been the focus of the DRSCW for many years, and the TOLLWAY in an effort to have the "Cleanest and Greenest" program possible is requesting that a partnership be developed between the PARTIES hereto, and a collaboration with permitting agencies, to achieve chloride offsets and reductions to enhance the water quality throughout the DRSCW's water-sheds affected by I-90 and the EOWA; and

WHEREAS, the waterways receiving storm water and snowmelt runoff from the I-90 and EOWA are on the IEPA's Section 303D List of impaired waters and thus require at a minimum no net increase in chlorides as defined in the "Clean Water Act"; and

WHEREAS, this MOU, for recording purposes shall be known as 002013-22, executed in duplicate, and has been prepared to outline the general understanding between the DRSCW and the TOLLWAY with regard to determine and establish their respective responsibilities toward a proposed "Chloride Offset Program" (hereinafter referred to as the "PROGRAM") and also serve as a basis for developing Intergovernmental Agreements with local watershed communities and agencies in the impacted area; and

WHEREAS the PARTIES agree that the entirety of the offset will occur with the impacted areas and be tailored to individual receiving stream segments to the maximum extent possible. As such local watershed communities and agencies participating in the PROGRAM will be responsible for winter operations on the land surfaces that drain to those segments and are herein referred to as "Tier 1 Communities";

NOW, THEREFORE, in consideration of the aforementioned recitals and the mutual covenants contained herein, the PARTIES hereto agree to the following summary of the responsibilities and participation of each PARTY in the implementation of the PROGRAM.

I. GOAL

A. The goal of the PROGRAM is to offset the increased chloride loadings from I-90 and the EOWA by affecting reductions in the use of winter de-icing salts from existing conditions. The TOLLWAY will reduce chloride applications in a quantifiable manner in support of the 401 Water Quality Certification process for I-90 and the EOWA projects and of local municipalities National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System ("NPDES MS4") permit requirements.

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B. The intent is to establish a partnership between the TOLLWAY and governmental bodies to achieve the chloride loading offset.

C. The partners will endeavor to achieve the offsets in communities straddling and or upstream of the I-90 and EOWA, but the TOLLWAY will expand beyond that area if needed to achieve the offset amounts.

D. Both structural and non-structural practices will comprise the PROGRAM to provide the needed improvements in water quality.

II. STRUCTURAL BEST MANAGEMENT PRACTICES

A. Grass swales, bio-swales, infiltration basins, etc. will be incorporated by TOLLWAY into the I-90 and EOWA projects in order to minimize the effects of roadway runoff and improve the quality of roadway runoff discharged to receiving waters and/or nearby wetlands.

III. NON-STRUCTURAL BEST MANAGEMENT PRACTICES

A. A salt reduction goal will be established by the TOLLWAY and DRSCW for the PROGRAM through further analysis of existing conditions, existing practices in the affected watersheds, and planned highway improvements. Offsets will include the adoption of salt reduction strategies (enhanced training, improved materials use, equipment upgrades), implemented by both the TOLLWAY and the Tier 1 communities. All participants will provide documentation on their salt application rates per lane mile, application totals, calibration logs and details on financial and other support to other mutually agreed upon partners.

B. The TOLLWAY recognizes that meeting the objectives of the Total Maximum Daily Loads ("TMDL's") will require reductions in area chloride loading above those set out in the PROGRAM and agrees to review its practices at an agency wide scale and to actively partner with the DRSCW, its members or successors, in working for PROGRAM area chloride reductions beyond the life of the PROGRAM with the goal of meeting the applicable water quality standard.

IV. TOLLWAY AND DRSCW RESPONSIBILITIES

A. Both PARTIES agree that the requirements embodied in Clean Water Act Section 401 certification(s) or Section 404 or NPDES permit(s), are the sole responsibility of the TOLLWAY, and that the DRSCW or participating agencies cannot be held liable in any way for failure to comply with such requirements.

B. The DRSCW will endeavor to unify stakeholders in the project areas with the common goal of improving chloride water quality. It is recognized that participating communities are voluntary agents and neither they nor the DRSCW can be held liable in any way for failure to collaborate in the plan.

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C. The DRSCW will determine the baseline conditions through appropriate studies with stakeholders and other environmental evaluation which shall include sampling and analyses, as well as flow evaluation.

D. The DRSCW will determine the opportunities for improving de-icing practices through surveys and interviews with stakeholders.

E. The DRSCW and the TOLLWAY will set priorities, tracking offset progress, and the timeframe for achievement with concurrence from the IEPA.

F. The TOLLWAY will provide ongoing financial assistance supporting capital investments of alternative de-icing methods potentially for municipalities and agencies that are participating in the PROGRAM until such time as the PROGRAM objectives are met.

G. The TOLLWAY with the DRSCW's technical assistance will establish training and certifications for operators that would enhance awareness of best practices for snow and ice management operations.

H. The TOLLWAY with the DRSCW will establish data sites/sources for weather data and other information helpful in managing roadway de-icing.

I. The DRSCW with the support of the TOLLWAY will conduct long term monitoring that records salt usage and stream conditions. Evaluation of future operating conditions will be compared to baseline conditions.

J. The TOLLWAY and the DRSCW will report annually by July 1st to the IEPA the resulting efforts and success of the PROGRAM on an annual basis beginning in July of 2014. Success will be measured primarily by the application rate and totals reported with consideration given to the ambient monitoring system.

K. The TOLLWAY and the DRSCW will collaborate to put in place an ambient monitoring system that will be part of the PROGRAM monitoring and evaluation, and will document pre and post PROGRAM chloride conditions in the receiving streams. A monitoring plan will be developed through input from both PARTIES with the intent of conducting stream monitoring on Addison Creek, Salt Creek mainstem, Spring Brook, Meacham Creek and West Branch mainstem. The pre and post conditions will be synthesized in a report and submitted to IEPA on an annual basis along with other reporting data. The system would assist in evaluating the success of the PROGRAM in meeting the TMLD's goals and will be funded wholly by the TOLLWAY.

L. The PARTIES agree that the PROGRAM may require several years of monitoring and reporting from PROGRAM partners.

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M. The PARTIES will develop and maintain a guidance document for the PROGRAM which will at minimum detail the methods for calculating the build scenario non-PROGRAM increase, the needed offset, BMP's the monitoring PROGRAM and reporting baseline requirements. The document will be updated by agreement between the PARTIES as the PROGRAM advances.

V. INTERGOVERNMENTAL AGREEMENTS

A. The TOLLWAY shall use its best efforts to enter into Intergovernmental Agreements prepared by the TOLLWAY and Tier 1 communities based upon this MOU to further determine and establish respective responsibilities toward financial partnerships, information sharing, and training.

B. These Intergovernmental Agreements shall not relieve the TOLLWAY of their responsibility to comply with the "Clean Water Act" as determined and enforced by the IEPA.

VI. FINANCIAL

A. The TOLLWAY will support financial partnerships through an Intergovernmental Agreement requiring cost sharing with a local partner as defined by the PROGRAM.

B. Project requests to the TOLLWAY will be subject to DRSCW and TOLLWAY approvals, to cost effectively promote salt usage reduction.

VII. TERMS OF THE MOU

A. The term of this MOU shall extend until such time that the PROGRAM offset has been achieved reductions have been demonstrated for a minimum of three (3) years. Either PARTY shall have the right to terminate this MOU at any time by providing at least ninety (90) days written notice to the other party in the event either PARTY breaches the terms and conditions of this MOU. At the end of the agreement period this document may be renewed by the mutual consent of the PARTIES.

(This space intentionally left blank)

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IN WITNESS THEREOF, the PARTIES have entered into this MOU as of the date written below.

THE DUPAGE RIVER SALT CREEK WORKGROUP

By: _____
David Gorman, President

Date: 10-30-13

Attest: _____
10-30-13.
(Please Print Name)

THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY

By: _____
Kristi Lafleur, Executive Director

Date: 10/31/13

Approved as to Form and Constitutionality

Tiffany I. Bohn, AAG. 10/31/13
Tiffany I. Bohn, Assistant Attorney General, State of Illinois

JMR_MOU_DuPage River Salt Creek Workgroup_I-90 & EOWA

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Illinois Tollway

The Illinois Tollway
2700 Ogden Avenue
Downers Grove, Illinois 60515-1703
Phone: 630/241-6800
Fax: 630/241-6100
TTY: 630/241-6898

November 4, 2013

Mr. Stephen McCracken
DuPage River Salt Creek Workgroup
The Conservation Foundation
10 S. 404 Knoch Knolls
Naperville, IL 60565

Re: Memorandum of Understanding between the The Illinois State Toll Highway Authority and the DuPage River Salt Creek Workgroup for Chloride Offset Program.

Dear Mr. McCracken:

Enclosed please find one (1) fully executed Memorandum of Understanding between the Illinois State Toll Highway Authority and The DuPage River Salt Creek Workgroup for Chloride Offset Program on I-90 and the Elgin O'Hare Western Access.

Very truly yours,

Tiffany I. Bohn
Assistant Attorney General

TIB:mw
Enclosure

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THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY

TO: Eileen Cosgriff, CIS

FROM: Tiffany I. Bohn, Assistant Attorney General

DATE: November 4, 2013

SUBJECT: ***Memorandum of Understanding between The DuPage River Salt Creek Workgroup and The Illinois State Toll Highway Authority for Chloride Offset Program.***

Attached please find one (1) fully executed original Memorandum of Understanding between the DuPage River Salt Creek Workgroup and the Illinois State Toll Highway Authority Chloride Offset Program.

This document is transmitted to your attention for the Department's records.

This Memorandum of Understanding does not require a Board Resolution.

TIB:mw
Attachment

cc:
V. Avila
T. Bohn
K. Kell
P. Kovacs
D. Manetti
M. Molliconi
P. Pearn
J. Romano
S. Talaber
B. Wagner
V. Yee
G. Zimmer
R. Zucchero

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ATTACHMENT 6

MEAN HARDNESS / SULFATE CALCULATIONS

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SampleGroup	StationCode	CollectionDate	CollectionTime	SampleMedium	Analyte	Result	ResultUnits	Qualifier	RESULT, MG/L
								Mean Hardness =	286.8 mg/L
								N =	23,208
B00097900	AD-02	1/19/2000	9:00	Water	Hardness, Ca, Mg	69	mg/l	C	69
B00476100	AD-02	4/4/2000	9:00	Water	Hardness, Ca, Mg	90	mg/l	C	90
B00711900	AD-02	5/11/2000	9:00	Water	Hardness, Ca, Mg	121	mg/l	C	121
B00978200	AD-02	6/19/2000	9:00	Water	Hardness, Ca, Mg	52	mg/l	C	52
B01243600	AD-02	7/25/2000	9:00	Water	Hardness, Ca, Mg	123	mg/l	C	123
B01487400	AD-02	8/21/2000	9:00	Water	Hardness, Ca, Mg	113	mg/l	C	113
B01768700	AD-02	10/2/2000	12:00	Water	Hardness, Ca, Mg	103	mg/l	C	103
B02121100	AD-02	11/29/2000	9:00	Water	Hardness, Ca, Mg	80	mg/l	C	80
B10163000	AD-02	1/31/2001	9:00	Water	Hardness, Ca, Mg	102	mg/l	C	102
B10393500	AD-02	3/15/2001	10:30	Water	Hardness, Ca, Mg	89	mg/l	C	89
B10595300	AD-02	4/16/2001	9:00	Water	Hardness, Ca, Mg	104	mg/l	C	104
B10748700	AD-02	5/9/2001	9:00	Water	Hardness, Ca, Mg	135	mg/l	C	135
B10963900	AD-02	6/6/2001	9:00	Water	Hardness, Ca, Mg	110	mg/l	C	110
B11337700	AD-02	7/25/2001	9:00	Water	Hardness, Ca, Mg	142	mg/l	C	142
B11592200	AD-02	8/27/2001	9:00	Water	Hardness, Ca, Mg	80	mg/l	C	80
B11905800	AD-02	10/11/2001	9:00	Water	Hardness, Ca, Mg	112	mg/l	C	112
B12179100	AD-02	11/20/2001	9:00	Water	Hardness, Ca, Mg	116	mg/l	C	116
B12337700	AD-02	12/19/2001	10:00	Water	Hardness, Ca, Mg	71	mg/l	C	71
B20254900	AD-02	2/6/2002	9:00	Water	Hardness, Ca, Mg	56	mg/l	C	56
B20461800	AD-02	3/18/2002	9:00	Water	Hardness, Ca, Mg	58	mg/l	C	58
B20715600	AD-02	4/23/2002	9:00	Water	Hardness, Ca, Mg	59	mg/l	C	59
B20986900	AD-02	6/3/2002	10:00	Water	Hardness, Ca, Mg	102	mg/l	C	102
B21273900	AD-02	7/11/2002	9:00	Water	Hardness, Ca, Mg	158	mg/l	C	158
B21570800	AD-02	8/15/2002	9:00	Water	Hardness, Ca, Mg	143	mg/l	C	143
B21872600	AD-02	10/1/2002	9:00	Water	Hardness, Ca, Mg	118	mg/l	C	118
B22388800	AD-02	12/23/2002	11:00	Water	Hardness, Ca, Mg	57	mg/l	C	57
B00054500	AK-02	1/10/2000	11:00	Water	Hardness, Ca, Mg	41	mg/l	C	41
B00207600	AK-02	2/9/2000	11:00	Water	Hardness, Ca, Mg	55	mg/l	C	55
B00651700	AK-02	5/2/2000	11:00	Water	Hardness, Ca, Mg	36	mg/l	C	36
B01031100	AK-02	6/26/2000	10:00	Water	Hardness, Ca, Mg	37	mg/l	C	37
B01433400	AK-02	8/17/2000	11:00	Water	Hardness, Ca, Mg	49	mg/l	C	49
B02085600	AK-02	11/20/2000	11:00	Water	Hardness, Ca, Mg	46	mg/l	C	46
B10124500	AK-02	1/23/2001	10:00	Water	Hardness, Ca, Mg	45	mg/l	C	45
B10310200	AK-02	2/27/2001	12:00	Water	Hardness, Ca, Mg	30	mg/l	C	30
B10493500	AK-02	4/3/2001	11:00	Water	Hardness, Ca, Mg	23	mg/l	C	23
B10748400	AK-02	5/10/2001	11:00	Water	Hardness, Ca, Mg	51	mg/l	C	51
B11068900	AK-02	6/20/2001	11:00	Water	Hardness, Ca, Mg	51	mg/l	C	51
B11284600	AK-02	7/18/2001	11:00	Water	Hardness, Ca, Mg	55	mg/l	C	55
B11496500	AK-02	8/15/2001	11:00	Water	Hardness, Ca, Mg	49	mg/l	C	49
B11852800	AK-02	10/3/2001	11:00	Water	Hardness, Ca, Mg	48	mg/l	C	48
B12113000	AK-02	11/7/2001	11:00	Water	Hardness, Ca, Mg	58	mg/l	C	58
B20012000	AK-02	1/2/2002	11:00	Water	Hardness, Ca, Mg	43	mg/l	C	43
B20227400	AK-02	2/4/2002	11:00	Water	Hardness, Ca, Mg	31	mg/l	C	31
B20566600	AK-02	4/3/2002	11:00	Water	Hardness, Ca, Mg	37	mg/l	C	37
B20884100	AK-02	5/15/2002	9:00	Water	Hardness, Ca, Mg	29	mg/l	C	29
B21065400	AK-02	6/12/2002	11:00	Water	Hardness, Ca, Mg	43	mg/l	C	43
B21345000	AK-02	7/17/2002	11:00	Water	Hardness, Ca, Mg	63	mg/l	C	63
B21620000	AK-02	8/21/2002	11:00	Water	Hardness, Ca, Mg	63	mg/l	C	63
B22160600	AK-02	11/7/2002	11:00	Water	Hardness, Ca, Mg	44	mg/l	C	44
B22312300	AK-02	12/9/2002	11:00	Water	Hardness, Ca, Mg	49	mg/l	C	49
B00054400	AT-06	1/10/2000	9:00	Water	Hardness, Ca, Mg	300	mg/l	C	300
B00207500	AT-06	2/9/2000	9:00	Water	Hardness, Ca, Mg	768	mg/l	C	768
B00651800	AT-06	5/2/2000	9:00	Water	Hardness, Ca, Mg	274	mg/l	C	274
B01031400	AT-06	6/26/2000	8:00	Water	Hardness, Ca, Mg	92	mg/l	C	92
B01434000	AT-06	8/17/2000	9:00	Water	Hardness, Ca, Mg	414	mg/l	C	414
B01635600	AT-06	9/14/2000	9:00	Water	Hardness, Ca, Mg	700	mg/l	C	700
B01768800	AT-06	10/3/2000	9:00	Water	Hardness, Ca, Mg	714	mg/l	C	714
B02085400	AT-06	11/20/2000	9:00	Water	Hardness, Ca, Mg	441	mg/l	C	441
B10124600	AT-06	1/23/2001	8:00	Water	Hardness, Ca, Mg	314	mg/l	C	314
B10310500	AT-06	2/27/2001	10:00	Water	Hardness, Ca, Mg	185	mg/l	C	185
B10310300	AT-06	2/27/2001	10:30	Water	Hardness, Ca, Mg	183	mg/l	C	183
B10493400	AT-06	4/3/2001	9:00	Water	Hardness, Ca, Mg	192	mg/l	C	192
B11068800	AT-06	6/20/2001	9:00	Water	Hardness, Ca, Mg	582	mg/l	C	582
B11284700	AT-06	7/18/2001	9:00	Water	Hardness, Ca, Mg	341	mg/l	C	341
B11852600	AT-06	10/3/2001	9:00	Water	Hardness, Ca, Mg	248	mg/l	C	248
B12113400	AT-06	11/7/2001	9:00	Water	Hardness, Ca, Mg	579	mg/l	C	579
B20011900	AT-06	1/2/2002	9:00	Water	Hardness, Ca, Mg	556	mg/l	C	556
B20227500	AT-06	2/4/2002	9:00	Water	Hardness, Ca, Mg	143	mg/l	C	143
B20566800	AT-06	4/3/2002	9:00	Water	Hardness, Ca, Mg	169	mg/l	C	169
B20884200	AT-06	5/15/2002	11:00	Water	Hardness, Ca, Mg	73	mg/l	C	73
B21065500	AT-06	6/12/2002	9:00	Water	Hardness, Ca, Mg	341	mg/l	C	341
B21344900	AT-06	7/17/2002	9:00	Water	Hardness, Ca, Mg	1060	mg/l	C	1060
B21619900	AT-06	8/21/2002	9:00	Water	Hardness, Ca, Mg	256	mg/l	C	256
B22160200	AT-06	11/7/2002	9:00	Water	Hardness, Ca, Mg	402	mg/l	C	402
B22311900	AT-06	12/9/2002	9:00	Water	Hardness, Ca, Mg	768	mg/l	C	768

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SampleGroup	StationCode	CollectionDate	CollectionTime	SampleMedium	Analyte	Result	ResultUnits	Qualifier	ReportingLimit
					Mean Sulfate =	86.8	mg/L		
					N =	19,580			
B00097900	AD-02	1/19/2000	9:00	Water	Sulfate	42.6	mg/l		
B01768700	AD-02	10/2/2000	12:00	Water	Sulfate	18.9	mg/l		
B21273900	AD-02	7/11/2002	9:00	Water	Sulfate	10.4	mg/l		
B00054500	AK-02	1/10/2000	11:00	Water	Sulfate	23.9	mg/l		
B00207600	AK-02	2/9/2000	11:00	Water	Sulfate	46.9	mg/l		
B00651700	AK-02	5/2/2000	11:00	Water	Sulfate	11.1	mg/l		
B01031100	AK-02	6/26/2000	10:00	Water	Sulfate	11.1	mg/l		
B01433400	AK-02	8/17/2000	11:00	Water	Sulfate	16.9	mg/l		
B02085600	AK-02	11/20/2000	11:00	Water	Sulfate	18.2	mg/l		
B10124500	AK-02	1/23/2001	10:00	Water	Sulfate	20.6	mg/l		
B10310200	AK-02	2/27/2001	12:00	Water	Sulfate	11.1	mg/l		
B10493500	AK-02	4/3/2001	11:00	Water	Sulfate		mg/l	ND	10
B10748400	AK-02	5/10/2001	11:00	Water	Sulfate	13.7	mg/l		
B11068900	AK-02	6/20/2001	11:00	Water	Sulfate		mg/l	ND	10
B11284600	AK-02	7/18/2001	11:00	Water	Sulfate		mg/l	ND	10
B11496500	AK-02	8/15/2001	11:00	Water	Sulfate		mg/l	ND	10
B11852800	AK-02	10/3/2001	11:00	Water	Sulfate		mg/l	ND	10
B12044900	AK-02	10/26/2001	12:20	Water	Sulfate	16.9	mg/l		
B12113000	AK-02	11/7/2001	11:00	Water	Sulfate	20.5	mg/l		
B20012000	AK-02	1/2/2002	11:00	Water	Sulfate	21.7	mg/l		
B20227400	AK-02	2/4/2002	11:00	Water	Sulfate	15.2	mg/l		
B20566600	AK-02	4/3/2002	11:00	Water	Sulfate	13.9	mg/l		
B20629400	AK-02	4/5/2002	16:30	Water	Sulfate	14	mg/l		
B20744800	AK-02	4/25/2002	15:30	Water	Sulfate	14.4	mg/l		
B20884100	AK-02	5/15/2002	9:00	Water	Sulfate	14.7	mg/l		
B20946000	AK-02	5/22/2002	14:30	Water	Sulfate	16.3	mg/l		
B21018600	AK-02	6/7/2002	13:20	Water	Sulfate	12.8	mg/l		
B21065400	AK-02	6/12/2002	11:00	Water	Sulfate	11.5	mg/l		
B21134500	AK-02	6/20/2002	14:40	Water	Sulfate	12.4	mg/l		
B21214400	AK-02	7/3/2002	12:00	Water	Sulfate	13.3	mg/l		
B21345000	AK-02	7/17/2002	11:00	Water	Sulfate		mg/l	ND	10
B21524200	AK-02	7/31/2002	17:00	Water	Sulfate	118	mg/l		
B21620000	AK-02	8/21/2002	11:00	Water	Sulfate	80.9	mg/l		
B21642900	AK-02	8/22/2002	16:30	Water	Sulfate	152	mg/l		
B21780800	AK-02	9/12/2002	18:20	Water	Sulfate		mg/l	ND	10
B22069000	AK-02	10/12/2002	14:30	Water	Sulfate	68.6	mg/l	J1,J3,J4	
B22205000	AK-02	11/1/2002	15:40	Water	Sulfate	20	mg/l	J1,J3,J4	
B22160600	AK-02	11/7/2002	11:00	Water	Sulfate	32.9	mg/l	J1,J3,J4	
B22204400	AK-02	11/15/2002	16:40	Water	Sulfate	17.3	mg/l	J1,J3,J4	
B22312300	AK-02	12/9/2002	11:00	Water	Sulfate	21	mg/l	J1,J3,J4	
B22385700	AK-02	12/12/2002	15:20	Water	Sulfate	23.1	mg/l	J1,J3,J4	
B00054400	AT-06	1/10/2000	9:00	Water	Sulfate	289	mg/l		
B00207500	AT-06	2/9/2000	9:00	Water	Sulfate	755	mg/l		
B00651800	AT-06	5/2/2000	9:00	Water	Sulfate	191	mg/l		
B01031400	AT-06	6/26/2000	8:00	Water	Sulfate	41.7	mg/l		
B01434000	AT-06	8/17/2000	9:00	Water	Sulfate	331	mg/l		
B01635600	AT-06	9/14/2000	9:00	Water	Sulfate	698	mg/l		
B01768800	AT-06	10/3/2000	9:00	Water	Sulfate	586	mg/l		
B02085400	AT-06	11/20/2000	9:00	Water	Sulfate	287	mg/l		
B10124600	AT-06	1/23/2001	8:00	Water	Sulfate	158	mg/l		
B10310500	AT-06	2/27/2001	10:00	Water	Sulfate	103	mg/l		
B10493400	AT-06	4/3/2001	9:00	Water	Sulfate	93.9	mg/l		
B11068800	AT-06	6/20/2001	9:00	Water	Sulfate		mg/l	ND	10
B11284700	AT-06	7/18/2001	9:00	Water	Sulfate	208	mg/l		
B11852600	AT-06	10/3/2001	9:00	Water	Sulfate	155	mg/l		
B12113400	AT-06	11/7/2001	9:00	Water	Sulfate	285	mg/l		
B20011900	AT-06	1/2/2002	9:00	Water	Sulfate	419	mg/l		
B20227500	AT-06	2/4/2002	9:00	Water	Sulfate	77.7	mg/l		
B20566800	AT-06	4/3/2002	9:00	Water	Sulfate	106	mg/l		

Exhibit 389B R04793

From: Andrew Rehn
To: EPA.PublicHearingCom; Lieberoff, Barb
Cc: Albert Ettinger; Cindy Skrukrud; Sabrina Hardenbergh; Jan thomas; Cameron J. Smith; Jane Cogie; Amanda Pankau; Jann.Stephen@epa.gov
Subject: [External] (Exhibits 2/4) IL0077666 Pond Creek Mine Post-Hearing Comments from PRN, SC, SAFE
Date: Friday, January 17, 2020 3:59:53 PM
Attachments: Exhibit_F NPDESMonitoringData_IL0077666.xlsx
Exhibit_H IEEFA report_ Dim future for Illinois Basin coal.pdf
Exhibit_G INHS Freshwater Mussels of the Big Muddy River.pdf
Exhibit_E WQBELs memo_12132016.pdf
Exhibit_I Commercial Fishing Memo.pdf
Exhibit_D Draft Field-Based Methods for Developing Aquatic Life Criteria for Specific Conductivity.pdf

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Please find the Exhibits D-I attached.

On Fri, Jan 17, 2020 at 3:56 PM Andrew Rehn <arehn@prairierivers.org> wrote:

> Dear Ms. Lieberoff and other Illinois EPA officials;
>
> On behalf of Prairie Rivers Network, Sierra Club and Southern Illinoisans Against Fracturing Our Environment, attached are post-hearing comments regarding the proposed NPDES Permit IL0077666 for the Pond Creek mine. As these comments will explain, the proposed permit plainly cannot be legally granted by the Illinois Environmental Protection Agency (IEPA) based on the current record. Please do not hesitate to reach out to us for further clarification.
>
> In 4 emails following this one, I will be including the exhibits to this comment letter. Please include those in the record with this submission.
>
> Thank you,
> Andrew
>
> --
> **Andrew Rehn**
> *Water Resources Engineer, Prairie Rivers Network*
> 1605 South State St, Suite 1, Champaign, IL 61820
>
> tel: 217.344.2371 x 8208
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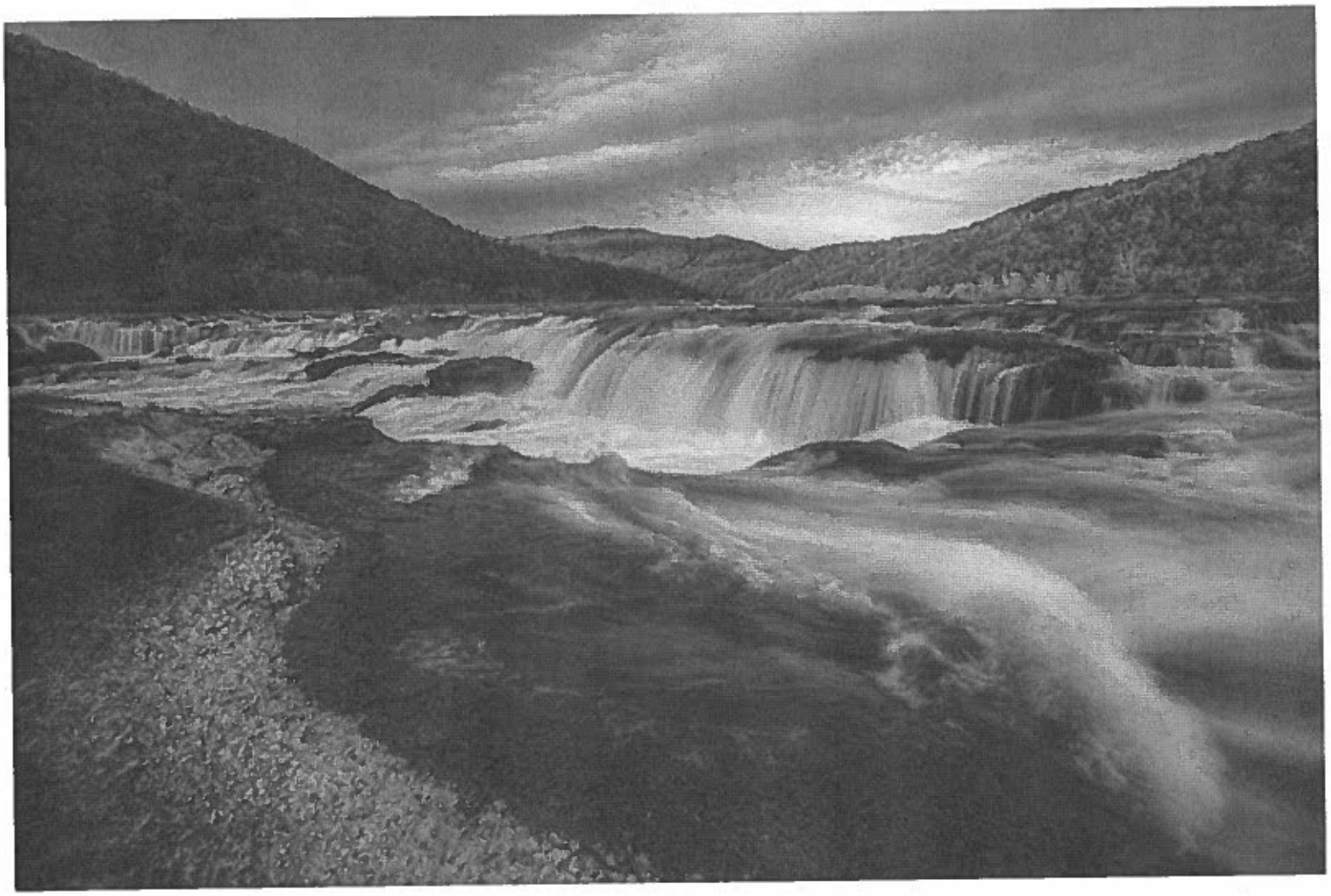
Field-Based Methods for Developing Aquatic Life Criteria for Specific Conductivity

U.S. Environmental Protection Agency
Office of Water
Office of Science and Technology
Washington, DC

EPA
United States
Environmental Protection
Agency

Office of Water
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Field-Based Methods for Developing Aquatic Life Criteria for Specific Conductivity

U.S. Environmental Protection Agency
Office of Water, Washington, DC

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LIST OF ABBREVIATIONS AND ACRONYMS

B-C	background-to-criterion
CCC	criterion continuous concentration
CDF	cumulative distribution function
CI	confidence interval
CMEC	criterion maximum exposure concentration
DO	dissolved oxygen
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
GAM	generalized additive model
HCx	hazardous concentration of the "*x*" centile of a taxonomic sensitivity distribution
LOWESS	Locally Weighted Scatterplot Smoothing
MAHA	Mid-Atlantic Highland Assessment
MAIA	Mid-Atlantic Integrated Assessment
NAPAP	National Acid Precipitation Assessment Program
NRSA	National Rivers and Streams Assessment
NWSA	National Wadeable Streams Assessment
PL	prediction limit
QA/QC	quality assurance/quality control
RBP	rapid bioassessment protocol
R-EMAP	Regional Environmental Monitoring and Assessment Program
S	Siemens
SAB	Science Advisory Board
SC	specific conductivity
TDS	total dissolved solids
TMDL	total maximum daily load
TSS	total suspended solids
USGS	U.S. Geological Survey
WABbase	Watershed Assessment Branch database
WDE	Washington Department of Ecology
WSA	Wadeable Streams Assessment
WVDEP	West Virginia Department of Environmental Protection
XCx	extirpation concentration affecting "*x*" percentage of individuals of a taxon
XCD	extirpation concentration distribution

NOTICES

This public review draft document has undergone two contractor-led external peer reviews as well as a review process within the U.S. Environmental Protection Agency (EPA). Final review by EPA's Office of Science and Technology, Health and Ecological Criteria Division, has been completed and the document has been approved for publication.

This document provides draft methods to assist states and tribes in the development of water quality criteria and other tools to protect aquatic life from effects of elevated ionic concentration as measured by specific conductivity (SC)[1] in flowing waters. States and tribes planning to develop water quality criteria for SC may consider using alternative, scientifically defensible methods. While this document reflects EPA's assessment of the best available science for identifying ambient concentrations of SC in flowing waters that protect aquatic life, it is not a regulation and does not impose legally binding requirements on EPA, states, tribes, or the regulated community, and might not apply to a particular situation based upon the circumstances. EPA may change this document in the future.

Mention of trade names or commercial products does not constitute endorsement or recommendation for use. This document can be downloaded from: https://www.epa.gov/wqc/aquatic-life-ambient-water-quality-criteria.

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[1]This document uses conductivity as a measure of ionic concentration rather than as description of an electrical property of water. As ionic concentration increases, conductivity increases. The terms specific conductivity and specific conductance are often used synonymously in the open literature indicating normalization or measurement at 25°C. Conductivity is a property of water expressed in units of micro-Siemens per centimeter (µS/cm). Conductance of a sample or electrical component is measured as Siemens (S). All measurements in this document refer to specific conductivity, µS/cm at 25°C.

FOREWORD

This document, *Draft Field-based Methods for Developing Aquatic Life Criteria for Specific Conductivity,* provides states and tribes with methods that may be used to develop criteria to protect aquatic life from effects of elevated ionic concentration as measured by specific conductivity (SC) in flowing waters. The EPA tailored these methods to enable derivation of specific conductivity criteria on the scale of Level III ecoregions (Omernik, 1995, 1987) in order to account for natural differences in background ionic concentrations among ecoregions. There are 85 Level III ecoregions in the contiguous United States. Each of the states in the contiguous United States contains 1 to 12 Level III ecoregions within their political boundaries. The EPA is also providing several case studies to illustrate how these draft methods may be applied to different ecoregions with varying background ionic concentrations. The EPA may change the field-based methods and/or provide additional case studies in the future as new scientific information becomes available.

This document is nonregulatory and provides only a scientific assessment of ecological effects. It does not establish or affect legal rights or obligations. It does not establish a binding norm and cannot be finally determinative of the issues addressed. Agency decisions in any particular situation will be made by applying the Clean Water Act and EPA regulations on the basis of specific facts presented and scientific information then available.

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EXECUTIVE SUMMARY

This document describes draft methods that states and tribes may use to derive field-based ecoregional ambient aquatic life criteria for specific conductivity (SC), a measurement of the concentration of ions, in flowing waters. The document also provides four case studies to illustrate how these draft field-based methods may be used to develop criteria in ecoregions with different background ionic concentrations measured as SC and to demonstrate how to assess the applicability of criteria developed for one ecoregion to a different ecoregion. The case studies use field data to demonstrate how to apply the methods described in this document to derive example criteria for SC for flowing waters dominated by calcium, magnesium, sulfate, and bicarbonate ions but not for flowing waters dominated by chloride salts. Elevated ionic concentration measured as SC has been shown to impact aquatic life in a range of freshwater resources. Different mixtures of ions that increase SC are associated with multiple anthropogenic sources, including discharges from wastewater treatment facilities, groundwater recharge affected by climate change, surface mining, oil and gas exploration, runoff from urban areas, and discharges of agricultural irrigation return waters, among others.

The EPA relied on its *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (1985) (EPA/822/R-85/100) and *A Field-Based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams* (hereafter referred to as the "*EPA Benchmark Report*") (EPA/600/R-10/023F), among other documents, to develop the draft field-based method for SC. In the *EPA Benchmark Report*, EPA used a field data set to estimate a numeric SC benchmark for Appalachian streams. The EPA validated the method and the benchmark using an independent data set. In 2011, internal and external reviewers, including EPA's Science Advisory Board (SAB) (U.S. EPA, 2011c), favorably reviewed the analyses and method. This current document uses that same method to estimate a protective criterion continuous concentration (CCC) for chronic (long-term) exposures as well as additional methods to estimate a maximum exposure concentration protective of acute toxicity. This document also provides recommendations for SC criterion duration and frequency.

The EPA typically relies on laboratory toxicity test data for surrogate species as defined in the Agency's *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (U.S. EPA, 1985) for aquatic life criteria

development. The draft field-based methods used here were adapted to be consistent with the intent of the Agency's traditional approach to derive aquatic life criteria (U.S. EPA, 1985). The draft field-based methods rely on geographically referenced, paired observations of SC and the presence and absence or abundance of freshwater benthic macroinvertebrate genera from wadeable perennial streams. The case studies that are included to illustrate the method are based on more than 4,000 paired biological (macroinvertebrate) and chemical (SC) field samples from more than 3,000 stations over a 15-year period (1996–2010). An analysis of data for fish from a composite of case study ecoregions demonstrates that the example criteria based on macroinvertebrates are also protective of fish.

For this draft field-based method, the valued resource is the aquatic community. The ecological entities defining the assessment endpoints are macroinvertebrate genera and the measure of effect is extirpation, or effective absence of such genera from a site (the desired attribute is occurrence). Two relationships are derived: one for each macroinvertebrate genus and one for the overall aquatic community. First, a weighted cumulative distribution function (CDF) is developed for each genus to determine the genus extirpation concentration (XC_{95} or 95th centile of the distribution of the occurrences of a genus), the level of exposure above which a macroinvertebrate genus is effectively absent from water bodies in a region or other study area (U.S. EPA, 2011a, 2003). That is, the probability is 0.05 that an observation of a genus would occur above its XC_{95} SC value. Second, the HC_{05} (hazard concentration 5th centile) is developed using a genus-level extirpation concentration distribution (XCD) for the community from the aggregation of the XC_{95} values. This effect threshold is consistent with the intent of EPA's guidelines for aquatic life criteria development (U.S. EPA, 1985), which are designed to protect aquatic animal species (i.e., 95%) in a community.

The HC_{05} is a chronic-duration endpoint and used for derivation of a CCC because it is derived from biological field data that include exposure over whole life cycles and multiple generations of the resident biota. A criterion maximum exposure concentration (CMEC), a level of protection from acutely toxic exposures, is also derived based on stream water chemistry data. The CMEC is estimated at the 90th centile of observations at sites with water chemistry regimes meeting the CCC. The CMEC is the maximum SC level that may occur for a short duration and be protective of 95% of macroinvertebrate genera. Both of these distinct expressions of the example SC criteria would need to be met in order to adequately protect aquatic life.

The type of model used in this draft method, a genus-level XCD, describes how genera in biotic communities in general respond to a stressor (e.g., an ionic mixture dominated by sulfate and bicarbonate salts). This method is based on a distribution of extirpation concentrations and is called the XCD method to distinguish it from other field-based methods. Like the surrogate aquatic taxa that form the minimum data set for laboratory-based aquatic life criteria, the macroinvertebrate taxa included in the case studies are surrogate taxa that represent a potentially exposed aquatic community (U.S. EPA, 1985).

GLOSSARY

Assessment endpoint—An explicit expression of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attribute or characteristics. An assessment endpoint may be identified at any level of organization (e.g., organism, population, community).

Assemblage, stream—A taxonomic or sampled subset of a community as may be collected from a stream.

Background specific conductivity—The specific conductivity (SC) in streams in a region that occurs naturally and not as the result of human activity. Background may also be characterized as a population of minimally affected sites or low SC sites using a weight of evidence.

Benchmark—A dose or concentration of a pollutant that, if exceeded, is expected to produce an adverse effect (called the benchmark response) in one or more assessment endpoints, signifying a decline in water quality or human health.

Bootstrapping—A statistical technique of repeated random sampling from a data set that is often used in environmental studies to estimate confidence and prediction limits of a parameter.

Box plot—A depiction of the 25th, 50th, and 75th quantiles of a distribution as a rectangle with a central line. The two standard deviation range is depicted as "whiskers" extending from the box. Data beyond two standard deviations are indicated by individual circles or dots beyond the whiskers.

Catchment area—The spatial extent of the surrounding landscape that drains into a particular river, stream, or other waterbody.

Chorionic covering—The outermost casing or membranous covering of the egg of various invertebrates.

Community—The full complement of interacting organisms within a defined area of an ecosystem.

Conductivity, specific (or specific electrical conductivity)—A measure of ionic concentration based on the electrical property of water and dissolved ions. As ionic concentration increases, conductivity increases. Standardized measurements in this document refer to specific conductivity, µS/cm (also seen as: µmho/cm) at 25°C.

Conductance, specific—Conductance is the inverse of resistance for a particular sample expressed as Seimens (S) usually at 25°C. In the literature, it is sometimes used synonymously with specific conductivity, but to avoid confusion, the term conductance is not used in this document.

Confounder—An extraneous variable that correlates with both the dependent and independent variable. The presence of confounders can interfere with the ability to characterize a causal relationship.

Criterion continuous concentration (CCC)—An estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

Criterion maximum exposure concentration (CMEC)—An estimate of the maximum concentration of a material in surface water to which an aquatic community can be exposed for a short time without resulting in an unacceptable effect. In this document, the CMEC is estimated at the 90th centile of specific conductivity observations that contribute to the annual CCC.

Cumulative distribution function (CDF)—The probabilities that a random variable with a given probability distribution will be found at a value less than or equal to x. Weighted CDFs are used to estimate extirpation concentrations of individual genera or species and unweighted CDFs to estimate a SC level that is expected to extirpate 5% of aquatic invertebrate genera.

Ephemeral stream—A stream that flows briefly only in direct response to local precipitation, and whose channel is above the local groundwater table at all times.

Extirpation—The depletion of a population of a species or genus to the point that it is no longer a viable resource or is unlikely to fulfill its function in the ecosystem.

Extirpation concentration—The level above which a genus is effectively absent from its normal habitat. The threshold for extirpation is operationally defined by the level below which 95% of the observations of the genus occur.

Extrapolation—The process of extending the applicability of a model beyond the measured range of the original data set from which the model was derived.

Flowing waters—Inland waters with a unidirectional flow including permanent, intermittent and ephemeral streams.

Generalized additive model—A nonparametric, likelihood-based local regression model that replaces the linear function of a generalized linear model with a locally smoothed additive function.

Hazardous concentration—A concentration threshold that is hazardous for a proportion of taxa. In this document, it is the concentration that is hazardous to 5% of genera calculated as the 5^{th} centile of a taxonomic extirpation concentration distribution.

Intermittent stream—A stream that flows continuously for only part of the time. During low flow there may be dry reaches alternating with wetted, nonflowing reaches. The stream bed may lie below the local groundwater table for at least part of the year.

Interpolate—Process of estimating an unknown value that lies between known values.

Ionic composition—The specific ions dissolved in water. In this document, the ionic composition is used to distinguish water dominated by chloride salts from those dominated by bicarbonate and sulfate salts.

Ionic mixture—An undefined or defined blend of dissolved ions. In this document, the example case studies refer to the most common mixture of ions contaminating U.S. streams, specifically those dominated by calcium, magnesium, sulfate, and bicarbonate ions.

Ionic regulation—The passive and active physiological processes that maintain the ionic composition, pH, and water content of tissues that is necessary for life.

Least disturbed condition—the best available physical, chemical, and biological habitat conditions given today's state of the landscape or the least disturbed by human activities (Stoddard et al., 2006). Contrast with "minimally affected condition."

Major ions—The most common contributors to ionic concentration in surface waters, consisting of the following cations: Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}; and anions: HCO_3^{-}, CO_3^{2-}, SO_4^{2-}, Cl^{-}.

Measure of effect—A measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint and is a measure of biological effects (e.g., survival, reproduction, growth). In this document it is the presence/absence of macroinvertebrate genera along a specific conductivity gradient.

Measure of exposure—A measured or estimated characteristic that is used to characterize the level of exposure to the stressor. In this document, the measure of ionic exposure is specific conductivity.

Minimally affected condition—The physical, chemical, and biological habitat found in the absence of significant human disturbance (Stoddard et al., 2006). Contrast with "least disturbed condition."

Osmoregulation—The physiological control of water content of an organism's tissues to maintain fluid and electrolyte balance within a cell or organism relative to the surrounding environment.

Perennial stream—A stream with continuous surface or shallow interstitial flow year-round, and whose stream bed intersects the local groundwater table throughout the year. Also referred to as a permanent stream.

Produced water—Waters that are produced by oil and gas development, mine dewatering, and related activities (e.g., coal bed methane mining, hydraulic fracturing).

Reference site—Sampling locations that have been identified as minimally affected or least disturbed based on land use, habitat, and water quality characteristics other than specific conductivity.

Salinity—The amount of salts dissolved in water. Traditionally expressed as parts per thousand (‰) or grams of salt per kilogram of water.

Sensitivity analysis—A process that involves changing input values of a model in various ways to see the effect on the output value. The main goal of sensitivity analysis is to gain insight into which assumptions are most critical for model building.

Total dissolved solids (TDS)—A measure of the combined content of all inorganic and organic substances dissolved in water, conventionally expressed as mg/L and operationally defined as those solids that pass through a filter, typically 0.45 μm.

Univoltine—An organism having one brood or generation per year.

Validation—Confirmation of the quality of a model and its results, typically by applying an independent data set.

Valley fill—A headwater valley filled with mining overburden. This practice usually occurs in steep terrain where there are limited disposal alternatives.

Verification—Demonstrating the accuracy of measurements or calculations.

1. INTRODUCTION AND BACKGROUND

This document describes a set of draft methods that states and authorized tribes may use to derive field-based ecoregional ambient aquatic life criteria for ionic mixtures measured as specific conductivity (SC), a measurement of ionic concentration. Four case studies illustrate how these draft methods may be applied to develop such criteria in different ecoregions with different background SC and data sets. The case studies illustrate how these methods may be used to develop criteria applicable to flowing waters dominated by sulfate and bicarbonate salts. Chloride constitutes less than half of the total anions in the case examples. Although the methods may be appropriate for use with other ionic mixtures, the example criteria generally are not appropriate for waters with different ionic compositions (e.g., waters dominated primarily by sodium chloride).

Among the documents the U.S. Environmental Protection Agency (EPA) relied upon to develop the draft field-based method for SC are EPA's *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (U.S. EPA, 1985) and *A Field-Based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams* (hereafter referred to as the "*EPA Benchmark Report*") (U.S. EPA, 2011a). The EPA used an extensive field data set in the *EPA Benchmark Report* to estimate a numeric SC benchmark. The EPA validated the method and benchmark using an independent data set. The *EPA Benchmark Report* provides details on the approach, as well as a causal analysis of the stressor-response relationship and a confounder analysis that explored the potential influence of habitat, water quality factors, other pollutants, and other factors. Internal and external reviewers, including EPA's Science Advisory Board (SAB), reviewed the primary method and derivation of the SC benchmark and validation exercises in 2011 (U.S. EPA, 2011c). Subsequently, the method and results of its application were published (Cormier and Suter, 2013a, b; Cormier et al., 2013a, b, c; Suter and Cormier, 2013). This current draft document uses that method as well as additional methods to estimate a protective maximum exposure concentration, duration, and frequency. It also presents a draft method for assessing applicability of field-based SC criteria developed in one geographic area to another area. In 2014 and 2015, panels of five external experts (selected independently by an EPA contractor) reviewed these additional draft methods.

These draft field-based methods may be used to develop SC criteria on the scale of Level III ecoregions (Omernik, 1995, 1987) in order to take into account natural ecoregional differences in background SC. In some areas, it may be appropriate to derive criteria at a different scale because background conductivity or ionic composition varies significantly across a Level III ecoregion (see Section 6 for an example). There are 85 Level III ecoregions in the continental United States (Omernik, 1995, 1987). SC tends to be low in most eastern and western montane ecoregions (25^{th} centiles of SC <200 µS/cm), intermediate in the midcontinent (200–600 µS/cm), and very high in arid areas (>600 µS/cm) (Griffith, 2014). States and tribes may use this method to derive ecoregional criteria for SC at a level that protects 95% of resident macroinvertebrate genera based on field sampling data from a set of sites within the ecoregion or from another ecoregion, when applicable.

The EPA typically relies on laboratory toxicity test data as defined in the Agency's *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (U.S. EPA, 1985). EPA designed the draft field-based methods described herein to be consistent with the intent of the Agency's traditional approach used to derive aquatic life criteria (U.S. EPA, 1985). Like the Agency's traditional approach, criteria derivation through field-based methods can capture characteristics of the stressor and the ecosystems potentially at risk (e.g., stressor occurrence and distribution, stressor-response relationships).

The structure of this draft document, *Field-based Methods for Developing Aquatic Life Criteria for Specific Conductivity*, is consistent with the EPA's *Guidelines for Ecological Risk Assessment* (U.S. EPA, 1998a; Suter and Cormier, 2008). The assessment begins with a planning phase, termed *Problem Formulation* (see Section 2), in which the stressor of concern is identified, its presence in the environment and potential impacts are described, and assessment endpoints (i.e., specific ecological entities and attributes to be protected and the level of protection to be achieved) are identified. In the case studies, the stressor is a mixture of ions in the form of dissolved bicarbonate and sulfate salts, measured as specific SC, in the field. The endpoint populations are aquatic benthic macroinvertebrates and the measure of effect is extirpation not to exceed 5% of genera. Section 2 serves as the *Problem Formulation* in general and for all four case studies.

In this draft document, the *Analysis Plan* (see Section 3), which is the last step in *Problem Formulation,* is included as a separate stand-alone section. The *Analysis Plan* describes three methods, (1) a field-based method that states may use to directly derive field-based aquatic life criteria for SC (the extirpation concentration distribution [XCD] method), (2) a regression model that can be used to derive criteria from minimally affected background (the background-to-criterion [B-C] model method), and (3) a method to assess the geographic applicability (extent) of the criteria using a weight-of-evidence approach. Section 3 serves as the *Analysis Plan* for this draft method in general and for all four of the case studies that follow in the *Case Study Analysis* sections. Each of the methods considers the causal relationship between exposure to major aqueous ions and the response of macroinvertebrates.

Next, in the *Case Study Analysis* sections (see Sections 4 and 5), the application of the draft XCD method is illustrated by deriving example SC criteria for different ecoregions with ecoregion-specific data sets. These sections describe magnitude, frequency, and duration as well as factors characterizing geographic range (see Case Studies I and II, Sections 4 and 5). Two other case studies demonstrate how to use the B-C regression method that predicts criteria from minimally affected background (see Case Studies III and IV, Sections 6 and 7). In these case studies, there are several factors relevant to determining geographic applicability (spatial extent of the criteria); among the most important are background SC and the composition of the ionic mixture present (ions of bicarbonate and sulfate salts).

Appendices A and B provide supporting materials, including assessments of potential confounding factors, and plots and effect levels for all genera represented in ecoregional XCDs used in the development of the Case Studies I and II (see Appendices A for Case Study I and B for Case Study II). Appendix C discusses the characterization of background SC and the seasonal regime of a region (a condition assessment) and includes a specific example for Case Study II. Appendix D provides the derivation of a B-C regression model that uses minimally affected background SC to calculate a SC criterion that is useful for areas lacking sufficient data to use the XCD method (see application of this model in Case Studies III and IV). Appendix E provides extirpation concentration (XC_{95}) values for the combined data sets used for Case Studies I and II. Appendix F provides results using an alternate measure of the ionic mixture, sulfate plus bicarbonate (as mg/L). Appendix G provides an analysis that shows that some fish

in streams are intolerant of high ionic concentrations and that fish are protected by criteria derived by applying the XCD method to benthic invertebrate data.

Data quality reviews of project data sets were conducted to ensure that the data used and the results of the analyses are accurate and complete. When invalid or incorrect data were identified, these data were either corrected or excluded from analyses. Methods for data extraction, data management, model development, and quality assurance/quality control (QA/QC) for this project are described in the Quality Assurance Project Plan, prepared by Tetra Tech, Inc. 2014. Validation and other QA analyses are described as each model or case study are also presented.

2. PROBLEM FORMULATION

This section serves as the *Problem Formulation* for the XCD method in general and for the case studies, which are presented in Sections 4, 5, 6, and 7. *Problem Formulation* begins with identification of the problem (see Section 2.1), the stressor of concern and its sources (see Section 2.2), and a description of how it can be measured (see Section 2.3). In the case examples, the stressor is a mixture of ions in a form dominated by bicarbonate and sulfate salts, measured using SC. The nature of effects (see Section 2.4), and mechanisms and modes of action are described (see Section 2.5). The assessment endpoints and measures of effect are described (see Section 2.6). The organisms are freshwater benthic macroinvertebrates and the measurement of effect is extirpation of 5% of genera. Extirpation is the depletion of an assessment population of a species or genus (in this case, it is the population in a stream) to the point that it is no longer a viable resource or is unlikely to fulfill its function in the ecosystem (U.S. EPA, 2003). Specifically, this effect threshold is defined in this document as the ionic concentration below which 95% of the observations of the genus occur, representing the extreme of an organism's tolerance to an ionic mixture. In the case studies, the ionic mixture as measured by SC is dominated by sulfate and bicarbonate salts, with either calcium and magnesium or sodium and potassium as the cations (U.S. EPA, 2011a). This effect threshold is consistent with the intent of EPA's guidelines for aquatic life criteria development (U.S. EPA, 1985), which are designed to protect aquatic animal species (i.e., 95%) in a community. The *Problem Formulation* section concludes with the rationale for selection of a field-based method for derivation of criteria for the ionic mixture (see Section 2.7).

2.1. PROBLEM IDENTIFICATION

Stress from elevated ionic concentration, measured as specific SC, has been shown to cause significant adverse effects on a range of freshwater ecosystems across the Nation (e.g., Cañeda-Argüelles, et al., 2013; Higgins and Wilde, 2005; Kaushal et al., 2013, 2005; Pond et al., 2008; U.S. EPA, 2011a). The sources of ions in surface waters may be natural, reflecting soils and geology, or anthropogenic. The two most common ionic mixtures in streams are those dominated by either chloride anions (Cl^-) or those dominated by bicarbonate (HCO_3^-) plus sulfate (SO_4^{2-}) anions based on mass (Hem, 1985; Griffith, 2014). The field-based methods are

illustrated using case examples with flowing waters with ionic mixtures dominated by HCO_3^- plus SO_4^{2-}. Based on mass, Cl^- constitutes less than half of the total anions in the case examples.

2.2. STRESSOR OF CONCERN—SALTS

Ionic stress has been implicated as a cause of biological impairment in aquatic systems throughout the United States (e.g., Findlay and Kelly, 2011; Farag, and Harper, 2012; Dunlop et al., 2015; Boelter, et al., 1992; Higgins and Wilde, 2005; Johnson et al., 2013; Karatayev et al., 2012; Kaushal et al., 2013, 2005; Fritz et al., 2010; Gerritsen et al., 2010; Palmer et al., 2010; Lindberg et al., 2011; Merriam et al., 2011; Pond et al., 2008, Pond, 2010; U.S. EPA, 2011a,b; Bernhardt et al., 2012; Cormier et al., 2013b; Timpano et al., 2011; Zhao et al., 2016). Nationally, sources of salts can be natural from rock formations and soils or can be associated with human activities and may be exacerbated by changes in climate. Sources include coastal salt water intrusion, irrigation, combustion wastes, resource exploration and extraction, demineralization of concrete, runoff from urban areas, inputs from deicing roads, and sewage and industrial waste (Ziegler et al., 2010; Cañeda-Argüelles, 2013) (see Table 2-1). Furthermore, salts from different sources have different ionic compositions. For example, marine evaporite deposits are dominated by NaCl whereas weathering of minerals such as limestone and dolomite produce Ca^{2+}, Mg^{2+}, and HCO_3^- salts (Hem, 1985).

Consistent with the *EPA Benchmark Report* (U.S. EPA, 2011a), these draft field-based methods may be applied for any waters with a defined ionic composition because the toxicity to aquatic organisms is dependent on the ionic composition of the solution (Mount et al., 1997; Mount et al., 2016; Erickson et al., 2016; Zalizniak et al., 2006; van Dam et al., 2010; Dunlop et al., 2005; Soucek and Kennedy, 2005; Bradley, 2009; Evans, 2008a,b; Nelson and Cox, 2005, Johnson et al., 2015). Aquatic organisms are adapted to different ionic regimes and have different tolerances to changes in ionic concentration and composition (Remane, 1971; Bradley, 2009). Although certain species, particularly of fish and Crustacea, have life histories and ionoregulatory adaptations that facilitate movement across a salinity gradient (Belli et al., 2009), most groups have distinct lineages of orders and families that are limited to either freshwater or marine environments (Remane, 1971; Berra, 2007). Outside of the physiological tolerance of a species, the toxicity of salts interferes with ionic regulation, osmoregulation, and acid-base balance (Bradley, 2009; Nelson and Cox, 2005).

Because toxicities of ions differ and because the example criteria are derived with data for streams where Ca^{2+} plus Mg^{2+}, and HCO_3^- plus SO_4^{2-} (i.e., not Na^+ and Cl^-) dominate the ionic composition on a mass basis, the case example criteria are not recommended for locations where Cl^- concentrations are greater than the combined concentrations of HCO_3^- plus SO_4^{2-}. However, the XCD method could be used to derive criteria for other ionic mixtures, including locations dominated by Cl^-.

Application of this XCD method relies on the availability of paired chemical and biological samples taken from waters with similar ionic composition (e.g., sulfate- and bicarbonate-dominated). The sites included in the data sets are screened based on ionic composition (e.g., chloride-dominated sites are removed from the data set in the case examples). However, removing them did not appreciably change the results in the case examples because there were so few sites that were chloride dominant.

2.2.1. Sources of Ions

Most fresh waters in the United States exhibit rock dominance (i.e., ion concentrations characteristic of natural weathering of minerals in the catchment) (Gibbs, 1970; Stallard and Edmond, 1987; Anning and Flynn, 2014), and the anion signature of these waters is usually dominated by HCO_3^- plus SO_4^{2-} (Wetzel, 2001; Griffith, 2014). SC tends to be low in mountainous and forested ecoregions (25^{th} centiles of SC ~50–200 µS/cm) and higher in more arid ecoregions (Griffith, 2014; Anning and Flynn, 2014). Nationally, the dominant cation combination is calcium (Ca^{2+}) plus magnesium (Mg^{2+}) and the dominant anions combination is bicarbonate (HCO_3^-) plus sulfate (SO_4^{2-}) (Griffith, 2014). Exposure of soils and geologic formations to weathering is a natural source of ions (Olson and Hawkins, 2012; Hem, 1985; Pond, 2004; U.S. EPA, 2011b). Factors such as rock texture and porosity, regional structural geology, the degree of fissuring (or fracturing), exposure time, and other factors may influence the composition of water flowing over and percolating through rocks (Hem, 1985). Igneous and metamorphic rocks do not increase the ionic concentration of water flowing over them as much as sedimentary rocks because they are generally more resistant to weathering (Anning et al., 2007). Carbonaceous sedimentary rocks, such as limestone ($CaCO_3$) and dolomite ($CaMg[CO_3]$), are sources of Ca^{2+}, HCO_3^- and Mg^{2+}, while other sedimentary rocks such as those containing gypsum ($CaSO_4 \cdot 2H_2O$) and anhydrite ($CaSO_4$) can be natural sources of SO_4^{2-},

particularly in arid regions (Hem, 1985). Sedimentary rocks and salt deposits associated with evaporation, such as ancient sea-beds, may contain high levels of Na^+ and Cl^-. Natural geologic variability among neighboring watersheds may result in differences in ionic concentration of associated streams. The ionic concentration of surface waters may increase naturally due to evapotranspiration, evaporation, or recharge from groundwater with higher ionic concentrations.

Precipitation (e.g., rain or snow melt) can also affect ionic concentration. SC increases during episodes of below-normal surface flow and decreases during periods of above-normal surface flow. Seasonal patterns can vary greatly with regional climate, with low SC associated with spring rain or during summer from snow-melt. Aerial deposition of wet and dry SO_4^{2-} strips soils of Ca^{2+} and Mg^{2+} and thus directly and indirectly increases SC (Krug and Frink, 1983; Kaushal et al., 2013). Near ocean coastlines, rain and dry deposition may contain more Cl^- from entrainment of aerosols from seawater (Griffith, 2014). Pure water has low SC, due to low concentrations of ions in solution. Surface and ground waters have a wide range of SC, from <50 microsiemens per centimeter (µS/cm), where water quality is dominated by rainfall and rocks are resistant to weathering, to over 200,000 µS/cm for brines (Hem, 1985).

Anthropogenic sources of ions can contribute to changes in both the ionic composition and concentration in freshwater resources. Human activities can increase the ionic concentration of natural waters either directly (e.g., by introducing new ions to freshwater systems) or indirectly (e.g., by changing land use to those that increase delivery of ions to freshwater systems and reduce freshwater input and recharge). For example, industrial, residential, and commercial activities may discharge ion-rich waters to surface water. Reservoirs increase evaporation, thus concentrating ions. Ionic concentration in freshwater systems can also increase as the result of discharges of brines and wastes from combustion effluents or mines, and runoff from treating pavements for icy conditions. Mining practices remove overlying vegetation and use explosives to break up underlying rock, leading to increased ionic leaching from mine overburden as well as from oxidation of exposed minerals such as pyrite (Johnson and Johnson, 2015; Bernhardt and Palmer, 2011; Fritz et al., 2010; Lindberg et al., 2011; Merriam et al., 2011; Palmer et al., 2010; Pond, 2010; Pond et al., 2008; Sams and Beer, 2000). Some mining practices deposit loosely packed spoils comprised of crushed rock overburden into valley fills, where both chemical leaching due to rainfall and direct transport of ions bound to particulate or suspended sediments (mechanical weathering) can result in an increase of major ions in receiving waters (Schlesinger,

1997) (see Figure 2-1). Most mines manage water and wastewater to minimize impacts on water quality.

Climate change can also contribute to increased salinity of freshwater from increased evaporation, intrusion through groundwater, and mobilization of geological salt deposits by changes in aquifer charge and recharge with increased rainfall. Global climate change is often linked to sea-level rises and intrusion of saltwater attributed to changes in pressure, expansion of oceans as water temperatures increase, and glacial melting (Werner and Simmons, 2009). Expansion and creation of estuarine tidal channels over time, from both anthropogenic and natural causes, and compaction of plain lands have been found to contribute to saltwater intrusion (Mulrennan and Woodroffe, 1998). Storm surges and flood tides in which water levels exceed normal high tide levels may also contribute to saltwater intrusion (Zhichang et al., 2001).

Saltwater intrusion has been well documented in coastal areas of the United States (Barlow and Reichard, 2010). Saltwater intrusion most commonly occurs as groundwater is removed and seawater infiltrates aquifers, potentially contaminating drinking water supplies and streams via groundwater discharge. Saltwater intrusion into freshwater systems can also be attributed to or exacerbated by road construction projects and culverts (Stewart et al., 2002).

Waters used for irrigation mobilize salts within the soil and may increase the ionic concentration of surface waters near agricultural fields. Agricultural irrigation return waters contain a variety of salt ions based on the water source, natural chemical composition of the soil, and ions associated with nutrient enrichment (NO_3^-, NH_4^+, and PO_4^{3-}). Ions including Na^+, Cl^-, F^-, Mg^{2+}, and SO_4^{2-} have been shown to mobilize in soils in the western United States leading to increased salinity of adjacent waterways and aquifers (El-Ashry et al., 1985; Leland et al., 2001; Scanlon et al., 2009). These processes are influenced by changes in the amount and patterns of rainfall and changes in climate. Elevated salinity is estimated to affect 10% of the world's irrigated lands (Duncan et al., 2008) and may increase as climates become more arid.

Salts are commonly used during periods of snow and freezing weather as a method for deicing roadways. The most common deicing agent is rock salt mainly in the form of sodium chloride (NaCl), though other compounds are available, such as calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), potassium acetate (KCH_3C0_2), or calcium magnesium acetate ($CaMg(CH_3CO_2)_4$) (Novotny et al., 2008; Forman and Alexander, 1998). The use of rock salt on snow and ice covered roads has increased salt usage in the United States from 163,000 metric

tons in 1940 to more than 23,000,000 metric tons in 2005 (Novotny et al., 2008), primarily in the northern states. As snow and ice melt, salt is transported via surface runoff to lakes and streams, or groundwater via recharge and has been found to increase concentrations of ions in surrounding waters (Blasius and Merritt, 2002; Novotny et al., 2008; Godwin et al., 2003). Water quality impacts can be important because of the greater percentages of pavement in urbanized watersheds. Salinity associated with deicing commonly occurs as seasonal pulses, as materials are applied during freezing conditions and are transported into waterways upon melting. However, in some areas, increased salinity attributed to deicing salts may persist in surface waters due to delayed transport of salts stored in soil and groundwater from previous winters (Jackson and Jobbágy, 2005, Kaushal et al., 2005).

Wastewater treatment plants and industrial discharges can contribute ions to freshwater systems and can dominate water quality in streams and rivers dominated by effluent discharge. Wastewater treatment plants have been shown to increase concentrations of Na^+, Cl^-, K^+. Total Kjehldahl nitrogen (TKN), SO_4^{2-}, and SC downstream of the treatment plant discharge (Andersen et al., 2004). Kaushal et al. (2005) found increasing concentrations of chloride in a long-term study of streams. Echols et al. (2009) measured SC below a point source brine discharge, which ranged from 5,900−18,000 µS/cm. Other industries including food processing, petroleum, and leather production also produce saline wastewaters as a byproduct of production (Lefebvre and Moletta, 2006).

Wright et al. (2011) have identified weathering of cement as a source of Ca^{2+} and HCO_3^- in streams draining urban areas. Rose (2007) also found these ions along with others to be elevated in urban subbasins.

Some specific examples of anthropogenic sources of ions illustrated in Figure 2-1 (adapted and updated from Ziegler et al., 2010) and their associated dominant ions are summarized in Table 2-1.

Table 2-1. Examples of ions associated with different anthropogenic sources

Source	Dominant ions	References
Surface coal mining and valley fills associated with mountaintop-removal coal mining	Ca^{2+}, Mg^{2+}, HCO_3^-, SO_4^{2-}	Bryant et al. (2002), Pond et al. (2008), EPA (2011a, b), Griffith et al. (2012)
Runoff and effluents from conventional coal mining and processing	Ca^{2+}, Mg^{2+}, HCO_3^-, SO_4^{2-}	Zielinski et al. (2001), Kennedy et al. (2003), Kimmel and Argent (2010)
Deep coal mining	Na^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}	Thomas (2002), Mayhugh and Ziemkiewicz (2005)
Combustion effluents	Ca^{2+}, Mg^{2+}, HCO_3^-, SO_4^{2-}	Samarina (2007), Ruhl et al. (2012)
Historical industrial sources, such as chlor-alkali plants	Na^+, Cl^-	Echols et al. (2009)
Wastewater treatment plants	Na^+, Cl^-, K^+, TKN, SO_4^{2-}	Paul and Meyer (2001), Andersen et al. (2004)
Sewage and industrial waste discharges	Na^+, Cl^-, NH_4^+, NO_3^-, PO_4^{3-}	Carey and Migliaccio (2009)
Salt water intrusion	Na^+, Cl^-	Barlow and Reichard (2010), Mulrennan and Woodroffe (1998), Barlow (2003)
Produced water from coalbed methane production	Na^+, HCO_3^-, Cl^-	Brinck et al. (2008), Dahm et al. (2011), Jackson and Reddy (2007), National Research Council (2010), Clark et al. (2001), Veil et al. (2004)
Produced water from shale gas production (i.e., hydrofracking)	Na^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-, K^+, SO_4^{2-}, Br^-	Haluszczak et al. (2013), Entrekin et al. (2011), Gregory et al. (2011), Veil et al. (2004)
Produced water from conventional production of crude oil or natural gas	Na^+, Cl^-	Meyer et al. (1985), Boelter et al. (1992), Veil et al. (2004)
Agricultural runoff, particularly associated with irrigation	Na^+, Mg^+, NH_4^+, Cl^-, F^-, SO_4^{2-}, PO_4^{3-} Ions may vary by region.	El-Ashry et al. (1985), Leland et al. (2001), Bernot et al. (2006), Lerotholi et al. (2004), Lenat (1984)
Road deicing treatments	Na^+, Cl^-, Ca^{2+}, Mg^+	Forman and Alexander (1998), Kelly et al. (2008), Environment Canada and Health Canada (2001), Evans and Frick (2001), Kaushal et al. (2005)
Impervious surfaces and weathering of concrete in urban drainage systems	Ca^{2+}, HCO_3^-, Cl^-	Kelting et al. (2012), Steffy et al. (2004) Wright et al. (2011), Rose (2007)
Dry and wet acid deposition	Ca^{2+}, Mg^{2+}, HCO_3^-, SO_4^{2-}	Kaushal et al. (2013)

2.2.2. Conceptual Model

A conceptual model consists of a written description and diagram that illustrates the relationships between human activities, stressors, and ecological effects on assessment endpoints (U.S. EPA, 1998a). The conceptual model links exposure characteristics with the ecological endpoints important for management goals.

The simplified conceptual model shown here (see Figure 2-1) summarizes natural and anthropogenic sources of ionic loadings in the case example study areas, transport pathways, and potential ecological responses, all of which are described in greater detail in the following sections. Sources are affected by processes or states that can result in delivery of a source to a proximate stressor to the aquatic system. Sources deliver stressors, in this case, dissolved ions to streams. The proximate stressor is the physical, chemical, or biological agent that directly causes one or more biotic responses of concern, in this case, an increase in ionic concentration and/or a change in the relative amounts of ions dissolved in the water. The physical biological exposure is the form or route of exposure or uptake, which is generally direct contact with semipermeable membranes such as gills and internal integument. The physiological mechanism is the molecular, cellular, tissue, or organ system alteration that results from exposure to the stressor. These include changes in ionic concentration, pH shifts, and possibly loss of epithelial integrity. The mode of action is the organismal effect that may reduce fitness and survivorship and increase emigration. The assessment endpoint is the adverse population level of effect, in this case, extirpation. Extirpation is the depletion of a population of a species to the point that it is no longer a viable resource or is unlikely to fulfill its function in the ecosystem (U.S. EPA, 2003). The threshold for extirpation is operationally defined by the level below which 95% of the observations of the genus occur, an XC_{95}. For a more general model showing other sources, such as marine intrusion associated with water withdrawal or fires resulting in ash, see the conceptual model for ionic concentration on the CADDIS website (http://www.epa.gov/caddis/ssr_ion4d.html).

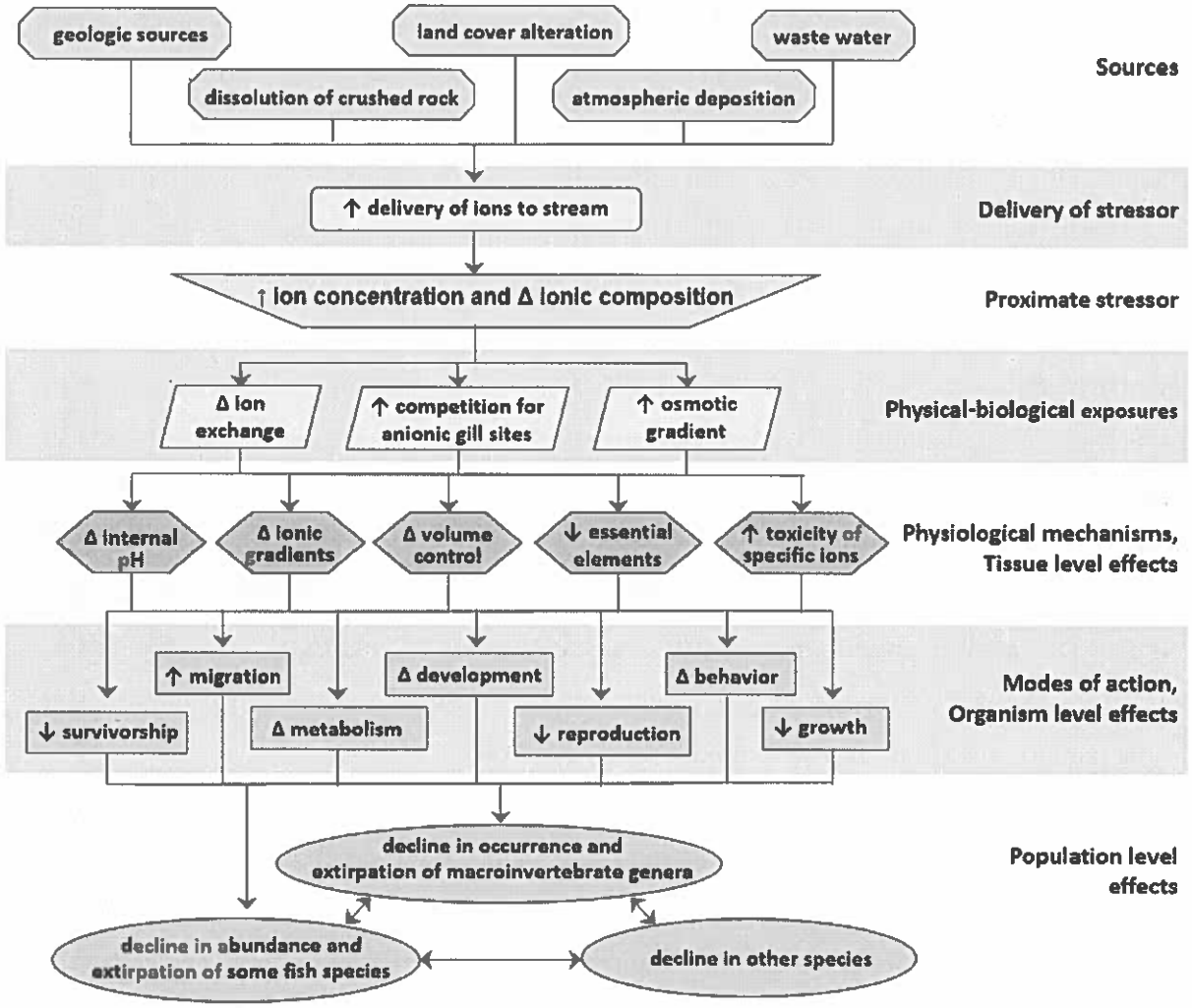


Figure 2-1. Conceptual model showing hypothesized relationships among selected sources of ions and biotic responses to ionic stress by salt intolerant taxa (adapted from Schofield and Ziegler, 2010).
Upward arrows indicate an increase, downward arrows indicate a decrease, and delta symbols indicate a change in the parameter in either direction depending on conditions. Inclusion of a linkage indicates that the linkage can occur, not that it always occurs.

2.2.3. Environmental Transport and Fate of Ions in the Aquatic Environment

The majority of calcium (Ca^{2+}) and magnesium (Mg^{2+}) found in most soils and surface water originates from chemical weathering of common minerals in rock or soils, such as limestones ($CaCO_3$) and dolomites ($CaMg(CO_3)_2$) (e.g., Goddard et al., 2007). Minerals rich in calcite, e.g., apatite ($Ca_5(PO_4)_3(F,Cl,OH)$), can be found in igneous, sedimentary, and

metamorphic rocks (e.g., Nezat et al., 2008). In many areas, these calcium and magnesium rich rocks are relatively easily weathered and soluble, with their mobility strongly affected by pH, becoming more mobile with decreasing pH (Likens et al., 1998). In forested catchments, the calcium and magnesium concentrations in surface waters can increase following disturbances, such as deforestation (Likens et al., 1970), and decrease in late successional forest stands relative to early successional forest stands (Hamburg et al., 2003). In general, anions (negatively charged ions) are more mobile than cations (positively charged ions) because they are not bound to negative binding sites on clays. Bicarbonate (HCO_3^-) ions in most soils and groundwater result from chemical weathering of calcareous minerals. Bicarbonate ions are also present in soils as a byproduct of plant and microbial respiration, as well as from the oxidation of organic matter whereby carbon dioxide released in the soil becomes hydrated to form carbonic acid (H_2CO_3) and is then dissociated into bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}), depending on the local soil pH. The relative concentration of HCO_3^- compared to H_2CO_3 and CO_3^{2-} is pH dependent, with HCO_3^- being the dominant form at circumneutral pH. HCO_3^- is readily leached from soils during rainfall. Alkalinity is a measure of HCO_3^- and CO_3^{2-}.

Sulfate (SO_4^{2-}) ions found in soil and rocks can result from chemical weathering of sulfate minerals, such as gypsum (Mullins and Hansen, 2006) or from chemical weathering of coal deposits (Schlesinger, 1997). Atmospheric deposition can also be a source of sulfate found in soils and is primarily anthropogenic in origin from the burning of fossil fuels (Schlesinger, 1997). Sulfate is readily leachable in soils, and sulfate mobility was found to be positively correlated with rainfall in relatively undisturbed forested watersheds in both Central Pennsylvania (Lynch and Corbett, 1989) and the Georgia Piedmont (Huntington et al., 1994). In the Allegheny River Basin in southwestern Pennsylvania, sulfate concentrations in surface waters draining relatively undisturbed watersheds ranged from 16–20 mg/L (Sams and Beer, 2000).

In addition to runoff, ions can be transported to surface waters through groundwater discharge. Major ions can enter groundwater through dissolution of minerals in soils and rocks during recharge. Particularly during periods of low streamflow, groundwater discharge can be a major contributor of ions to surface waters (Larson and Marti, 1996).

Once mobilized, the majority of major ions that contribute to SC behave conservatively in aquatic systems and are transported in surface water and groundwater to receiving waters.

Although the ions that are the focus of these field-based methods are essential elements for living organisms (within specific ranges), biological uptake does not effectively reduce ionic concentrations in streams (U.S. EPA, 2011b). In addition, Ca^{2+}, Mg^{2+}, SO_4^{2-}, Na^+, and K^+ are not significantly degraded nor adsorbed (U.S. EPA, 2011b). As a consequence, concentrations of the transported major ions tend to increase in receiving waters unless diuted by precipitation or inflow from tributaries with lower ionic concentrations (Johnson et al., 2010; Merriam et al., 2011). An exception is bicarbonate ions, which can be taken up by photosynthetic plants. Geologically bound carbonates (HCO_3^-) are also released into the atmosphere. Vesper et al. (2016) reported a total flux of dissolved organic carbon from two sites near a coal mine that ranged from 13 to 249 kg-C/year (18–364 metric tons of CO_2/year).

2.3. MEASURE OF EXPOSURE

The concentration of a dissolved salt mixture can be measured in a number of ways: as SC, total dissolved solids (TDS), freezing point depression (also referred to as osmotic pressure or osmolarity), refractive index, density, or the sum of the concentrations of individually measured ions. A comparison of the capabilities of these different measurement methods is shown in Table 2-2. The EPA has selected SC as the parameter to represent the measure of exposure for this stressor. SC was selected as the measure of the ionic mixture for these field-based methods because (1) SC is a measure of all ions in the mixture; (2) the measurement technology is fast, inexpensive, accurate, and precise; (3) it measures only dissolved ions; (4) it can be used to provide continuous monitoring records with in situ instrumentation; (5) it is a sensitive measure in dilute waters; (6) it is less influenced by other nonfilterable material such as oils and carbohydrates that may be dissolved in water compared to some measurement methods (e.g., TDS); and (7) it is monitored by most state water monitoring programs at bioassessment sampling sites. Several approved methods for measuring SC are available, including EPA method 120.1 (U.S. EPA, 1982 revised).

SC has been commonly used as a measure of ionic concentration, and as an estimate of major solute concentrations and total dissolved solids concentrations of natural waters (McCleskey, 2011; Ziegler et al., 2010). SC is a measure of a material's ability to conduct electric current, including natural waters, and is typically expressed in units of microsiemens per centimeter (µS/cm).

Table 2-2. Comparison of methods to measure ionic concentration

Measurement method	All ions?	Speed	Approximate sample range and sample volume	Sample filtration required	Field use	Continuous measure possible	Affected by nonionic constituents
Specific conductivity	Yes	Seconds	Wide range, µL–mL, volume or in situ	No	Yes	Yes	No
Total dissolved solids (gravimetric)	Yes	Days	Requires larger volumes for freshwater	At times	No	No	Yes
Freezing point depression	Yes	Minutes	Wide range, few µL to mL volumes	At times	No	No	Yes
Refractometry	Yes	Minutes	Better suited for higher salinities, µL volumes	At times	Yes	Industrial application	Yes
Densitometry	Yes	Minutes	Better suited for higher salinities, dl volumes	No	Yes	No	Yes
Sum of ion concentrations	Typically major ions only; e.g., Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-}, and HCO_3^{-}	Hours to days	Variable depending on analytical methods	Yes	No	No	No

Because SC predictably increases with increasing ionic concentration, it is used to measure salinity (usually referring to NaCl) or ionic concentration (for any dissolved salts) (Standard Methods #2510 [APHA, 1992]; EPA method 120.1, 0950A [U.S. EPA, 1982]). SC measurements in natural waters indicate the presence of inorganic dissolved solids (e.g., chloride, nitrate, sulfate, bicarbonate, nitrite/nitrate, and phosphate anions and sodium, potassium, magnesium, calcium and iron cations). Electrical currents are carried by both positively charged cations and negatively charged anions—but to differing degrees depending on charge and mobility. Thus, the SC of a mixture depends on the type and concentration of the

ions in solution. SC is also dependent on temperature and is known to increase approximately 2% for every 1°C increase in water temperature. The term "Specific Conductivity" indicates the measurement has been standardized to 25°C, a reference temperature (Wetzel, 2001). SC is commonly reported in state monitoring programs, rather than the unstandardized conductivity measurement.

Both specific conductivity and specific conductance are often used synonymously in the open literature indicating normalization or measurement at 25°C. Conductivity is a property of water expressed as µS/cm. Conductance of a sample or electrical component is measured as Siemens (S). All measurements in this document refer to specific conductivity/specific conductance expressed as µS/cm at 25°C as it relates to water samples.

SC is an aggregate measurement of the full ionic mixture of a water sample. The total ionic concentration of natural waters is associated with biological effects. However, waters with similar SC levels may have different ionic compositions, and as a result can have different toxicities to freshwater organisms in the laboratory and in the field (Mount et al., 2016; Zalizniak et al., 2006; Dunlop et al., 2015). Therefore, when using SC as a measure of ionic concentration, it is important to characterize the specific ions and their relative concentrations.

Some states and authorized tribes may want to use an alternative measurement of ionic concentration when developing aquatic life criteria. If a different measure of the ionic mixture is selected as the measure of exposure, the reliability of the measurement should be considered. For example, TDS has greater variability than other methods. If some states and tribes prefer to measure specific ions known to be toxic to aquatic organisms, the interaction of ions within the mixture also needs to be considered. Appendix F provides an example using an alternative measure of exposure for waters dominated by Ca^{2+} and Mg^{2+}, the sum of HCO_3^- and SO_4^{2-} in mg/L.

2.4. NATURE OF THE EFFECT

All tolerances of stressors are determined by the evolutionary adaptations of organisms. The background levels of naturally occurring habitat variables such as temperature, pH, and SC are important determinants of those adaptations. Because aquatic species evolved in unpolluted waters, background levels define aspects of the niche to which the biota of a community is naturally adapted and which it potentially tolerates (MacArthur and Levins, 1967; Colwell and

Rangel, 2009; Peterson et al., 2011; Futuyma and Moreno, 1988; Wiens, 2004). Aquatic species inhabit nearly pure water, estuarine and marine conditions, hypersaline pools, and everything in between (Remane, 1971, Potapova and Charles, 2003; Potapova, 2005; Berra, 2007). In most of the United States, freshwater habitats have very low concentrations of dissolved ions relative to marine systems, so that is the condition to which most freshwater biota are adapted.

Algae, protozoans, zooplankton, and bacteria have all been shown to have SC preferences in freshwater systems (Potapova and Charles, 2003; Potapova, 2014; Bos et al., 1996). Nationally, of 230 soft-bodied algae identified to the lowest practical taxonomic level, 56% had estimated optima <500 µS/cm (Potapova, 2014). Nationally, of 683 diatoms also identified to the lowest practical taxonomic level, 84% had optima <500 µS/cm and 35% did not occur in water >500 µS/cm (Potapova, 2014).

Freshwater benthic macroinvertebrates are extirpated at different ionic concentrations (U.S. EPA, 2011a). In West Virginia, 17% of genera that occur at background SC are extirpated at 500 µS/cm and many more genera decline at that SC (Cormier et al., 2013b). Effects are not limited to Appalachia. In Nevada streams, differences between observed and expected invertebrate communities increased above natural background levels of approximately 300 µS/cm (Vander Laan et al., 2013). Freshwater fish also decline and are extirpated as ionic concentration increases (see Appendix G). Although these data are from waterbodies with a wide range of background SC values, they demonstrate that many species and genera are adapted to particular SC regimes, and many of them are quite low.

The physiological limits of species determine their tolerance ranges, in this case, their potential SC niche with respect to concentrations of a defined ionic mixture (Olson, 2012; Vander Laan et al., 2013). At the extremes of their physiological tolerance, species are less able to develop, grow, and reproduce. A species may not exploit its full tolerance range, because competitor species are better suited for a particular ionic concentration or for other ecological reasons such as predation, parasitism, and habitat requirements. The SC range that is actually inhabited by a species is called a realized niche.

The range of SC conditions varies in natural aquatic systems. Species do not occur where the SC is lower or higher than their SC tolerance. The lowest SC in a freshwater system, therefore, is the lowest possible limit of the potential SC niche (see lower tolerance limit in Figure 2-2). When mineral salts are added to an aquatic system, SC increases, part of the

potentially habitable SC niche space is lost, and the size of the realized niche for species adapted to low SC decreases. When the SC is above the physiological tolerance of a species due to natural or anthropogenic causes, it does not persist and the species is extirpated.

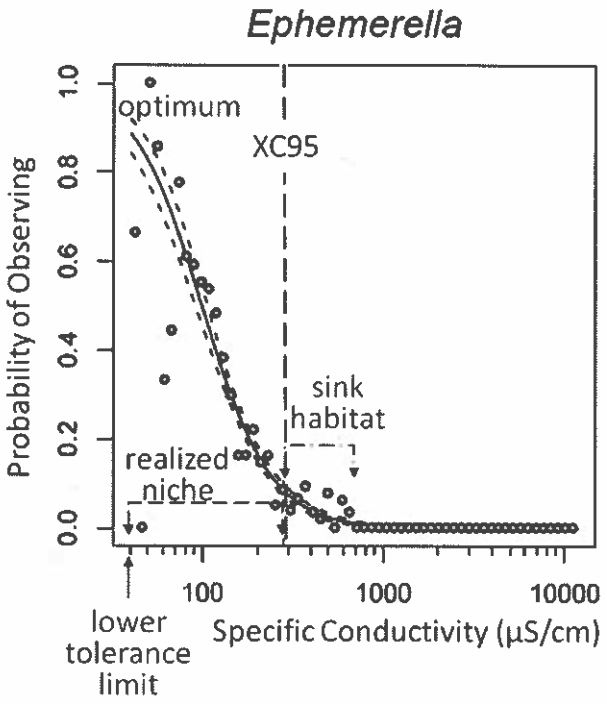


Figure 2-2. A species' (or genus') realized niche is defined by its lower and upper limits of occurrence. In this case, the lower tolerance limit is less than or equal to the lowest specific conductivity (SC), which is the lower limit of occurrence. The XC_{95} represents the upper tolerance limit. Approximately 5% of observations of a taxon are assumed to occur in sink habitats where a population cannot persist without immigration from source habitats. A species or genus optimum is the environmental condition most easily tolerated both physiologically and competitively and can be estimated by the conditions where the taxon is most often observed. The optimum SC may be estimated at the maximum probability of observing the taxon from a generalized additive model, shown here to be the minimum SC. The example involves the genus *Ephemerella* which is comprised of several species of mayflies.

The upper tolerance limit of a species is estimated by its XC_{95} (see Figure 2-2). Extirpation is the depletion of a population of a species to the point that it is no longer a viable resource or is unlikely to fulfill its function in the ecosystem (U.S. EPA, 2003). The occurrences of benthic invertebrate species at locations with a SC greater than their XC_{95} value are believed

to represent sink habitats (Pond et al., 2014). Sink habitats are those locations where occurrence of species is primarily the result of immigration from locations with low SC termed source habitats from which immigrants originate. They are "sinks" in the sense that immigrants have low success in establishing sustainable populations in those locations.

These phenomena have practical application. The proportion of species or genera extirpated as a result of increased SC in an ecoregion can be determined and is the basis for the XCD method.

Several other predictions can be made from niche theory. Species with niches that limit them to low SC water are not expected to occur where low SC water does not occur. The source of high SC could be natural or due to anthropogenic inputs (Cormier et al., 2012, Coffey et al., 2014). For example, in an ecoregion lacking streams <400 µS/cm, any species with an upper tolerance limit <400 µS/cm SC would not be expected to occur because there is no habitat for them. As a corollary, where there is a low SC habitat in an ecoregion, species tolerant to low SC will occur.

The relationship between ambient SC levels and SC tolerances of species that are present has at least two practical implications. First, it is inappropriate to set criteria below natural background for a location. Second, the lower limit for any XCD in any given ecoregion cannot be lower than the natural background of the ecoregion. In practical terms, this shifts the origins of XCDs and their 5th centiles toward higher SC (graphically to the right) as the background SC increases. Hence, when XCDs from regions of low to high natural background are simultaneously plotted on the same graph, the curves progress to the right. (For an example, see the XCDs in Appendix D, Figure D-3). Therefore, the background SC of an ecoregion is strongly associated with a predictable extirpation of 5% of species or genera. This relationship between background SC and the proportion of extirpation can be used to predict the SC that will extirpate 5% of species or genera in an ecoregion solely based on ecoregional background (see Section 3.7.2 and Appendix D, Figure D-4).

2.5. MECHANISMS AND MODES OF ACTION

The measure of effect for these field-based methods is extirpation (U.S. EPA, 2011a). The three most likely modes of action for extirpation of a genus or species are the population-level processes mortality, emigration, and failure to recruit (Rubach et al., 2011; Williams and Hynes,

1976; Clements and Kotalik 2016). The sections below discuss some physiological mechanisms of action through which SC acts on organisms and on the processes that constitute the potential modes of action.

2.5.1. Physiological Mechanisms

In exposures to elevated ionic concentrations, physiological stress could cause mortality or drift (a process in which invertebrates emigrate by releasing the substrate and allowing themselves to be carried downstream). The stress occurs because the freshwater organisms cannot maintain or need to use more energy to maintain their internal ionic concentration and pH with altered ionic composition and concentration, and water volume in waters with very high ionic concentration. The mechanism of action is believed to be due to adverse ionic gradients formed by the concentration and relative proportions of ions. For all freshwater organisms, microbes, plants and animals alike, ionic concentration is higher inside an organism than in freshwater. To concentrate and maintain the internal ion concentration, organisms have evolved many interrelated strategies. One cannot describe the specific action of toxicity of one ion or pH without considering all the others (Zhang and Wakamatsu, 2002 Griffith, 2016; Bradley, 2009; Evans, 2008a, b; Wood and Shuttleworth, 2008; Nelson and Cox, 2005; Marshall, 2002; Hille, 2001; Smith, 2001; Thorp and Covich, 2001; Komnick, 1977; Sutcliffe, 1962). For example, Na^+ and Cl^- concentrations are much higher inside organisms than in freshwater. One mechanism used by invertebrates and fish to concentrate Cl^-, an anion with a negative charge, is to exchange Cl^- for a nonmineral anion waste product (CO_2) that is produced during metabolism of sugar. An enzyme, carbonic anhydrase, rapidly and reversibly catalyzes water and CO_2 to HCO_3^- and H^+. HCO_3^- concentrations are higher inside the organism and lower in the water. This concentration gradient is favorable for the exchange of Cl^-. However, a cation also needs to be removed from the organism or else H^+ will accumulate and cause acidosis. Acidosis causes complex cellular reactions and affects function of cellular organelles that lead to many adverse effects including death (Gesser and Poupa, 1983; Vafai and Mootha, 2012). Freshwater animals exploit this increased concentration of H^+ by exchanging it for another cation, such as Na^+. Thus, Na^+ and Cl^- are concentrated inside organisms relative to freshwater. However, when the HCO_3^- concentration in freshwater is high, the concentration gradient does not favor movement of HCO_3^- out of the organism and other ions are not readily brought into the organism. Because

this anion-cation exchange mechanism uses waste CO_2, it requires less energy to maintain. Low-energy regulation of ions that depend on favorable HCO_3^- concentrations can be supplemented by adenosine triphosphate-dependent transport of ions as ion concentrations increase outside the organism and concentration gradients become less favorable for passive or low energy transport. The inability to regulate internal ionic concentrations or the greater energy demand for ion regulation may causes stress resulting in death, drift, reduced growth, or reduced reproduction, but definitive cellular studies for most aquatic organisms are lacking.

Organisms use many strategies to minimize loss of ions and the exclusion of water (see references in previous paragraph). At the interface between water and the organism's surface, epithelial tissue integrity is essential. Cell membranes are a barrier to water because they are hydrophobic bilayers of lipids. The membranes are selective for the ions and direction of movement using proteinaceous ion channels, ports, and carriers (for a review see Griffith, 2016). Between the cells making up the epithelial pavement, ultrastructural features called tight junctions hold adjacent cells together and complete the epithelial barrier restricting water and ion movement into or out of the organism. External Ca^{2+} helps maintain tight junctions (Gonzales and McDonald, 1992; Smith et al., 2005; Brown and Davis, 2002). There is some evidence from human studies of the gut that SO_4^{2-} may interfere with tight junctions causing loss of epithelial integrity but the physiological interactions of SO_4^{2-} have not been well studied in freshwater organisms. Note that ion concentrations in freshwater are always less than inside the animal and do not cause loss of water from the animal. Rather, loss of epithelial integrity can lead to excess water or loss of ions. This is a key difference between marine and freshwater organisms.

In summary, the full complement of anions and cations, including others not described here, need to be maintained by organisms. There is an extensive literature on ionoregulation of cations and anions. The higher concentration of ions inside organisms compared to freshwater provides opportunities to use ionic gradients for ionoregulation. Acid-base regulation is linked to the production of hydrogen ions involved in ionoregulation. Because useful gradients are dependent on low concentrations of ions in freshwater, relative amounts of each ion, not necessarily any individual ion, accounts for toxic effect.

2.5.2. Mortality, Growth, and Reproduction

Death of juvenile aquatic invertebrates exposed to different ionic concentrations has been demonstrated in the laboratory (Echols et al., 2010; Kennedy et al., 2003, 2004, 2005; Lasier and Hardin, 2010; Merricks et al., 2007; Mount et al., 1997; Wang et al., 2013, Kunz et al., 2013, Bringolf et al., 2007). Sublethal effects reported from laboratory studies include reduced growth, reproduction (Johnson et al., 2015), early emergence (Nietch et al., 2014), and premature release of unionid glochidia (Gillis, 2011). When death of an entire population occurs, the area remains depopulated until recolonized by aerial dispersion and egg-laying (oviposition) (Smith et al., 2009) or by organisms floating downstream (drift) from refugia at upstream reaches or tributaries to the depopulated stream reach (Williams and Hynes, 1976; Pond et al., 2014).

2.5.3. Emigration

Emigration occurs when organisms vacate a stressful environment after being challenged with a noxious stimulus or lack of food or other resources. In numerous studies, benthic invertebrate drift is induced within minutes of exposures to a range of stressors in natural and artificial streams (Svendsen et al., 2004; Wood and Dykes, 2002). Stress induced drift and avoidance behaviors have been shown to occur with salts, toxic chemical spills, floods, pesticides, drought, sediment, low dissolved oxygen (DO), heat, and organic pollution (Wood and Dykes, 2002; Svendsen et al., 2004; Crossland et al., 1991; Doeg and Millage, 1991; Wallace, 1990; Brittain and Eikeland, 1988; Sheehan and Winner, 1984; Geckler et al., 1976; Waters, 1966, 1972, 1995). In independent studies, colonized substrates were exposed to continuous flowing treatments of ionic mixtures (Clements et al., 2014, 2016; Nietch et al., 2014). The studies showed increased drift, reduced numbers of taxa, and other effects. Drift is more likely to occur when there is an abrupt change in environmental conditions rather than a slow change that allows organisms to physiologically adapt. For example, after a moderate increase in ionic concentration, some aquatic insects synthesize more ionic channels for ionic regulation (Wichard et al., 1973; Sutcliffe, 1974; Komnick, 1977).

2.5.4. Failure to Recr'uit

Development begins with gamete production. Fertilization during the terrestrial phase of the life cycle occurs internally in most aquatic insects and is unlikely to be affected by aqueous

ions. At oviposition, contact with freshwater causes the swelling and formation of an extrachorionic coating that is necessary for adherence of the eggs of some invertebrates to substrates in the stream (Percivale and Whitehead, 1928). Eggs oviposited into water with higher specific SC do not form the adhesive coating (Percivale and Whitehead, 1928) and the eggs are washed downstream and presumably perish (Gaino and Bongiovanni, 1992). Ionic gradients that initiate biological changes are also necessary to permit propagation of a fertilization potential over the surface of some eggs and to allow successful embryonic development and hatching in some species such as fish (Jaffe, 1991; Coward et al., 2002). Similarly, toxicity tests with fathead minnow larvae were more sensitive during the transitional period from embryo development to hatching (Wang et al., 2016a). Mesocosm experiments with mayflies also indicated greater vulnerability during early life stages and during emergence to winged adults (Clements and Kotalick, 2016; Nietch et al., 2014).

2.5.5. Community Interactions

Increased competition, predatation, or parasitism have been suggested as possible modes of action leading to loss of some species and an increase in salt-tolerant taxa where ions are elevated (Olson, 2012; Olson and Hawkins, 2012; Micieli et al., 2012; Wood-Eggenschwiler and Barlocher, 1983). These processes may affect the benthic invertebrate communities that form at different ionic concentrations.

2.6. ASSESSMENT ENDPOINTS AND MEASURES OF EFFECT

2.6.1. Assessment Endpoints

Assessment endpoints represent the actual environmental value to be protected. They are defined by an ecological entity (e.g., species, community, or other entity) and attributes, (e.g., survival, growth, and reproduction) (U.S. EPA, 1998a). In the development of water quality criteria for SC, the entities are aquatic biotic communities and the attribute is protection of all but a small fraction of species from extirpation.

The relevant ecological entities for these field-based methods are macroinvertebrate assemblages, which are characterized by their taxonomic composition at the genus level. Macroinvertebrates were selected because they are susceptible to ionic stress, they are important to stream function and ecosystem integrity, they provide numerous ecosystem services that

benefit humans, they can be found in all types of streams, and they are intrinsically valuable aquatic life forms (Suter and Cormier, 2015). Furthermore, because macroinvertebrates constitute the great majority of multicellular species in streams and have a wide range of sensitivities, they are excellent indicators of adverse effects on ecological processes and on the larger aquatic community. For these reasons, all states and many tribes monitor aquatic macroinvertebrates to assess the health of the aquatic community (U.S. EPA, 2002).

The most commonly recognized contribution of aquatic macroinvertebrates is that they are food for larger invertebrates and fish and other vertebrates, including recreationally important fish species (Allan, 1981; Richardson, 1993; Sweka and Harman, 2008; Hitt and Chambers, 2014), amphibians (Burton, 1976; Wallace et al., 1997), insectivorous bird species (Nakano and Murakami, 2001; Gray, 1993; Epanchin et al., 2010), bats (Clare et al., 2011), and mammals. However, the overall function of freshwater aquatic ecosystems is also dependent on macroinvertebrates (Hooper et al., 2005; Cardinale, 2011). Macroinvertebrates improve water quality through forest and stream nutrient retention (Newbold et al., 1983, 1982; Wallace and Webster, 1996; Huryn and Wallace, 2000; Evans-White et al., 2005), aid in leaf litter decomposition (Wallace and Webster, 1996), and remove pathogens and nuisance periphyton blooms by filtering and grazing (Wallace and Merrit, 1980; Yasuno et al., 1982; Hall et al., 1996). Because macroinvertebrates provide many ecosystem services, it is well understood that stream macroinvertebrate diversity and abundance are important indicators of overall stream condition (Carter et al., 2006; Resh, 1995), and many stream monitoring programs and stream condition indices rely on macroinvertebrate sampling metrics (Gerritsen et al., 2000; Pond et al., 2008; U.S. EPA, 2002).

These field-based methods can be used to develop ecoregional criteria that are fully protective of aquatic life. Many freshwater insects are among the most salt-intolerant organisms relative to other taxa, including crustaceans such as crayfish and daphnids, fish, and amphibians (compare Appendices A.4 and B.4 with Appendix G of this report). Recent studies suggest that mussels in the family Unionidae are acutely salt-intolerant (Kunz et al., 2013; Wang et al., 2016a, b), particularly during early (glochidia and juvenile) life stages (Bringolf et al., 2007; Gillis, 2011; Wang et al., 2016a, b).

Fish also are adversely affected by ionic stress (see Appendix G, Stauffer and Ferreri, 2002; Kimmel and Argent, 2010; Mount et al., 1997; Kennedy et al., 2005, 2004, 2003; Harper

et al., 2012; Farag and Harper, 2012, Hopkins and Rousch, 2013, Hitt and Chambers, 2014). EPA's assessment of fish in Appendix G indicates that they are sensitive to ionic stress but are extirpated at slightly higher SC levels than macroinvertebrates. Therefore, fish are expected to be protected by criteria based on macroinvertebrate data. More complex organisms (e.g., fish) generally have a greater ability to regulate internal ionic concentrations and water volumes than simpler organisms, such as benthic invertebrates (Dunlop et al., 2005). Fish also have greater mobility and may be able to more readily migrate from high SC sites to more habitable areas (e.g., Goldstein et al., 1999; Woodward et al., 1997, 1995).

In sum, macroinvertebrates are a critical component of ecological integrity, provide numerous ecosystem services, and appear to be a salt-intolerant ecological taxonomic group; therefore, they are used as an assessment endpoint for these field-based methods.

2.6.2. Measures of Effect

The measures of effect for these field-based methods have been selected to be consistent with the intent of the conventional laboratory-based method for developing aquatic life criteria (U.S. EPA, 1985). Two relationships are derived from the paired SC and macroinvertebrate field data: one for each macroinvertebrate genus and one for the overall macroinvertebrate community in the study area. First, a cumulative distribution function (CDF) is developed for each genus[2] to determine its genus XC_{95}, the SC level above which a genus is effectively absent from water bodies in a region (U.S. EPA, 2003). It is defined in this method as the 95th centile of the distribution of occurrences of a macroinvertebrate genus. In other words, the probability of observing a genus above its XC_{95} SC value is 0.05; i.e., if a genus is observed at 100 sites, only 5 sites would be expected to have SC above the XC_{95}. XC_{95} values that are uncertain or unmeasured within the exposure range are noted and generally do not influence the hazardous concentration (HC_{05}) because their estimated XC_{95} values are greater than those genera in the 5th centile. Second, the HC_{05} is developed using a genus-level XCD for the macroinvertebrate community from the aggregation of the XC_{95} values.

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[2]Conventionally, species have been aggregated to the genus level. However, effect levels may be different for species within a genus due to niche partitioning afforded by naturally occurring causal agents such as dissolved ions. (Remane, 1971; Suter, 2007). Hence, an apparently salt-tolerant genus may contain both salt-intolerant species and tolerant species. Analyses with fish species indicate that the range of XC_{95} values within a genus can be quite broad and the empirical genus-level XC_{95} tends to represent the maximum XC_{95} of the species in the data set (see Appendix G).

One key difference from laboratory-based methods used to develop aquatic life criteria for chronic exposures is the measure of effect. In the XCD method, the measure of effect is genus extirpation (population-level) rather than an effect at the organism level. In the laboratory-based method, the measures of effect represent survival, growth, or reproduction (U.S. EPA, 1985). Because the example ecoregional criteria are based on field data for a large number of macroinvertebrate genera across many sites across a broad SC gradient, the EPA anticipates that a reasonable level of protection of the overall aquatic community will be provided if all except a small fraction (i.e., 5%) of sampled macroinvertebrate genera from the region are protected. In their review of the *EPA Benchmark Report*, the EPA SAB stated that this approach provides a degree of protection comparable to or more protective than a conventional water quality criteria based on conventional chronic toxicity testing (U.S. EPA, 2011c).

The genus-level XCD used in the XCD method represents the response of genera in biotic communities in general to a stressor (e.g., an ionic mixture dominated by sulfate plus bicarbonate). XCDs do not require that the species or genera be the same in all applications or at all locations (Posthuma et al., 2001; Cormier and Suter, 2013a; Cormier et al., 2013a). Similarly, the genera that form the minimum data set for laboratory-based aquatic life criteria are not intended to match any particular community; rather, they are surrogate taxa that represent any potentially exposed freshwater community (U.S. EPA, 1985). In the same way, the distribution of genera in the XCDs used in the XCD method (e.g., see Section 4.2) represent all stream communities from a similar background ionic concentration exposed to a similar ionic mixture. All of the macroinvertebrate taxa used to develop an XCD may not occur at any one site in an ecoregion.

Because this approach relies directly on paired observations of in situ measurements of SC and benthic invertebrate assemblage information, the potential adverse effects of ionic stress on all life stages is considered in the context of other complex relationships (e.g., food web dynamics) and aquatic ecosystem processes. The measures of effect (i.e., XC_{95} and HC_{05}; see Sections 3.1.2 and 3.1.3) are considered chronic-duration endpoints because the field data reflect exposures over whole life cycles and multiple generations of the resident biota (see Table 2-3). A field-based method to directly develop acute criteria for SC is not yet available due to a lack of field data with sufficiently high temporal resolution (e.g., daily measurements of SC paired with

macroinvertebrate sampling for at least 1 year). However, these field-based methods include a method that uses within-site variability of SC levels to derive a criterion maximum exposure concentration (CMEC) that will protect aquatic life from acutely toxic exposures (see Section 3.2). The CMEC differs from a criterion maximum concentration (U.S. EPA, 1985) because it is not calculated using laboratory or field data showing a direct relationship between SC and an acutely toxic biological response. However, the protectiveness of the CMEC was corroborated with field biological and SC data in Case Examples I and II (see Appendices A and B).

Table 2-3. Summary of assessment endpoints and measures of effect used in this field-based method to derive a criterion continuous concentration (CCC) and criterion maximum exposure concentration (CMEC) for specific conductivity

Stressor of concern	Measure of exposure
Mixture of ions (e.g., $([HCO_3^-] + [SO_4^{2-}]) > [Cl^-]$	Specific conductivity
Assessment endpoints for the aquatic community	**Measures of effect**
Occurrence of macroinvertebrate populations	Chronic XC_{95} (genus-level effect) Chronic HC_{05} (assemblage-level effect)

XC_{95} = Extirpation concentration, the SC value below which 95% of the observations of a genus occur.

To summarize, for these field-based methods, the valued resource is the aquatic community, characterized by the macroinvertebrate populations that occur at a site. The ecological entities defining the assessment endpoints are populations of macroinvertebrates (aggregated to genera) and the measure of effect is extirpation (the desired attribute is occurrence). Macroinvertebrate populations are appropriate assessment entities because they occur in all but the poorest-quality streams, they are important to ecosystem structure and function, they are highly diverse, they are common forms of aquatic life, and they are affected by many different agents including ionic stress. Extirpation is the depletion of a population of a species or genus to the point that it is no longer a viable resource or is unlikely to fulfill its function in an assessed ecosystem. Extirpation of genera is an appropriate attribute for these methods that rely upon analyses of field data to determine population-level effect thresholds. Aquatic life criteria developed using these field-based methods are set at a SC level that protects

95% of resident macroinvertebrate genera that occur at reference sites in the relevant ecoregion. Aquatic communities are expected to be resilient to these effects and support the overall integrity and function of the aquatic ecosystem if the derived ecoregional criteria (magnitude, duration and frequency) are not exceeded.

2.7. SELECTION OF A FIELD-BASED METHOD

The EPA typically relies on laboratory toxicity test data for the development of aquatic life criteria (U.S. EPA, 1985). To the extent laboratory toxicity tests have been performed on similarly mixed proportions of these major ions, these tests with commonly tested laboratory species have not indicated sensitivity at the concentrations associated with loss of macroinvertebrate genera in the field (U.S. EPA, 2011a). Although it is impractical to replicate in the laboratory the range of taxa, conditions, effects, or interactions that occur in natural streams, a number of recent toxicity studies have begun to bridge the gap between physiological studies and field observations (Mount et al., 2016; Erickson et al., 2016; Wang et al., 2016a; Kunz et al. 2013). Also, mesoscosm studies have begun to identify the modes of action that likely lead to extirpation in the field and corroborate effects observed in the field (Clements and Kotalik, 2016; Nietch et al., 2014).

Analyses of field data show the reduced presence of many benthic macroinvertebrate genera at increasing SC levels. The associations between SC and benthic macroinvertebrate occurrence observed in the field have been assessed as causal (e.g., see Section 2.2 of this document; [e.g., Gerritsen et al., 2010; Palmer et al., 2010; Lindberg et al., 2011; Merriam et al., 2011; Pond et al., 2010, 2008; U.S. EPA, 2011a, b; Bernhardt et al., 2012; Cormier et al., 2013b, c; Timpano et al., 2014; Dunlop et al., 2015; Zhao et al., 2016]). Furthermore, the field data used in this analysis represent exposures to regionally representative assemblages of taxa and life stages at levels and proportions of ions under realistic physical and chemical conditions. In this case, field data can be used to directly assess ecologically-relevant measures of effects, such as extirpation of genera in aquatic communities as a result of exposure to these ionic mixtures in the field. Protection of a diverse assemblage of benthic macroinvertebrates is protective of stream communities and aquatic life.

For these reasons, the EPA concluded that a field-based approach is appropriate for developing SC criteria where there are sufficient data for analysis.

3. ANALYSIS PLAN: FIELD-BASED METHODS TO DEVELOP SPECIFIC CONDUCTIVITY CRITERIA

This section presents field-based methods that may be used to derive SC water quality criteria for the protection of aquatic life where sufficient data are available. The methods describe how to derive a criterion continuous concentration (CCC) to protect against effects from chronic exposure (see Section 3.1) and a CMEC to protect against effects from acute exposure (see Section 3.2). The methods also describe how to estimate duration (see Section 3.3) and frequency (see Section 3.4), how to assess causation (see Section 3.5), and how to determine the applicable geographic range of criteria (see Section 3.6). Because the primary method (the XCD method) requires large, paired chemical and biological data sets which are not available for all ecoregions in the United States, EPA developed another method which uses a model to calculate a CCC for SC. This method is useful for Level III ecoregions where sufficient paired biological data are lacking (see Section 3.7). Section 3 serves as the *Analysis Plan* for the case studies in Sections 4, 5, 6 and 7. Some ecoregion-specific examples are included in this section to illustrate key concepts and methods.

3.1. DERIVING A CRITERION CONTINUOUS CONCENTRATION (CCC)

The XCD method requires a field data set with paired in situ measurements of SC and benthic macroinvertebrate survey results for streams in the study area. The field SC measurements allow for the development of exposure-response relationships across a SC gradient. The inclusion of high quality and impaired sites in the data sets assures a range of SC (exposure) for characterizing changes in taxa occurrence (response). In aggregate, the in situ field measurements of SC from many sites from different times of the year represent the variability over a year.

Using this method, two relationships are derived from the field data: one for each macroinvertebrate genus and one for the overall macroinvertebrate assemblage in the study area. First, a weighted CDF is developed for each macroinvertebrate genus to determine each XC_{95}. Second, the HC_{05} is developed using a genus XCD for the macroinvertebrate community from the aggregation of the XC_{95} values (an example is provided in Figure 3-1).

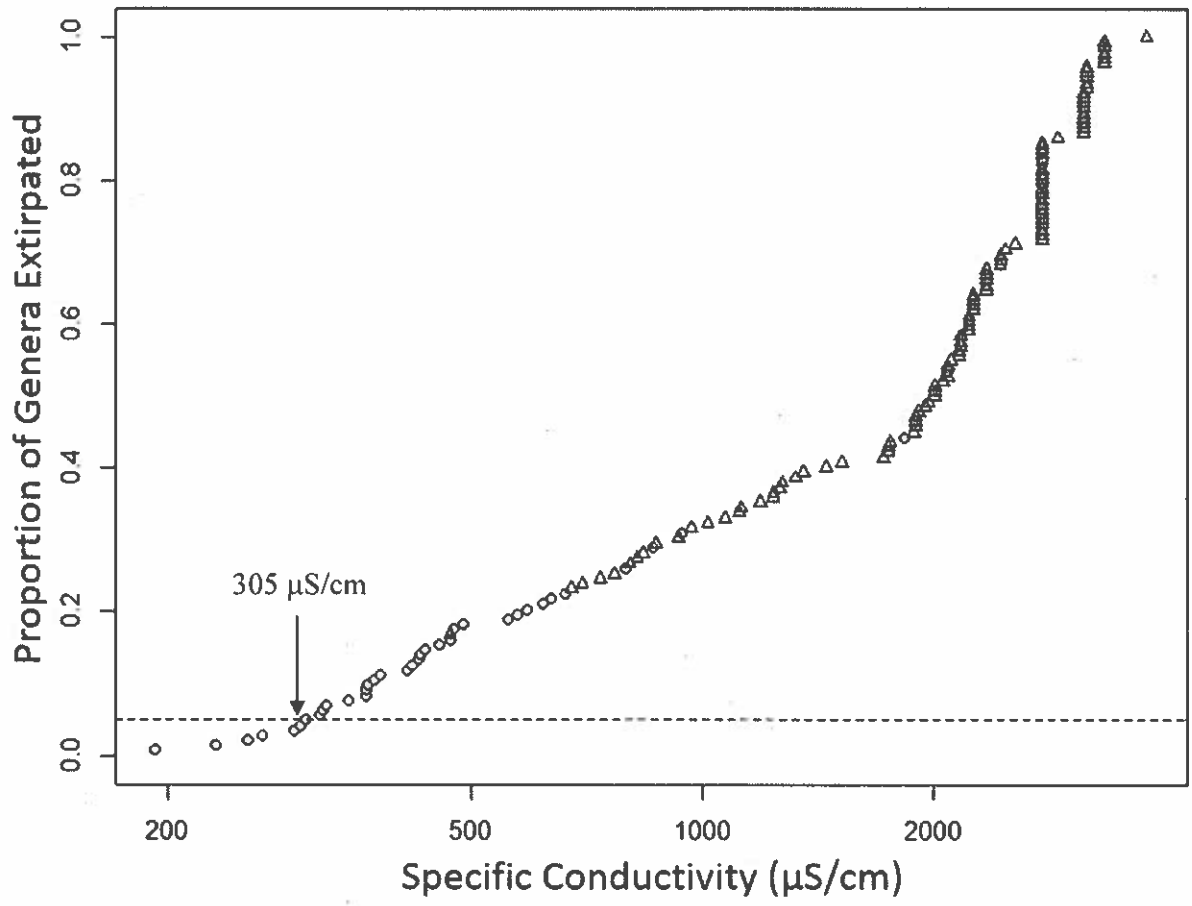


Figure 3-1. Example of a genus extirpation concentration distribution (XCD) depicting the proportion of genera extirpated with increasing ionic concentration measured as specific conductivity (SC). Each point on the XCD plot represents an extirpation concentration (XC_{95}) value of one genus arranged from the least to the most salt-tolerant. XC_{95} values that were defined as greater than values are indicated by triangles. The 5th centile of the XCD is shown as a dotted horizontal line. The 5th centile hazardous concentration (HC_{05}) is the SC at that intercept of the XCD and the 5th centile line. In this example, the HC_{05} is 305 µS/cm.

Several methods were evaluated prior to selection of a weighted CDF model to estimate an XC. They included models of XC from logistic regression, a generalized additive model (GAM), unweighted CDF, and other options. A weighted CDF model was selected because the HC_{05} value fell within the range of the other methods, and it was computationally simple. Weighting normalizes the distribution of samples taken across the SC gradient. The weighted CDF does not assume any particular shape to the distribution and does not fit a function to the

data points. Outliers were not identified or removed because little was known about the sustainability of populations in high SC water or the movement of salt-intolerant taxa from biological sources to sinks. However, at least one study indicates that apparent outliers may represent transient occurrences of genera drifting from low SC to a high SC stream reach (Pond et al., 2014). Removal of the outliers or using the area under a fitted curve such as a GAM generally yields lower XC_{95} values and a lower HC_{05}. As new information arises, the method for modeling the XC_{95} may be updated. The EPA SAB endorsed EPA's selection (U.S. EPA, 2011c) of the weighted CDF model for this field-based method (U.S. EPA, 2011a). The statistical package *R*, Version 2.12.1 (December 2010), was used for all statistical analyses in the Case Studies (*R*-Development Core Team, 2011). The program "R" is open-source and open-access computational software that runs on Microsoft Windows, Apple MacOS, and UNIX platforms. The calculations can also be performed with a hand-held calculator or with a spreadsheet such as Microsoft Excel.

Different forms of the exposure-response relationships (i.e., decreasing, unimodal, increasing, and no relationship) are expected given the nature of the ions and the physiology of a macroinvertebrate genus. For example, many ions are required for survival and are beneficial at low levels but elicit toxic effects at high levels; such a stressor-response relationship is expected to have a unimodal distribution (see Appendix A.3, *Isonychia*). In the ascending (left) limb, requirements for ions are increasingly being met; in the descending (right) limb, toxicity is increasing. However, many empirical exposure-response relationships for ions do not display both limbs of the distribution. For example, some may show: (a) only the descending portion of the curve because none of the observed SC levels are sufficiently low to show elemental deficiency for the taxon (see Appendix A, *Ephemerella and Leuctra*); (b) only the ascending portion because none of the observed SC levels are sufficiently high to show toxicity for the taxon (see Appendix A, *Cheumatopsyche*); or (c) no trend at all because the optimum is more of a plateau than a peak so it extends across the range of observed SC levels (see Appendix A.3, *Brilla*).

The steps involved in selecting, characterizing, and analyzing macroinvertebrate sampling field data to derive a CCC are depicted in Figure 3-2 and described in the following sections.

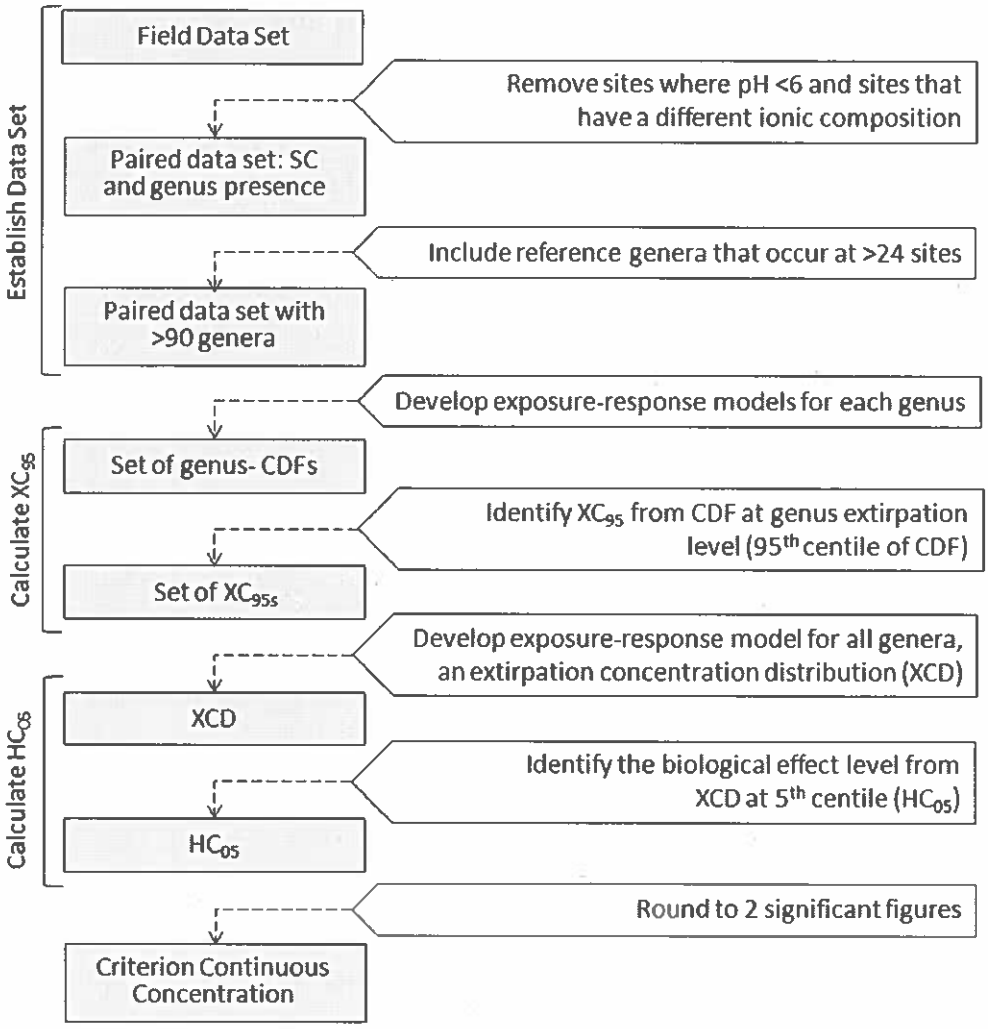


Figure 3-2. Main steps in the derivation of a chronic specific conductivity (SC) criterion using the extirpation concentration distribution (XCD) method. Rectangular boxes on left are products and pentagonal boxes on right are operations performed on those products. In the Case Studies (see Sections 4, 5, 6 and 7), example SC criteria are derived using data from sites in a defined area that have an ionic composition dominated by sulfate plus bicarbonate anions. Cumulative distribution function (CDF), 95th centile extirpation concentration (XC_{95}), 5th centile hazardous concentration (HC_{05}).

3.1.1. Establishing the Data Set

3.1.1.1. *Information Sources*

The data sets are developed at an ecoregional scale to account for natural differences in background SC levels found in different ecoregions, and QA/QC of the data sets are described.

Several data sets were used to illustrate the method in the case studies, details of which are provided in Sections 4, 5, 6, and 7. In addition to the description of field data, information available in the scientific literature is considered in the development of ecoregional SC criteria, particularly for assessing causation and confounding factors (see for example Appendices A and B in U.S. EPA, 2011a; Cormier et al., 2013b; Suter and Cormier, 2013) and to support recommendations for duration and frequency of the criteria. Relevant literature related to the characteristics of the receptor organisms, the ions of interest, and the potential confounding agents are also considered, much of which is presented in Section 2 (*Problem Formulation*) of this document and also in the precursor reports and manuscripts (U.S. EPA, 2011a; Cormier et al., 2013b; Suter and Cormier, 2013).

3.1.1.2. *Selection and Adequacy of Data Sets*

Developing aquatic life criteria for SC using the XCD method requires a large data set with certain characteristics. The adequacy of the data set can be judged by the following attributes (U.S. EPA, 2011c):

- Measurements of the agent(s) are paired in space and time with biological sampling;
- High-quality (i.e., minimally affected) sites are included in the data set;
- Background SC levels are similar throughout the region (see Section 3.7.1);
- Characteristics of the agent (i.e., ionic composition) are similar across the region for the paired data (i.e., other mixtures may occur but they are analyzed separately);
- Some biological sampling occurs when salt-intolerant genera are likely to be collected (e.g., March through June in Appalachia) and where they are likely to occur (e.g., leaf packs, riffles);
- The exposure gradient is broad enough to include no effects, weak effects, and strong effects;
- Data are available to evaluate potential confounding factors; and
- An independent data set or statistical models are available to validate the criteria.

Inclusion of many genera and a representative proportion of salt-intolerant genera help to ensure that the XCD model is representative of the aquatic community. A sensitivity analysis of data sets has determined that a reliable HC_{05} can be determined from 90–120 genera and 500–800 sites, based on the stability of the HC_{05} value as those variables increased (U.S. EPA, 2011a; see Sections 4 and 5 of this report). Samples taken throughout the year reduce biases from seasonal SC regimes and seasonal occurrence of some genera. For example, samples taken only in dry seasons when SC tends to be higher would likely bias results toward more salt-tolerant genera and to maximum SC exposures rather than an annual average.

3.1.1.2.1. Sample size

The number of observations of a genus can affect the reproducibility of the XC_{95} and the HC_{05} (Cormier et al., 2013a). Similarly, the number of genera affects the reproducibility of the HC_{05} (U.S. EPA, 2011a; Cormier et al., 2013a) and the number of genera depends on the overall number of samples in the data set and individuals in the sample that are identified to genus.

For the example case studies, EPA estimated XC_{95} values using the XCD method with genera that were observed in ≥25 samples in the ecoregion (Cormier et al., 2013a) because estimations of the 95th centile with <25 observations are less robust. The recommended number of genera in an XCD using this method is 90 (Cormier et al., 2013a). For a sampling protocol that identifies 200 individuals in a sample, the adequate number of sampling stations in an ecoregion using this method is about 500 (U.S. EPA, 2011a). However, if more individuals are identified in each sample, e.g., 300 or a full count of individuals, then fewer sampling stations may be needed to obtain XC_{95} values for 90 or more genera (see Appendix G in U.S. EPA, 2011).

The effect of selecting a minimum number of observations of a genus for calculating an XC_{95} value can be visualized in several ways. For example, for a range of genus sample sizes (e.g., N = 5–60), the HC_{05} is calculated and the number of genera in the XCD is enumerated. The resulting HC_{05} values and number of genera versus minimum number of samples are plotted. As taxa with fewer occurrences are excluded from the XCD, the number of genera decreases and the HC_{05} increases (see Figures 4-11 and 5-11). To ensure representation of salt-intolerant taxa and reasonable accuracy of the HC_{05}, the minimum number of samples is chosen that maximizes the number of taxa in the XCD while minimizing the variance in the XC_{95} and resulting XCD

near the 5th centile. The number of observations of a genus is also chosen to provide sufficient occurrences to estimate the genus XC_{95} values while minimizing bias due to eliminating salt-intolerant genera that have few occurrences. A minimum sample size of 25 maximizes the number of taxa that are included without having to extrapolate beyond the range of the data set (Cormier et al. 2013a, on-line supplemental material). Therefore, a sample size of 25 was utilized in the case studies, and in general, is a recommended minimum sample size for this method.

The effect of sample size on the HC_{05} and its confidence bounds can be estimated using a bootstrapping technique (see Section 4.5 and 5.5). Bootstrapping is a statistical technique of repeated random sampling from an empirical data set that is often used in environmental studies to estimate confidence limits of a parameter (Newman et al., 2001, 2000). This is akin to having different samples to compare results and fidelity of the model. A similar method is used to calculate confidence bounds on the HC_{05} values (described in Section 3.1.3.1). Using this technique, a data set of a selected sample size with replacement is randomly selected from the original set of samples. Next, the XC_{95} for each genus is calculated from the bootstrap data set by the same method applied to the original data, and the HC_{05} is calculated. The uncertainty in the HC_{05} value can be evaluated by repeating the random sampling and HC_{05} calculation numerous times (e.g., 1,000 times) for each selection. The distribution of 1,000 HC_{05} values is used to generate two-tailed 95% confidence bounds on these bootstrap-derived values. The whole process is repeated for a selected sample size ranging from 100 to the full data set of all samples. The mean of all bootstrapped HC_{05} values, the numbers of genera used for the HC_{05} calculation, and their 95% confidence bounds are plotted to show the effect of sample size. The number of samples at which the HC_{05} values reach an approximate asymptote (500–800) suggests the minimum sample size (500) for a data set (see Figures 4-12 and 5-12).

3.1.1.2.2. Treatment of multiple samples from a particular site

Multiple samples collected from the same site can provide valuable information especially when they are from different seasons (when SC may be different and different genera may be present), but they can be problematic if they introduce a bias (e.g., if extremely low or high SC sites are more likely to be sampled repeatedly).

In the case studies, most of the sites were sampled only once, but a portion of them were sampled more than once (see Sections 4.1 and 5.1). To assess for a potential bias, a simple inverse weighting scheme can be applied (e.g., if a site is sampled twice, each observation is weighted 0.5). In the example case studies, this weighting scheme did not substantially change the magnitude of the HC_{05} values; therefore, all data were used with no weighting. In cases where geographic distribution of sites and/or SC levels affects the HC_{05}, then some form of correction may be warranted, such as random selection of only one sample per site. In the case studies, sites were fairly evenly distributed; therefore, no weighting was performed for replicates.

3.1.1.2.3. Stressor identity

The stressor identity in this case is the proportion of constituent ions, characterized on the basis of the field data set. The stressor of concern in the example case studies is an ionic mixture dominated by sulfate (SO_4^{2-}) plus bicarbonate (HCO_3^-) (see Section 2.2). As a result, for these example criteria, sites with an ionic mixture dominated by chloride (i.e., those where the concentration of HCO_3^- plus $SO_4^{2-} \leq Cl^-$, in mg/L) are removed from the data set. The ionic mixture in the example case studies (see Section 4, 5 and 7) are dominated by the cations on a mg/L basis by ($[Mg^{2+}] + [Ca^{2+}]$) > $[Na^+]$ and one by ($[Mg^{2+}] + [Ca^{2+}]$) < ($[Na^+] + [K^+]$) (see Section 6). Alternatively, other data can be removed to focus on other mixtures or salts (e.g., NaCl).

3.1.1.2.4. Ambiguous taxa

The XCD method uses genus-level taxonomic identification. This method does not mix data of lower or higher levels of taxonomic identification. However, species-level taxonomic identification can be used when it is available and the number of species is sufficient for constructing an XCD (see Appendix G for an example). Data records with ambiguous taxonomic identification or family-level or higher identification (i.e., no genus-level identifications) are excluded from the data sets.

3.1.1.2.5. Exclusion of genera from extirpation concentration distribution (XCD)

This method is for freshwater systems, and therefore, estuarine and marine genera were not included in the XCD. One way to ensure that only freshwater organisms are represented in

the XCD is to only include genera that are present at a minimum of one freshwater reference site. The selection of reference sites is beyond the scope of this document (Stoddard et al., 2006; Herlihy et al., 2008; Whittier et al., 2007b; Hawkins, et al. 2010; U.S. EPA, 2011d; Environment Canada, 2012). For the example case studies, the reference sites used in analyses were identified by the sampling organization, but only after EPA reviewed the reference site selection criteria (see Sections 4 and 5). When reference sites were not identified by the sampling organization, all genera were used (see Appendix D).

3.1.1.2.6. Confounding factors

Field observations are uncontrolled, largely unreplicated, and may not be randomized; as a result, they are subject to confounding. Confounding is the appearance of apparently causal relationships that are due to noncausal correlations. Noncausal correlations and the inherent noisiness of environmental data can obscure true causal relationships. Reducing confounding as much as possible is recommended by identifying potential confounding variables; determining their contributions, if any, to the relationships of interest; and eliminating their influence when possible and as appropriate based on credible and objective scientific reasoning.

A method to assess the potential effect of confounders is described in the *EPA Benchmark Report* (U.S. EPA, 2011a) and in Suter and Cormier (2013). The analysis of potential effects on the model by potential confounders used a weighted scoring system to evaluate ten types of evidence that determined whether the observed relationship between benthic macroinvertebrate community composition and SC was affected by other factors. The weighted scoring system was based on work by Hill (1965) and Cormier et al. (2010) and is described in detail in Appendix B of EPA (U.S. EPA, 2011a) and in Suter and Cormier (2013). As described in the *EPA Benchmark Report*, the potential for other stressors to affect the XCD model was evaluated using a weight-of-evidence assessment that considered habitat quality, organic enrichment, nutrients, deposited sediment, pH (low and high), selenium, temperature, lack of headwaters, catchment area, settling ponds, dissolved oxygen, and metals (see Appendix B in U.S. EPA, 2011a). Overall, the analyses showed that the effects attributed to increased ionic concentration were not due to other stressors.

In these analyses (U.S. EPA, 2011a), only one of the assessed factors (pH <6) was identified as a likely confounder, so samples with pH <6 were removed from the data set to

minimize the influence of acidity and associated dissolved metals. Due to the toxicity at low pH, unless shown to the contrary, sites with pH <6 are excluded from data sets prior to analysis.

Also, when using this method, the EPA recommends that at least one sequence of analyses be used to evaluate the effect of confounding on the XCD model. For example, potential confounding can be evaluated using multiple regression analyses followed by modification of the data set to control for the strongest potential confounding factors and then calculating the HC_{05}. If the HC_{05} is not appreciably altered by this data set manipulation, the full data set can be used. If the HC_{05} is appreciably altered, the criterion data set may be modified to minimize that factor's effect on model prediction. The model is accepted if the confidence bounds of the original and new HC_{05} overlap. Examples for confounding analyses and reducing effects of confounding can be found in Case Studies I and II in Appendices A.2 and B.2, respectively.

There are two common means for reducing the influence of confounders. First, sites with a confounder can be removed from the data set, thus reducing its influence on the XC_{95} estimates and XCD model. For example, the EPA removed samples with low pH in the case study examples (see Appendices A.2.3 and B.2.3). Secondly, the effect of a confounder can be minimized by normalizing the influence of a confounder with appropriate weighting. The EPA used this approach to assess the influence of temperature and season in the case study examples and these methods could be used to adjust for confounders if necessary (see Section 3.1.4, and Appendices A.2.3 and B.2.3). Removing samples from the data set can reduce the number of species or the range of exposures of the stressor of interest, thus affecting the reliability of the estimates. Therefore, it is important to evaluate whether the manipulation of the data set improves the accuracy of the HC_{05}. Each case is different, and professional judgment is recommended.

3.1.1.3. *Quality Assurance/Quality Control (QA/QC)*

Information is reported about the specific methods used to choose sampling locations, to sample water SC and macroinvertebrates, and to assure data quality. Some considerations include whether standardized quantitative or semiquantitative techniques are used for macroinvertebrate sampling, the mesh size used in the field and lab for sampling and sorting, whether samples are subsampled, and if so, what percentage was subsampled. The data set

description and metadata include sampling dates; total number of chemical, physical, and biological samples from distinct locations (and total samples); sampled years; stream types represented by samples; and ecoregions represented by sites. Annual sampling when salt-intolerant genera are likely to be present is usually sufficient and avoids damage to the habitat and stream biota due to repeated sampling during the year. If sampling occurs more than once per year from the same location, the use or restriction of repeat samples is described. Similarly, a full description or literature references are provided for the chemical and physical parameters that are used in any analysis (see an example in Section 4.1). Additional information regarding QA/QC and other critical technical elements of a robust biological assessment program (e.g., taxonomic resolution, sample collection, sample representativeness, sample processing, data management, and professional review) can be found in EPA's technical assistance document, *Biological Assessment Program Review: Assessing Level of Technical Rigor to Support Water Quality Management* (U.S. EPA, 2013a).

3.1.2. Calculating Genus Extirpation Concentrations (XC_{95})

For each genus meeting the data-selection conditions, a CDF is constructed that is weighted to correct for any potential bias from the unequal distribution of sampling of sites across the range of logarithm10 transformed SC values. This weighted CDF represents the proportion of observations of a genus with respect to increasing exposure levels. The extirpation effect threshold for a genus is 95% of the total occurrences of the genus. The two exposure levels bracketing the 95th centile are linearly interpolated to give an XC_{95} for a genus.

In the case examples, all calculations are performed using logarithm base 10 (log10) transformed SC values. Variables are routinely log transformed when applying the field-based methods. Because environmental data are usually skewed, log transformation normalizes the data so that normality assumptions are not violated. Log transformation also tends to increase equality of variance, increase the linearity of relationships, and makes plotted relationships clearer.

First, equally-sized bins are defined to compute weights for each sample. Bin size depends on the data set and is based on balancing the requirements of sufficient observations in a single bin to define the proportion and a sufficient number of bins to define the form of the response. The effect of bin size can be analyzed by developing a series of HC_{05} values using

different bin and sample sizes. In general, 40 to 60 bins usually gives acceptable results. For example, for Case Studies I and II, the width of each bin is $1/60^{th}$ of the range of the log10 transformed SC values. Thus, each bin was assigned a width equal to 0.017 (1/60 bins) multiplied by the range of the log10 transformed SC values within the data set (for examples see Figures 4-6 and 5-6).

Next, the bins are weighted to ensure that sites in bins with many observations are not overly influential. The assigned weight for each sample within a given bin is $w_i = 1/n_i$, where n_i is the number of samples in the ith bin. The value of the weighted cumulative distribution function, $F(x)$, is computed using the following equation for each unique observed value of the agent x associated with observations of a particular genus:

$$F(x) = \frac{\sum_{i=1}^{N_b} w_i \sum_{j=1}^{M_i} I(x_{ij} < x \text{ and } G_{ij})}{\sum_{i=1}^{N_b} w_i \sum_{j=1}^{M_i} I(G_{ij})} \qquad (3\text{-}1)$$

where

x_{ij} is the stressor value in the j^{th} sample of bin i,
N_b is the total number of bins,
M_i is the number of samples in the i^{th} bin,
G_{ij} is true if the genus of interest is observed in j^{th} sample of bin i,
I is an indicator function that equals 1 if the indicated conditions are true, and 0 otherwise,
W_i is the assigned weight of a sample within the i^{th} bin, $w_i = 1/M_i$.

The XC_{95} value is defined as the stressor value corresponding to $F(x) = 0.95$. Equation 3-1 is an empirical cumulative distribution function, and the output is the proportion of observations of the genus that occur at or below a given exposure level. See Figure 3-3 for examples of weighted CDFs. Figure 3-3 shows weighted proportions of samples with *Epeorus* and *Nigronia* present at or below the indicated SC value (µS/cm). The XC_{95} is the SC at the 95^{th} centile of the weighted CDF (vertical dashed line). Within the observed ranges of SC, the weighted CDFs of some

genera demonstrate a response to SC (e.g., *Epeorus*) as shown by a steep slope and asymptote well below the maximum exposures. Conversely, genera unaffected within this SC range (e.g., *Nigronia*) have a steady increase over the entire range of measured exposure and do not reach a clear asymptote.

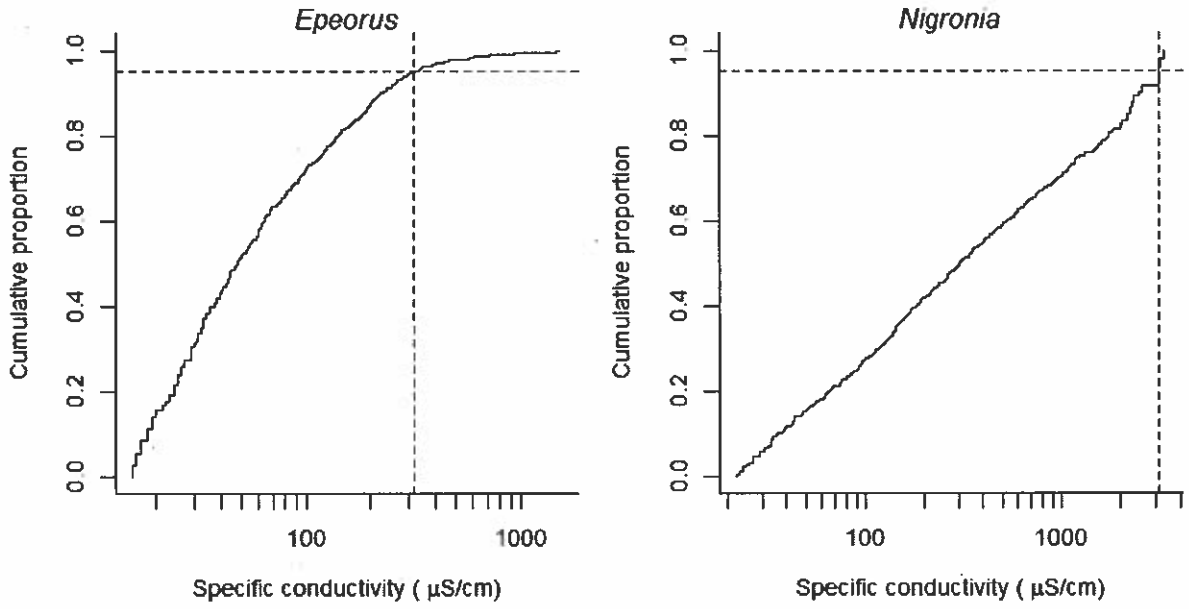


Figure 3-3. Examples of weighted cumulative distribution functions (CDFs) and the associated 95th centile extirpation concentration values.
The plot for *Epeorus* rises steeply and reaches a plateau, indicating that the genus is affected by increasing specific conductivity (SC). The plot for Nigronia increases linearly without reaching an asymptote, indicating that this genus is not as affected by changes within the tested range of SC.

This method for calculating the XC_{95} will generate a value even if the genus is not extirpated. For example, the occurrence of *Nigronia* changes little with increasing SC (i.e., the cumulative distribution is linear [see Figure 3-3]). Because of the data distributions, not all 95th centiles correspond to extirpation, and some imprecisely estimate the extirpation threshold. The weighted CDFs (see Figure 3-3, Appendices A and B) and scatter plots (see Figure 3-4, Appendices A and B) should be visually inspected for anomalies; if there is no clear trend in the response or if the response does not include extirpation, the XC_{95} can be given a qualifying assignation such as either approximately (~) or greater than (>) the calculated value. The

assignation of > or ~ does not affect the HC_{05} if the values are above the 5th centile, but it alerts users of the uncertainty of the XC_{95} values (see Section 3.1.2.1).

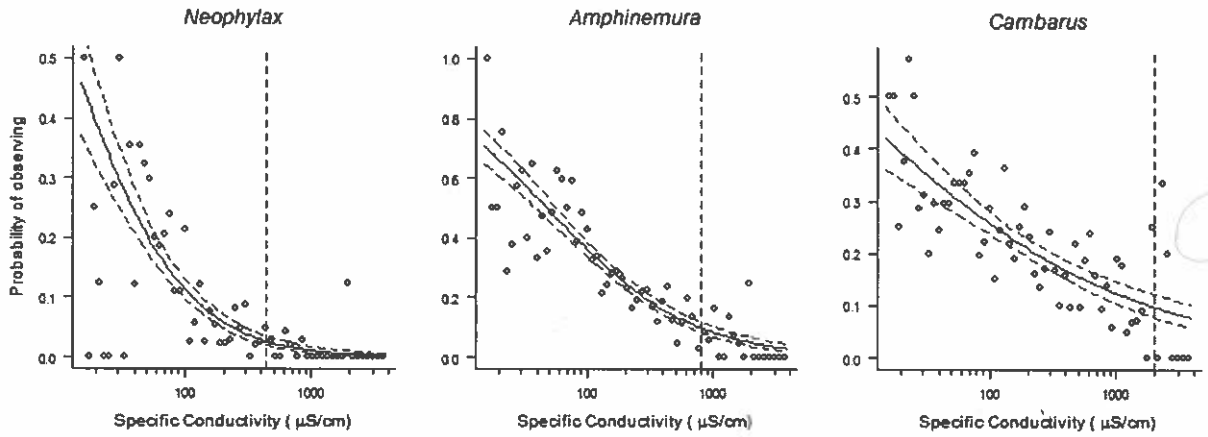


Figure 3-4. Examples of extirpation concentration (XC_{95}s) for three genera listed as being definitive (*Neophylax*), approximate (*Amphinemura*), and greater than (*Cambarus*). In this example, the probability of observing a genus is the proportion of sampled stations in a SC bin with the genus present based on taxonomic identification of 200 individuals per sample. Qualifications based on the slopes of the confidence bounds as described above. For *Neophylax*, both upper and lower 90% confidence limits intersect *x*-axis, for *Amphinemura* only the lower intersects, and for *Cambarus* neither intersect. The vertical line is the XC_{95} calculated from the weighted cumulative distribution functions.

3.1.2.1. *Assigning Qualifying Designation to Extirpation Concentration (XC_{95}) Values*

The uncertainty bounds of a GAM are used to indicate the confidence in the calculated XC_{95} and whether the value is greater than the tested range. A GAM is not used to estimate the XC_{95}. In order to examine the trend of taxa occurrence along the SC gradient, a GAM is used to model the likelihood of a taxon being observed with increasing SC (Hastie and Tibshirani, 1986). In the example, the probability of observing a genus is the percentage of sampled stations in a given SC bin with the genus present based on taxonomic identification of 200 individuals per sample (see Figure 3-4).

Three typical distributions of observational probabilities are shown in Figure 3-4. A GAM is similar to a regression model except that it iteratively fits a line to the data using a scatterplot smoother which can use any function, not only a straight line or polynomial. The form of the fit is automated and the final shape of the fitted line is useful for revealing nonlinear covariate effects. In this analysis, the GAM shows whether a genus is increasing, decreasing, or

unchanging along the SC gradient. The 90% confidence interval (CI) of the GAM is used to judge whether a decreasing model identifies the XC_{95}, approximates the XC_{95}, or is not measured within the exposure range of the data set, which is indicated as being greater than (>) the estimated value. In the figure, the solid line is the mean smoothing spline fit, and the dots are the mean observed probabilities of observing a genus within a defined SC range, estimated as the proportion of samples within each SC bin. The SC at the vertical dashed line is the estimated XC_{95} previously calculated from the weighted cumulative distributions such as depicted in Figure 3-3.

If the GAM mean fitted curve at maximum SC is approximately equal to 0 (defined as less than 1% of the maximum modeled probability), as in the *Neophylax* example in Figure 3-4, then the XC_{95} is listed without qualification (*Neophylax* XC_{95} is listed as 434 µS/cm without qualification; Appendix A.4). If the GAM mean fitted curve at maximum SC is greater than 0, but the lower 5% confidence limit is approximating to 0 (<1% of the maximum mean modeled probability), as in the *Amphinemura* example in Figure 3-4, then the value is listed as approximate (*Amphinemura* XC_{95} ~805 µS/cm). If the GAM lower 5% confidence limit is greater than 0, as in the *Cambarus* example in Figure 3-4, then the XC_{95} is listed as a greater than value (*Cambarus* XC_{95} > 1,974 µS/cm). The assignations of greater than (>) and approximately (~) does not affect the HC_{05}. They are provided to alert users of the uncertainty of the XC_{95} values for other uses such as comparison with toxicity test results or with results from other geographic regions.

3.1.3. Calculating the Community-Level Effect Estimate Hazardous Concentration (HC_{05})

The XCDs are cumulative distribution plots of XC_{95} values for each genus relative to SC level (see Figure 3-1). The XCD is useful for visualization, but not necessary to calculate the HC_{05}. The cumulative proportion for each genus P is calculated as $P = R/(N + 1)$, where R is the rank of the genus and N is the number of genera. Relatively tolerant genera coded as ~ or > are included. They are reported as ''approximate" or "greater than'' values. Their inclusion assures that N is the correct number of genera, but they do not otherwise contribute substantially to the HC_{05} because they fall in the upper portion of the XCD. The HC_{05} is derived by two-point interpolation between the XC_{95} values bracketing $P = 0.05$ (i.e., the 5th centile of modeled

genera). For an example of an XCD cumulative distribution plot of XC_{95} and HC_{05} derivation, see Figure 4-7.

3.1.3.1. *Validating the Effect Estimate Hazardous Concentration (HC_{05}) by Bootstrapping*

The EPA's Science Advisory Board (U.S. EPA, 2011c) recommended using bootstrapping as one way to validate the XCD model and estimate uncertainty around the HC_{05} values. This method generates distributions and confidence bounds for each genus in the first step and propagates the statistical uncertainty of the first step through the later steps in which the XCD is created and the HC_{05} is estimated (see Figure 3-5). A data set of the same sample size as the original data set is randomly selected with replacement from the original set of samples (Efron and Tibshirani, 1993). The XC_{95} for each genus that occurs at least once in the original data set's reference sites and in more than 24 sampled sites is calculated from the bootstrap data set by the same method applied to the original data. The XC_{95} for each genus is stored and later used to estimate the confidence bounds of each genus' XC_{95}. Then, the HC_{05} is calculated and stored. The uncertainties in the XC_{95} and HC_{05} values are estimated by repeating the sampling and calculations 1,000 times. The distribution of 1,000 HC_{05} values is used to generate two-tailed 95% confidence bounds on these bootstrap-derived values (see Figure 4-13 for an example). The particular genera and the number of genera in any bootstrapped XCD differ in each bootstrapped sample of sites; therefore, the number of bootstrapped XC_{95} values of genera may be more or less than the number of genera in the original data set. The distribution of 1,000 XC_{95} values for each genus is also used to generate two-tailed 95% confidence bounds on these bootstrap-derived XC_{95} values. See Appendices A.3 and B.3 for example 95% confidence bounds for each genus.

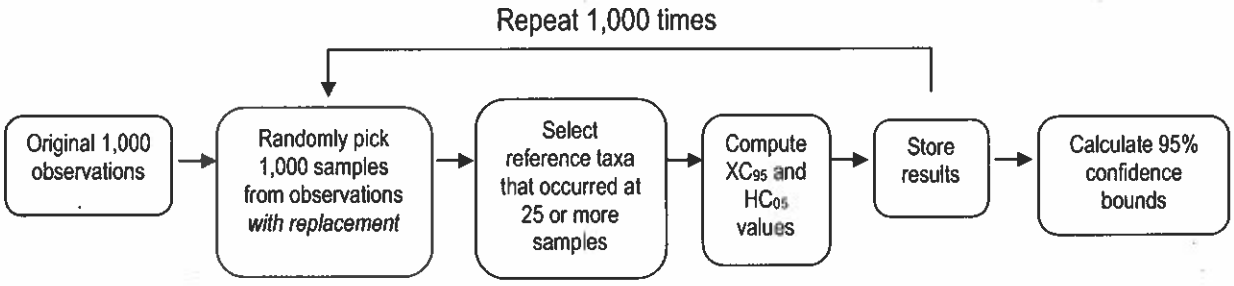


Figure 3-5. Diagram from *EPA Benchmark Report* depicting the process for estimating uncertainty. Bootstrapping is a resampling of the original data set to create 1,000 new data sets and from each of the 1,000 data sets, the extirpation concentration (XC_{95}) values are calculated. After each run, an extirpation concentration distribution (XCD) is made and a hazardous concentration (HC_{05}) estimated. This process is repeated until there are 1,000 HC_{05} values and then the confidence limits of the HC_{05} are estimated. The number of samples varies depending on the data set. The same resampling process is used to evaluate the effect of different sample sizes, exclusion of genera using different database selection criteria, or other parameter choices (see Section 3.1.1.2).

Confidence bounds represent the potential range of HC_{05} values using the XCD approach based on the data set. Conceptually, these confidence bounds may be thought to represent the potential range of HC_{05} values that one might obtain by returning to the field and resampling the same set of streams. The contributors to this uncertainty include measurement variance in determining SC and sampling variance in the locations for monitoring, collecting, and enumerating organisms. These also include variance due to differences in stream reaches, weather, and other random factors.

The confidence bounds do not address potential systematic sources of variance such as differences in sampling protocols. The contributions of those sources of uncertainty, in addition to the sampling uncertainty, can best be evaluated by comparing the results of independent studies. One estimate of that uncertainty may be provided by comparing the all-year HC_{05} values derived from the region for which criteria is being derived to another comparable region. Even if data are obtained in different areas by different agencies using different laboratory processing protocols, the HC_{05} values may be similar.

In the *EPA Benchmark Report*, the HC_{05} value was validated by an independent data set which had a similar background SC, and the values differed by less than 5% (see Appendix G in U.S. EPA, 2011a). Large data sets for ecoregions from more than one sampling organization are

rare and so EPA has provided this bootstrapping method (Newman et al., 2000) as an alternative method to validate the XCD model as suggested by the SAB in their review of the *EPA Benchmark Report* (U.S. EPA, 2011c).

3.1.4. Assessing Seasonality, Life History, and Sampling Methods

The seasonality of life-history events such as emergence of aquatic insects can affect the probability of detecting a species because eggs and early instars are not collected by most sampling methods. As an illustration, in the example cases in Sections 4 and 5, annual insects (univoltine) that emerge in the spring, although present, are less likely to be detected in the summer, when coincidently, SC levels increase in some streams (e.g., due to decreased flow). In other locations, this pattern may be different. For example, high mountain systems may be affected by melting snow pack. Seasons may shift based on latitude. Also, sampling restricted to a season can bias the estimate of natural background or effect estimates (i.e., XC_{95} values). Both high-concentration and low-concentration periods should be represented when the salt-intolerant genera are collected in order to ensure that the tolerated range is evaluated. These periods may vary by time of year among regions, and among years (based on climate variability) for any given region. Professional experience with the SC regimes and the life cycles of vulnerable species is required when assessing whether a data set is suitable for using the XCD method.

Because the hydrologic and SC regime and the natural history of salt-intolerant taxa vary by region, the potential effect of sampling date on the form of the XCD model may be assessed using several methods. As an illustration, in the example cases in Sections 4 and 5, the HC_{05} using the spring (March–June) only data set was compared with the HC_{05} based on the full-year data set for the ecoregion. If the spring HC_{05} is within the confidence bounds of the full-year data set, then the full annual data set can be used (see example in Appendix A, Figure A-8); if this is not the case, further correction for a confounding factor may be necessary as described below for the example using sampling date.

A scatter plot and regression model can be developed to evaluate the mean relationship between measurements of SC at the time of the biological sample and annual mean SC (for an example, see Appendix A, Figure A-9). The annual geometric mean SC values are calculated from at least six water samples collected before biological samples were taken. At least one

spring (when salt-intolerant taxa can be collected) and one summer macroinvertebrate sample is recommended in order to increase the likelihood that salt-intolerant taxa will be included in the data set. On the *x*-axis is the SC when biological samples are collected and on the *y*-axis is the annual geometric mean value during that rotating year for a site. A Model II regression is fitted to the data because the two SC measurements are uncertain. [A Model I regression using least squares is not used because it underestimates the slope of the linear relationship between the variables when they both contain error (Legendre, 1998)]. The mean relationship between measurements of SC at the time of the biological sample and annual mean SC is supported if the relationship approaches 1:1, and prediction for the annual mean from the regression model is within the confidence bounds of the HC_{05}.

A third approach to account for seasonal variability involves adjusting SC results collected at the time of biological sampling to estimate annual mean SC values. In situations where the SC tends to be lower in the spring than in the summer, the effect of seasonality on the HC_{05} is evaluated by converting the instantaneous biological sample SC into an annual mean value based on monthly weighting factors. Then, the XC_{95} and HC_{05} values are estimated. The average weighting factors for each month can be calculated from the previous sampling year. One way to do this is to select a subset of stations where multiple SC measurements are taken within a rotation year (e.g., from July to the following June). For each site, the annual mean SC is calculated using the monthly measurements. Then, the weights for each month are calculated as a ratio of the annual mean SC to the observed SC at each site on the day of biological sampling. Next, the average weight within each month is calculated. Finally, for the data set used to develop the XCD and the HC_{05}, the SC on the day the biological sample was collected is multiplied by the weighting factor for that month to yield the estimated annual SC for each site. The resulting products are considered the annual mean SC at each station in that rotation year, adjusted by month. The weighting factors vary slightly for different months in different data sets (see Appendix A, Table A-2 for an example). This approach may be adapted to different seasonal SC patterns, as appropriate.

If the confidence bounds of the weighted HC_{05} overlap the confidence bounds of the unweighted HC_{05}, the unweighted model is accepted. For example, the HC_{05} values in Case Studies I and II vary by less than 3%, suggesting that the impact of sampling date (seasonality) is minor for these data sets. As a result, seasonally unweighted XCDs are used for the assessment

in these case studies. In general, the use of unweighted XCDs is easier and requires fewer data points. However, all data sets may not yield similar results, and thus this method provides a way to evaluate the influence of season and also provides a method for normalizing for sampling date when necessary.

3.2. DERIVING A CRITERION MAXIMUM EXPOSURE CONCENTRATION (CMEC)

A CMEC is defined as the SC level that protects aquatic life from acutely toxic exposures. The CMEC analysis described here estimates the 90th centile of observations at sites with water chemistry regimes for sites meeting the CCC. It is not directly estimated from paired biological and water chemistry during acute exposures. However, if sufficient data are available (e.g., daily measurements of SC paired with macroinvertebrate sampling), a protective criterion maximum concentration could be estimated from the maximum concentration in a year prior to the observation of salt-intolerant genera at a site. An example of this type of analysis is provided in Appendices A.3 and B.3, but such data sets are rare. Even for the case studies using the large data sets in Ecoregions 69 and 70, there are only modest amounts of data to estimate such a criterion maximum concentration in this manner.

Using only water chemistry measurements and a previously determined CCC, a CMEC is estimated such that where the CCC is attained, 90% of observations are likely to be less than the CMEC. The steps involved in selecting, characterizing, and analyzing SC (chemistry) sampling data to derive a CMEC for flowing waters in the study area are described below (see Figure 3-6) and example derivations in Sections 4.2.2 and 5.2.2.

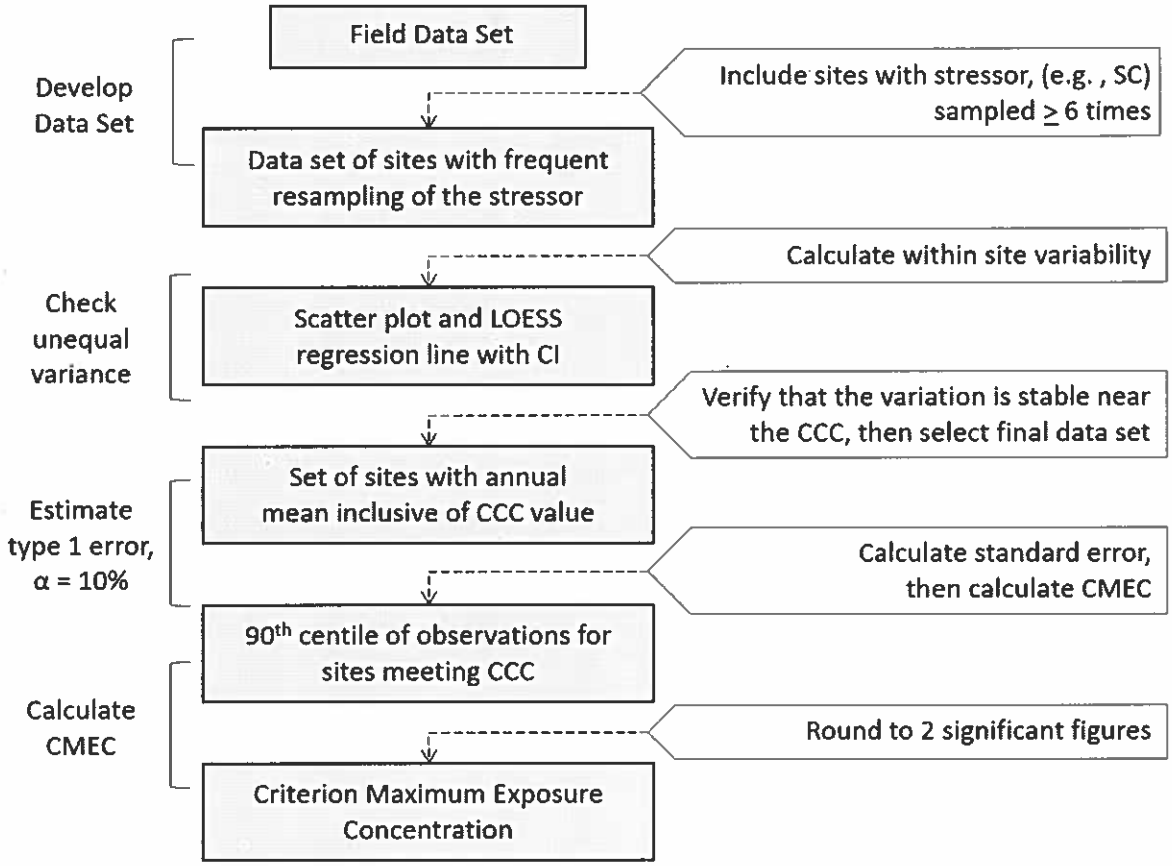


Figure 3-6. Main steps in the derivation of a criterion maximum exposure concentration (CMEC) based on field water chemistry data. Rectangular boxes on left are products and pentagonal boxes on right are operations performed on those products. A locally weighted scatterplot smoothing (LOWESS) estimates a line for a scatter plot by iteratively calculating many nonparametric regression models using local approximations (linear polynomial) from neighboring points.

The CCC is expressed as an annual geometric mean of the SC values measured from a sampling station in a particular region. Because SC values vary spatially and temporally, it is expected that the maximum SC values (or the CMEC) at any given station may be estimated by incorporating both among-station (spatial), and within-station (temporal) variability. Using the mean SC at the CCC and the variance of a SC distribution, a centile near the maximum, such as the 90th centile, for that distribution can be estimated. Thus, where the CCC is met within the region, only 10% of the observations (grab samples) would be predicted to exceed the CMEC.

To do this, a subset of frequently sampled sites is developed. For Case Studies I and II, a representative sample set was identified in which n stations (j in $1,..,$ n stations) were sampled at least six times (sample size k_i, i^{th} in $1,...,$ k_i observations) on a rotating yearly basis (in the case example from July to June). The preferred data set would have multiple SC measurements evenly distributed throughout the year. A minimum of one sample during the low SC season (e.g., March–June in Appalachia), and one sample in the high SC season (e.g., July–October in Appalachia) may be sufficient to capture temporal variability. As with the derivation of the CCC, a range of exposures that leads to adverse effects on the most salt-intolerant taxa needs to be represented in the data set and there needs to be assurance that there is no bias in the sampling within that range. The grand mean and standard deviation of this data set are calculated. The CMEC can be calculated at the 90th centile of the distribution from log values of SC in the region from this equation:

$$CMEC = 10^{(\bar{X}+z_\alpha * \sigma_r)} \quad (3\text{-}2)$$

Where $\bar{X}$ is the proposed annual geometric mean value limit for all stations ($\bar{x}_j$) (i.e., the CCC), z_α is the one-tail critical value for the 90th centile of a normal distribution (α, 10%), σ_r is the total residual standard deviation, i.e., the square root of the standard deviation. The CMEC is calculated based on eq 3-2 with $\bar{X}$ equal to log10 of the CCC for the ecoregion. For example, if the grand mean of all sites is 310 µS/cm, and the standard deviation is 0.243 µS/cm, and the z_α at 90th centile is 1.28, then the estimate of 634.1 µS/cm is rounded to two significant figures resulting in a CMEC of 630 µS/cm (see eq 3-3).

$$10^{\log10(310) + 1.28*0.243} = 630 \text{ µS/cm} \quad (3\text{-}3)$$

3.3. ESTIMATION OF CRITERIA DURATION

The water quality standards handbook (U.S. EPA, 1983) describes duration as follows:

> The quality of ambient water typically varies in response to variations of effluent quality, stream flow, and other factors. Organisms in the receiving water are not experiencing constant, steady exposure but rather are experiencing fluctuating

exposures, including periods of high concentrations, which may have adverse effects. Thus, the EPA's criteria indicate a time period over which exposure is to be averaged, as well as an upper limit on the average concentration, thereby limiting the duration of exposure to elevated concentrations.

Because this field-based approach relies directly on paired in situ measurements of SC and benthic invertebrate assemblage composition, the potential adverse effects of ionic stress on all life stages are considered in the context of other complex relationships (e.g., food web dynamics) and aquatic ecosystem processes. The measures of effect (i.e., XC_{95} and HC_{05}) are considered chronic-duration endpoints because the field data reflect exposures over whole life cycles and multiple generations of the resident biota (see Table 2-3).

The EPA typically recommends an averaging period of 4 days for a CCC, which may be appropriate for some field-derived criteria (U.S. EPA, 1985). Important considerations for estimating duration are the temporal resolution of the biological data set and the seasonal window for observing salt-intolerant genera (typically early in the year). Based on available field data, salt-intolerant macroinvertebrate genera may be exposed to a range of SC levels greater than the CCC throughout the year and often for more than 4 days (see example in Figure 3-7). For example, biological samples collected once annually (as in Case Studies I and II in Sections 4 and 5) represent the average stream chemistry and macroinvertebrate assemblage information over the course of 1 year. In cases where samples were collected on an annual basis the EPA recommends a duration of 1 year for CCCs for SC derived using the XCD method unless there are sufficient data to support an alternative duration.

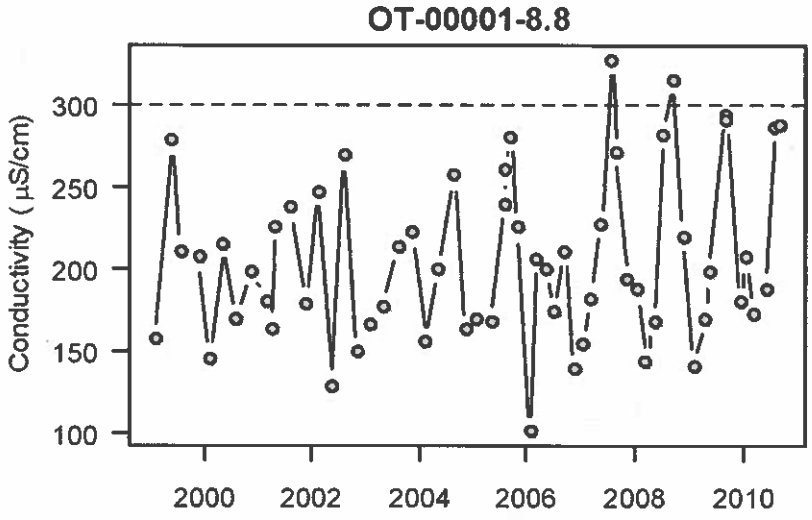


Figure 3-7. Typical specific conductivity (SC) pattern of a stream with annual mean SC well below 310 µS/cm. Aquatic life is typically exposed to a range of SC levels throughout the year.

The duration for the CMEC in Case Studies I and II is based on a literature review of the rate of onset of critical biological responses and the sampling duration used in the field data set used to establish the CMEC. Although reproductive effects (see Section 2.5) may occur rapidly following exposure, they occur only during distinct temporal windows that vary with species (life history). Increased drift (benthic invertebrates floating downstream), in contrast, can occur any time a spike in exposure occurs. In numerous studies, increased drift may be induced within minutes of stressful exposures in streams and in artificial test channels (Svendsen et al., 2004; Wood and Dykes, 2002). Most ecological studies describe drift as a part of the natural history of dispersal and colonization, but disturbance has also been identified as a cause of drift (Svendsen et al., 2004; Wood and Dykes, 2002; Crossland et al., 1991; Doeg and Millage, 1991; Wallace, 1990; Brittain and Eikeland, 1988; Sheehan and Winner, 1984; Geckler et al., 1976; Waters, 1995, 1972, 1966). In a study that induced drift from the addition of sodium chloride (NaCl), the onset of drift occurred within 15 minutes, and on average, the greatest occurrence of drifting genera took place within 4 hours (Wood and Dykes, 2002). In that study, prior to the addition of salt, SC was 110 µS/cm (River Holmes). During three trials, drift occurred at maximum total dissolved solids (~110 mg/l or SC ~157 µS/cm) and not at the lower concentration (~85 mg/L or SC ~121 µS/cm). In stream mesocosm studies with HCO_3^- and SO_4^{2-} salts, Clements and

Kotalik (2016) reported an approximate doubling of drift within 24 hrs (196 µS/cm). Avoidance and drift behaviors, in general, typically occur quickly following most noxious stimuli.

Unlike laboratory studies, maximally tolerated SC exposures were not measured. Rather, the CMEC is the 90th centile of observations measured at sites meeting the CCC. Therefore, the duration parameter is based on the rate of onset of drift described in published field experiments; the recommended duration for the CMEC is 1 day.

3.3.1. Summary of Recommended Duration for Criterion Continuous Concentration (CCC) and Criterion Maximum Exposure Concentration (CMEC)

The temporal resolution of the biological data set and the seasonal window for observing salt-intolerant genera are key considerations when estimating the duration for the CCC and CMEC for SC. In cases where sampling occurs once annually, as in Case Studies I and II provided in Sections 4 and 5, the recommended durations for the CCC and CMEC are 1 year and 1 day, respectively.

3.4. ESTIMATION OF CRITERIA FREQUENCY

The water quality standards handbook (U.S. EPA, 1983) describes frequency as follows:

> To predict or ascertain the attainment of criteria, it is necessary to specify the allowable frequency for exceeding the criteria. This is because it is statistically impossible to project that criteria will never be exceeded. As ecological communities are naturally subjected to a series of stresses, the allowable frequency of pollutant stress may be set at a value that does not significantly increase the frequency or severity of all stresses combined.

The frequency with which criteria may be exceeded depends on the rate of recovery of the biotic community. In general, if the interval between exceedances is less than the time to recovery, impairment is perpetuated. Time to recovery may be estimated mechanistically from the life histories of the organisms involved or empirically from field studies of stream community recovery.

In this case, to estimate the interval between extirpation and reestablishment of a reproducing population, the EPA adapted a list of potential factors that may affect recovery time of stream organisms (Wallace, 1990). Although these considerations were originally outlined

with respect to pesticide exposure, they are a reasonable list of factors to consider for any stressor. The revised considerations are listed below with corresponding numbers from Wallace (1990):

1a. Magnitude of the initial stressor load

1b. Adverse effect of the stressor

1c. Areal extent of continued inputs of the stressor

2. Spatial scale of the disturbance

3. Persistence of the stressor at the site

4. Vagility of the populations (ability to move and disperse) influenced by exposure

5. Timing of contamination in relation to life history stage

6. Position within the drainage network

For the purposes of estimating frequency, the concentration of the initial stressor load (see Item 1a) is greater than the magnitude of an annual average CCC or a daily CMEC. The initial adverse effects (see Item 1b) are extirpation resulting from drift and failure to recruit. Because insect colonization (the predominant invertebrate group in streams) is sometimes possible via aerial dispersal, frequency was estimated for conditions where the effect of areal extent (see Item 1c) or spatial scale of the disturbance (see Item 2) is minimal. However, on a case-by-case basis, if the disturbance by ionic concentration is spatially extensive, the frequency recommendation for these criteria might not be protective (Smith et al., 2009; Lindberg et al., 2011; Bernhardt et al., 2012). Wallace (1990) defines persistence (see Item 3) as continuation of exposure in the environment after cessation of new inputs. Because salts are highly soluble in water, they are flushed downstream (in flowing waters) when loading stops, and therefore, they are not persistent chemicals in the sense defined by Wallace (1990) although lag times can be long when contaminated groundwater flows to surface waters. Although intermittent releases of water with high specific SC result in intermittent exposures, the aquatic impacts appear to be long term owing to persistent exposures (U.S. EPA, 2011b; Pond et al., 2014; Evans et al., 2014; Williams, 1996; Feminella, 1996; Delucchi, 1988; del Rosario and Resh, 2000). Recolonization rates from upstream sources or connected tributaries that provide a source of drifting juveniles

was not used to estimate frequency so as to provide a conservative estimate and because in some situations, such as headwater streams, there may not be an upstream source of recolonizing juveniles (see Item 6). Using these conditions, the life history of salt-intolerant benthic invertebrates (see Item 5) is considered with respect to recolonization potential (vagility) (see Item 4) from aerial dispersal of adults and oviposition.

3.4.1. Recovery Rates in Literature Reviews

The frequency parameter for this method is estimated from ecosystem recovery rates following disturbance as reported in the literature. In this case, frequency is an estimate of the period of time between macroinvertebrate extirpation and recovery (reestablishment) of the population. The estimate of time to recovery is based on life cycles and natural history. The assessment is supported by a literature review of the recovery of aquatic macroinvertebrates following chemical and nonchemical-induced effects in 31 nonflowing systems (lentic) and 111 flowing (lotic) systems reviewed by Niemi et al. (1990) and more than 12 streams reviewed by Wallace (1990). Niemi et al. (1990) indicated that recovery time was less than 3 years *except* when (1) the disturbance resulted in physical alteration of the existing habitat, (2) residual pollutants remained in the system, or (3) the system was isolated and recolonization was suppressed. The frequency estimated for SC criteria applies when the three factors listed above are not operative; that is, physical alteration has not taken place, pollutants are flushed from the system, and colonization is possible.

Ionic regimes may be long lasting. In a study of 15 valley fills, Pond et al. (2014) found that SC remained elevated 11–33 years after reclamation. Despite good instream habitat, nearly 90% of these streams exhibited biological impairment. Valley fill sites with higher index scores were near unaffected tributaries, an indication that drifting colonists accounted for the presence of sensitive taxa. Based on 137 valley fills, Evans et al. (2014) estimated that it would take approximately 20 years to potentially attain SC levels <500 µS/cm after initiation of valley-fill construction. These two studies underscore the fact that although recovery can occur within 3 years when the exposure no longer exists, some streams may take decades to return to levels that salt-intolerant genera can tolerate and maintain viable populations.

Wallace (1990) also indicated that the definition of recovery was inconsistently applied in the scientific literature and in most cases true recovery was not attained within the study interval;

that is, some species had recolonized but the original assemblage was altered. Many other studies of invertebrate recovery times from single events, such as toxic chemical spills, floods, pesticides, drought, and organic pollution, indicate recovery times of a few months to several years (e.g., Kattwinkel et al., 2012; Molles, 1985; Minshall et al., 1983; Heckman, 1983; Fisher et al., 1982; Hynes, 1960; Mebane et al., 2015). However, in some situations, biological communities may have faster recovery times (Wood and Dykes, 2002) if the exposure duration is short and if there are upstream sources for recolonization. In a more recent review of 200 studies with pesticide exposures, Kattwinkel et al. (2012) reported that migration from upstream uncontaminated areas is a main driver for recovery and that recolonization varied with generation time and source of migrants; however, upstream sources of colonizers may not be present (e.g., in headwater streams). Faster recovery times were related to drift from external sources (Caquet et al., 2007; Liess and Schulz, 1999) or untreated refugia (Brock et al., 2009). Salt-intolerant univoltine species (life cycles of 1 year) do not recover within 1 year after exposure (Liess and Beketov, 2011; Liess and Schulz, 1999). Overall, most studies reported that recovery took two or more generations and as many as five generations even with upstream sources that can recolonize by drift. Furthermore, there is a trend of longer population recovery time with increasing generation time; species with long generation cycles often take longer for population recovery.

Most of the macroinvertebrate genera sensitive to ionic stress have a univoltine generation time (1-year life cycle), and therefore, their recovery time is likely to be longer compared to multivoltine genera (having less than 1-year life cycles). Where recolonization by juveniles drifting from upstream refugia is not possible, aerial dispersal from nearby streams would be necessary to reestablish populations of aquatic insects; in this case, recovery may take longer than 3 years. The frequency recommended for this method assumes there are either sources from upstream or airborn dispersal for recolonization.

In summary, if the concentration of major ions in a stream can be returned to levels that are capable of supporting aquatic life, and if the physical habitat is suitable, and if there are opportunities for recolonization from an upstream source and/or through aerial dispersal from nearby streams, then the allowable recommended frequency of exceedance for criteria derived using this method is once every 3 years. If any of these conditions are not met, then the

frequency parameter is expected to be more than 3 years, because the stream lacks the ability to recover within that span of time.

3.4.2. Life History Considerations

Often, more than 90% of benthic invertebrates in streams are insects. Several of the most salt-intolerant benthic insects (e.g., mayflies, stoneflies, caddisflies, and true flies) have a 1–2 year life cycle with emergence, mating, and early development occurring in the spring months (Merritt and Cummins, 1996; Brittain, 1982; Clifford, 1982). Hypothetically, if a univoltine genus is extirpated in the first year and in the following spring migrating insects laid eggs, offspring from the colonizers would be large enough to be observed in the collections the following year (i.e., 2 years after the initial extirpation event). Assuming that a recovered population required two reproductive seasons (Liess and Beketov, 2011; Liess and Schulz, 1999), the earliest measurable recovery would be the year after that, or 3 years after the initial extirpation event. The genetic diversity of the population founded by a few colonists may be low (i.e., the founder effect) and as a result the population may be less resilient.

Gastropods, amphipods, isopods, and crayfish tend to be more tolerant to ionic stress (see Appendix E); these taxa would likely remain provided that SC levels did not exceed their predicted extirpation concentrations. Extirpation of most noninsect benthic invertebrates is not expected to occur if the yearly average is <960 µS/cm, the XC_{95} of the most salt-intolerant crustacean based on values calculated using a combined data set from Case Studies I and II (U.S. EPA, 2011a, see Appendix D). The natural history of fish suggests that they may be able to recolonize quickly due to their greater mobility; however, immigration may be limited for some species because they are endemic to specific drainages or there may be barriers to emigration (Hitt and Chambers, 2014; see Appendix G). Unionid mussels were not evaluated by the EPA, but some field and laboratory studies suggest that Unionidae are also salt-intolerant (Price et al., 2014; Gillis, 2011; Wang et al., 2013, Kunz et al., 2013). If immigration of fish is restricted or if less mobile species such as mollusks and crayfish are extirpated, their recolonization could take much longer than 3 years, or may require reestablishing a colonizing population by stocking (Wallace, 1990).

3.4.3. Summary for Field-Based Frequency for Criterion Continuous Concentration (CCC) and Criterion Maximum Exposure Concentration (CMEC)

If SC criteria derived using this method are exceeded, it is expected that at least 5% of macroinvertebrate genera will be extirpated, and many more genera will have been exposed to levels that reduce their occurrence (U.S. EPA, 2011a). However, recovery is expected to occur in 3 years if the following conditions are met: (1) the SC regime returns to a yearly average below the CCC, (2) there are nearby streams with low SC supporting a diverse community, and (3) there is an upstream source of colonizers or the flight or recolonizing distance is within the dispersal range of genetically diverse, reproducing adult colonizers. This frequency recommendation is based on consideration of the life history of insects that are able to recolonize a site by drifting from upstream sites or aerially dispersing from a nearby stream, and published studies of recovery of stream communities. If any of these conditions are not met, the time necessary for community recovery (and thus, the allowable frequency of exceedance) would likely be longer than 3 years.

3.5. ASSESSING CAUSATION

Field studies can generate statistical relationships between environmental attributes and biological responses, but those relationships are not necessarily causal. Epidemiologists evaluate whether an apparent relationship is causal by weighing evidence of causation in terms of lists of considerations (Norton et al., 2015). General causation between SC and macroinvertebrate occurrences was previously assessed (U.S. EPA, 2011a; Cormier et al., 2013b) and therefore does not need to be repeated. Many other studies have corroborated that assessment for the particular ionic mixture, Ca^{2+}, Mg^{2+}, HCO_3^- and SO_4^{2-}, and for different salt mixtures, e.g., Na^+, K^+, HCO_3^- and SO_4^{2-}, and Na^+ and Cl^- (see Section 2.2). A new general causal assessment is recommended when it is uncertain whether an agent, for example a newly synthesized chemical or novel mixture, can or has ever harmed aquatic life. If a new causal assessment is warranted, EPA recommends using epidemiological methods to demonstrate that the agent or mixture can and does cause extirpation at concentrations using the method described in the *EPA Benchmark Report* (U.S. EPA, 2011a; Cormier and Suter, 2013b). The causal assessment methodology does not compare the relative importance of ionic-induced impairment with other known stressors such as metal toxicity, stream bed erosion and siltation, or eutrophication (U.S. EPA, 2011b; Gerritsen et al., 2010). Effects from these stressors are likely to occur and do occur in any given

ecoregion and at times concurrently with increased ionic inputs. Rather, the causal assessment is designed to determine whether the addition of ions to streams can and does cause extirpation of aquatic life.

Although causal assessments of most ionic mixtures do not need to be repeated, it is good practice to evaluate the predictive performance of the XCD model, that is, how well the model characterizes the modeled relationship, e.g., SC and extirpation. See Section 3.1.1.2.6 for analytical approaches for assessing potential confounders.

In summary, the causal relationship between elevated ionic concentration and extirpation of macroinvertebrates can be assessed using an approach modified from Hill's (1965) considerations (for complete details see Appendix A in U.S. EPA, 2011a; Cormier et al., 2013b). Hill's approach for establishing a probable causal relationship has been adapted for ecological applications (Cormier et al., 2010; Fox, 1991; Suter et al., 2001; U.S. EPA, 2000b). Based on that assessment, the body of evidence indicates that the loss of macroinvertebrate genera occurs where SC is high even when potentially confounding causes are low, but is rare when SC is low. Furthermore, there are sources of ions that increase stream SC in the region, and aquatic organisms are directly exposed to these ions. Physiological laboratory studies indicate that ionic gradients in high SC streams would not favor the exchange of ions across gill epithelia and that physiological functions of organisms are affected by elevated ionic concentration. Some genera, composite metrics, and assemblages are affected at sites with higher SC, while others are not. Laboratory studies using moderately salt-intolerant species and ionic compositions relevant to the study area support ionic stress as a cause of extirpation; and increased exposure to ionic stress affects macroinvertebrate abundance and diversity based on field observations. More recently, mesocosm studies have corroborated adverse effects at similar exposures (Clements and Kotalik, 2016).

The causal assessment confirmed that the mixture of ions in streams with elevated SC and neutral or somewhat alkaline waters can and is causing the extirpation of salt-intolerant genera of macroinvertebrates as well as in low pH systems (U.S. EPA, 2011a; Cormier et al., 2013b). The relative SC level of waters with a similar ionic composition, rather than any individual constituent of the mixture, is implicated as the cause of impairment (see Section 2.5.1). The causal relationship describes how *Ephemeroptera* and similarly salt-intolerant invertebrates, in general, respond to ionic stress and does not require that the

species or genera be the same in all applications or at all locations. Although the specific constituents of the ionic mixture were not individually assessed, the cause of impairment is attributable to one or more of the primary constituents of the mixture. Therefore, based on the causal assessment (U.S. EPA, 2011a), it is expected that SC levels sufficient to cause extirpations would occur with a similar salt mixture containing HCO_3^-, SO_4^{2-}, Ca^{2+}, and Mg^{2+} in other regions. Furthermore, based on other studies (see Section 2.2), different salt mixtures also cause extirpation, e.g., Na^+, K^+, HCO_3^- and SO_4^{2-}, and Na^+ and Cl^-.

3.6. ASSESSING WATERBODY APPLICABILITY

3.6.1. Stream pH

Due to the nature of ions and pH, it is important to consider the potential impact of pH on the XCD. Acidity (e.g., associated with acid mine drainage, atmospheric deposition and other sources) and potentially associated dissolved metals could affect the field-based XC_{95} values and the XCD model. As a result, unless shown to the contrary, it is recommended that sites with pH <6 be excluded from data sets prior to analysis.

In Case Studies I and II provided in Sections 4 and 5, sites with pH <6 were excluded from the data set prior to analysis. Therefore, the case studies were developed without the influence of pH, analogous to controlling for confounders in a laboratory test. Nevertheless, field data show that even below pH 4.5, high SC was a stronger predictor than acidity on the occurrence of *Ephemeroptera* (see Appendix B in U.S. EPA, 2011a). A contingency table showed that *Ephemeroptera* were observed at low pH unless SC was high. Also, calculating the HC_{05} using the data set from the *EPA Benchmark Report* (U.S. EPA, 2011a), with and without the inclusion of low pH sites, yielded very similar results (295 µS/cm for all sites compared to 288 µS/cm pH <6 sites removed). Therefore, although EPA recommends the removal of pH sites from the data set prior to analysis, there is evidence to suggest that the derived criteria are applicable to all streams regardless of pH.

3.6.2. Waterbody Type

Another important consideration when it comes to applicability of the field-based approach is waterbody size and type. The EPA recommends analyzing the effect of catchment size on the XCD model and documenting the decision, rationale, and supporting analyses for

applicable water body types for SC criteria derived using this method. For example, in Case Study I, the data used to derive the CCC are from perennial streams with catchments that range from 0.34 to 17,985 km^2. Literature reviews and analyses (described below) were performed in the Problem Formulation phase of this assessment to determine relevant (applicable) waterbody types. As a result, all stream types and sizes were included in the data sets for these case studies.

Although the field data used in the case studies were only collected from perennial streams, available information from the open literature indicates that many of the macroinvertebrate taxa persist in intermittent and perennial channels, albeit at different densities and for varying amounts of time. For example, Grubbs (2010) assessed the relationship between stream-flow permanence and macroinvertebrate community structure along temporary and perennial hydrologic gradients in forested headwater streams in a Cumberland Plateau watershed in the Kentucky River Basin. Grubbs found that the vast majority (91 out of 108) of macroinvertebrate taxa were observed in both the perennial and temporary channels. Macroinvertebrate taxa have many adaptations to survive temporary dry periods including egg diapause, nymph aestivation, and nymph migration into hyporheic zones (the area beneath a streambed, where shallow groundwater and surface water mix) or intermittent pools (Datry, 2012). Macroinvertebrates may use temporary stream resources for portions of their life cycle (e.g., nursery habitat) and move downstream as they get older and larger and conditions require emigration to areas of greater flow (De Jong and Canton, 2013; Feminella, 1996; Stout and Wallace, 2003). These studies suggest that temporary streams are used, at least for a portion of their life cycle, by many of the macroinvertebrate taxa considered in the XCD method.

Discharge to ephemeral streams ultimately affects downstream intermittent/perennial streams (via gravity and flow through the tributary system during precipitation events). As a result, addressing SC in upstream ephemeral streams is often critical to ensuring that downstream aquatic life is not exposed to harmful levels of SC above the criteria.

Although intermittent and perennial streams are likely to have similar SC regimes, larger catchments may not have the same background SC as smaller streams owing to hydrological contributions from different geologies or other factors. Options include limiting the use of derived criteria to the range of sampled catchments represented in the data set, developing criteria for different stream classes, or demonstrating that there is no difference due to catchment size.

In the *EPA Benchmark Report*, larger streams (catchment areas >155 km^2) were originally screened from the data set that was used because sampling methods might differ for nonwadeable streams (U.S. EPA, 2011a; Flotemersch et al., 2006). However, a subsequent analysis indicated that 25 of the 30 most salt-intolerant genera based on derived XC_{95} values for Ecoregions 69 and 70 (see Appendix E) were documented in these larger rivers (see also Appendix B in U.S. EPA, 2011a). Inclusion of the data from large streams did not significantly change the magnitude of the HC_{05} (289 µS/cm) compared to the HC_{05} without data from larger systems (295 µS/cm). Additional analyses support that result. An analysis of 3,115 sites (3,736 samples total: 1,661 in Ecoregion 69 and 2,075 in Ecoregion 70) with drainage areas up to 17,986 km^2 suggests that SC and drainage area are very weakly correlated ($r^2 = 0.044$, see Figure 3-8). These are neither random samples nor reference streams and may not represent natural background. The apparent background SC, estimated as the 25th centile of probability sites, for streams draining areas >155 km^2 in Ecoregion 69 and 70 are 148 and 188 µS/cm, respectively; both of these estimates are within the confidence bounds for estimated background SC using the example criterion-derivation data sets. Therefore, the example ecoregional criteria in the case studies are relevant for all stream sizes. However, professional judgment is warranted when applying the example criteria to streams crossing ecoregional boundaries and stream catchments draining >1,000 km^2 because they are less well represented in the data sets (see Figure 3-8). For example, great rivers such as the Ohio and Mississippi Rivers were not represented in the data set, and they cross many ecoregional boundaries.

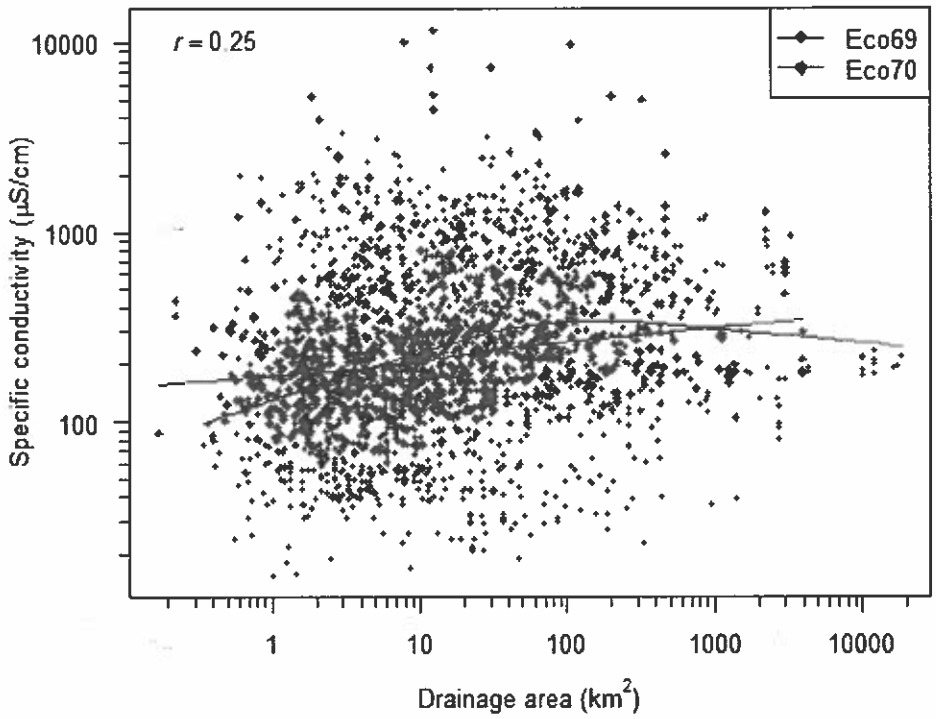


Figure 3-8. Correlation of specific conductivity and drainage area up to 17,986 km², Spearman's $r = 0.25$. This analysis shows a very weak correlation between specific conductivity and drainage area and supports inclusion of data from all stream sizes in the data set for example criteria derivation. The fitted lines are the locally weighted scatterplot smoothing (LOWESS, span = 0.75, linear polynomial) for each data set.

3.7. METHODS FOR APPLICATIONS TO NEW AREAS

Not all areas of the country have sufficient water chemistry and biology data to derive criteria for SC by the XCD method of calculating XC_{95} and HC_{05} values. For such cases, the EPA is providing alternative methods that geographically extend results of the primary XCD method (see Section 3.1). One alternative method extends criteria developed in one area to other areas within the same ecoregion. This method is termed background matching. A second alternative method estimates criteria for new areas with different background SC using a background-to-criterion regression model. Both of these methods rely on the estimated background SC.

The feasibility of applying a conductivity benchmark outside its area of derivation was considered by the EPA SAB in their review of the *EPA Benchmark Report* (see Section 3.7

Transferability of the Method to Other Regions in U.S. EPA, 2011c). In general, the SAB concluded that the numeric benchmark was applicable to the regions where the field data were collected and could be applicable to other areas where sufficient data allow for evaluation of applicability of the benchmark. Since then, the EPA has developed an understanding of the mechanistic relationship between background SC and the extirpation of salt-intolerant invertebrates. This relationship allows the EPA to relate HC_{05} values from one area to another based on background SC.

Background SC in a region and the associated HC_{05} are expected to be strongly related based on ecological and evolutionary theory and the observed responses of invertebrates to major ions (see Section 2.4). The most salt-intolerant invertebrates occur in streams with the lowest background SC (see Appendix D). As SC increases, the most salt-intolerant species are adversely affected and ultimately cannot persist. As a result, where regional background SC is higher, those taxa adapted to low SC are absent, and the SC level that is protective of 95% of taxa (HC_{05}) is higher.

The EPA developed the B-C method using 24 field XCDs from ecoregions with background SC ranging from 22 to 626 µS/cm. Relatively salt-intolerant genera, as indicated by low XC_{95} values, occupy habitats in each region with the lowest ionic concentration. When both are log-scaled, the increase in background SC is linearly related to the HC_{05}. This regular and biologically relevant relationship between background SC and the HC_{05} confirms that the lower portion of the XCDs are similar in similarly exposed communities even though the represented genera may differ among ecoregions. The relationship between background SC and the HC_{05} identified from the XCD is sufficiently strong to identify a CCC for areas with sufficient stream chemistry data but little or no paired biological data within an ecoregion or for new ecoregions (see Appendix D).

The association between background SC and the HC_{05} was used to develop the background matching approach and the approach using the B-C method described in Sections 3.7.1 and 3.7.2, respectively.

3.7.1. Application within an Ecoregion—Background Matching

If paired SC and biological data are not available for a new area within an ecoregion, the background SC may be used to assess applicability of the derived CCC to the new area using a

technique called background-matching. Regional background SC is defined here as the range of SC naturally occurring in waters that have not been affected by human activity. Background SC is important to water quality protection because it represents the ionic concentrations to which organisms in the region are naturally adapted. Minimally affected waters with low SC play a particularly important role by diluting polluted downstream waters and serving as refugia for salt-intolerant organisms. The background-matching approach is demonstrated in Case Studies I and II (see Sections 4 and 5) for the new areas within an ecoregion that were not included in the original example criterion-derivation data sets.

In this discussion, the phrase, original area, refers to the geographic area from which the data are obtained to develop SC criteria using the XCD method. The phrase, new area, refers to a geographic area within the same Level III ecoregion that was not represented in the criterion derivation data set. When applying field based SC criteria developed with data from the original area to a new area, the background SC levels and the ion composition should be similar in both areas. For instance, the example criteria are derived with data for streams where the ionic mixture is dominated on a mass basis by $([SO_4^{2-}] + [HCO_3^-]) > [Cl^-]$.

The relationship between background SC and the HC_{05} identified from the XCDs is sufficiently strong to identify a HC_{05} for areas without biological sampling within an ecoregion or for new ecoregions. This B-C regression model was developed using biological data paired with SC data from waters with ionic mixtures dominated by calcium, magnesium, sulfate and bicarbonate ions and where background SC did not exceed 626 µS/cm. Therefore, the model is most appropriate for waters with similar ionic characteristics. The model has not been thoroughly tested and professional judgment is required for places where on a mass basis the major ions are $([HCO_3^-] + [SO_4^{2-}]) < [Cl^-]$ or $([Ca^{2+}] + [Mg^{2+}]) < ([Na^+] + [K^+])$. In particular, the B-C model is not appropriate for waters dominated by NaCl (Haluszczak et al., 2013, Entrekin et al., 2011; Gregory et al., 2011; Veil et al., 2004) or road salt (Forman and Alexander, 1998; Kelly et al., 2008; Environment Canada and Health Canada, 2001; Evans and Frick, 2001; Kaushal et al., 2005). The B-C model may also be defensible for ionic mixtures dominated by sodium, sulfate and bicarbonate ions (Brinck et al., 2008; Dahm et al., 2011; Jackson and Reddy, 2007; National Research Council, 2010; Clark et al., 2001; Veil et al., 2004). This is because the toxicity of these mixtures are more similar to that of calcium, magnesium, sulfate and

bicarbonate ions than the toxicity of NaCl (Mount et al., 2016; Kunz et al., 2013; Soucek and Dickinson, 2015).

In the background-matching approach, the background for the ionic mixture of the new area is compared with the background of the original area. If the 95% CI of the background SC of the new area overlaps with the 95% CI of the background in the original area, the original criterion is considered applicable. If the CIs for the two areas do not overlap, then a dichotomous decision tree is used to guide further evaluations (see Figure 3-9). The dichotomous decision tree for assessing the applicability of criteria from the original area to a new area of an ecoregion may require a weight-of-evidence assessment described in detail in Appendix C, calculation of an HC_{05} using a regression model described in Section 3.7.2 and Appendix D, or collection of sufficient data to derive a different HC_{05} for the new area.

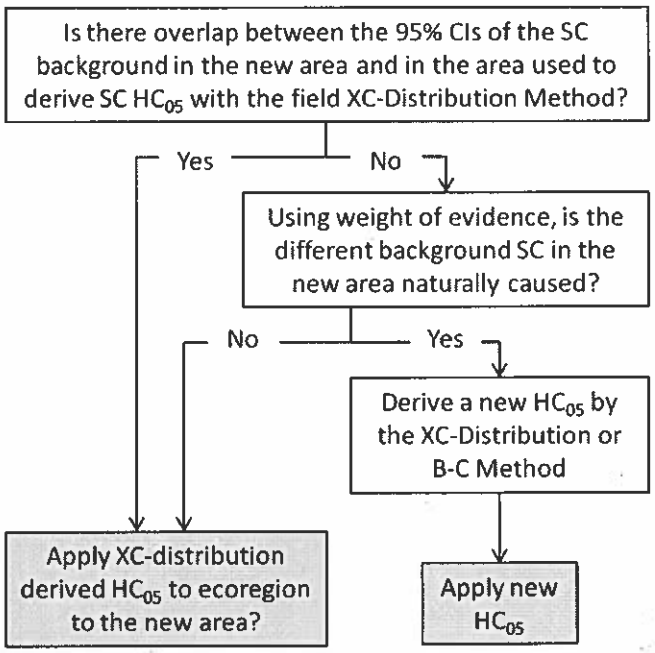


Figure 3-9. Method for selecting a criterion continuous concentration (CCC) for a new area within an ecoregion using minimally affected background. The hazardous concentration of the 5th centile of a taxonomic extirpation concentration distribution (HC_{05}) from a field derived extirpation concentration distribution (field XCD) is one that has been previously developed using a large data set. The background-to-criterion (B-C) method uses a regression model to predict a criterion and confidence interval (CI) from background specific conductivity (SC).

Portions of the same ecoregions in different political jurisdictions are expected to have similar characteristics with respect to the primary factors that control background SC (Hem, 1985, Griffith, 2014, Olson and Hawkins, 2012, see Section 2.1). These primary factors are underlying geology, physiography, and climate; secondary factors include soils and vegetative cover (Olson and Hawkins, 2012; Griffith, 2014; Hem, 1985). Because Level III ecoregions were delineated based on similar considerations (Omernik, 1987), the SC regime and ionic composition of dissolved salts in streams within an ecoregion tend to be similar throughout. However, there may be situations where it is not appropriate to apply criteria derived for the ecoregion to a particular stream reach. For example, naturally lower or higher concentrations of ions may occur due to subecoregional differences such as cross boundary influences, glacial melt, salt springs, highly soluble rock, or other natural sources.

3.7.1.1. *Obtaining a Data Set*

The first step in the background-matching approach is to assemble the data sets from sampled sites that are distributed across the full range of SC conditions in the new area. All else being equal, the larger the data set, the more reliable the estimate of background SC. Next, sites with qualitatively different ionic mixtures are removed from the data set. In the example case studies, chloride-dominated sites are removed from the data set so that background SC is estimated only for sites dominated by sulfate and bicarbonate (i.e., $([HCO_3^-] + [SO_4^{2-}]) > [Cl^-]$ in mg/L). For three of the example case studies, Sections 4, 5, and 7, the dominant cations are Ca^{2+} and Mg^{2+}. For the example case study, Sections 6, the dominant cation is Na^+.

3.7.1.2. *Estimating Background Specific Conductivity (SC)*

If minimally affected background SC is not known, it can be estimated from field data that are representative of SC throughout the year. In particular, the data set should not be biased toward seasonal extremes by sampling only during seasons of freshets or droughts. Background SC may be estimated as a proportion of a regional sample of sites or a sample of reference sites that are judged to be among the best within a region (U.S. EPA, 2011a).

Regional samples from a random or probability-based design (Stevens and Olsen, 2004) include all waters within the sampling frame, including impaired sites. To characterize the minimally affected streams in a regional sample, the 25th centile is conventionally used (U.S. EPA, 2000a). However, when land cover modification (or other anthropogenic disturbance) is pervasive, selection of a centile lower than the 25th may be justifiable.

When estimating background concentrations using minimally affected reference sites, it is conventional to use only the lower 75% of reference values (U.S. EPA, 2000a). One indication of the need for a different centile is when reference sites have a broad range of SC values suggesting that the reference condition contains some sites with anthropogenic disturbance, or that the sites are not classified to partition natural variability (e.g., headwaters draining through limestone glacial till into an area of weathered bedrock). An expanded list of possible considerations is provided in Appendix C. When there is great confidence in the quality of reference sites, a 90th centile may be used.

When there are sufficient good quality reference sites, the regional and reference methods yield similar background estimates (NYSDEC, 2000, TDEC, 2000, U.S. EPA, 2000a). But, in

general, estimation based on a random sample of the region tends to yield a more accurate estimate of current background when there are sufficient data to characterize the full distribution of SC in the region. Unlike the selection of reference sites, a random sample does not depend on the original intent of data collection or the judgement of the data collectors (Whittier et al., 2007a, b).

After estimating background SC for both the original and new areas using the method in this section, the background-matching approach requires estimating their variability so that confidence intervals can be calculated. The confidence interval for a background SC estimate can be calculated using a bootstrapping technique. Bootstrapping is a statistical resampling technique that is often used in environmental studies to estimate confidence limits of a parameter. This bootstrapping application involves randomly resampling the original water chemistry data set 1,000 times with replacement, storing the 1,000 data sets, calculating the background for each data set, and then estimating the 95% CI for the mean of the set of 1,000 background values generated by the bootstrapping procedure. This is similar to the procedure described in Section 3.1.3.1.

3.7.1.3. *Background-Matching Approach*

Once the means and confidence limits on the background SC in the original area and new area have been estimated, they can be compared to determine whether they sufficiently match using the decision criteria depicted in Figure 3-9.

1. If the 95% CI of the background SC values from the new area overlaps with the 95% CI of the background SC values from the original area, then apply the XCD derived HC_{05} for that ecoregion throughout the new area.

2. If the 95% CIs do not overlap, then use a weight-of-evidence approach to determine whether the background in the new area represents natural or anthropogenic sources as described in Appendix C.

3. If the difference in 95% CIs is due to anthropogenic alteration, then apply the XCD derived HC_{05} from the original area to the new area.

4. If the difference in SC is naturally caused by geology, climate, or other natural factors, then derive a new HC_{05} for the new area using a sufficiently large and appropriate data set from the new area (see Section 3.1) or calculate an HC_{05} based on background SC for the new area using the B-C regression method (see Section 3.8).

For example, the decision matrix was used to determine the applicability of XCD SC criteria from an original area to a new area using this background-matching approach (see Example Case Studies in Sections 4 and 5).

3.7.1.4. *Options When Background in New Area is Different than in Original Area*

If the estimated background SC is higher or lower in the new area and the ion composition is similar compared to the original area, two possible causes should be considered. First, differences may be due to natural geological factors (e.g., higher SC due to salt springs, lower SC due to glacial melt, or other differences due to natural geological features) or to climatological factors. In these situations, criteria for the new area can be developed using either the XCD method or the B-C regression method. Second, differences may be due to widespread anthropogenic changes that have increased the apparent background (e.g., due to irrigation, agriculture, impervious surfaces, resource extraction, or acid deposition, etc.). In this second situation, the criteria developed for the original area may or may not be applicable to the new area.

To distinguish between these two possibilities, the cause of the apparent background can be evaluated in a weight of evidence. Considerations may include analysis based on geology, land use, ionic signatures and known inputs, historical and recent trend analysis, atmospheric sources, discontinuities in background across political boundaries, identification of high and low SC anomalies, stream size and connectivity, data set characteristics, sampling methods, and biological evidence of past and present observation of susceptible genera (see Appendix C).

3.7.1.5. *Summary of Background Matching Method*

The original criteria are ***applicable*** to a new area in the same region if the background SC is not different from the background of the original area (i.e., overlapping 95% CIs) and the ionic mixture is the same (e.g., in the case studies, $([HCO_3^-] + [SO_4^{2-}]) \geq [Cl^-]$ in mg/L). The original criteria are ***not applicable*** to the new area if the background for the ionic mixture is different owing to natural causes or if the ionic mixture is different. If the background SC is higher or lower than the original background, a new criterion may need to be developed for the new area. A weight-of-evidence analysis can be done to evaluate whether the difference in background SC

is due to natural causes. When possible, an independent data set should be used to corroborate the estimates of background SC.

3.7.2. Developing a Criterion Using Background-to-Criterion Regression Method

Because large sets of paired chemical and biological data are not available for all ecoregions in the United States, the EPA developed a model to calculate a CCC using the background SC of an ecoregion. The B-C regression method can be used in a new ecoregion or a new area within an ecoregion with a different SC regime (e.g., at a scale smaller than Level III ecoregions).

The relationship between minimally affected background SC and HC_{05} for 24 Level III ecoregions was characterized using least squares linear regression (see Figure 3-10). The relationship between background SC and HC_{05} was modeled and the association was strong ($r = 0.93$), as was expected given the importance of the concentrations of major ions in defining the tolerance of species (see Section 2.4). The relationship between background SC and HC_{05} is sufficiently reliable for identifying a CCC for areas without biological sampling within an ecoregion or for new ecoregions (see Appendix D).

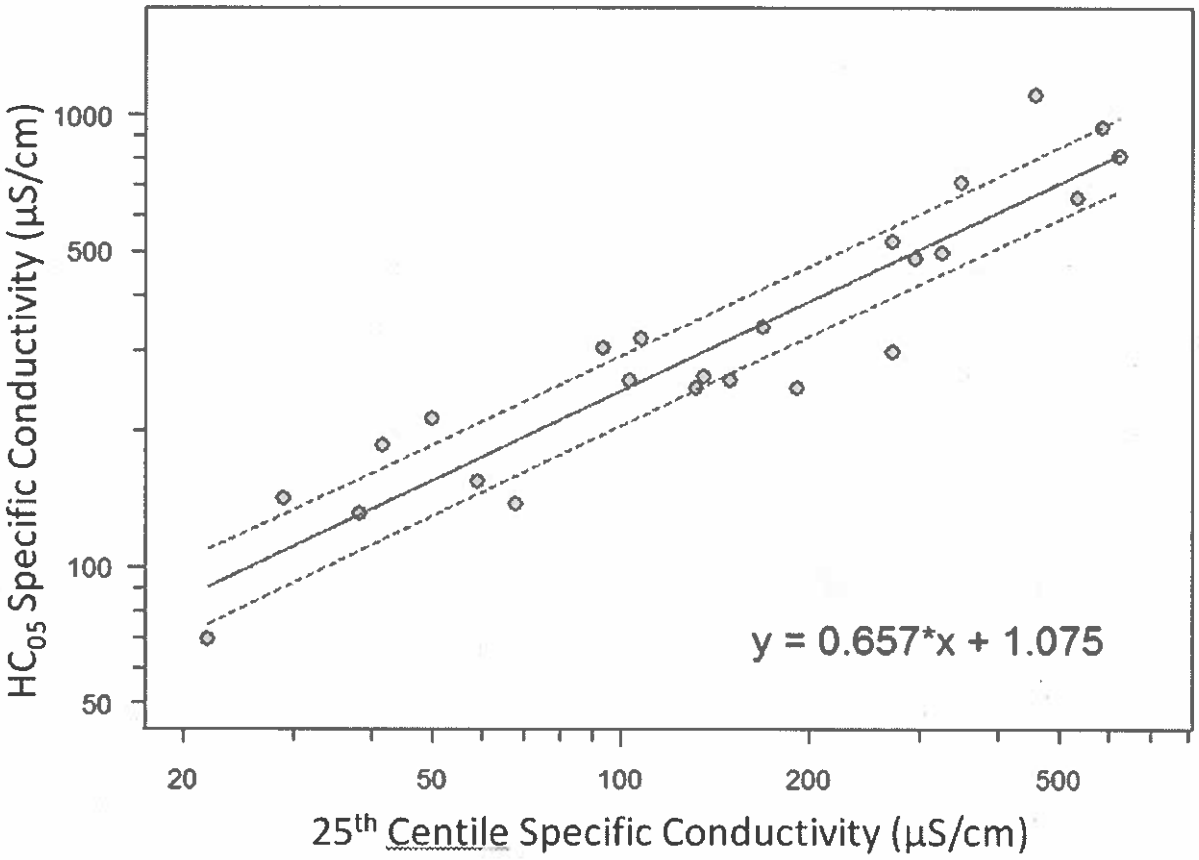


Figure 3-10. Empirical model of the 5th centile of a hazardous concentration (HC_{05}) and background specific conductivity (SC) estimated at the 25th centile for 23 distinct ecoregions (24 data sets). Solid line is the log10-log10 normal regression line; therefore, *x* and *y* are log10 expressions. Dotted lines demarcate the 50% prediction intervals, that is, the 50% probability that any new HC_{05} would plot within those bounds and only 25% below the lower prediction limit (PL). The regression coefficient $R^2 = 0.87$.

The B-C regression method shown in Figure 3-10 was derived using independent data sets from 24 ecoregions (see Appendix D). First, SC XC_{95} values were estimated. From these, 24 genus-level XCDs were constructed and HC_{05} values derived. Those HC_{05} values were regressed against the estimate of background SC for each ecoregion. In an ecoregion with low background SC, very salt-intolerant taxa are represented. In an ecoregion with a moderate background SC, taxa with an XC_{95} greater than the moderate background are likely to survive and contribute to the XCD, whereas salt-intolerant taxa with XC_{95} values less than the moderate background are not likely to contribute to the XCD. As XCDs are developed for ecoregions with

increasingly higher background SC levels, each XCD begins at a higher background SC, and thus the most salt-intolerant genera in an ecoregion occur at progressively higher SC levels. This association is evidence that where low ionic concentration waters are present in an ecoregion, organisms that are specialized for that niche are likely to inhabit them; and, where low ionic concentration waters are not present, salt-intolerant species are not likely to occur. The resulting B-C regression model provides a convenient method to predict an HC_{05} from the minimally affected or least disturbed background SC of an ecoregion. Descriptions of the derivation of the regression model, the data sets used, and the individual XCD models are presented in Appendix D.

The central tendency of a regression model is more robust than any single measurement. For the purpose of model development, data requirements were relaxed relative to those for calculating a HC_{05} using the XCD method (i.e., fewer than 90 genera across 500 sites) (see Appendix D for a description of data requirements for the B-C method). Individually, many of the 24 HC_{05} values used to develop the B-C method have not been subject to analyses needed for development of a CCC and should be considered as provisional. For example, the HC_{05} estimates used in this model were not supported by full confounding analyses, as is described in the *EPA Benchmark Report* (U.S. EPA, 2011a). However, the true HC_{05} value is expected lie between the upper and lower 50% prediction limit (PL). Values in Appendix D, Table D-3 are provisional with a good degree of confidence owing to the larger sample sizes (>60 samples) used to estimate background SC. Table D-4 lists ecoregions with background estimates based on modest survey data sets ($N = 20–60$ samples) and would benefit from additional sampling to confirm the calculated background SC and the calculated HC_{05}. Table D-5 lists ecoregions where the data set may represent fewer than 25% minimally affected streams and therefore are protective of aquatic life in least disturbed streams. Table D-6 lists ecoregions that may not be served by the B-C method because the ionic mixture is likely to be different (e.g., chloride dominated), the estimated natural background SC exceeds the range of the model, and/or there were fewer than 20 samples available. In all cases, the EPA recommends using the largest data set possible to estimate background SC, understanding and accounting for areas with different (higher or lower) background SC, and performing independent calculations to derive HC_{05} values.

3.7.2.1. *Using Background to Calculate a Hazardous Concentration of the 5th centile (HC_{05}) of a Taxonomic Extirpation Concentration Distribution (XCD)*

The HC_{05} for a defined geographic area or ecoregion without a sufficient data set or without suitable biological data may be calculated using the B-C method based on the background SC of that area or region. The decision tree for calculating a CCC from minimally affected background is shown in Figure 3-11. Equations 3-1 and 3-4 can be used to calculate the mean HC_{05} and eq 3-5 calculates the lower 50% PL for the area or region. Sections 6 and 7 provide examples that use the decision tree to develop example criteria for 2 ecoregions in the West, one with low and one moderately high background SC.

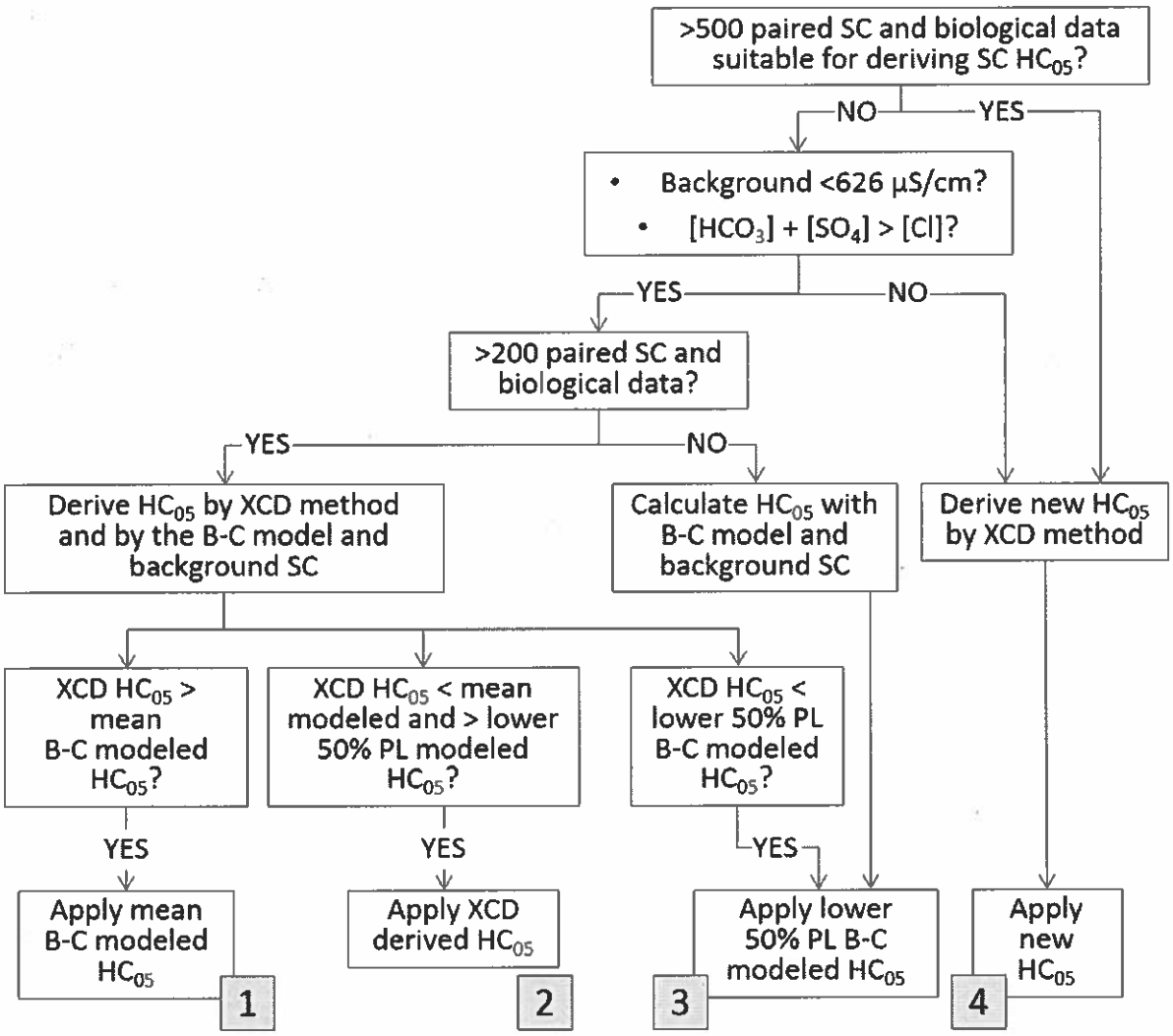


Figure 3-11. A decision tree for calculating and applying a hazardous concentration of the 5th centile of a hazardous concentration (HC_{05}). This flow chart may be used when developing a criterion continuous concentration (CCC) for new ecoregion, a new area within an ecoregion, or other defined geographic area using the field extirpation concentration distribution (XCD) method, background-to-criterion (B-C) method and minimally affected or least disturbed background specific conductivity (SC). Numbered product paths are described in the body of the text.

Where the background is less than 626 µS/cm and the waters have a similar ion composition to those used to derive the model, the B-C method can be used (see Figure 3-11). Where there are >200 but <500 sites with paired biological and SC data, HC_{05} values are derived using the XCD method and compared to the mean and lower 50% PL of the B-C model. These

values are compared to select the appropriate HC_{05} as follows. (1) If the XCD HC_{05} (see eq 3-1) is greater than the mean B-C modeled HC_{05} (see eq 3-4), then the mean B-C modeled HC_{05} is recommended (see eq 3-4) as a conservative approach to account for uncertainty associated with a smaller data set. (2) If the XCD HC_{05} is between the mean B-C modeled HC_{05} and the lower 50% PL, then the XCD HC_{05} is recommended because the XCD from measured data from the region is more likely to represent the region than the more general B-C model. (3) If the XCD estimate is below the lower 50% PL, then the lower 50% PL is recommended as the HC_{05} (see eq 3-5). This is recommended because the XCD is calculated from a smaller data set. Also, it may be overly protective because it is more uncertain than the modeled results which indicate that 75% of HC_{05} values from areas with a similar background SC are estimated to be greater than a value less than the lower PL. The lower 50% PL is also recommended when there are fewer than 200 paired biological samples because there is no XCD for comparison. For both situations, the SC data and the B-C model is used to estimate the HC_{05}. (4) Where the background SC is greater than 626 µS/cm, the range of the model is exceeded, and it is recommended that data be collected to derive the HC_{05} using the XCD method (see Section 3.1).

3.7.2.2. *Formula for Calculating the Hazardous Concentration of the 5th centile of a Taxonomic Extirpation Concentration Distribution (HC_{05}) from the Background-to-Criterion Model*

The B-C model is described by the following formula:

$$Y = 0.657X + 1.075. \quad (3\text{-}4)$$

Where:

X is the log10 of the ecoregional background SC

Y is the log10 of the predicted HC_{05}

3.7.2.3. *Formula for Calculating the Lower and Upper 10% Prediction Limits*

The upper and lower PL for a predicted log10 HC_{05} value $\hat{y}$ can be calculated from the regression line using eq 3-5 (Zaiontz, 2014) and log10 transformed SC values (x) as follows:

$$\hat{y} \pm t_{\alpha/2,n-2} S_y \sqrt{1 + \frac{1}{n} + \frac{(x^{\circ} - \bar{x})^2}{SS}} = \text{PL} \qquad (3\text{-}5)$$

Symbol	Explanation	Example from the 23 ecoregion B-C model
$\hat{y}$	Log10 of the mean predicted HC_{05}	Variable differs for each case
n	Number of samples	$n = 24$
α	Alpha error rate for prediction interval (desired confidence level)	50% prediction interval ($\alpha = 0.5$)
t_{n-2}	Student's t-value at specified confidence level (alpha, α) and n-2 degrees of freedom	For 50% prediction interval ($\alpha = 0.5$), $t_{(1-0.5)/2,24-2} = 0.686$
S_y	Residual standard error of prediction (standard deviation)	$S_y = 0.11$
SS	Sum of square of x deviation from their mean, $SS = \sum_{i=1}^{n}(x_i - \bar{x})^2$	$SS = 4.21$
$\bar{x}$	Mean x values used in the model generation	$\bar{x} = 2.15$
x°	A new log10 background *(x)* value for a new prediction interval	SC value differs for each case
PL	Upper and lower prediction limits of mean predicted $\hat{y}$	SC value differs for each case

The estimated backgrounds listed in Tables D-3, D-4, and D-5 of Appendix D for 62 of 85 Level III ecoregions were used to estimate the HC_{05} from the B-C model. HC_{05} values and the lower 50% PLs were estimated using eqs 3-4 and 3-5 and estimated background from probability survey data. Predicted base-flow SC (Olson and Hawkins, 2012) was used to assess whether the 25th centile SC used in the calculation is minimally affected (see Tables D-3 and D-4) or least disturbed background SC (see Table D-5). Although the B-C Model is strongly log-linear within the sampled SC range, the EPA recommends estimation of HC_{05} only for ecoregions with a background <626 µS/cm to avoid extrapolation beyond modeled data. Some regions may have different ionic matrices (e.g., chloride-dominant) for which the derivation of a CCC using this method has not been verified. Those ecoregions are identified in Table D-6. The decision tree depicted in Figure 3-11 was used to select example HC_{05} values that if rounded to two significant figures generates an example CCC.

3.7.2.4. *Criterion Continuous Concentration (CCC) with <200 Paired Biological Data*

When there are insufficient paired data, background SC is used to calculate the lower 50% PL of the mean HC_{05} which is rounded to two significant figures to yield the CCC (see eq 3-5). This result is shown in the Box 3 in Figure 3-11. The estimated CCC at the lower 50% PL for 62 ecoregions can be found in Tables D-3, D-4, and D-5 in Appendix D.

3.7.2.5. *Criterion Continuous Concentration (CCC) with 200 to 500 Paired Biological Data*

If a suitable paired biological and SC data set of 200 to 500 sites is available that meets the requirements outlined in Appendix D.2.1, then the HC_{05} is estimated from that data set using the XCD method (see eq 3-1) and the B-C model (see eq 3-4). The lower of the two estimates is recommended as the HC_{05} unless the XCD estimate is below the lower 50% PL from the B-C model (see Figure 3-11). This result is shown in Boxes 1 or 2 in Figure 3-11. If the XCD estimate is less than the lower 50% PL of the HC_{05} from the B-C model, then the lower PL is used (see eq 3-5). This result is shown in Box 3 in Figure 3-11. In either case, the predicted mean or the lower 50% PL HC_{05} is rounded to two significant figures to yield the CCC. The provisional or comparative values for the CCC based on the mean regression line for 62 ecoregions are shown in Tables D-3, D-4 and D-5.

3.7.2.6. *Calculation of the Criterion Maximum Exposure Concentration (CMEC)*

A CMEC based on water chemistry data can be calculated as described in Section 3.2. If there are insufficient data to calculate a CMEC, the upper 50% PL can be used to approximate a CMEC.

3.7.2.7. *Summary*

Although the B-C regression model is strong, there is scatter in the 24 HC_{05} values, so the lower 50% PL is used. In addition, when there are >200 and <500 paired biological and SC data, the XCD method is applied to check the B-C model results. The B-C model can also be used to evaluate estimates with data sets >500 when they do not meet other requirements for the SC range of exposure, unbiased sampling, seasonal bias, etc. Section 6 provides an example case for deriving an HC_{05} for the Northwestern Great Plains, Ecoregion 43 in Montana, Wyoming, North Dakota, South Dakota, and Nebraska. Section 7 provides an example case for deriving an HC_{05}

for the Level III Cascades, Ecoregion 4, in Washington, Oregon, and California. The estimation of an HC_{05} from background described here is a recommended approach for developing water quality criteria for those ecoregions lacking sufficient data to develop one by the XCD method from a regional data set.

4. CASE STUDY I: EXAMPLE USING EXTIRPATION CONCENTRATION DISTRIBUTION (XCD) METHOD IN A LOW BACKGROUND SPECIFIC CONDUCTIVITY ECOREGION

This section presents a case study for the Central Appalachians (Ecoregion 69) to illustrate how the analytical methods described in Section 3 can be used to derive example SC criteria using the XCD method in an ecoregion with low background SC. Ecoregion 69 results, including estimates of the CCC and CMEC, duration, frequency, and discussion of applicability are included as examples to demonstrate the method. The derivations of the CCC and CMEC analyses and results are based on data from Ecoregion 69 in West Virginia, and SC data from the Ecoregion 69 outside of West Virginia was used to assess applicability of the criteria throughout the ecoregion.

4.1. DATA SET CHARACTERISTICS

The Central Appalachians (Ecoregion 69) stretch from central Pennsylvania through West Virginia and Kentucky to northern Tennessee with small portions in Maryland and Virginia. The primary physiographic feature is a high, rugged plateau composed of sandstone, shale, conglomerate, limestone outcroppings, and coal. Elevation ranges from 366 to 1,402 m, with an average elevation of >790 m. Local relief between valleys and peaks can range from as low as 15 m to as high as 594 m. Rainfall is highly variable due to the topographic diversity, ranging from 96–152 cm/year, with the lowest rainfall in valleys and the highest at the peaks. The region is characterized by distinct summer and winter seasons, with growing seasons in agricultural regions (located within valleys) lasting as long as 165 days. However, pasture and agriculture are limited owing to the rugged terrain, cool climate, and infertile soils. The landcover is mostly forested with oak and northern hardwood forests. The high hills and low mountains are covered by a mixed hardwood forest. Underground and surface bituminous coal mines are common (Woods et al., 1999, 1996). Headwater streams in this ecoregion have some of the freshest (lowest SC) water in the United States. These headwater streams play an important role in diluting downstream waters that are anthropogenically impacted, and serve as refugia for fish and other salt-intolerant organisms.

The data used in this case study are from a large field data set, the West Virginia Department of Environmental Protection (WVDEP's) in-house Watershed Assessment Branch

database (WABbase). Chemical and biological samples are from 1996–2011 and 1997–2010, respectively. The WABbase contains data from Level III Ecoregions 66, 67, 69, and 70 in West Virginia (U.S. EPA. 2010; Omernik, 1987; Woods et al., 1996). The WABbase data set provides consistent sampling and analytical methods, high quality, broad spatial coverage and a large number of perennial streams (2,299 distinct locations) in Ecoregion 69.

The WABbase contains data from a mixed sampling design that collects measurements from long-term monitoring stations, targeted sites within watersheds on a rotating basin schedule, randomly selected sample sites (Smithson, 2007), and sites chosen to further define impaired stream segments in support of total maximum daily load (TMDL) development (WVDEP, 2008a). Most sites are sampled once during an annual sampling period, but some sites are sampled monthly for water quality. The data set contains water quality, habitat, watershed characteristics, macroinvertebrate data (both raw data and calculated metrics), and geographic location (WVDEP, 2008a). A wide range of SC levels were sampled, which is useful for modeling the response of organisms to different levels of ionic concentration. The WABbase includes assignation of reference status using a tiered approach. Analyses involving the use of these reference sites were drawn from the Level 1 reference status (WVDEP, 2008b) which selects reference sites that "are thought to represent the characteristics of stream reaches that are minimally affected by human activities and are used to define attainable chemical, biological and habitat conditions for a region" (WVDEP, 2013; Stoddard et al., 2006). Sites are initially selected by a map coordinator based on GIS land use data that indicate minimal human disturbance. Streamside, the appropriateness of the selected site is confirmed based on the level of anthropogenic disturbance, lack of point discharges, habitat quality, pH, dissolved oxygen, and SC (>500 µS/cm) is used to flag a site for further investigation before inclusion as a reference site (WVDEP, 2013).

Macroinvertebrate records in the data set are based on collections from a total of 1 m^2 area of a 100 m reach at each site. Using a 0.5 m wide rectangular kicknet (595 µm mesh), four 0.25 m^2 riffle areas were sampled. In narrow or shallow water, nine areas were sampled with a 0.33 m wide D-frame dipnet of the same mesh size. Composited samples were preserved in 95% denatured ethanol. A random subsample of 200 individuals (±20%) was identified in the laboratory. All contracted analyses for chemistry and macroinvertebrate identification followed WVDEP's internal quality control and quality-assurance protocols (WVDEP, 2008b, 2006).

Quality assurance of the data set was judged by the EPA to be excellent, based on the database itself and supporting documentation.

Several data filters, described in Section 3.1 (see Figure 3-2), were applied prior to finalization of the data set and analyses. A total of 9,806 records from Ecoregion 69 are included in the data set; of these, SC measurements were included in 8,989 samples. Many of these are measurements of water quality without biological sampling. There are 1,911 paired samples with SC measurements and biological samples. Of these, a total of 250 samples were removed from the data set due to low pH ≤6 (237 samples) and high proportion of chloride ions ($[HCO_3^-] + [SO_4^{2-}]) \leq [Cl^-]$ (13 samples). Additional criteria were applied to identify macroinvertebrates for inclusion in the example extirpation concentration distribution: occurrence at reference sites and occurrence in 25 or more samples. Of the 219 macroinvertebrate genera identified in this ecoregion in the WABbase, 193 genera occurred at least once at one of the 64 identified reference sites where invertebrate samples were collected. A total of 142 genera occurred at 25 or more sampling locations. The final example "Criterion-data set" has 1,661 samples belonging to 1,420 sites (stations) (depicted in Figure 4-1). Of these 1,661 samples, 186 (11.2%) were sampled more than once between 1996 and 2010. Summary statistics for the data set used to derive the example CCC is shown in Table 4-1. The statistical package R, Version 2.12.1 (December 2010), was used for all statistical analyses (R Development Core Team, 2011).

SC ranged from 15.4–3,794 µS/cm which allowed the response of organisms to be modeled for a wide range of SC levels. Scatter plots of parameters and SC are depicted in Appendix A.1.

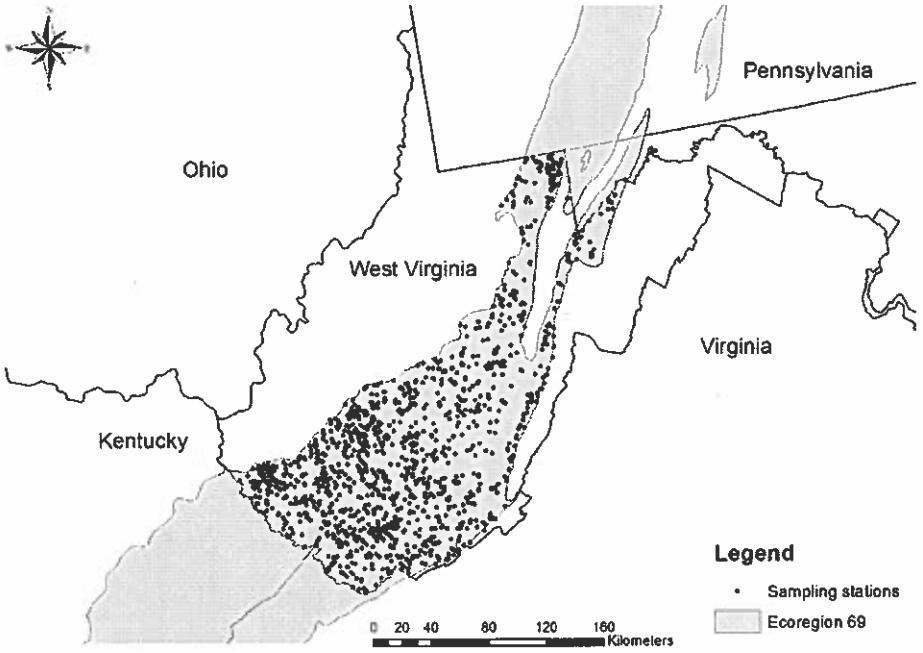


Figure 4-1. Ecoregion 69 extends from central Pennsylvania to northern Tennessee. Sampling sites (stations) (N = 1,420) in the example Criterion-data set that were used to derive the criterion continuous concentration (CCC) are indicated as points.

Table 4-1. Summary statistics of the measured water-quality parameters used to derive the example specific conductivity criteria in Ecoregion 69.
The example Criterion-data set has 1,661 samples belonging to 1,420 stations.

Parameter	Units	Min	25th	50th	75th	Max	Geomean	*N*
SC	µS/cm	15.4	94	229	540	3,794	225	1,661
Hardness	mg/L	2.18	28.03	64.31	132.7	1,492	64.43	834
Total alkalinity	mg/L	2	14	41	90	560	37	1,144
SO_4^{2-}	mg/L	1	12	32	126	2,097	39	1,146
Chloride	mg/L	0.5	2	3	8	650	4	930
$SO_4^{2-} + HCO_3^-$	mg/L	8.66	36.3	99.4	252	2,256	99.3	1,142
Ca, total	mg/L	0.67	6.9	16.9	33.5	430	15.8	842
Mg, total	mg/L	0.5	2.4	5.0	12	204	5.6	832
Na, total	mg/L	0.5	1.8	3.5	13	423	5.2	166
K, total	mg/L	0.5	0.7	1.2	2.4	16	1.4	164
TSS	mg/L	1	3	3	5	80	4	1,151
Fe, total	mg/L	0.02	0.09	0.18	0.38	4.9	0.19	1,170
Fe, dissolved	mg/L	0.01	0.02	0.03	0.07	1.1	0.04	995
Al, total	mg/L	0.01	0.06	0.1	0.19	3.3	0.11	1,142
Al, dissolved	mg/L	0.01	0.02	0.03	0.06	0.9	0.04	1,007
Mn, total	mg/L	0.003	0.02	0.03	0.06	4.4	0.03	1,142
Se, total	mg/L	0	0.001	0.001	0.003	1.3	0.002	665
DO	mg/L	2.06	8.47	9.27	10.2	17.1	9.41	1,644
Total phosphorus	mg/L	0.01	0.02	0.02	0.02	1.3	0.02	897
NO_x	mg/L	0.01	0.14	0.28	0.45	11	0.26	910
Fecal	Counts/100 mL	0.5	15	65	300	250,000	71	1,405
pH	SU	6.01	7.00	7.54	7.97	10.48	7.48	1,661
Catchment area	km^2	0.34	4.36	17.6	65.2	17,986	19.3	1,408
Temperature	°C	−0.28	14.2	17.9	20.7	30.2	17.5	1,661
RBP 10Sc	RBP score	53	126	142	156	195	140	1,641
RBP 7Sc	RBP score	30	84	98	110	137	97	1,647
Embeddedness	RBP score	1	11	13	16	20	13	1,649
Percentage fines (sand + silt)	-	0	10	12	20	100	15	1,620

All means are geometric means except pH, DO, Temperature, and Habitat Scores.
RBP = rapid bioassessment protocol (Barbour et al., 1999; RBP 10Sc has 10 parameters while RBP 7 does not include 3 flow-related parameters); TSS = total suspended solids.

4.1.1. Background Specific Conductivity

Background SC was estimated at the 25th centile of the subset of probability-based samples from the example Criterion-data set because its sampling design more closely matched the ecoregional EPA-survey data set. Using this probability-based subsample of the WABbase data set, the estimated background was 80 µS/cm (25th centile, 585 samples from 544 sites; see Figure 4-2). Background was also estimated to be 63 µS/cm based on field data from reference sites from the WABbase data set (75th centile, 112 samples from 82 reference sites; see Figure 4-3). By comparison, the 25th centile was 94 µS/cm for all samples (reference and nonreference sites) from the example Criterion-data set that was used to derive the HC_{05} (1,661 samples from 1,420 sites; see Figure 4-4). The monthly 25th centiles of probability-sampled sites (see Figure 4-2) and all samples in the data set (reference and nonreference sites, see Figure 4-4) were relatively consistent and at or below 100 µS/cm except in July through October (see Figure 4-2). The effects of seasonal variability of SC on the subsequent analyses was further evaluated and are presented in Appendix A. The large size of the data set and the wide range in SC levels in the example Criterion-data set allowed for characterization of the XC_{95}.

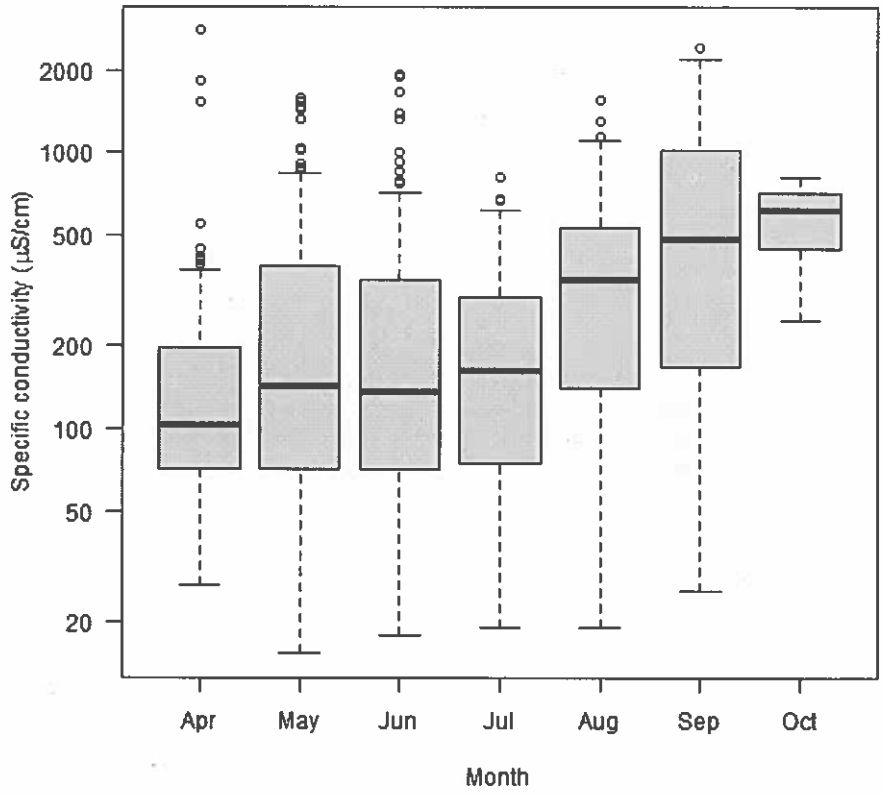


Figure 4-2. Box plot showing seasonal variation of specific conductivity (µS/cm) from probability-sampled sites from Watershed Assessment Branch database (WABbase) 1997–2010. This represents a total of 544 sites with 585 samples from 1997–2010 from Ecoregion 69 with pH >6. Note the difference in scale along the *y*-axis between Figure 4-2 (probability-sampled sites) and Figure 4-3 (reference sites). There are only eight October samples. See Table 4-2 for number of samples per month.

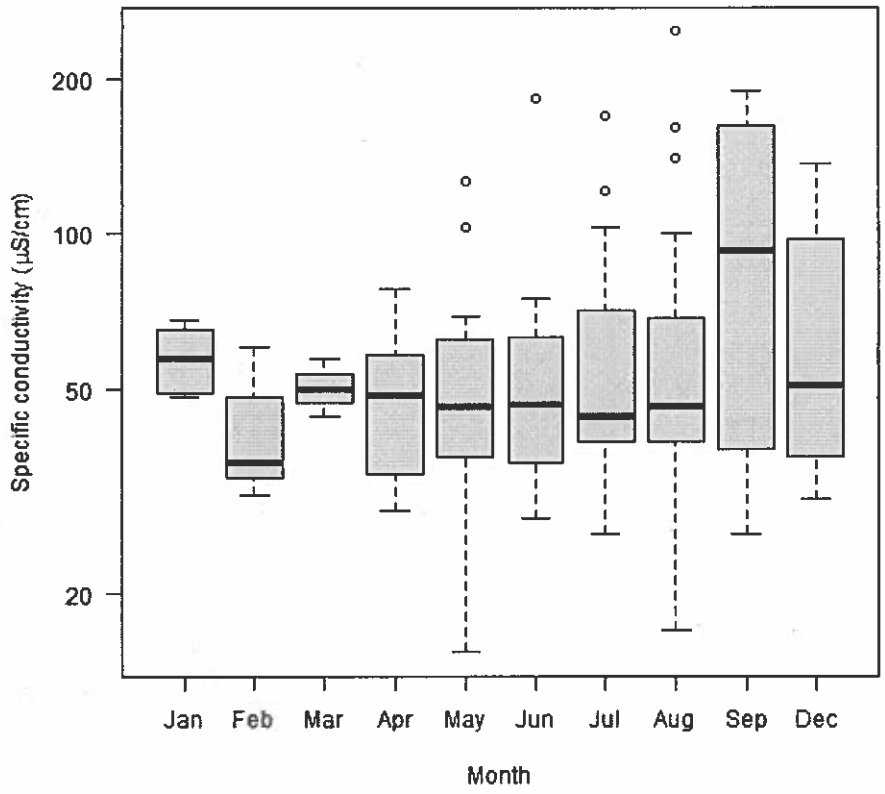


Figure 4-3. Box plot showing seasonal variation of specific conductivity (µS/cm) in the reference streams from Watershed Assessment Branch database (WABbase) 1997–2010.
A total of 112 samples from 82 reference stations were used for this analysis to estimate background specific conductivity. Please note the smaller scale on the *y*-axis compared to Figures 4-2 and 4-4. A total of 112 samples from 82 reference stations were used for this analysis to estimate background specific conductivity. Please note the smaller scale on the *y*-axis compared to Figures 4-2 and 4-4. See Table 4-2 for number of samples per month.

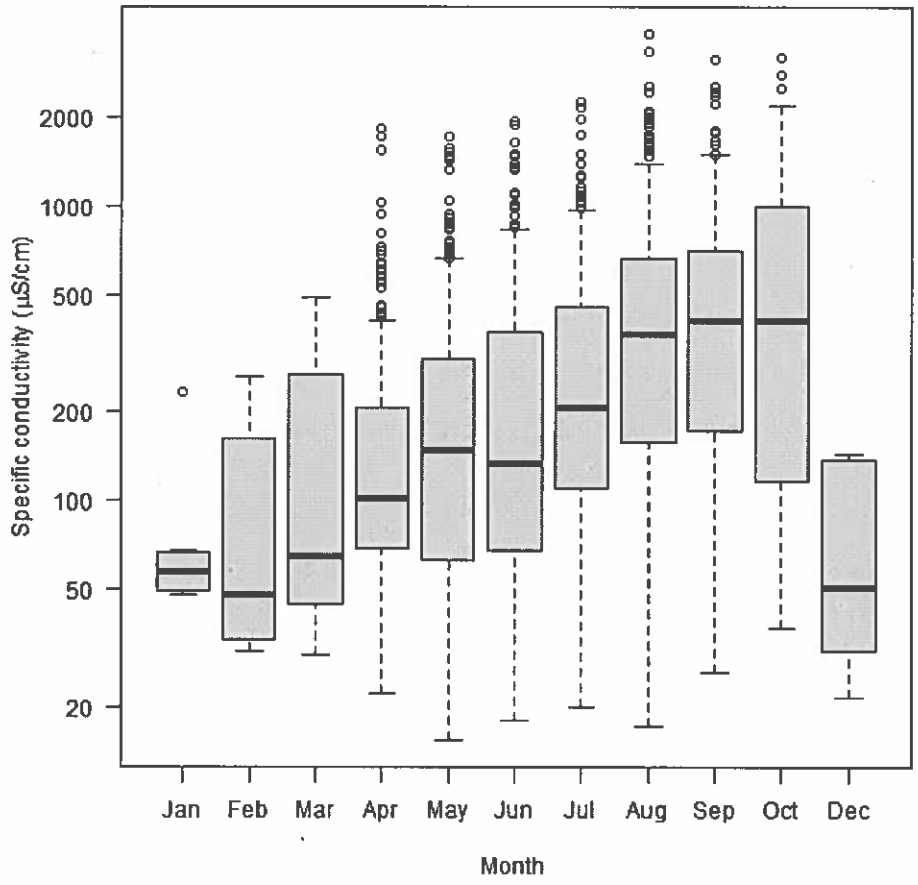


Figure 4-4. Box plot showing seasonal variation of specific conductivity (µS/cm) from all Ecoregion 69 sites from Watershed Assessment Branch database (WABbase) 1997–2010 used to develop the example criteria. This represents a total of 1,661 samples from 1,420 sites from 1997–2010. Note the difference in scale along the *y*-axis between Figure 4-4 (all sites, reference and nonreference) and Figure 4-3 (reference sites). See Table 4-2 for number of samples per month.

4.1.2. Ionic Composition

The ionic composition of the samples in the Ecoregion 69 data set was assessed to ensure that the example criteria were derived for waters dominated by sulfate and bicarbonate anions (see Figure 4-5). Of the 1,674 samples after low pH samples were removed, 56% of samples (938 in total) included measures of calcium, magnesium, sulfate, bicarbonate, and chloride. All but 13 sites (>98%) were dominated by bicarbonate and sulfate anions ($[HCO_3^-] + [SO_4^{2-}]) > [Cl^-]$. The 13 chloride-dominated sites were excluded from the derivation

analysis but are shown in Figure 3. Sodium and potassium were less frequently measured, but did not exceed calcium and magnesium where measured for samples in the data set. Sites with no ion measurements were retained in the data set because the data had shown that >98% of samples were dominated by bicarbonate and sulfate anions; thus, it is expected that less than 2% of samples in the Ecoregion 69 Criterion-data set are chloride-dominated.

The analysis may also be defensible for mixtures dominated by sodium, sulfate and bicarbonate ions, e.g., produced water from deep coal mines (Thomas, 2002; Mayhugh and Ziemkiewicz, 2005). This is because the toxicity of these mixtures are more similar to that of calcium, magnesium, sulfate and bicarbonate ions than the toxicity of NaCl (Mount et al., 2016; Kunz et al., 2013; Soucek and Dickinson, 2015).

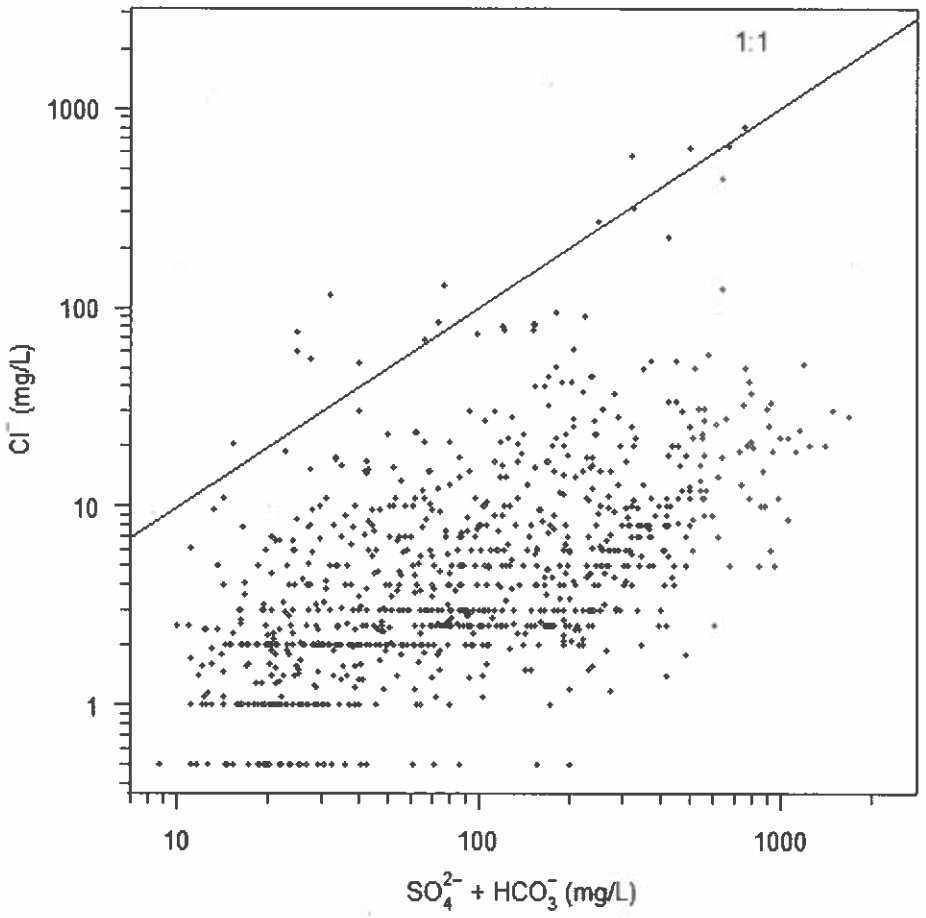


Figure 4-5. Scatter plot of relationship between [Cl^-] and ([HCO_3^-] + [SO_4^{2-}]) concentrations in streams in Ecoregion 69 data set from 1997–2010 with ionic measurements. Most (98.6%) of the samples (n = 938) are below the diagonal line representing the separation between ([HCO_3^-] + [SO_4^{2-}])-dominated and Cl^--dominated mixtures. Sites above the 1:1 line were excluded from the example Criterion derivation data set. Samples depicted here include all sites regardless of pH.

4.1.3. Seasonal Specific Conductivity Regime

For this case study, chemical, physical, and/or biological samples were collected during the sampling years 1997–2010 (January–December). Most (>85%) sites were sampled once during an annual sampling period, but some (e.g., sites being studied to improve stream condition within the TMDL Program) were sampled monthly for water quality parameters (see Table 4-2).

Table 4-2. Number of samples with reported genera and specific conductivity meeting acceptance criteria for the Ecoregion 69 analysis

Number of samples[a]	Month												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Full data set	8	4	36	159	269	163	197	388	342	89	0	6	1,661
Probability sites	0	0	0	66	190	116	84	68	53	8	0	0	585
Reference sites	6	3	3	10	19	12	27	24	4	0	0	4	82
Percentage of total	0.5	0.2	2.2	9.6	16.2	9.8	11.9	23.4	20.6	5.4	0	0.4	(100)

[a]Number of samples is presented for each month.

Samples collected from the WVDEP-identified reference sites indicate that SC levels are generally low and similar throughout the year, although slightly higher in September (see Figure 4-3). These data show that SC concentrations in flowing waters in the study area can vary somewhat by season, likely depending on stream discharge, rainfall, snowmelt, and other hydrological factors. As described in Section 3.1.4 (and in greater detail in the *EPA Benchmark Report*), the effects of seasonal differences in SC levels and aquatic insect life history were evaluated by comparing HC_{05} values partitioned for season. After careful consideration of the similarity between the spring HC_{05} and the HC_{05} based on the full data set at the low end of the XCD, the example ecoregional criteria were derived using all available data, regardless of the time of year they were collected (see Sections 3.1.4 and Appendix A.2 in this assessment, and U.S. EPA, 2011a).

4.2. RESULTS

4.2.1. Extirpation Concentration (XC_{95}) and Hazardous Concentration (HC_{05}) Values (Example Criterion Continuous Concentration [CCC])

The Ecoregion 69 example Criterion-data set (see Table 4-1) was used to develop XC_{95} values from weighted CDFs. The histogram used to develop weights is depicted in Figure 4-6. The XC_{95} values that were used in the XCDs are listed in the order of least to most salt-tolerant in Appendix A.3. The generalized additive model plots used to designate ~ and > values for those XC_{95} values are depicted in Appendix A.4. The weighted CDFs used to derive the XC_{95}

values are shown in Appendix A.5. The HC_{05} for Ecoregion 69 was calculated at 305.4 µS/cm (see Figures 4-7 and 4-8); the two-tailed 95% confidence bounds were 233–329 µS/cm. Those bounds, derived by bootstrap resampling, indicate that different data sets could yield HC_{05} values within that interval. Rounding to two significant figures, the example CCC for Ecoregion 69 is 310 µS/cm.

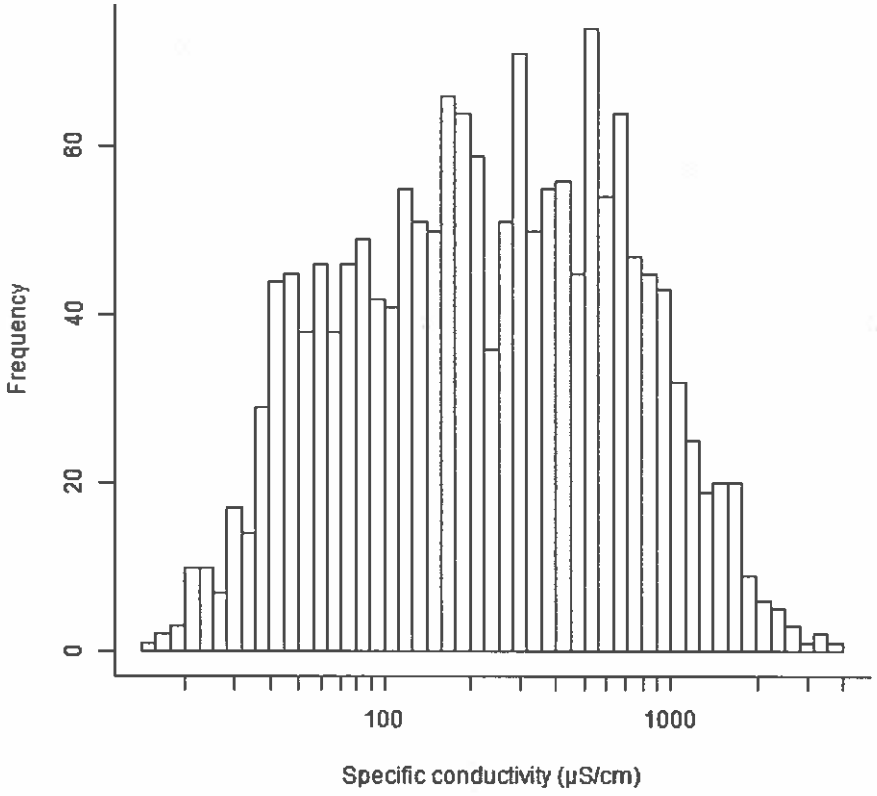


Figure 4-6. Histograms of the frequencies of observed specific conductivity values in samples from Ecoregion 69 sampled between 1997 and 2010. Bins are each 0.017 (1/60) of the range of log10 specific conductivity units wide.

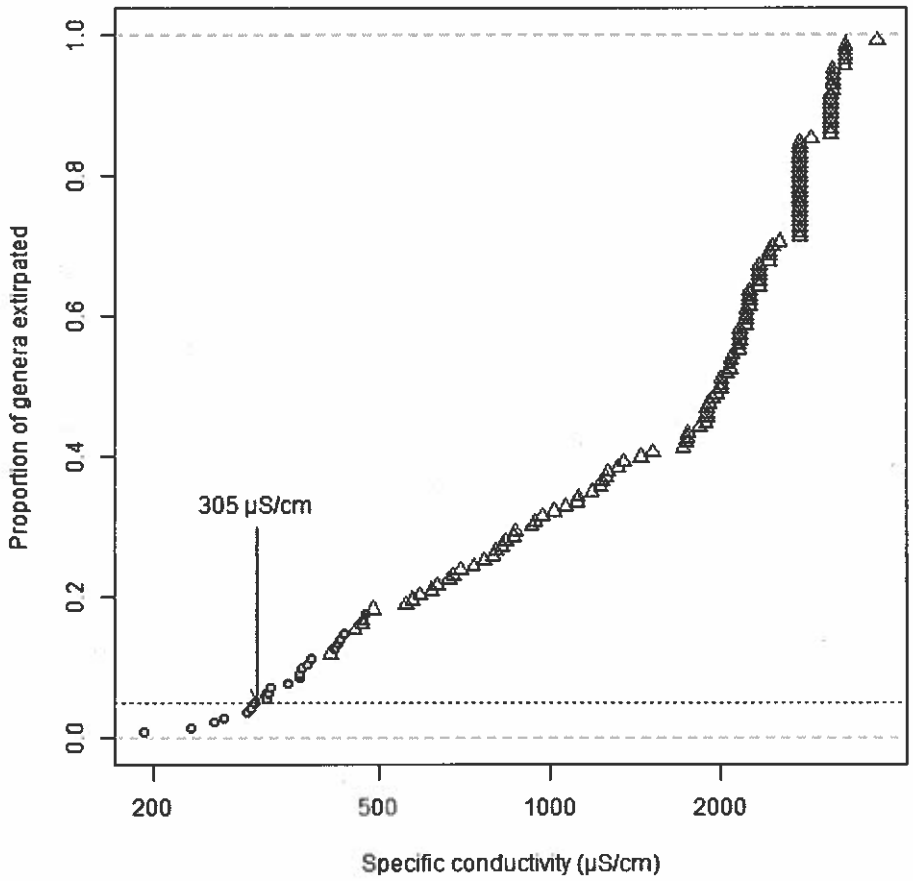


Figure 4-7. Example genus extirpation concentration distribution (XCD) for Ecoregion 69. Each point is an extirpation concentration (XC_{95}) value for a genus. There are 142 genera. The hazardous concentration (HC_{05}) is 305 µS/cm (95% confidence interval is 233−329 µS/cm) and is the specific conductivity at the intersection of the XCD with the horizontal line at the 5th centile. XC_{95} with an approximate or greater than designation are shown as triangles.

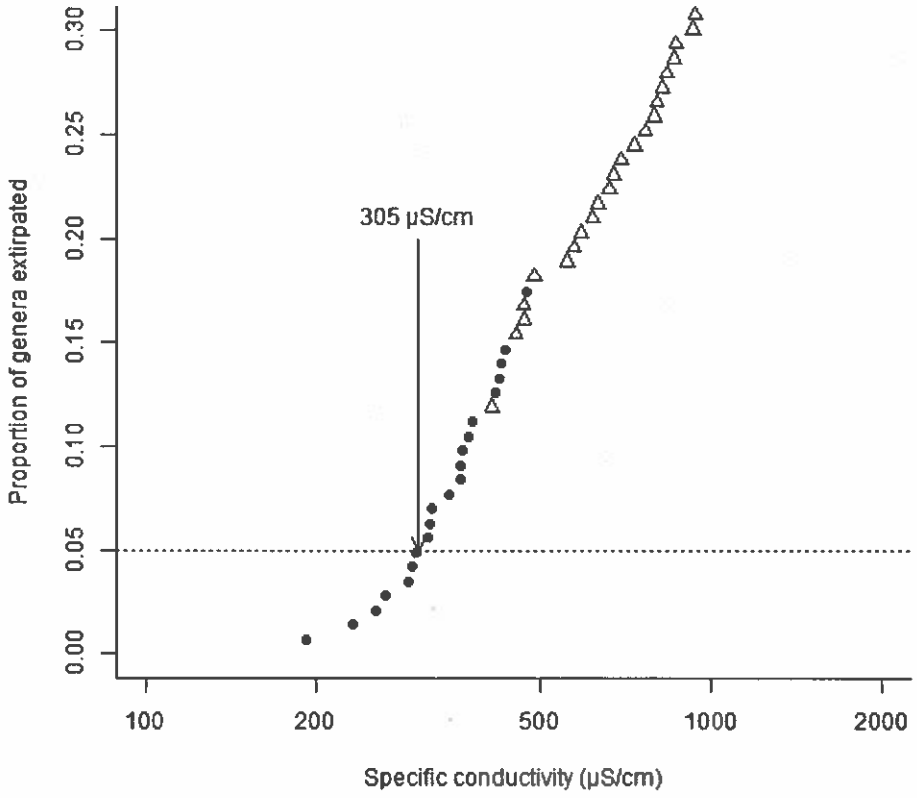


Figure 4-8. The lower end of the example genus extirpation concentration distribution for Ecoregion 69. The dotted horizontal line is the 5th centile. The vertical arrow indicates the hazardous concentration (HC_{05}) of 305 µS/cm (95% confidence intervals 233–329 µS/cm). Only the 50 most salt-intolerant genera are shown to better discriminate the points on the left side of the distribution. The six most salt-intolerant genera (i.e., extirpation concentration [XC_{95}] ≤ 305 µS/cm) are *Leptophlebia, Remenus, Pycnopsyche, Paraleptophlebia, Bezzia,* and *Alloperla*). XC_{95} values with an approximate or greater than designation are shown as triangles.

4.2.2. Example Criterion Maximum Exposure Concentration

At sites meeting the CCC of 310 µS/cm, 90% of the SC observations are estimated to occur below the CMEC (see Section 3.2). The CMEC was derived using the full Ecoregion 69 data set (9,806 samples collected between 1996–2011). Of the 9,806 samples in this ecoregion, there are 5,823 samples in a July to June rotating year representing 564 rotation years, 536 unique stations, with at least 1 sample from July to October and 1 sample from March to

June, and at least 6 samples within a rotation year (see Table 4-3). Note that inclusion of samples is not contingent on biological data. Reference and nonreference sites were included to ensure a range of SC (see Table 4-1).

Table 4-3. Summary data related to the calculation of the example criterion maximum exposure concentration (CMEC) for Ecoregion 69

Number of samples July to June prior to biological sampling	5,811
Number of unique stations/rotation years	536/564
Number of WVDEP reference sites	15
CCC	310 µS/cm
CMEC	630 µS/cm

Of the 564 rotation years (536 unique stations) with multiple SC measurements, the variability of within station SC was found to differ for streams with different mean SC (see Figure 4-9). The locally weighted scatterplot smoothing (LOWESS) lines indicated that the average variability (residual standard deviation for a station) in the middle of the SC gradient is slightly higher than both the lower and higher ends of the gradient. The stations with annual mean SC values between the 25th and 75th centile (which is approximately between 120−520 µS/cm) have relatively similar variances, and therefore, could be used to estimate the standard deviation components of annual mean SC (310 µS/cm). There are 2,855 samples from 278 station years (265 stations) in the selected data sets for Ecoregion 69 with streams having mean SC values between 120 and 520 µS/cm. The grand mean and standard deviation of this data set were determined and the CMEC was calculated. The example CMEC calculation is shown below:

$$\text{CMEC for Ecoregion 69: } 10^{\log10(310) + 1.28*0.243} = 634.1 \text{ µS/cm} \qquad (4\text{-}1)$$

The example CMEC (see Table 4-3) rounded to two significant figures yields a CMEC of 630 µS/cm for Ecoregion 69. At this level, where the annual average SC is <310 µS/cm, 90% of the observations are expected to be less than the CMEC.

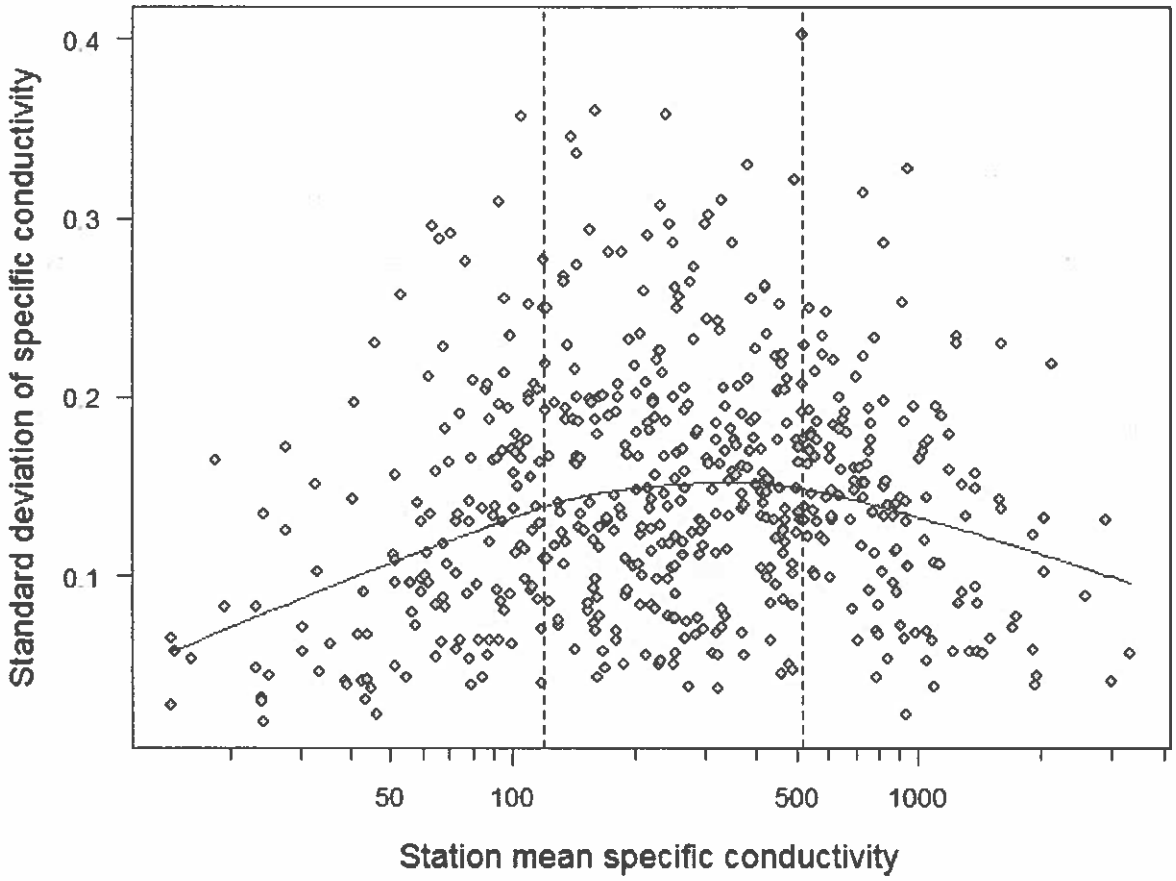


Figure 4-9. Illustration of within site variability (residual standard deviation for each station) along the specific conductivity gradient (station mean) in Ecoregion 69. The *x*-axis is log annual mean specific conductivity. Each dot represents a station. The fitted line is a locally weighted linear scatterplot smoothing (LOWESS, span = 0.75, linear polynomial model), while the two vertical dashed lines represent logarithm mean specific conductivity of 120 and 520 µS/cm, respectively. Within those bounds the standard deviation is fairly constant.

4.3. GEOGRAPHIC APPLICABILITY

The geographical applicability of the criteria throughout Ecoregion 69 was assessed using the background-matching approach (see Section 3.7.1). The background SC of the new area (i.e., the portion of Ecoregion 69 beyond the original data set) was estimated at the 25th centile

(see Section 3.7.1.2; and Cormier and Suter, 2013a) and compared with the background SC estimates for the original data set.

Because the example SC criteria presented here have been developed for a dissolved mixture dominated by sulfate and bicarbonate anions, ($[HCO_3^-] + [SO_4^{2-}]) > [Cl^-]$ in mg/L, all chloride-dominated samples, ($[HCO_3^-] + [SO_4^{2-}]) \leq [Cl^-]$ in mg/L, were removed from the data set before estimating background SC. Thereby, the background for the new area is estimated for the same ionic mixture as the example criteria.

4.3.1. Data Sources

Two data sets were used for this example applicability assessment: the original data set used to derive the HC_{05} described in Section 4.1 and an EPA-survey data set (see Table 4-4).

The EPA-survey data set was used to evaluate and characterize ion concentrations and water chemistry in the ecoregion (see Table 4-5). The primary sources of the combined data are from EPA survey programs including the National Rivers and Streams Assessment (NRSA) 2008–2009 surveys (U.S. EPA, 2013b, 2009), Wadeable Streams Assessment (WSA) 2004 survey (U.S. EPA, 2006), Environmental Monitoring and Assessment Program (EMAP) 1993–1998 and Regional-EMAP (R-EMAP) 1999 surveys (U.S. EPA, 2013c), and National Acid Precipitation Assessment Program (NAPAP) 1986 survey (NADP, 2013). Data sets are based on random samples from June through September. Most report SC, alkalinity, hardness, sulfate, chloride, bicarbonate, pH, and other water quality parameters. Ecoregions and sampling sites are shown in Figure 4-10. All samples were collected from first-through fourth-order streams as part of a probability-based design intended to estimate proportions of parameters for various stream classes. The probability-design weights were not used in this characterization. Analysis of water chemistry samples followed EPA procedural and QA/QC protocols from EMAP (U.S. EPA. 2001, 1998b, 1994, 1987), Wadeable Streams Assessment (U.S. EPA, 2004a, b), the NRSA (U.S. EPA, 2009), and NAPAP (Drousé et al., 1986; U.S. EPA, 1987). These data sets were also selected so that methods would be comparable across the data set, and because these studies used probability-based designs (i.e., randomly assigned sampling locations).

Table 4-4. Description of survey data sets combined to form the EPA-survey data set used to assess applicability of the example ecoregional criteria throughout Ecoregion 69

Data set	Sampling period	Total *N*	KY	MD	PA	TN	VA
MAHA EMAP	1993–1995	42	0	3	35	0	4
MAIA EMAP	1997–1998	12	0	0	8	0	4
WSA	2004	9	3	1	0	3	2
NRSA	2008–2009	8	4	0	1	2	1
NAPAP	1986	41	2	6	29	4	0
Region 4 Wadeable Streams R-EMAP	1999–2002	9	7	0	0	2	0
Total		121	16	10	73	11	11

MAHA = Mid-Atlantic Highland Assessment; MAIA = Mid-Atlantic Integrated Assessment.

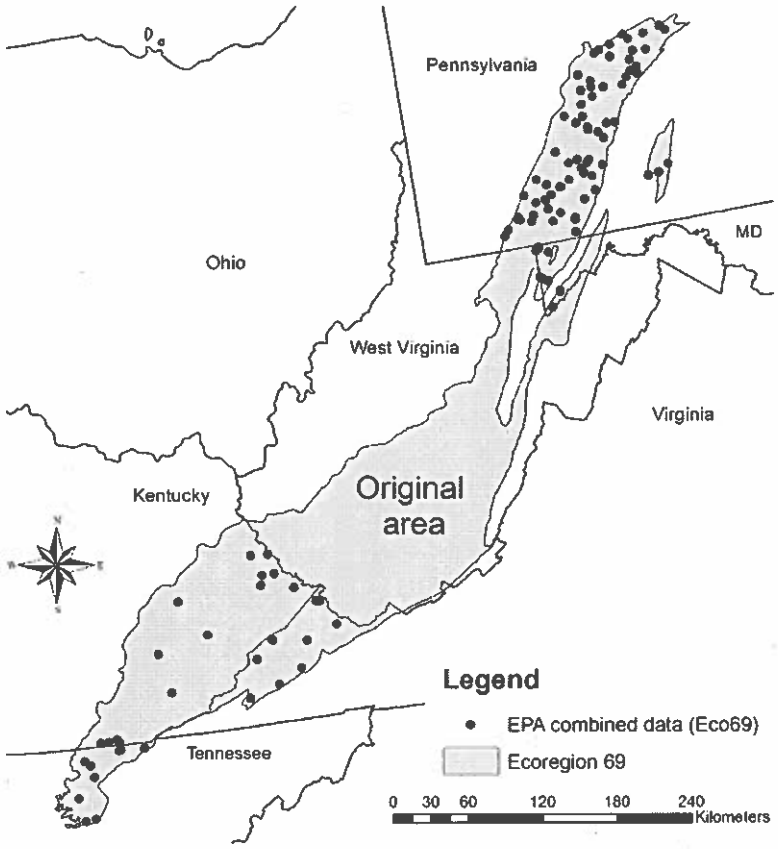


Figure 4-10. Ecoregion 69 extends from central Pennsylvania to northern Tennessee. Sampling sites in the EPA-survey data set that were used to estimate background in the "new" area for Ecoregion 69 are indicated as points. The figure depicts 121 samples from 121 stations.

4.3.2. Geographic Applicability Results

A summary of water quality for the EPA-survey data set (see Section 4.3.1) for Ecoregion 69, including major ionic constituents, is provided in Table 4-5. Background SC in the new area was estimated from the full EPA-survey data set because no sample was dominated by chloride ions.

Background SC for bicarbonate and sulfate dominated waters estimated as the 25th centile of the EPA-survey data set for the new area in Ecoregion 69 (outside the area used to develop the example criteria) was 63.5 µS/cm (95% CI 46–89 µS/cm) (see Table 4-6). The 25th centile from the probability sample from the example Criterion-data set was 66 µS/cm (95% CI 60–75) (see Table 4-6). The confidence bounds for background estimated from the example Criterion-data

set overlap with the confidence bounds for background estimated for the rest of Ecoregion 69. Therefore, the background SC regime throughout Ecoregion 69 appears to be similar, and thus, the example criteria (CCC = 310 µS/cm, CMEC = 630 µS/cm) are considered geographically applicable throughout the ecoregion. Other estimates of background from the reference sites in the example Criterion-data set (63 µS/cm; 95% CI 60–65 µS/cm) and the example Criterion data set (94 µS/cm; 95% CI 86–101 µS/cm) also overlap with the CI of the background for the rest of Ecoregion 69 (see Table 4-6).

Table 4-5. Summary of water quality parameters for Ecoregion 69 from the EPA-survey data set excluding the sites in West Virginia

Ecoregion	Ion	Min	Centile				Max	Relevant *N*
			10th	25th	50th	75th		
Ecoregion 69	HCO_3^- (mg/L)	0.0	0.1	1.3	12.5	37.3	241.8	102
	SO_4^{2-} (mg/L)	3.2	7.6	10.0	21.4	136.3	1,622.8	112
	Cl^- (mg/L)	0.5	1.1	1.7	3.0	8.6	59.0	112
	Ca^{2+} (mg/L)	1.2	2.2	5.6	13.7	39.1	186.0	112
	Mg^{2+} (mg/L)	0.6	1.0	1.5	4.5	17.3	152.1	112
	Na^+ (mg/L)	0.2	0.6	1.1	2.9	9.3	93.4	112
	K^+ (mg/L)	0.4	0.6	0.8	1.3	2.2	8.0	112
	pH (SU)	3.0	4.7	6.2	7.1	7.7	8.6	121
	[a]$(HCO_3^- + SO_4^{2-})/Cl^-$	1.4	3.0	5.4	13.6	41.4	497.5	102
	SC (µS/cm)	23.7	34.5	63.5	183.5	426.8	2,515	121

[a]Value within category calculated from individual sample ion concentrations. $HCO_3^- + SO_4^{2-}/Cl^-$ in mg/L greater than 1 indicates the mixture is dominated by $HCO_3^- + SO_4^{2-}$.

Table 4-6. Background specific conductivity estimates for Ecoregion 69

Data set	Centile used to estimate background	Background µS/cm	Confidence interval µS/cm	Relevant *N* (sites/samples)
EPA-survey data set from geographic area not represented in the example criterion derivation data set	25th	64	46–89	121/121
WABbase data set, probability sample subset	25th	66	60–75	544/583
WABbase data set, reference sample subset	75th	63	60–65	82/112
Example criterion derivation data set, full data set	25th	94	86–101	1,420/1,661

4.4. SUMMARY OF EXAMPLE CRITERIA FOR ECOREGION 69

The case example for Ecoregion 69 includes an annual geometric mean (i.e., CCC) and a 1-day mean (i.e., CMEC), not to be exceeded more than once in 3 years on average. Both of these distinct expressions of the example SC criteria would need to be met in order to adequately protect aquatic life. These values indicate that freshwater animals in Ecoregion 69 would be protected if the annual geometric mean SC concentration in flowing waters does not exceed 310 µS/cm and the 1-day mean does not exceed 630 µS/cm, more than once every 3 years on average. These example criteria would apply to all flowing freshwaters (ephemeral, intermittent, and perennial streams) in Ecoregion 69 inclusive of portions of Kentucky, West Virginia, Maryland, Virginia, Tennessee, and Pennsylvania. On a site-by-site basis, these example ecoregional criteria apply if the ionic mixture is dominated by anions of bicarbonate and sulfate. For streams crossing into Ecoregion 69, professional judgment may be needed to assess the potential effect of different ionic composition or concentration. Professional judgment is recommended when applying to sites with a catchment area greater than 1,000 km^2 (386 mi^2) owing to lesser representation in the example data set by this class of stream. On a site-by-site basis, alternative specific conductivity criteria may be more appropriate if the natural background of a site is shown to be lower or higher than its regional background specific conductivity.

4.5. EXAMPLE CRITERION CHARACTERIZATION

4.5.1. Factors Potentially Affecting the Extirpation Concentration Distribution (XCD) Model

An assessment of potential confounders and an analysis of the influence of habitat quality and sampling date for Ecoregion 69 can be found in Appendix A.2.

4.5.1.1. *Sensitivity Analyses*

As the minimum number of occurrences of a genus for inclusion in the data set increases, fewer genera are included in the XCD. The HC_{05} increases greatly when a taxon in the lower 5th centile is removed because it does not meet the minimum number of samples and then more slowly alternates between increasing and decreasing as genera either above or below the 5th centile are removed because they do not meet the minimum number of samples (see Figure 4-11). The pattern repeats until all genera above and below the lower 5th centile have the same XC_{95} value (not shown). To maximize the number of genera included in the XCD, a minimum of 25 occurrences was utilized.

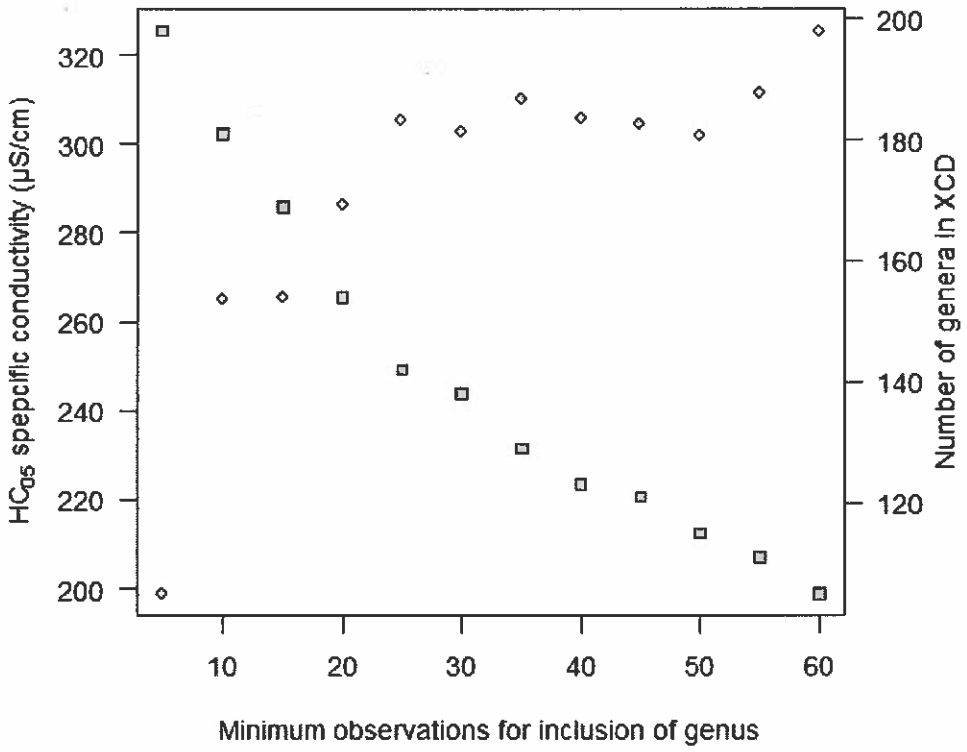


Figure 4-11. Relationship of the number of occurrences of a genus and the hazardous concentration (HC_{05}) based on Ecoregion 69 example Criterion-data set. Estimates of HC_{05} values (blue diamonds, left axis) and the number of taxa in the extirpation concentration distribution (XCD) (red squares, right *y*-axis) based on minimum number of samples (5–60, *x*-axis). As the minimum number of observations of a genus increases, fewer are included in the XCD.

The number of samples in the data set affected the number of genera included in the XCD and the resulting example HC_{05}. The effects of data set size on the HC_{05} estimates and on their confidence bounds were estimated using a bootstrapping technique. The mean of all bootstrapped HC_{05} values, the numbers of genera used for the HC_{05} calculation, and their 95% CI were plotted to show the effect of sample sizes. As shown in Figure 4-12, the HC_{05} for this data set stabilizes, reaching an asymptote at approximately 500–800 sites sampled and 90–120 genera evaluated. Therefore, the original data set was considered adequate for estimating the example.

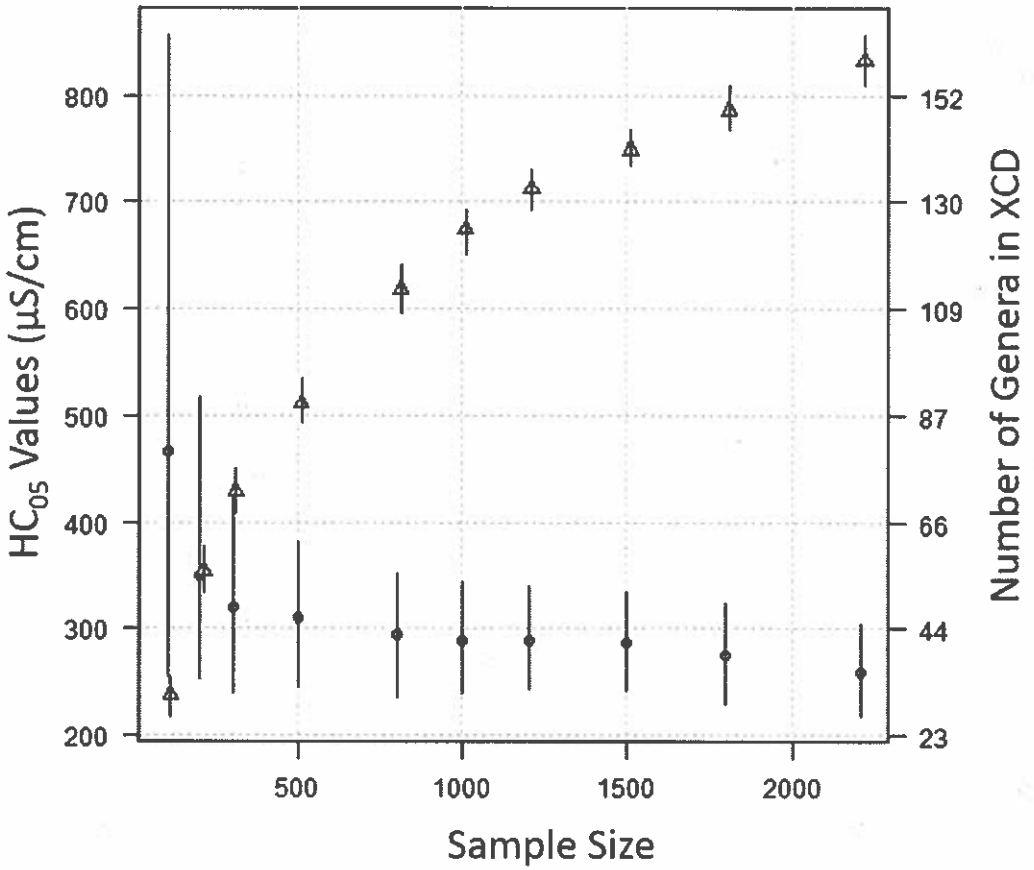


Figure 4-12. The effect of the size of the data set used to model the hazardous concentration (HC_{05}) based on the Ecoregion 69 example Criterion-data set. As size of the data set increases, the number of genera included in the extirpation concentration distribution (XCD) increases (triangles). The HC_{05} stabilizes reaching an asymptote at approximately 500−800 sites sampled (circles) and 90−120 evaluated genera.

4.5.2. Validation of the Extirpation Concentration Distribution (XCD) Model

The XCD model was validated and uncertainty around the HC_{05} values was estimated using bootstrapping, as recommended by the EPA SAB in their review of the *EPA Benchmark Report* (U.S. EPA, 2011c). The median HC_{05} estimated from bootstrapping was 281 µS/cm (95% CI 233−329 µS/cm) which is similar to the HC_{05} of 305 µS/cm measured using a 2-point interpolation of the original XCD. The similarity between the two HC_{05} values indicates a similar model would be generated using an independent data set (see Figure 4-13).

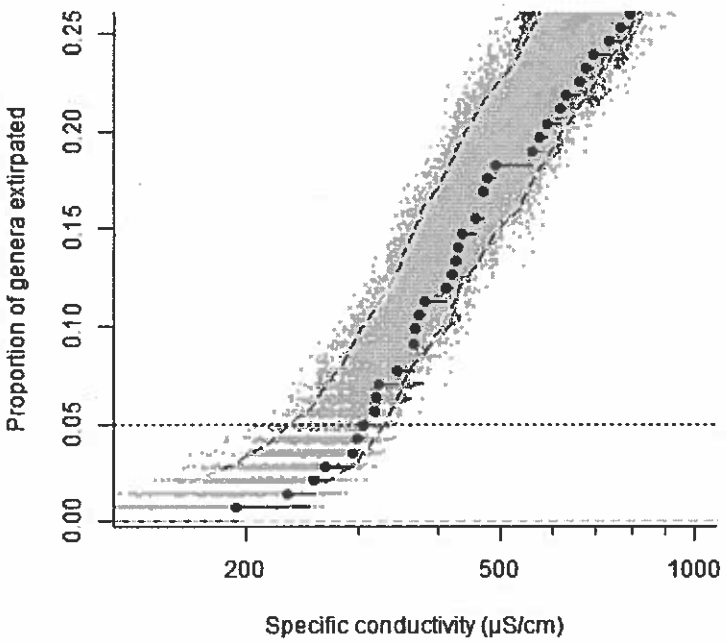


Figure 4-13. Cumulative distribution of the extirpation concentration (XC_{95}) values for the 25% most salt-intolerant genera (blue circles) and 95% confidence intervals (dotted lines) based on 1,000 extirpation concentration distribution (XCD) bootstrapping results. Each tiny gray dot represents an XC_{95} value for a bootstrapping iteration (note that the genera in each percentage varies with each XCD iteration). Each larger blue filled dot represents the calculated XC_{95} of the XCD for the criterion continuous concentration (CCC). The median bootstrapped hazardous concentration (HC_{05}) is 281 µS/cm.

4.5.3. Duration and Frequency

Numeric criteria include magnitude (i.e., how much), duration (i.e., how long), and frequency (i.e., how often) components. Appropriate duration and frequency components of criteria are determined based on consideration of available data and understanding the exposure-response relationship in the context of protecting the aquatic life of a water body. The significant consideration used in setting the duration component of aquatic life criteria is how long the exposure concentration can be above the criteria without affecting the endpoint on which the criteria are based (U.S. EPA, 1991, 1985). Based on the temporal resolution of the available field data set and an analysis of within-site variability of SC levels, EPA developed two

different expressions for the example SC criteria in order to provide adequate protection for aquatic life.

In this case, the majority (>85%) of sites used to derive the example CCC for Ecoregion 69 were sampled once during an annual sampling period and thus represent the average stream SC and macroinvertebrate assemblage information over the course of 1 year. As a result, the appropriate duration for the CCC is 1 year. The duration for the CMEC, a level of protection from acutely toxic exposures, is 1 day based on a review of the literature regarding the onset of macroinvertebrate drift in response to elevated SC (see Section 3.3). At sites meeting the CCC, 90% of the SC observations are estimated to occur below the CMEC.

EPA anticipates that an appropriate allowable frequency of exceedance for these example criteria is no more than once in 3 years, based on recovery rates from literature reviews and consideration of the life history of insects able to recolonize a site via drift or aerial dispersal (see Section 3.4). Recovery is expected to occur in 3 years if the following conditions are met: (1) the SC regime returns to a yearly average below the CCC, (2) there are nearby streams with low SC supporting a diverse community, and (3) there is an upstream source of colonizers or the flight or recolonizing distance is within the dispersal range of genetically diverse, reproducing adult colonizers. If any of these conditions are not met, the time necessary for ecosystem recovery (and thus, the allowable frequency of exceedance) would likely be longer than 3 years.

4.6. PROTECTION OF FEDERALLY-LISTED SPECIES

Although the derivation of the example criteria was limited to the macroinvertebrate taxa represented in the data sets, the available evidence indicates that other taxa in the streams would likely be protected as well (see Section 2.6 and Appendix G). Hence, no adjustment was made for unanalyzed taxa. However, on a site-specific basis, the example criterion could be adjusted or recalculated to protect important species, highly valued aquatic communities, or specially protected waters.

5. CASE STUDY II: EXAMPLE USING THE EXTIRPATION CONCENTRATION DISTRIBUTION (XCD) METHOD IN A MODERATE BACKGROUND SPECIFIC CONDUCTIVITY ECOREGION

This section presents a case study for the Western Allegheny Plateau (Ecoregion 70) to illustrate how the analytical methods described in Section 3 can be used to derive example SC criteria using the XCD method in an area with slightly higher background SC than Ecoregion 69 (see Section 4). Ecoregion 70 results, including estimates of the CCC and CMEC, duration, frequency, and discussion of applicability are included as examples to demonstrate the method. The derivations of the CCC and CMEC analyses and results are based on data from Ecoregion 70 in West Virginia, and SC data from the Ecoregion 70 outside of WV was used to assess applicability of the criteria throughout the ecoregion.

5.1. DATA SET CHARACTERISTICS

The Western Allegheny Plateau (Ecoregion 70) extends from the corner of southwestern Pennsylvania and southeastern Ohio into Kentucky and West Virginia. The hilly and wooded terrain of the Western Allegheny Plateau is mostly unglaciated and well dissected, with local relief of 61 to 229 m, and peak elevations of around 610 m. Many of the rivers in this ecoregion are entrenched, as a result of the rugged, hilly terrain, particularly within the Permain Hills (70a) and Monongahela Transition Zones (70b). The ecoregion is predominantly forested, but also consists of a mosaic of urbanized areas, pastures, farms, and coal mines (Woods et al., 1999). Extensive mixed mesophytic forests and mixed oak forests originally grew in the Western Allegheny Plateau and, today, most of its rounded hills remain in forest; dairy, livestock, and general farms, with residential developments concentrated in the valleys. The Western Allegheny Plateau is composed of horizontally bedded sandstone, shale, siltstone, limestone, and coal. The horizontally-bedded sedimentary rock underlying the region has been mined for bituminous coal (Woods et al., 1996).

The data used in this case study are from a large field data set, the WVDEP's in-house WABbase. Chemical and biological samples are from 1996–2011 and 1997–2010, respectively. The WABbase contains data from Level III Ecoregions 66, 67, 69, and 70 in West Virginia (U.S. EPA, 2000a; Omernik, 1987; Woods et al., 1996). The WABbase data set provides

consistent sampling and analytical methods, high quality, broad spatial coverage of a large number of perennial streams (2,011 distinct locations) in Ecoregion 70.

The WABbase contains data from a mixed sampling design that collects measurements from long-term monitoring stations, targeted sites within watersheds on a rotating basin schedule, randomly selected sample sites (Smithson, 2007), and sites chosen to further define impaired stream segments in support of TMDL development (WVDEP, 2008a). Most sites are sampled once during an annual sampling period, but most TMDL sites are sampled monthly for water quality. The data set contains water quality, habitat, watershed characteristics, macroinvertebrate data (both raw data and calculated metrics), and geographic location (WVDEP, 2008a). A wide range of SC levels were sampled, which is useful for modeling the response of organisms to different ionic concentrations. Level 1 reference status (WVDEP, 2008b) which selects reference sites that "are thought to represent the characteristics of stream reaches that are minimally affected by human activities and are used to define attainable chemical, biological and habitat conditions for a region" (WVDEP, 2013). Sites are initially selected by a map coordinator based on GIS land use data that indicate minimal human disturbance. Streamside, the appropriateness of the selected site is confirmed based on the level of anthropogenic disturbance, lack of point discharges, habitat quality, pH, dissolved oxygen, and SC (>500 µS/cm) is used to flag a site for further investigation before inclusion as a reference site (WVDEP, 2013).

Macroinvertebrate records in the data set are based on collections from a total of 1 m^2 area from a 100 m reach at each site. Using a 0.5 m wide rectangular kicknet (595 µm mesh), four 0.25 m^2 riffle areas were sampled. In streams narrower than 1 m, nine areas were sampled with a 0.33 m wide D-frame dipnet of the same mesh size. Composited samples were preserved in 95% denatured ethanol. A random subsample of 200 individuals (±20%) was identified in the laboratory. All contracted analyses for chemistry and macroinvertebrate identification followed WVDEP's internal quality control and quality-assurance protocols (WVDEP 2008b, 2006). Quality assurance of the data set was judged by EPA to be excellent, based on the database itself and supporting documentation.

Several data filters, described in Section 3.1 (see Figure 3.2), were applied prior to finalization of the data set and analyses. A total of 12,909 records from Ecoregion 70 are included in the data set; of those, SC measurements were included in 11,600 of these samples.

Many of these are measurements of water quality without biological sampling. Of the 11,600, there are 2,126 paired samples with SC measurements and biological samples identified to genus. Of these, a total of 51 samples were removed from the data set due to low pH ≤6 (48 samples) and high proportion of chloride ions, ($[HCO_3^-] + [SO_4^{2-}]) \leq [Cl^-]$ (3 samples). Additional criteria were used to identify macroinvertebrates for inclusion in the extirpation concentration distribution: occurrence at reference sites and occurrence in 25 or more samples. Of the 217 macroinvertebrate genera identified in this ecoregion of the WABbase, 179 genera occurred at least once at one of the 29 identified reference sites where invertebrate samples were collected and identified to genus. A total of 139 genera occurred at 25 or more sampling locations. The final example Criterion-data set has 2,075 samples belonging to 1,695 stations (as depicted in Figure 5-1). Multiple samples were obtained from 19% of stations. Summary statistics for the data set used to derive the criterion is shown in Table 5-1. The statistical package R, Version 2.12.1 (December 2010), was used for all statistical analyses (R Development Core Team, 2011).

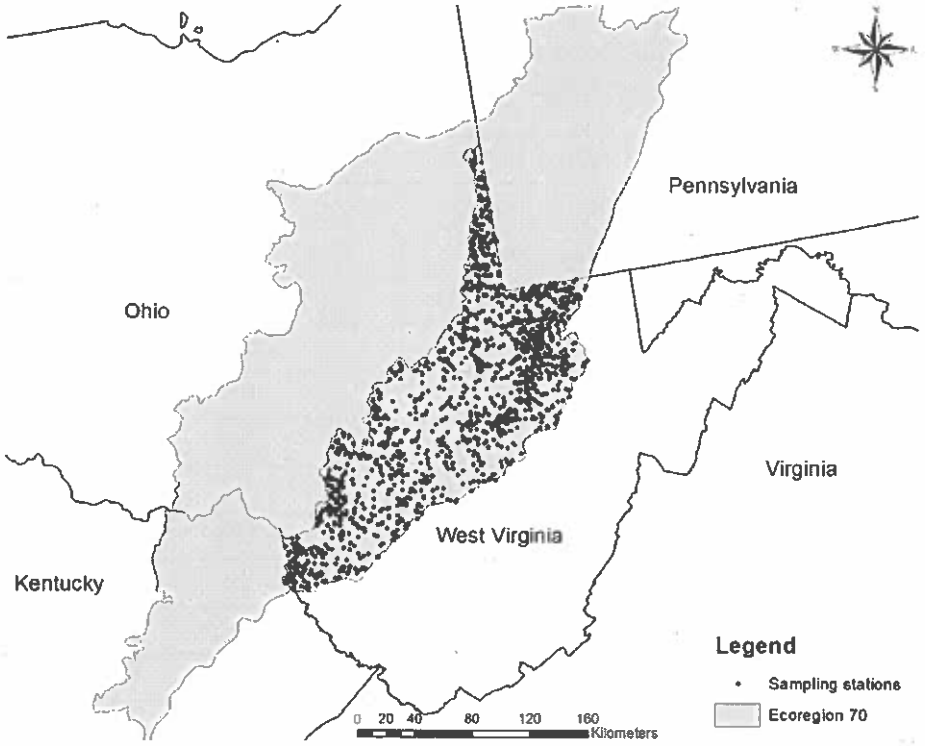


Figure 5-1. Ecoregion 70 extends from central Pennsylvania to northern Tennessee. Sampling sites (stations) (N = 1,695) in the example Criterion data set that were used to derive the example criterion continuous concentration (CCC) are indicated as points.

Table 5-1. Summary statistics of the measured water-quality parameters used to derive the example specific conductivity criteria in Ecoregion 70.
The example Criterion data set has 2,075 samples belonging to 1,695 stations.

Parameter	Units	Min	25th	50th	75th	Max	Mean [a]	*N*
SC	µS/cm	40	169	259	563	11,646	322.8	2,075
Hardness	mg/L	14.21	67.38	106.44	234.4	2,271.3	130.7	1,050
Total alkalinity	mg/L	1	47.35	84.15	135.75	810	77.3	1,378
SO_4^{2-}	mg/L	1	19.4	42	253	6,560	67.7	1,405
Chloride	mg/L	0.5	4	7.4	19	1,153	9.4	1,074
$SO_4^{2-} + HCO_3^-$	mg/L	5.7	87.3	168.2	414.4	6,664.9	192.8	1,375
Ca, total	mg/L	1	19.1	30.8	64	621	36.6	1,052
Mg, total	mg/L	1.1	4.64	7.1	15.9	175	9.2	1,053
Na, total	mg/L	1.4	6.4	18.3	52	2,340	22.2	197
K, total	mg/L	0.6	1.2	2.3	4	25.3	2.3	194
TSS	mg/L	1	3	4	7	506	4.5	1,682
Fe, total	mg/L	0.02	0.16	0.3	0.54	137	0.31	1,673
Fe, dissolved	mg/L	0.02	0.02	0.05	0.07	114	0.048	1,285
Al, total	mg/L	0.01	0.09	0.13	0.26	12	0.15	1,392
Al, dissolved	mg/L	0.02	0.02	0.04	0.05	0.4	0.038	1,304
Mn, total	mg/L	0.003	0.02	0.047	0.118	15.9	0.053	1,269
Se, total	mg/L	0.001	0.001	0.001	0.002	0.033	0.002	524
DO	mg/L	1.02	7.89	9.04	10.33	18.35	9.2	2,038
Total phosphorus	mg/L	0.004	0.02	0.02	0.03	2.36	0.023	971
NO_{2+3}	mg/L	0.01	0.071	0.1	0.3	30	0.133	971
Fecal	Counts/100 mL	0.5	64	200	581.5	180,000	189	1,955
pH	SU	6.07	7.33	7.64	7.96	10.07	7.6	2,075
Catchment area	km^2	0.17	2.88	9.1	38.2	3,912.2	12.2	958
Temperature	°C	0.08	15.9	19.5	22.3	31.9	18.8	2,074
RBP_Sc	RBP score	49	110	123	136	181	122.9	2,055
RBP_7Sc	Seven most relevant parameters	31	72	83	94	129	82.8	2,059
Embeddedness	RBP score	0	10	12	14	19	11.4	2,065
Percentage fines (sand + silt)	Percentage	0	10	20	25	100	20.19	2,033

[a]All means are geometric means except pH, DO, Temperature, and Habitat variables.
RBP = rapid bioassessment protocol (Barbour et al., 1999; RBP 10Sc has 10 parameters while RBP 7 does not include three flow-related parameters).

SC ranged from 40–11,646 µS/cm, which allowed the response of organisms to be modeled for a wide range of SC levels. This maximum is SC is three times higher than the background SC estimated for the data set analyzed in Case Study I (15–3,794 µS/cm). Scatter plots of parameters and SC are depicted in Appendix B.1.

5.1.1. Background Specific Conductivity

Background SC was estimated at the 25th centile from the probability-based samples from the example Criterion-data set because its sampling design more closely matched the ecoregional EPA-survey data set. Using this probability-based subsample of the WABbase data set, the estimated background for Ecoregion 70 was 147 µS/cm (681 samples from 617 sites; see Figure 5-2). Background was also estimated to be 201 µS/cm based on field data from 30 reference sites from the WABbase data set (75th centile; see Figure 5-3). By comparison, the 25th centile for all samples used to derive the example HC_{05} was estimated (166 µS/cm) (see Figure 5-4). The higher estimated background SC based on state-selected reference sites (n = 30)[3] reflects the importance of habitat in site selection and the smaller data set. Seasonal patterns of SC are evident in the probability-based samples and example Criterion-data set (see Figures 5-2 and 5-4). The apparent Background SC is <200 µS/cm December through June and >200 µS/cm July through October (no samples were available for November; see Figure 5-4). The effect of seasonal variability of SC on the subsequent analyses was further evaluated and presented in Appendix B. The large size of the data set and the wide range in SC levels in the example Criterion-data set allowed for genus XC_{95} to be calculated.

[3]29 of these sites have biological sampling available as described in Section 5.1.

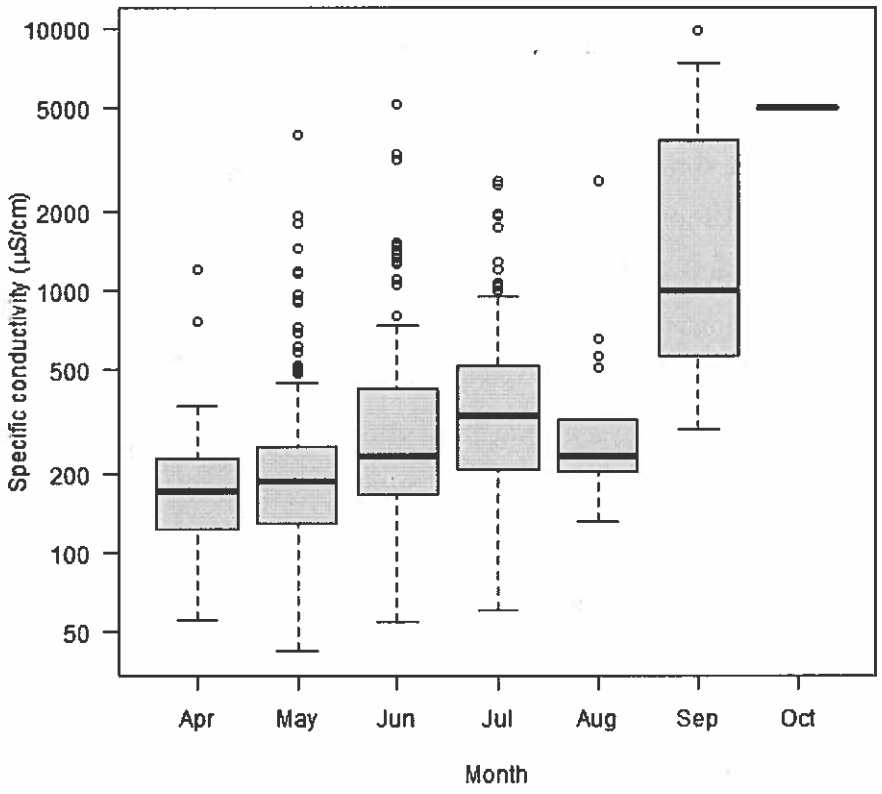


Figure 5-2. Box plot showing seasonal variation of specific conductivity (µS/cm) from probability sites from Watershed Assessment Branch database (WABbase) 1997–2010. This represents a total of 617 sites with 681 samples from 1997–2010 from Ecoregion 70 with pH >6. Note the difference in scale along the *y*-axis between Figure 5-2 (probability sites) compared to Figure 5-3 (reference sites). See Table 5-2 for sample sizes.

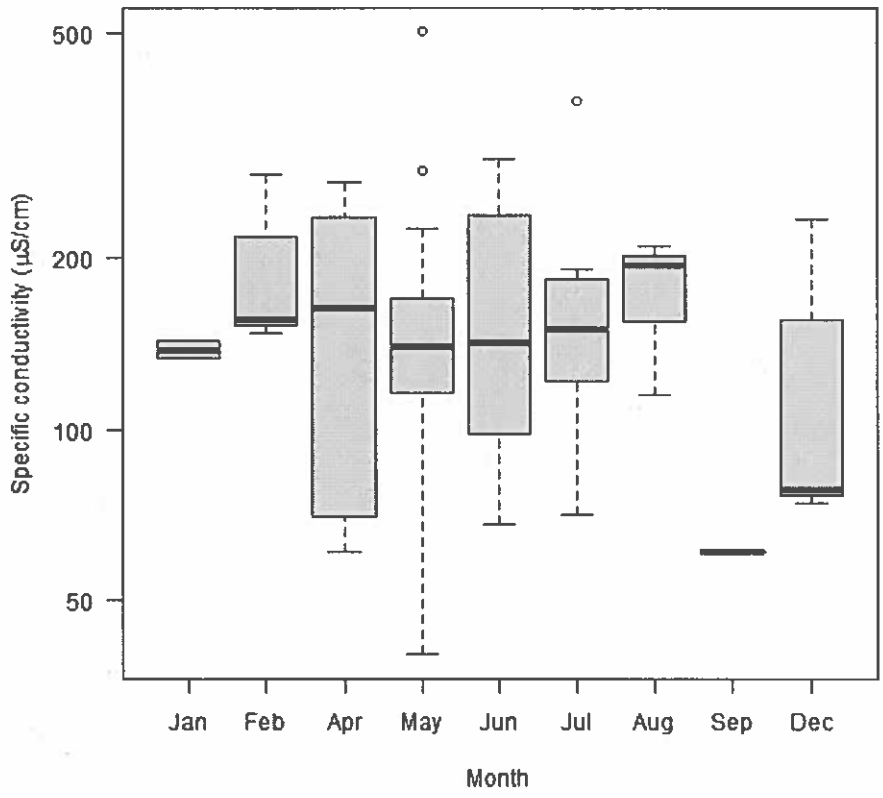


Figure 5-3. Box plot showing seasonal variation of specific conductivity (µS/cm) in the reference streams of Ecoregions 70 from 1997 to 2010. A total of 55 samples from 30 reference stations were used for this analysis. Please note the smaller scale on the *y*-axis compared to Figures 5-2 and 5-4. See Table 5-2 for sample sizes.

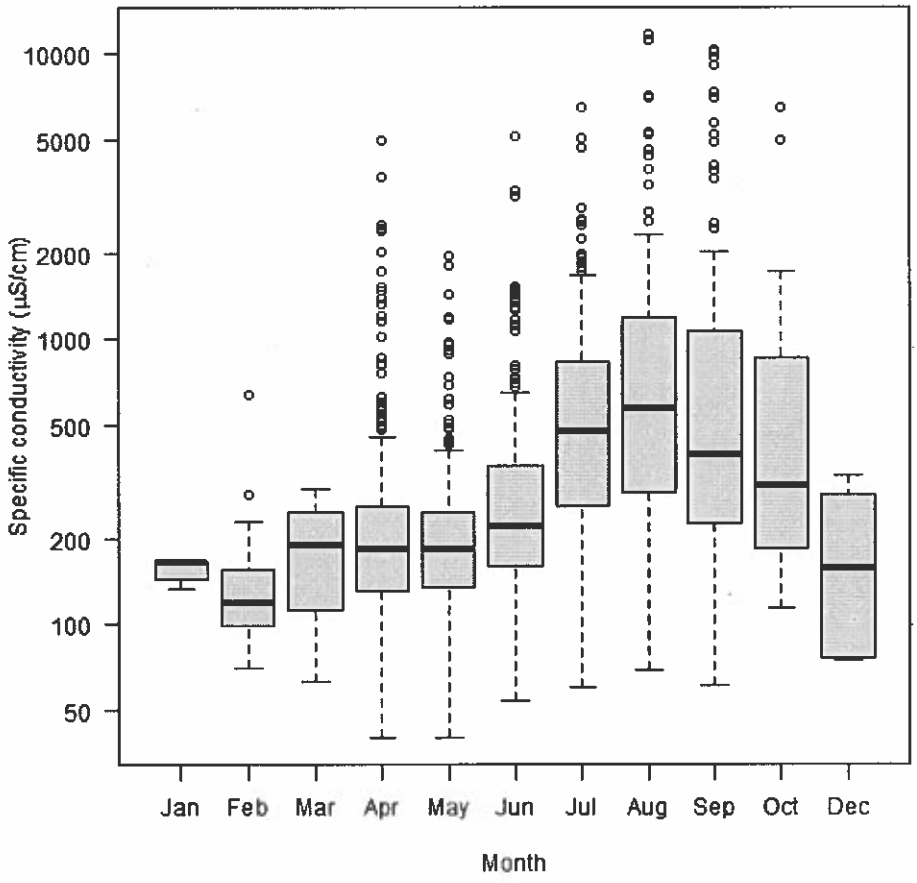


Figure 5-4. Box plot showing seasonal variation of specific conductivity (µS/cm) from all Ecoregion 70 sites from Watershed Assessment Branch database (WABbase) 1997–2010 used to develop the example criteria. The example Criterion-data set has 2,075 samples from 1,695 sites. Note the difference in scale along the *y*-axis between Figure 5-2 (all sites, reference and nonreference) and Figure 5-3 (reference sites). See Table 5-2 for sample sizes.

5.1.2. Ionic Composition

The ionic composition of the samples in the data set for Ecoregion 70 waters was assessed to ensure that the example criteria were derived for waters dominated by sulfate and bicarbonate anions (see Figure 5-5). Of the 2,082 samples after low pH samples were removed, 50.3% of samples (1,048 in total) included measures of calcium, magnesium, sulfate, bicarbonate, and chloride. All but three sites (>99.7%) were dominated by bicarbonate and sulfate anions, ($[HCO_3^-] + [SO_4^{2-}]) > [Cl^-]$. The three chloride-dominated sites were excluded from the derivation analysis but are shown in Figure 3. Sodium and potassium were less

frequently measured, but did not exceed calcium and magnesium where measured. Sites with no ion measurements were retained in the data set because the data had shown that >99.7% of samples were dominated by bicarbonate and sulfate anions; thus, it is expected that less than 1% of samples in the Ecoregion 70 Criterion-data set are chloride-dominated. However, the analysis may also be defensible for ionic mixtures dominated by sodium, sulfate and bicarbonate ions, e.g., produced water from deep coal mines (Thomas, 2002; Mayhugh and Ziemkiewicz, 2005). This is because the toxicity of these mixtures are more similar to that of calcium, magnesium, sulfate and bicarbonate ions than the toxicity of NaCl (Mount et al., 2016; Kunz et al., 2013; Soucek and Dickinson, 2015).

5.1.3. Seasonal Specific Conductivity Regime

Chemical, physical, and/or biological samples were collected during the sampling years 1997–2010 (January–December). Most sites were sampled once during an annual sampling period, but some (e.g., sites being studied to improve stream condition within the TMDL Program) were sampled monthly for water quality parameters (see Table 5-2).

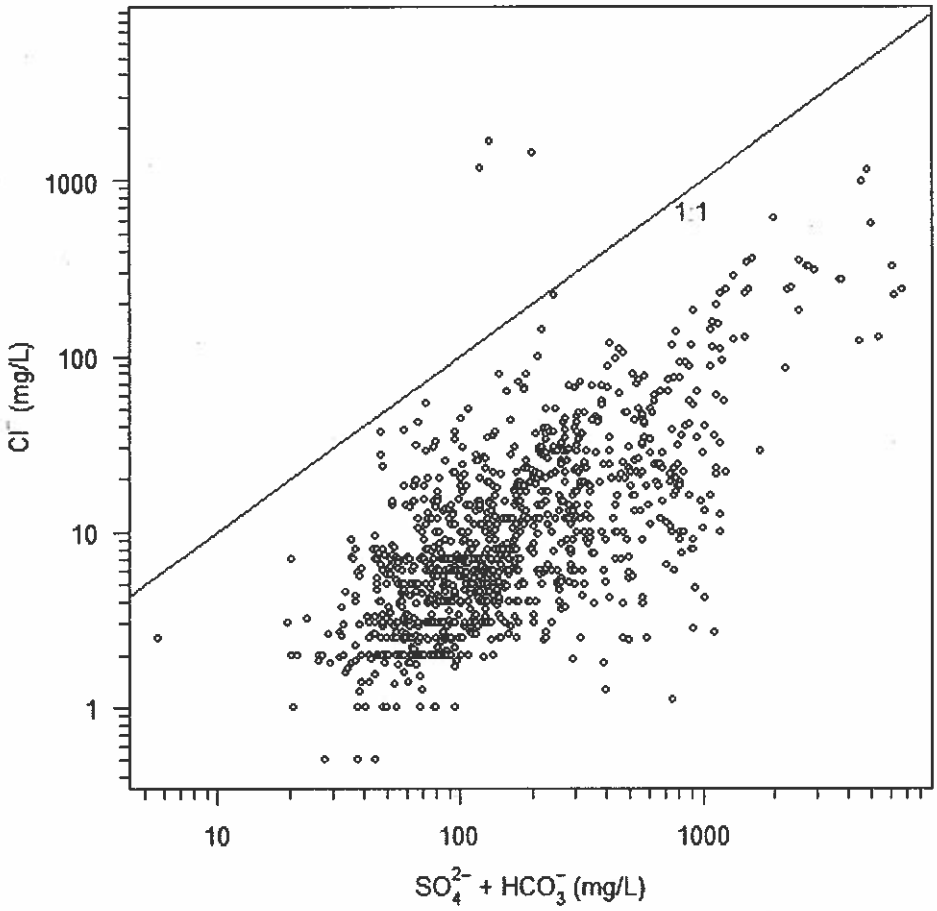


Figure 5-5. Scatter plot of relationship between [Cl^-] and ([HCO_3^-] + [SO_4^{2-}]) concentrations in streams of Ecoregion 70 data set. Most (99.7%) samples (n = 1,045) are below the diagonal line representing the separation between (HCO_3^- + SO_4^{2-})-dominated and Cl^--dominated mixtures. Sites above the 1:1 line were excluded from the example criterion derivation data set. The Ecoregion 70 data set includes all samples with (HCO_3^- + SO_4^{2-}), and Cl^- measurements. Samples depicted here include all sites regardless of pH.

Table 5-2. Number of samples with reported genera and specific conductivity meeting data-inclusion acceptance criteria for the Ecoregion 70 analysis

Number of samples[a]	Month												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Full data set	5	33	11	362	381	290	333	439	193	24	0	4	2,075
Probability sites	0	0	0	151	262	157	70	17	18	1	0	0	676
Reference sites	2	3	0	6	15	8	7	3	1	0	0	3	48
Percentage of total	0.2	1.6	0.5	17.4	18.4	14	16	21.1	9.3	1.2	0	0.2	100

[a]Number of samples is presented for each month.

Samples collected from the WABbase-identified reference sites indicate that SC levels are generally low and similar throughout the year, although slightly higher in summer/fall (see Figures 5-2 and 5-3). These data show that SC concentrations in flowing waters in the study area can vary somewhat by season, likely depending on stream discharge, rainfall, snowmelt, and other hydrological factors. As described in Section 3.1.4 (and in greater detail in U.S. EPA, 2011a), the effects of seasonal differences in SC levels and aquatic insect life history were evaluated by comparing HC_{05} values partitioned for season. After consideration of the similarity between the spring HC_{05} and the HC_{05} based on the full data set at the low end of the genus XCD, the example ecoregional criteria were derived using all available data, regardless of the time of year they were collected (see Section 3.1.4 and Appendix B.2 in this assessment and U.S. EPA, 2011a).

5.2. RESULTS

5.2.1. Extirpation Concentration (XC_{95}) and Hazardous Concentration (HC_{05}) Values (Example Criterion Continuous Concentration)

The Ecoregion 70 example Criterion-data set (see Table 5-1) was used to develop XC_{95} values from weighted CDFs. The histogram used to develop weights is depicted in Figure 5-6. The XC_{95} values that were used in the XCDs are listed in the order of least to most salt-tolerant

in Appendix B.3. The GAM plots used to designate ~ and > values for those XC_{95} values are depicted in Appendix B.4, and the weighted CDFs used to derive the XC_{95} values used to assign the XC_{95} values are shown in Appendix B.5. The example HC_{05} was calculated at 338 µS/cm (see Figures 5-7 and 5-8); the two-tailed 95% confidence bounds were 272−365 µS/cm. Those bounds, derived by bootstrap resampling, indicate that different data sets could yield HC_{05} values within that interval. Rounding to two significant figures, the example CCC is 340 µS/cm.

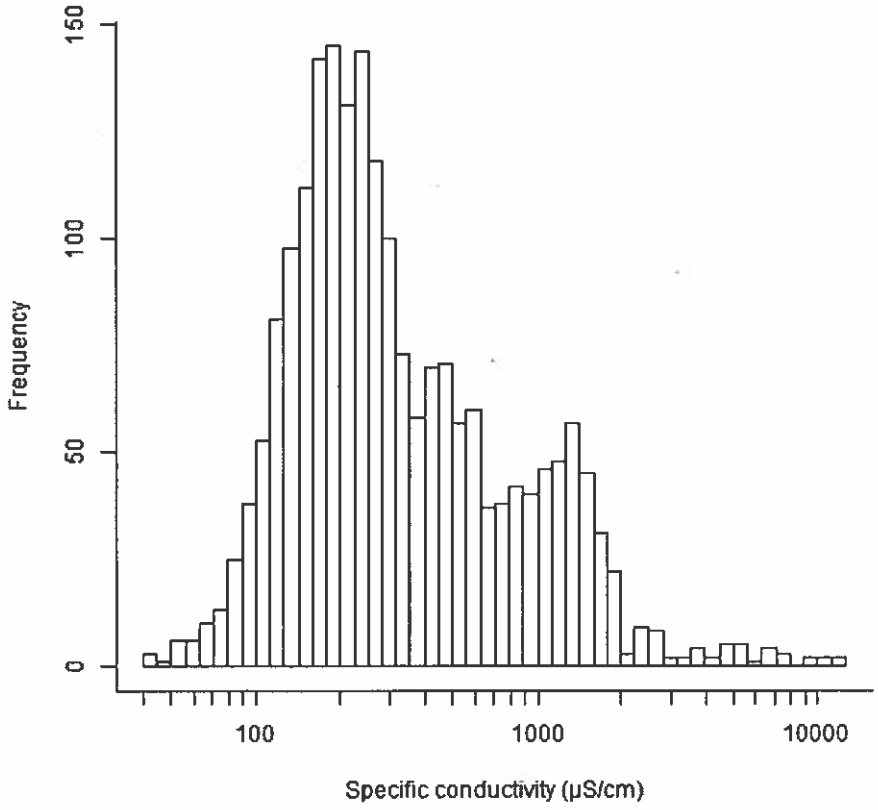


Figure 5-6. Histograms of the frequencies of observed specific conductivity values in samples from Ecoregion 70 sampled between 1997 and 2010.
Bins are each 0.017 (1/60) of the range of log10 specific conductivity units wide.

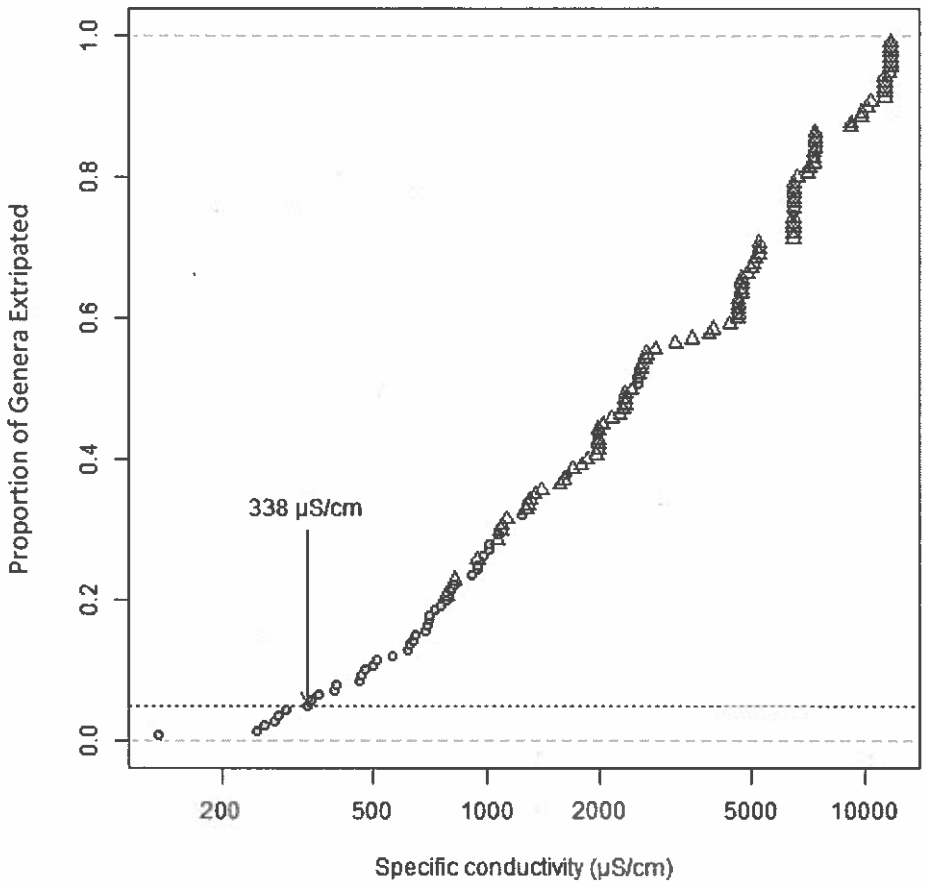


Figure 5-7. Example genus extirpation concentration distribution (XCD) for Ecoregion 70. Each point is an extirpation concentration (XC_{95}) value for a genus (n = 139 genera). The hazardous concentration (HC_{05}) is 338 µS/cm (95% confidence interval 272−365 µS/cm) and is the specific conductivity at the intersection of the genus XCD with the horizontal line at the 5th centile. XC_{95} values with an approximate or greater than designation are shown as triangles.

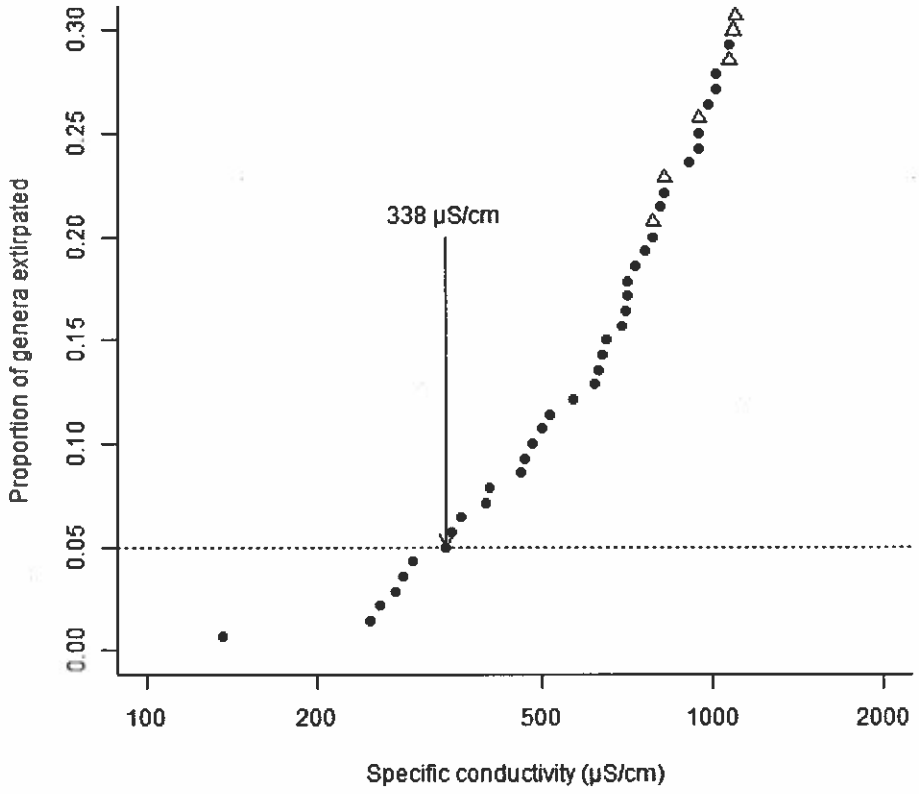


Figure 5-8. The lower end of the example genus extirpation concentration distribution for Ecoregion 70. The dotted horizontal line is the 5th centile. The vertical arrow indicates the hazardous concentration (HC_{05}) of 338 µS/cm (95% confidence interval 272–365 µS/cm). Only the 50 most salt-intolerant genera are shown to better discriminate the points on the left side of the distribution. The six most salt-intolerant genera (i.e., extirpation concentration [XC_{95}] ≤ 338 µS/cm) are *Drunella, Utaperla, Cinygmula, Alloperla, Ephemerella* and *Heptagenia.* XC_{95} values with an approximate or greater than designations are shown as triangles.

5.2.2. Example Criterion Maximum Exposure Concentration

At sites meeting the CCC of 340 µS/cm, 90% of the SC observations are estimated to occur below the CMEC (see Section 3.2). The CMEC was derived using the Ecoregion 70 data set. Out of the 12,909 samples collected between 1996–2011, 8,302 samples had a July-to-June rotating year representing 819 rotation years and 805 unique stations, with at least 1 sample from July to October and one from March to June, and at least 6 samples within a rotation year with

SC measurements (see Table 5-3). Note that inclusion of samples is not contingent on biological data. Reference and nonreference sites were included to ensure a range of SC (see Table 5-1).

Table 5-3. Summary data related to the calculation of the example criterion maximum exposure concentration (CMEC) for Ecoregion 70

Number of samples June to July prior to biological sampling	8,302
Number of rotation years (# unique stations)	819 (805)
Number of WVDEP reference sites	12
CCC	340 µS/cm
CMEC	680 µS/cm

Of the 819 rotation years (805 unique stations) with multiple SC measurements, the variability of within station SC was found to differ among streams (see Figure 5-9); however, the LOWESS line indicated that the average variability (residual standard deviation for a station) is not very different across the entire gradient in Ecoregion 70. The stations with annual mean SC between the 25th and 75th centile (120 and 520 µS/cm) were used to estimate the variance components of annual mean SC (at 340 µS/cm). The selected data sets with mean SC values between 120 and 520 µS/cm in respective data sets have a sample size of 518 rotation years (513 stations) and 5,272 observations. The grand mean and standard deviation of this data set were determined and the CMEC was calculated. The CMEC calculation is shown below:

$$\text{CMEC for Ecoregion 70: } 10^{\log10(340)+\ 1.28*0.237} = 684\ \mu S/cm \qquad (5\text{-}1)$$

The example field-based calculated CMEC rounded to two significant figures yields a CMEC of 680 µS/cm for Ecoregion 70. At this level, where the annual average SC <340 µS/cm, 90% of the observations are expected to be less than the CMEC.

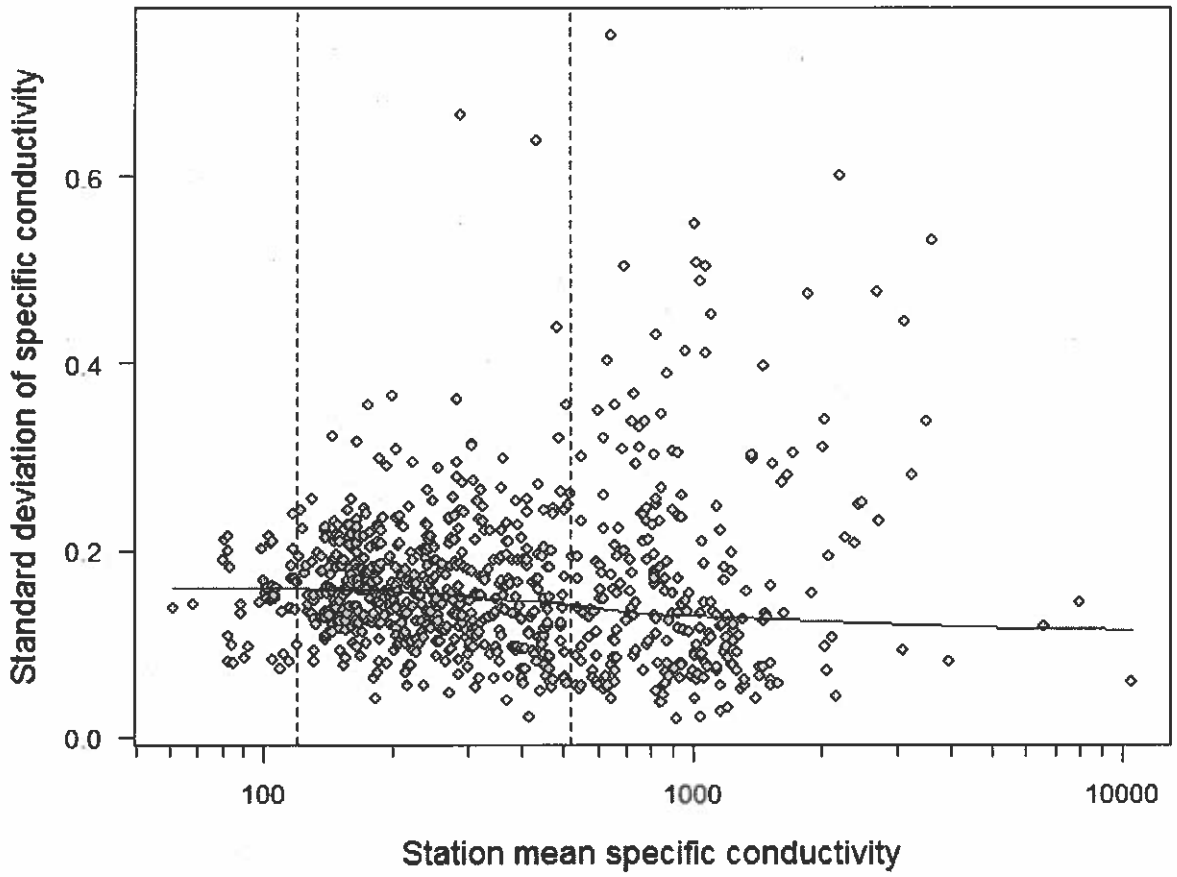


Figure 5-9. Illustration of within site variability (residual standard deviation for each station) along the specific conductivity gradient (station mean) in Ecoregion 70. The *x*-axis is log annual mean specific conductivity. Each dot represents a station. The fitted line is the locally weighted scatterplot smoothing (LOWESS, span = 0.75, linear polynomial model), while the two vertical dashed lines represent logarithm mean specific conductivity of 120 and 520 µS/cm respectively. Within those bounds, the standard deviation is fairly constant.

5.3. GEOGRAPHIC APPLICABILITY

The geographical applicability of the example criteria throughout Ecoregion 70 was assessed using the background-matching approach (see Section 3.7.1). The background SC of the new area (i.e., Ecoregion 70 beyond West Virginia) was estimated at the 25th centile (see Section 3.7.1.2; and Cormier and Suter, 2013a) and compared with the background estimates for Ecoregion 70 within West Virginia.

Because the example SC criteria presented here have been developed for a dissolved mixture dominated by sulfate and bicarbonate anions ($[HCO_3^-] + [SO_4^{2-}]) > [Cl^-]$ in mg/L), all chloride-dominated samples ($([HCO_3^-] + [SO_4^{2-}]) \leq [Cl^-]$ in mg/L) were removed from the data set before estimating background SC. Thereby, the background for the new area is estimated for the same ionic mixture as the example criteria.

5.3.1. Data Sources

Two data sets were used for this example applicability assessment: the original data set used to derive the HC_{05} described in Section 5.1 and an EPA-survey data set.

An EPA-survey data set was used to evaluate and characterize ion concentrations and water chemistry in the ecoregion. The primary sources of the combined data are from EPA survey programs: the NRSA 2008–2009 data set (U.S. EPA, 2013b), WSA 2004 data set (U.S. EPA, 2006), EMAP 1993–1998 data sets and R-EMAP 1999 data set (U.S. EPA, 2013c), and NAPAP data set collected in 1986 (NADP, 2013) (see Table 5-4). Data sets are based on single random samples from June through September. Most report SC, alkalinity, hardness, sulfate, chloride, bicarbonate, pH and other water quality parameters. Ecoregions and sampling sites are shown in Figure 5-10. All samples were collected from first-through fourth-order streams as part of a probability-based design intended to estimate proportions of parameters for various stream classes. The probability-design weights were not used in this characterization. Analysis of water chemistry samples followed EPA procedural and quality assurance/quality control protocols from EMAP (U.S. EPA, 2001, 1998b, 1994, 1987), Wadeable Streams Assessment (U.S. EPA, 2004a, b), NRSA (U.S. EPA, 2009), and NAPAP (Drousé et al., 1986; U.S. EPA, 1987). These data sets were also selected so that methods would be comparable across the data set and because these studies used probability-based designs (i.e., randomly assigned sampling locations).

Table 5-4. Description of survey data sets combined to form the EPA-survey data set used to assess applicability of example ecoregional criteria throughout Ecoregion 70

Data set	Sampling period	Total *N*	KY	OH	PA
MAHA EMAP	1993–1995	14	0	0	14
MAIA EMAP	1997–1998	10	0	0	10
WSA	2004	16	5	6	5
NRSA	2008–2009	14	4	6	4
NAPAP	1986	5	0	0	5
Region 4 Wadeable Streams R-EMAP	1999–2002	2	2	0	0
Total		**61**	**11**	**12**	**38**

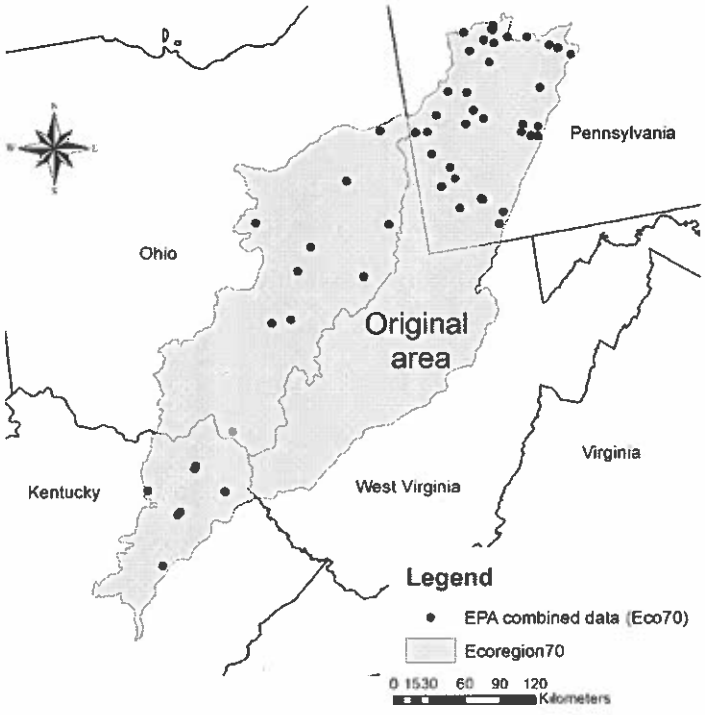


Figure 5-10. Ecoregion 70 extends from southwestern Pennsylvania and southeastern Ohio into Kentucky. Sampling sites in the EPA-survey data set that were used to estimate background in the "new" area for Ecoregion 70 are indicated as points. There are 61 samples from 61 stations.

5.3.2. Geographic Applicability Results

A summary of water quality for the ecoregion, including major ionic constituents, for the EPA-survey data set is listed in Table 5-5. Sites with HCO_3^- + SO_4^{2-} concentrations on a mass basis greater than or equal to Cl^- were used to estimate background SC. This mixture is common in the ecoregion, and only one site was dominated by chloride anions in the EPA-survey data set and none in the example Criterion-data set. Therefore, this one site was excluded so the natural background was estimated from the altered EPA-survey data set.

Background SC for bicarbonate and sulfate dominated waters estimated as the 25th centile of the EPA-survey data set for the area in Ecoregion 70 outside the area used to develop the example criteria was 197 µS/cm (95% CI 145–272 µS/cm) (see Table 5-6). The 25th centile from the probability sample from the example Criterion-data set was 147 µS/cm (95% CI 136–159) (see Table 5-6). The confidence bounds for background estimated from the example Criterion-data set overlap with the confidence bounds for background estimated for the rest of the ecoregion. Therefore, the background SC regime throughout Ecoregion 70 appears to be similar, and the example criteria (CCC = 340 µS/cm, CMEC = 680 µS/cm) are considered geographically applicable throughout the ecoregion. Other estimates of background from the reference sites in the example Criterion-data set (201 µS/cm; 95% CI 164–210 µS/cm) and the example Criterion data set (169 µS/cm; 95% CI 161–171 µS/cm) also overlap with the CI of the background for the rest of the ecoregion. As a validation of background specifically for the portion of Ecoregion 70 in Ohio, a weight of evidence was performed (see Appendix C).

Table 5-5. Summary of water quality parameters for Ecoregion 70 EPA-survey data set

Ion or specific conductivity	Min	Centile				Max	[a]*N*
		10th	25th	50th	75th		
HCO_3^- (mg/L)	0.0	1.8	18.1	52.2	121.0	241.8	42
SO_4^{2-} (mg/L)	11.5	17.2	24.1	52.6	144.7	955.8	58
Cl^- (mg/L)	1.0	3.8	6.0	9.6	26.3	204.5	58
Ca^{2+} (mg/L)	4.9	10.5	19.0	47.8	69.3	240.8	58
Mg^{2+} (mg/L)	1.8	3.5	6.2	12.5	22.7	87.7	58
Na^+ (mg/L)	1.0	3.1	4.3	9.1	22.8	161.2	58
K^+ (mg/L)	1.0	1.6	1.9	2.4	3.0	9.6	58
pH (SU)	4.0	6.3	7.3	7.7	8.1	8.6	60
[b]$(HCO_3^- + SO_4^{2-})/Cl^-$	1.7	3.7	8.0	10.6	22.8	103.8	42
SC (µS/cm)	66.7	108	197	398	631	1,860	60

[a]Relevant *N* indicates the number of samples from the large data set relevant to each water quality parameter.
[b]Value within category calculated from individual sample ion concentrations. $HCO_3^- + SO_4^{2-}/Cl^-$ in mg/L greater than 1 indicates the mixture is dominated by $HCO_3^- + SO_4^{2-}$. One site dominated by Cl^- was removed from the data set.

Table 5-6. Background specific conductivity estimates for Ecoregion 70

Data set	Centile used to estimate background	Estimated background µS/cm	Confidence interval µS/cm	Relevant *N* (stations/ samples)
EPA-survey data set from geographic area in Ecoregion 70 not represented in the example criterion derivation data set	25th	197	135–240	60/61
WABbase data set, probability sample subset	25th	147	136–159	617/681
WABbase data set, reference sample subset	75th	201	164–210	30/55
Ecoregion 70 example criterion derivation data set, full data set	25th	169	161–171	1,695/2,075

5.4. SUMMARY OF EXAMPLE CRITERIA FOR ECOREGION 70

The case example for Ecoregion 70 includes an annual geometric mean (i.e., CCC) and a 1-day mean (i.e., CMEC), not to be exceeded more than once in 3 years on average. Both of these distinct expressions of the example SC criteria would need to be met in order to adequately protect aquatic life. These values indicate that freshwater animals would be protected if the annual geometric mean SC concentration does not exceed 340 µS/cm and the 1-day mean does not exceed 680 µS/cm, more than once every 3 years on average. These example criteria would apply to all flowing freshwaters (ephemeral, intermittent, and perennial streams) in Ecoregion 70 inclusive of portions of Kentucky, West Virginia, Pennsylvania, and Ohio. On a site-by-site basis, these example ecoregional criteria apply if the ionic mixture is dominated by anions of bicarbonate and sulfate. For streams crossing into Ecoregion 70, professional judgment may be needed to assess the potential effect of different ionic composition or concentration. Professional judgment is recommended when applying to sites with a catchment area greater than 1,000 km^2 (386 mi^2) owing to lesser representation in the example data set by this class of stream. On a site-by-site basis, alternative SC criteria may be more appropriate if the natural background of a site is shown to be lower or higher than its regional background specific conductivity.

5.5. EXAMPLE CRITERION CHARACTERIZATION

5.5.1. Factors Potentially Affecting the Extirpation Concentration Distribution (XCD) Model

An assessment of potential confounders and an analysis of the influence of habitat quality and sampling date for Ecoregion 70 can be found in Appendix B.2.

5.5.1.1. *Sensitivity Analyses*

As the minimum number of occurrences of a genus for inclusion in the data set increases, fewer genera are included in the XCD. The HC_{05} increases greatly when a taxon in the lower 5th centile is removed because it does not meet the minimum number of samples and then more slowly alternates between increasing and decreasing as genera either above or below the 5th centile are removed because they do not meet the minimum number of samples (see Figure 5-11). The pattern repeats until all genera above and below the lower 5th centile have the same XC_{95} value (not shown). To maximize the number of genera included in the XCD, a minimum of 25 occurrences was utilized.

The number of samples in the data set affected the number of genera included in the XCD and the resulting example HC_{05}. The effects of data set size on the HC_{05} estimates and on their confidence bounds were estimated using a bootstrapping technique. The mean of all bootstrapped HC_{05} values, the numbers of genera used for the HC_{05} calculation, and their 95% CI were plotted to show the effect of sample sizes. As shown in Figure 5-12, the HC_{05} for this data set stabilizes, reaching an asymptote at approximately 500–800 sites sampled and 90–100 genera evaluated. Therefore, the original data set was considered adequate for estimating the example CCC.

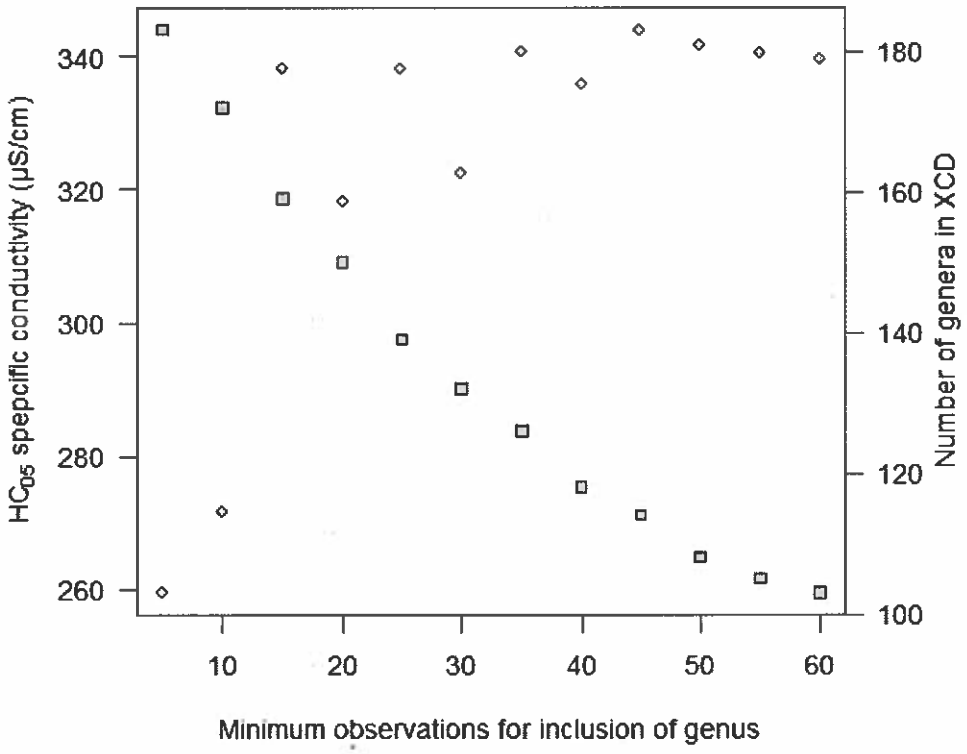


Figure 5-11. Relationship of the number of occurrences of a genus on the hazardous concentration (HC_{05}) based on Ecoregion 70 example Criterion-data set. Estimates of HC_{05} values (blue diamonds, left axis) and the number of taxa in the extirpation concentration distribution (XCD) (red squares, right *y*-axis) based on minimum number of samples (5–60, *x*-axis). As the minimum number of occurrences of a genus increases, fewer are included in the XCD.

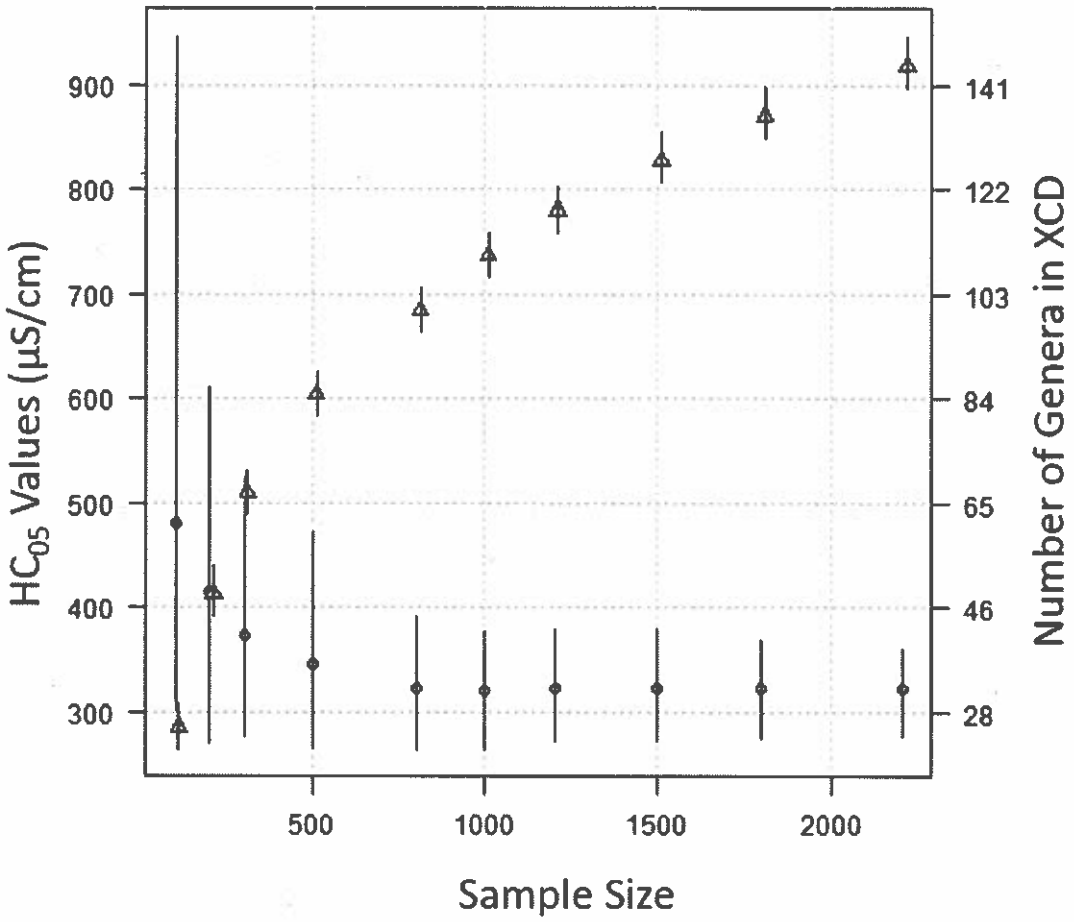


Figure 5-12. Adequacy of the size of the data set used to model the hazardous concentration (HC_{05}) based on the Ecoregion 70 example Criterion-data set. As size of the data set increases, the number of genera included in the genus extirpation concentration distribution (XCD) increases (triangles). The HC_{05} stabilizes, reaching an asymptote at approximately 500−800 sites sampled (circles) and 90−100 evaluated genera.

5.5.2. Validation of the Model

As recommended by the SAB (U.S. EPA, 2011c), the XCD model was validated and uncertainty around the HC_{05} values was estimated using bootstrapping. The median HC_{05} estimated from bootstrapping was 323 µS/cm (95% CI 272−365 µS/cm) which is similar to the HC_{05} of 338 µS/cm measured using a two-point interpolation from the original XCD. The similarity between the two HC_{05} values indicates a similar model would be generated using an independent data set (see Figure 5-13).

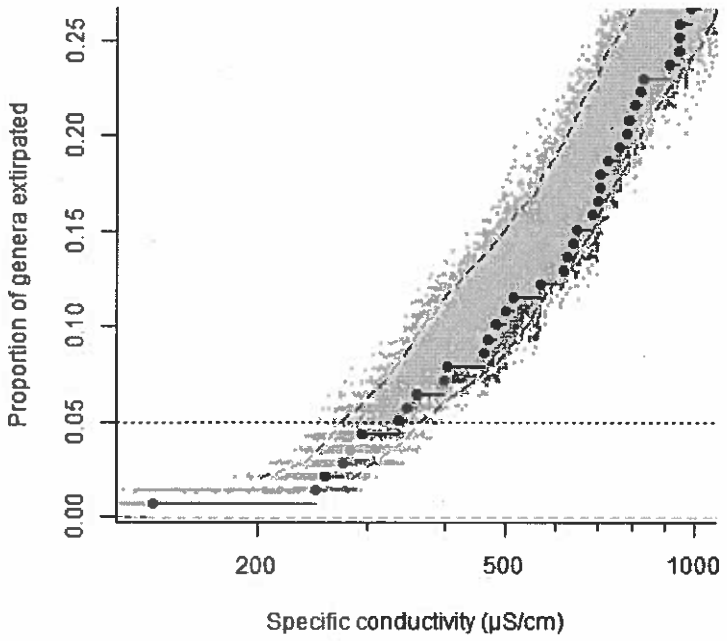


Figure 5-13. 95% confidence intervals (hatched oblique lines) for the lower portion of the Ecoregion 70 genus extirpation concentration distribution (XCD). Each tiny gray dot represents an extirpation concentration (XC_{95}) value from one of 1,000 XCD bootstrapping iterations (note that the genera and their order varies with each XCD-iteration). Each of the 36 blue filled dots represents the calculated XC_{95} of the XCD for the example criterion continuous concentration (CCC). Hazardous concentration (HC_{05}) based on the bootstrap medians is 323 µS/cm.

5.5.3. Duration and Frequency

Numeric criteria include magnitude (i.e., how much), duration (i.e., how long), and frequency (i.e., how often) components. Appropriate duration and frequency components of criteria are determined based on consideration of available data and understanding the exposure-response relationship in the context of protecting the aquatic life of a water body. The significant consideration used in setting the duration component of aquatic life criteria is how long the exposure concentration can be above the criteria without affecting the endpoint on which the criteria are based (U.S. EPA, 1985, 1991). Based on the temporal resolution of the available field data set and an analysis of within-site variability of SC levels, EPA developed two

different expressions for the example SC criteria in order to provide adequate protection for aquatic life.

In this case, the majority (>81%) of sites used to derive the example CCC for Ecoregion 70 were sampled once during an annual sampling period and thus represent the average stream chemistry (SC) and macroinvertebrate assemblage information over the course of 1 year. As a result, the appropriate duration for the CCC is 1 year. The duration for the CMEC, a level of protection from acutely toxic exposures, is 1 day based on a review of the literature on the onset of macroinvertebrate drift in response to elevated SC (see Section 3.3). At sites meeting the CCC, 90% of the SC observations are estimated to occur below the CMEC.

EPA anticipates that an appropriate allowable frequency of exceedance for these example criteria is no more than once in 3 years, based on recovery rates from literature reviews and consideration of the life history of insects able to recolonize a site via drift or aerial dispersal (see Section 3.4). Recovery is expected to occur in 3 years if the following conditions are met: (1) the SC regime returns to a yearly average below the CCC, (2) there are nearby streams with low SC supporting a diverse community, and (3) there is an upstream source of colonizers or the flight or recolonizing distance is within the dispersal range of genetically diverse, reproducing adult colonizers. If any of these conditions are not met, the time necessary for ecosystem recovery (and thus, the allowable frequency of exceedance) would likely be longer than 3 years.

5.6. PROTECTION OF FEDERALLY-LISTED SPECIES

Although the derivation of the example criteria was limited to the macroinvertebrate taxa represented in the data sets, the available evidence indicates that other taxa in the streams would likely be protected as well (see Section 2.6 and Appendix G). Hence, no adjustment was made for unanalyzed taxa. However, on a site-specific basis, the example criterion could be adjusted or recalculated to protect important species, highly valued aquatic communities, or specially protected waters.

6. CASE STUDY III: EXAMPLE USING THE BACKGROUND TO CRITERION (B-C) REGRESSION METHOD

This section presents an example calculation of an ecoregional CCC using the B-C method (see Section 3.7.2 and Appendix D). In this example, a CCC for the Northwestern Great Plains, Level III Ecoregion 43, was calculated using SC data from the ecoregion and the B-C method because there were insufficient paired SC and biological data to use the XCD method in this ecoregion.

First, the water chemistry data set was screened for ionic composition to ensure samples were dominated by sulfate and bicarbonate anions, and sampled sites were mapped to determine whether the geographic distribution of sites was representative of (dispersed throughout) the ecoregion. Minimally affected background SC of the new ecoregion was estimated at the 25th centile of probability samples (see Section 3.7.1.2; Cormier and Suter, 2013a). Least disturbed background SC was estimated at the 25th centile of a combined data set of targeted and probability samples. The CCC was calculated using the least disturbed 25th centile background SC as the independent variable (x) in the B-C regression model to yield an HC_{05} (y). Depending on available data and analytical results (see Figure 3-11), an HC_{05} may take the form of (1) the y-value at the mean of the regression line from the B-C mode, (2) the y-value at the lower 50% PL of the regression line, or (3) an HC_{05} derived from a data set based on ≥200 paired SC and biological samples. In this example case for Ecoregion 43, there were <200 paired SC and biological samples, so the lower 50% PL was used to develop the example CCC.

6.1. DATA SET CHARACTERISTICS

The Northwest Great Plains is mostly an unglaciated, semiarid, rolling plain with rolling hills and occasional buttes and badlands (Woods et al., 2002). Elevation ranges from 458 to 1,200 meters (McNab and Avers, 1994). The area covers approximately 347,000 km^2 and extends from southeastern Montana and northeastern Wyoming into western parts of North Dakota and South Dakota. Ecoregion 43 is bordered by the Northwestern Glaciated Plains to the north and east, the Middle Rockies and Wyoming Basin to the west, the Eastern High Plains and Nebraska Sand Hills to the south. An outcropping of the Middle Rockies occurs in the south of the ecoregion. The shallow soil is underlain with shale, siltstone, and sandstone. Where there is

sandstone, aquifers can produce groundwater. Otherwise, there are few perennial rivers, and the rainfall is erratic with approximately 250–510 ml/year. The low precipitation and high evapotranspiration lead to less groundwater recharge and baseflow contributing to streams; therefore, many small streams are intermittent or ephemeral. Grazing and ranching is a common land use with some dryland and irrigated agriculture. Surface coal mining and oil and gas production also occur. The often alkali-rich soils in the steppes are dominated by sagebrush; whereas, the buttes are more moist and can support forests.

Only existing data were used for this example assessment (see Table 6-1). An EPA-survey data set and a U.S. Geological Survey (USGS) data set were combined to characterize ion concentrations and water chemistry and then used to calculate a provisional CCC. The USGS data set was also used to calculate the CMEC. The statistical package R, Version 2.12.1 (December 2010), was used for all statistical analyses (R Development Core Team, 2011).

Table 6-1. EPA and U.S. Geological Survey (USGS) chemistry data sets included in this study.
Years indicate the period during which the samples were collected. Western Environmental Monitoring and Assessment Program (EMAP) survey sites are included in the count of sites from the National Wadeable Streams Assessment (NWSA).

Survey	Years	# of sites	# of samples
EPA probability samples			
EMAP and Regional EMAP	1993–2003	12	12
NWSA	2000–2004	53	53
NRSA	2008–2009	53	53
USGS mixed sampling			
USGS: full data set	1946–2008	281	45,489
USGS: subset ≥ six samples per rotation year, July–June	1946–2008	148	41,648

This B-C regression model was developed using biological data paired with SC data from 24 data sets with waters having ionic mixtures dominated by calcium, magnesium, sulfate and bicarbonate ions and where background SC did not exceed 626 µS/cm. Therefore, the model is

most appropriate for waters with similar ionic characteristics. The model has not been thoroughly tested with waters dominated by other mixtures, i.e., ($[SO_4^{2-}] + [HCO_3^-]$) < $[Cl^-]$, and ($[Ca^{2+}] + [Mg^{2+}]$) < ($[Na^+] + [K^+]$) in mg/L. In particular, the B-C model is not appropriate for waters dominated by NaCl (Haluszczak et al., 2013, Entrekin et al., 2011; Gregory et al., 2011; Veil et al., 2004) or road salt (Forman and Alexander, 1998; Kelly et al., 2008; Environment Canada and Health Canada, 2001; Evans and Frick, 2001; Kaushal et al., 2005). However, the model and this analysis may be defensible for ionic mixtures dominated by sodium, sulfate and bicarbonate ions (Brinck et al., 2008; Dahm et al., 2011; Jackson and Reddy, 2007; National Research Council, 2010; Clark et al., 2001; Veil et al., 2004). This is because the toxicity of these mixtures are more similar to that of calcium, magnesium, sulfate and bicarbonate ions than the toxicity of NaCl (Mount et al., 2016; Kunz et al., 2013; Soucek and Dickinson, 2015).

In this example case study, more than half of the sampled sites were dominated by sulfate, bicarbonate, sodium, and potassium ions, ($[SO_4^{2-}] + [HCO_3^-]$) > $[Cl^-]$, and ($[Ca^{2+}] + [Mg^{2+}]$) < ($[Na^+] + [K^+]$) in mg/L. No samples were excluded based on cations. All samples in the EPA-survey data set were used because no samples were dominated by chloride ions. A USGS data set of 281 sites was used to verify ionic composition. Of 7,461 samples, 7,456 (>99.9%) were dominated by sulfate plus bicarbonate. The five samples not dominated by sulfate and bicarbonate occurred at sites sampled multiple times that more often than not were dominated by sulfate and bicarbonate, so these sites were retained. All sites in the combined EPA-USGS data set had pH data, but none were <6 nor >9.8, so no sites were removed from the data set.

6.1.1. EPA-Survey Data Set

Data sources, sampling period, and number of samples used to estimate background SC in the new area (Ecoregion 43) are provided in Table 6-1. The NRSA 2008–2009 data set (U.S. EPA, 2013b), WSA 2004 data set (U.S. EPA, 2006), EMAP 1993–1998 data sets and R-EMAP 1999 data sets (U.S. EPA, 2013c), are based on single random (i.e., probability-based design) samples from June through September.

EPA-survey data sampling sites within the ecoregion are shown in Figure 6-1. Water quality parameters collected in Ecoregion 43 are included in Table 6-2. Most of the samples

have reported SC, alkalinity, hardness, sulfate, chloride, bicarbonate, and pH, as well as other water quality parameters. When necessary, ionic concentrations in milliequivalents (meq/L) were converted to mg/L [(meq/L) × (ion MW)/(ionic charge)] (Hem, 1985).

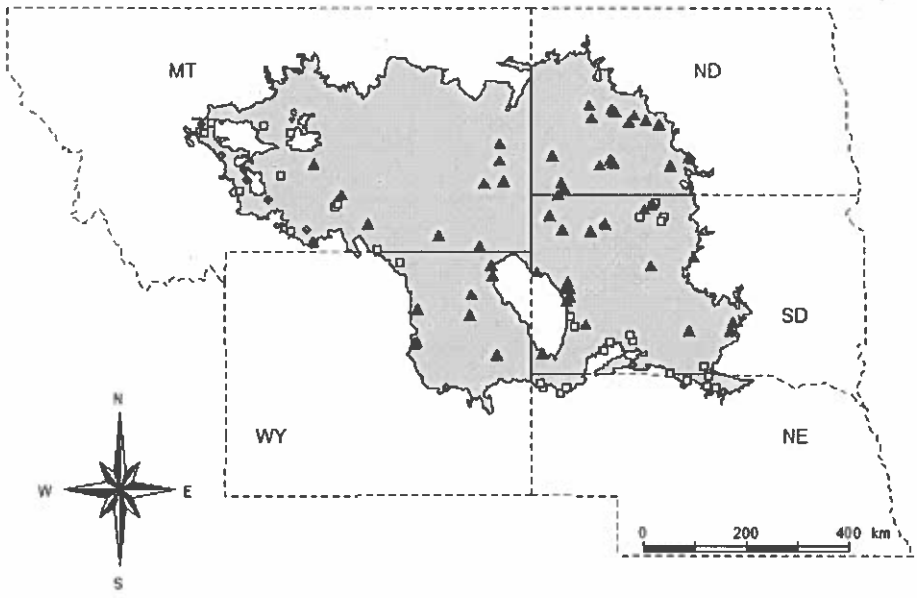


Figure 6-1. Sampling sites in the EPA-survey data set that were used to estimate minimally affected background in Ecoregion 43. For the purpose of demonstrating the background-to-criterion approach, Level III Ecoregion 43 which encompasses portions of Montana, North and South Dakota, Wyoming, and Nebraska is shaded gray. A total of 115 sampling sites is depicted. Sampling locations are color-coded by site-specific conductivity range: green diamonds <300 µS/cm, yellow squares 300−1,000 µS/cm, and red triangles ≥1,000 µS/cm. Geodetic reference system = North American Datum (NAD83).

Table 6-2. Summary of data for the example case for Northwestern Great Plains, Level III Ecoregion 43 from EPA-survey samples.
Geometric means were calculated except for pH and ion ratio.

Parameter	*N*	Minimum	25th	50th	Mean	75th	Maximum
SC (µS/cm)	118	57	483	1,257	1,041	2,406	5,769
pH (SU)	118	6.70	8.06	8.27	8.30	8.47	9.88
Ca^{2+} (mg/L)	111	3.62	37.6	53.5	62.6	139	511
Mg^{2+}(mg/L)	111	0.65	9.34	33.0	26.8	82.1	240
Na^{+} (mg/L)	106	1.23	23.7	162.97	99.2	390	1,059
K^{+} (mg/L)	106	0.44	4.16	7.95	6.73	12.6	80.1
HCO_3^{-} (mg/L)	53	45.8	205	277	286	429	987
SO_4^{2-} (mg/L)	106	3.33	52.4	367	214	1,074	2,750
Cl^{-} (mg/L)	106	0.20	3.80	8.50	8.63	18.9	520
[a] $HCO_3^{-} + SO_4^{2-}/Cl^{-}$	53	3.26	35.2	73.3	99.4	129	464

[a]Ratio of mg/L $HCO_3^{-} + SO_4^{2-}/Cl^{-}$ greater than 1 indicates the mixture is dominated by $HCO_3^{-} + SO_4^{2-}$.

All samples were collected from first-through fourth-order streams as part of a probability-based design intended to estimate proportions of parameters for various stream classes. The probability-design sampling weights for stream order were not used in the characterization. Analysis of water chemistry samples followed procedural and QA/QC protocols of EPA and EMAP (U.S. EPA, 2001, 1998b, 1994, 1987), Wadeable Streams Assessment (U.S. EPA 2006, 2004a, b), NRSA (U.S. EPA, 2009), and NAPAP (Drousé et al., 1986; U.S. EPA, 1987).

6.1.2. U.S. Geological Survey (USGS) Data Set

The USGS survey data set used in this example is composed of 45,489 water quality samples, from 281 stations within Ecoregion 43 (see Table 6-1; Figure 6-2). Some stations were sampled only once while others were sampled as many as 5,445 times. The data were collected between 1946 and 2015 during all seasons. Water quality parameters collected in Ecoregion 43 are included in Table 6-3. Most of the samples have reported SC, alkalinity, hardness, sulfate, chloride, bicarbonate, and pH, as well as other water quality parameters. Analysis of water

chemistry samples followed procedural and QA/QC protocols for USGS data sets (Mueller et al. 1997).

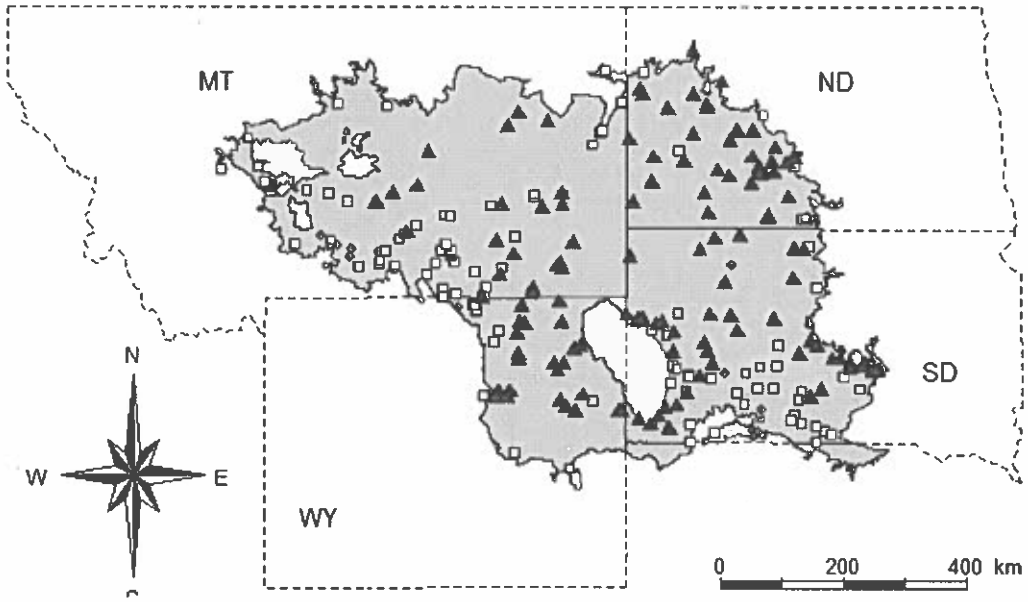


Figure 6-2. Sampling sites in the U.S. Geological Survey (USGS) data set in Ecoregion 43. Ecoregion 43 is shaded gray. Geometric mean specific conductivity at sampling locations is color-coded: green diamonds <300 µS/cm, yellow squares 300−1,000 µS/cm, and red triangles ≥1,000 µS/cm. Geodetic reference system = North American Datum (NAD83).

Table 6-3. Summary of data for the example case for Northwestern Great, Level III Ecoregion 43 from U.S. Geological Survey (USGS).
Geometric means were calculated for all variables except for pH and ion ratio.

Parameter	*N*	Minimum	25th	50th	Mean	75th	Maximum
SC (µS/cm)	281	85	564	1,045	986	1,816	7,330
pH (SU)	170	7.30	8.1	8.2	8.2	8.3	9.0
Ca^{2+} (mg/L)	118	21.87	50.9	69.0	76.4	114.9	464
Mg^{2+} (mg/L)	118	5.81	28.4	46.6	45.0	75.5	654
Hardness (mg/L)	52	121.1	290	479.7	432.4	608.1	1,040
Na^{+} (mg/L)	118	1.55	59.4	180.3	132.5	325	1,186
K^{+} (mg/L)	110	0.74	5.1	9.2	8.1	13.3	25.1
HCO_3^{-} (mg/L)	92	2.00	224.4	278.5	204.2	405	765
SO_4^{2-}(mg/L)	120	4.56	189.5	464.2	362.4	808.3	2,283
Cl^{-} (mg/L)	117	0.97	6.9	10.7	14.7	27.6	938
[a]$HCO_3^{-} + SO_4^{2-}/Cl^{-}$	86	2.35	22.9	77.6	82.6	116	363

[a]ratio of mg/L $HCO_3^{-} + SO_4^{2-}/Cl^{-}$ greater than 1 indicates the mixture is dominated by $HCO_3^{-} + SO_4^{2-}$.

All samples were collected from first-through fourth-order streams for various research purposes and thus the targeted sampling design may emphasize areas with increased anthropogenic disturbance or some geologic formations. In this respect, the data may skew the background SC estimates. Background SC was not estimated from this data set because sampling stations were not randomly assigned. However, after weighing the potential bias that could be introduced with the benefits of having greater coverage across the ecoregion, the EPA-survey and USGS data sets were combined and used to estimate background SC.

Because the USGS data set contained multiple measurements in an annual rotation from sampling locations, the data set was used to estimate a CMEC and to explore the variability of SC patterns within the region. Therefore, a second data set was selected by excluding stations with fewer than six SC measurements throughout the year. A minimum of one sample during the first 6 months and one in the last 6 months of the previous year were also required so that at least one low and high SC sample was included in the data set. The second USGS data set that included 41,648 samples from 168 stations was used to calculate the variance near the CCC for the CMEC calculation.

6.1.3. Modeled Mean Baseflow Background Specific Conductivity (SC)

Predicted mean natural base-flow SC in catchments of Northwestern Great Plains, Ecoregion 43, was also considered for comparison purposes (Olson and Hawkins, 2012). The stream length weighted, mean natural SC (each SC was multiplied by the proportion of stream segment length) at base flow for each ecoregion (see Appendix D). Figure 6-3 shows the predicted SC at 300m resolution in order to emphasize the general trends across Ecoregion 43.

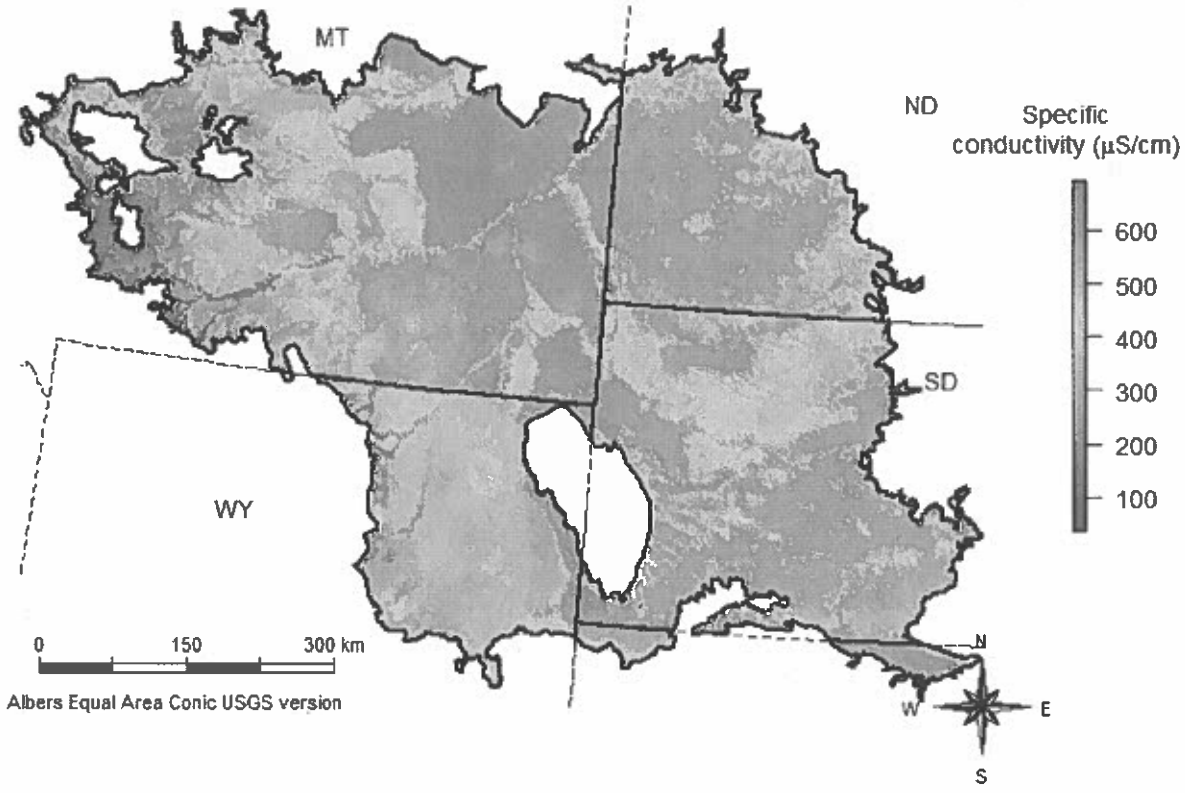


Figure 6-3. Predicted mean natural base-flow specific conductivity in catchments of Northwestern Great Plains, Ecoregion 43, using the Olson-Hawkins model. Albers projection used for mapping.

6.1.4. Characterization of Ionic Matrices

6.1.4.1. *EPA-Survey Data Set Ionic Characteristics*

A summary of water quality ionic constituents including major ionic constituents for Ecoregion 43 is provided in Table 6-2. Centiles were calculated using each sample observation

because most measurements were single grab samples. There were no chloride-dominated sites where ($[Cl^-] \geq [HCO_3^-]) + [SO_4^{2-}]$ in the EPA-survey data ($N = 118$); therefore, no sites were excluded from the data sets. Sodium was the dominant cation at more than half the sampled sites. This mixture was judged as acceptable for use with the B-C model, but with less confidence than a calcium and magnesium dominated mixture. Ionic characteristics for Ecoregion 43 are shown for the EPA-survey in Table 6-2 and the USGS data set in Table 6-3.

6.1.4.2. *U.S. Geological Survey (USGS) Data Set Ionic Characteristics*

Table 6-3 summarizes the water quality parameters including major ionic constituents for Ecoregion 43 in the USGS data set. Unlike the EPA-survey data set, the USGS data set contains targeted sites of interest rather than probability samples. Also, in some cases, there are multiple measurements from the same site, and other sites are autocorrelated with downstream sampling locations. Therefore, the distribution of sites in this data set is not necessarily representative of Ecoregion 43 in its entirety; however, the data set can be used to define the overall pattern of SC for the ecoregion because it contains samples in areas not represented in the EPA-survey data set. Centiles were calculated using the geometric mean of site measurements (except pH and the ionic ratio) and were qualitatively compared to the probability-based EPA-survey data set.

Two samples with pH <6 and a few observations (less than 10) with some ion concentrations recorded as 0 were removed from the USGS data set. Only 5 out of 45,489 samples collected in this data set were dominated on some days by chloride, $[Cl^-] \geq ([HCO_3^-] + [SO_4^{2-}])$ in mg/L; however, on average, these 5 sites were not dominated by chloride ions, so those samples were not removed. Sodium was the dominant cation in more than half of the samples. This mixture was judged as acceptable for use with the B-C model, but with less confidence than a calcium and magnesium dominated mixture.

6.1.5. Comparison of Background Specific Conductivity (SC) Estimates

In this case example, the stream length weighted average predicted mean base flow SC from the Olson-Hawkin's model in Ecoregion 43 is 489 µS/cm. Raw values for predicted mean flow for stream segments are shown as box plot in Figure 6-4. The 25th centile of the EPA-survey data set is 483 µS/cm. The USGS SC data set has a slightly narrower overall range and mid-range of values resulting in a slightly higher quartile SC than the EPA survey data set

(564 µS/cm) (see Figure 6-4 and Table 6-3). When the USGS data set is combined with the EPA-survey data set, the 25th centile (542 µS/cm) is also greater than the predicted mean baseflow of 489 µS/cm (see Table 6-4, Figure 6-4). Therefore, this background SC estimated from the combined EPA-USGS data set is least disturbed.

The 25th centile of the combined EPA-survey and USGS data set was used to calculate the HC_{05} following the decision tree described Section 3.7.2 and Figure 3-11. Because the lower quartile ranges from 85 to 564 µS/cm, additional analysis is recommended for streams known to have low SC regimes.

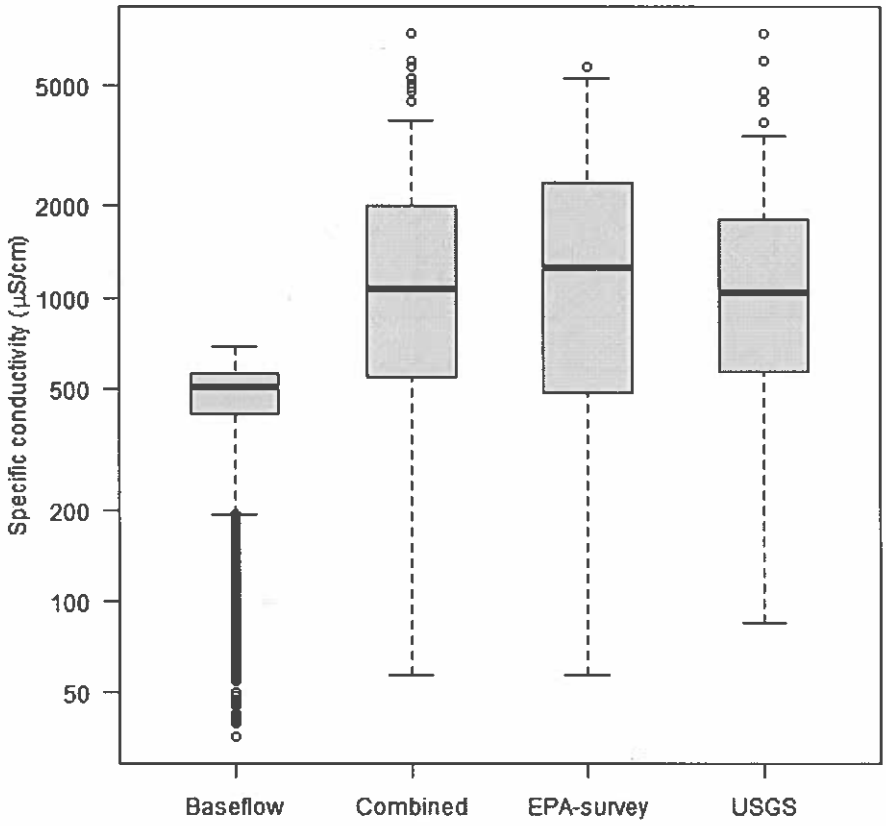


Figure 6-4. Box plots of specific conductivity (SC) distributions for EPA-survey, U.S. Geological Survey (USGS), combined EPA-survey and USGS data sets and predicted mean base-flow. The USGS data set captures a slightly narrower midrange of values possibly owing to the targeted sampling and the mean values rather than the single measurements in the EPA sample. The 25th centile of the combined and USGS data set is greater than the mean predicted base-flow. The mean baseflow model predicts many outliers for the region <200 µS/cm.

Table 6-4. Summary of data for the example case for Northwestern Great Plains, Level III Ecoregion 43 from the combined EPA-survey and U.S. Geological Survey (USGS) data set.
Geometric means for sampled sites were calculated for all variables except for pH and ion ratio.

Parameter	*N*	Minimum	25th	50th	Mean	75th	Maximum
SC (µS/cm)	399	57	542	1,074	1,002	2,006	7,330
pH (SU)	288	6.7	8.1	8.2	8.3	8.4	9.9
Ca^{2+} (mg/L)	229	3.6	46.2	63.0	69.4	122.5	511.2
Mg^{2+} (mg/L)	229	0.65	20.0	43.7	35.0	77.6	654.4
Hardness (mg/L)	163	11.7	184.5	377.8	325.0	642.5	1,828.1
Na^{+} (mg/L)	224	1.2	49.1	173.7	115.5	337.7	1,185.6
K^{+} (mg/L)	216	0.44	4.5	8.7	7.4	12.9	80.1
HCO_3^{-} (mg/L)	145	2.0	212.9	277.8	231.0	410.8	986.7
SO_4^{2-}(mg/L)	226	3.33	129.5	452.9	283.0	940.8	2,750.7
Cl^{-} (mg/L)	223	0.20	5.3	9.9	11.4	20.6	937.8
[a]$HCO_3^{-} + SO_4^{2-}/Cl^{-}$	139	2.35[b]	33.6[b]	76.25[b]	89[b]	123.0[b]	464[b]

[a]Ratio of mg/L $HCO_3^{-} + SO_4^{2-}/Cl^{-}$ greater than 1 indicates the mixture is dominated by $HCO_3^{-} + SO_4^{2-}$.

6.1.6. Calculation of Ecoregion 43 Criterion Continuous Concentration (CCC) from Background

Because available paired SC and biological data represented <200 sites, the HC_{05} was estimated at the lower 50% PL using the B-C model (see Figure 6-5). The 25th centile of SC from the EPA-survey data set of Ecoregion 43 was used to identify the lower 50% PL using eqs 3-4 and 3-5. The B-C model development is described in Appendix D. The *x*-variable is the background SC in Ecoregion 43 which was log10 transformed. The calculated *y*-value is the predicted mean log10 HC_{05}. In this example case, the least disturbed background is 542 µS/cm (see Table 6-4). It was estimated at the 25th centile from the combined EPA-survey and USGS data set to improve representation of samples from the entire ecoregion. The calculation of the predicted mean log10 of HC_{05} (*y*) is shown in eqs 6-1 and 6-2 and that value is used to estimate the lower 50% PL using eq 6-3.

The B-C model is described by the following formula:

$$Y = 0.657X + 1.075 \quad (6\text{-}1)$$

Where:

X is the log10 of the ecoregional background SC

Y is the log10 of the predicted HC_{05}

The background for Ecoregion 43 (542 µS/cm) is converted to log10, replacing X in the formula with that value and Y is computed (see eq 6.2). The predicted value Y is converted from log10 to a number that is the modeled HC_{05} for that region. In Ecoregion 43 the mean modeled HC_{05} is 740 µS/cm after rounding to two significant figures.

$$\text{Log Predicted } HC_{05} = (0.657 \times 2.73) + 1.075 = 2.87 \text{ µS/cm} \quad (6\text{-}2)$$

Then

$$\text{Predicted } HC_{05} = 10^{2.87} \text{ µS/cm} = 743 \text{ µS/cm}$$

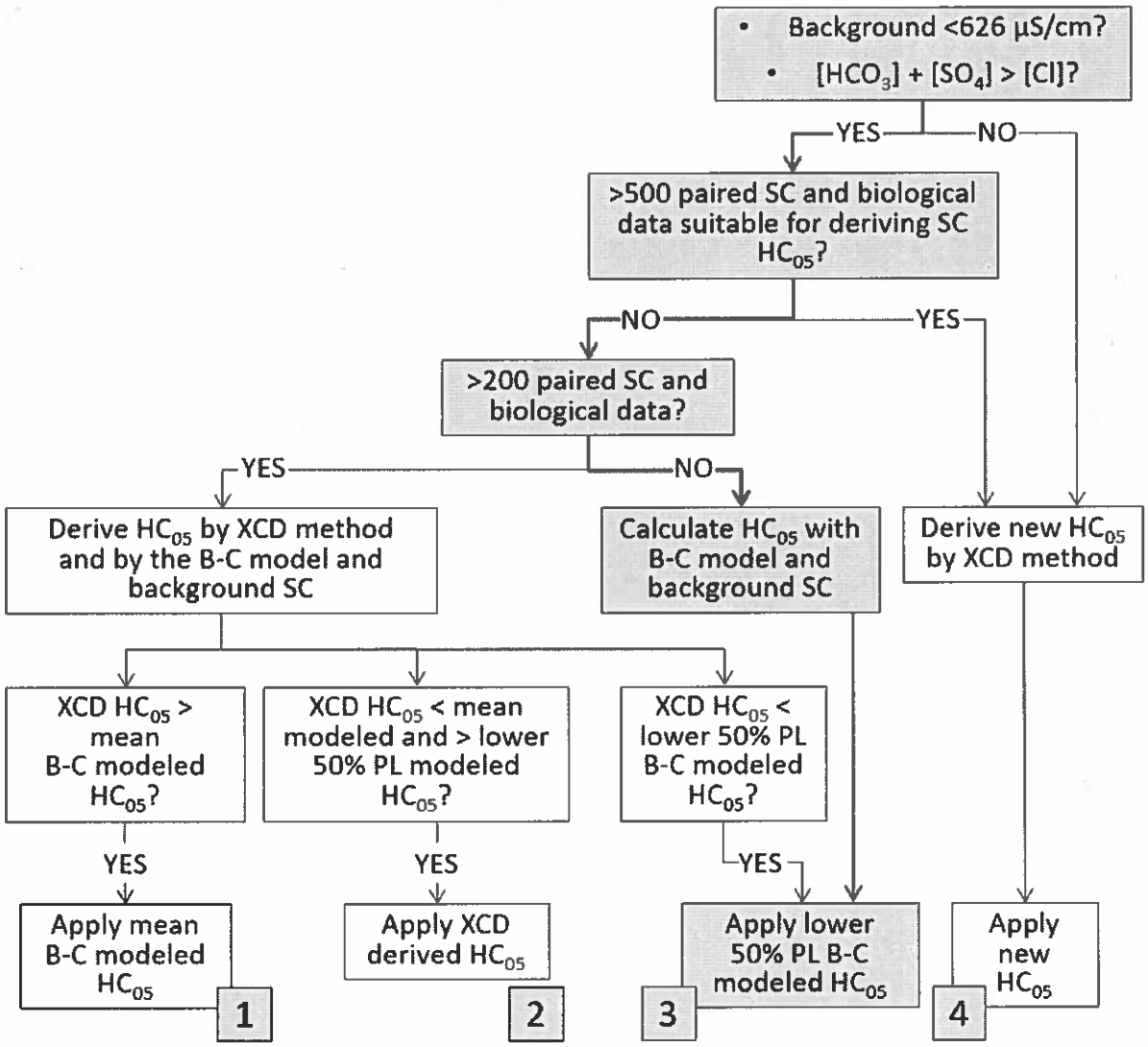


Figure 6-5. Process and decision path case example for Ecoregion 43. Decision path is highlighted in gray and connected by bold lines. Because there was no previously derived hazardous concentration at the 5th centile (HC_{05}) of a taxonomic extirpation concentration distribution (XCD) for Ecoregion 43, and the background was <626 µS/cm, and there were <200 paired specific conductivity (SC) measurements, the HC_{05} was calculated with the background-to-criterion (B-C) model at the lower 50% prediction limit (PL).

6.1.7. Formula for Calculating the Lower 50% Prediction Limit

Because the available paired SC and biological data constitute <200 sites, the HC_{05} was estimated at the lower 50% PL (see Figure 6-5). The 25th centile of background SC and the predicted mean HC_{05} of a region and variance of the B-C model is used to calculate the lower

50% PL (see eq 6-3). In this case example for Ecoregion 43, the background is 542 µS/cm and the mean modeled HC_{05} is 743 µS/cm. Both values are converted to log10 (x, y) as shown in eq 6-4. The prediction interval from the regression line for a mean predicted value $\hat{y}$ can be calculated as follows or more conveniently using statistical software thus avoiding rounding errors:

$$\hat{y} \pm t_{\alpha/2,n-2} S_y \sqrt{1 + \frac{1}{n} + \frac{(x^* - \bar{x})^2}{SS}} = \log 10 \text{ PL} \qquad (6\text{-}3)$$

Symbol	Explanation	Example from the B-C model
$\hat{y}$	Log10 of mean predicted HC_{05}	2.87 µS/cm, log10 of 743 µS/cm
n	Number of samples in the model	$n = 24$
α	Alpha error rate for prediction interval (desired confidence level)	50% prediction interval (α = 0.5)
t_{n-2}	t-value at specific level (alpha, α) and degrees of freedom $(n - 2)$ of interval	For 50% prediction interval (α = 0.5), $t_{(1-0.5)/2,24-2} = 0.686$
S_y	Residual standard error of prediction (standard deviation)	$S_y = 0.11$
SS	Sum of square of x deviation from their mean, $SS = \sum_{i=1}^{n}(x_i - \bar{x})^2$	$SS = 4.21$
$\bar{x}$	Mean x values used in the model generation	$\bar{x} = 2.15$
x^*	x value for a new prediction interval	Log10 542 µS/cm = 2.73
PL	Upper and lower prediction limits of mean predicted $\hat{y}$	calculated in eq 6-4

Using x^* = log10 (542) µS/cm and the mean predicted HC_{05} for Ecoregion 43 value, ($\hat{y}$ = 2.87, the log10 of 743 µS/cm) the lower 50% PL is calculated as follows in eq 6-4. Note, the upper 50% PL is not calculated but is included in the formula because it may be used to estimate a CMEC where there are insufficient data to calculate a CMEC using the method described in Section 3.2.

$$log10\ (743)\ \pm 0.686 \times\ 0.11\sqrt{1+\frac{1}{24}+\frac{(log_{10}(542)-2.15)^2}{4.21}} \quad (6\text{-}4)$$

So:

$$2.87-0.686\ \times 0.11\sqrt{\frac{25}{24}+\frac{(2.73-2.15)^2}{4.21}}$$

$$2.87-0.686\ \times 0.11\times 1.06$$

$$10^{2.79} = 617\ \mu S/cm$$

The log of the lower calculated 50% PL is 2.79 which equals 617 µS/cm after back transformation. The lower 50% PL rounded to two significant figures yields a CCC of 620 µS/cm.

6.1.8. Example Criterion Maximum Exposure Concentration

At sites meeting the CCC of 620 µS/cm, 90% of the SC observations are estimated to occur below the CMEC (see Section 3.2). The CMEC was derived using the USGS data set (45,489 samples collected between 1946–2015). This data set was used because it contained multiple measures of SC within a year whereas the EPA survey data set consisted of single measurements at each site. Of the 45,489 samples in this ecoregion, there are 41,648 samples in a July-to-June rotating year representing 1,241 rotation years, 148 unique stations, with at least 1 sample from July to October and one from March to June and at least 6 samples within a rotation year. Note that inclusion of samples is not contingent on biological data.

Of the 1,241 rotation years (148 unique stations) with multiple SC measurements, the variability of within station SC slightly differed for streams with different mean SC (see Figure 6-6). However, the LOWESS indicated that the average variability (residual standard deviation for a station) was relatively stable (see Figure 6-6); therefore, the entire data set was used to estimate the standard deviation components of annual mean SC (620 µS/cm). The grand mean and standard deviation of this data set was determined, and the CMEC was calculated. The example calculation of the CMEC for Ecoregion 43 is shown below using eq 3-2 from Section 3.2:

$$10^{\log10(620) + 1.28*0.333} = 1{,}656\ \mu S/cm \qquad (6\text{-}5)$$

The example CMEC (see Table 6-5) rounded to two significant figures yields a CMEC of 1,700 µS/cm for Ecoregion 43. If this level is not exceeded, where the annual geometric mean SC <620 µS/cm, 90% of the observations are expected to be less than the CMEC.

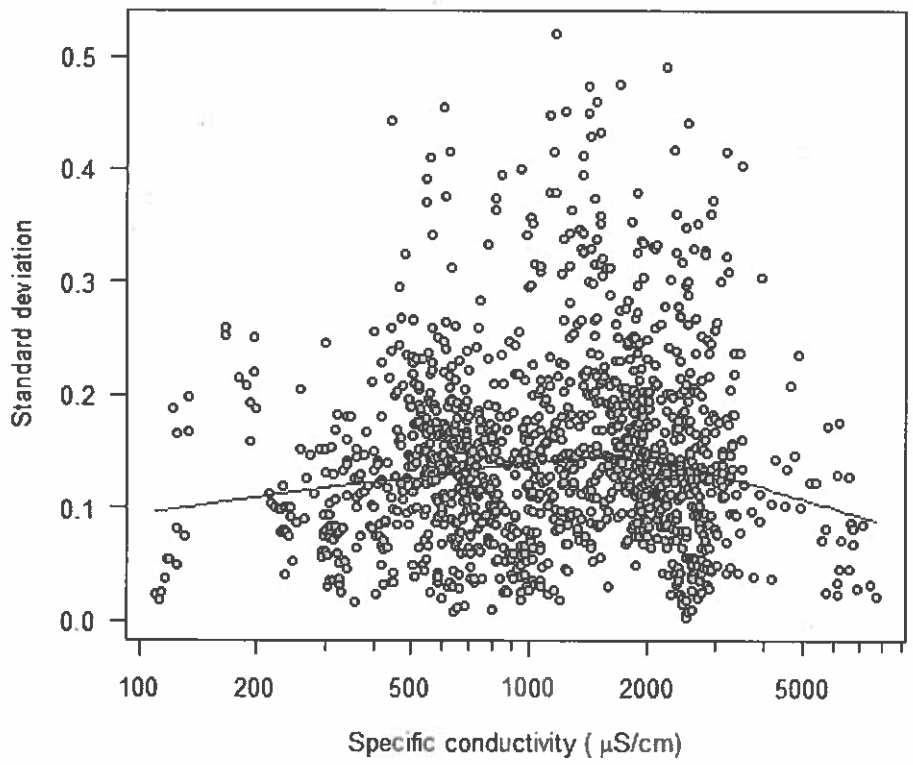


Figure 6-6. Illustration of within site variability (residual standard deviation for each station) along the specific conductivity gradient (station mean) in Ecoregion 43. The *x*-axis is annual mean specific conductivity. Each dot represents a station. The fitted line is a locally weighted scatterplot smoothing (LOWESS, span = 0.75, linear polynomial model).

Table 6-5. Summary data related to the calculation of the example criterion maximum exposure concentration (CMEC) for Ecoregion 43

Number of samples July to June prior to biological sampling	41,648
Number of unique stations/rotation years	148/1,241
CCC	620 µS/cm
CMEC	1,700 µS/cm

6.2. EXAMPLE CRITERION CHARACTERIZATION FOR ECOREGION 43 BASED ON A BACKGROUND-TO-CRITERION MODEL

The case example for Ecoregion 43 includes an annual geometric mean (i.e., CCC) and a 1-day mean (i.e., CMEC), not to be exceeded more than once in 3 years on average. Both of these distinct expressions of the example SC criteria would need to be met in order to adequately protect aquatic life. These values indicate that freshwater animals are protected if the annual geometric mean SC concentration in flowing waters does not exceed 620 µS/cm and the 1-day mean does not exceed 1,700 µS/cm more than once every 3 years on average. These example criteria would apply to all flowing freshwaters (ephemeral, intermittent, and perennial streams) in Ecoregion 43 inclusive of portions of Montana, Wyoming, South Dakota, North Dakota, and Nebraska. On a site-by-site basis, these example ecoregional criteria apply if the ionic mixture is dominated by anions of bicarbonate and sulfate and either sodium or calcium cations. For streams crossing into Ecoregion 43 from ecoregions with either lower or higher background SC, professional judgment may be needed to assess the potential effect of different ionic composition or concentration. Professional judgment is recommended when applying to sites with a catchment area greater than 1,000 km^2 (386 mi^2) owing to lesser representation in the data set by this class of stream in the development of the B-C model. On a site by site basis, alternative SC criteria may be more appropriate if the natural background of a site is shown to be lower or higher than its regional background SC.

In particular, some streams in Ecoregion 43 may have consistently low SC throughout the year (Keya Paha Tablelands [43i], Niobara River Breaks [43r], Noncalcareous Foothill Grasslands [43s], Shield-Smith Valleys [43t], Limy Foothill Grassland [43u], and Pryor-Big Horn Foothills [43v]). Because all or most of the sampled sites in these Level IV ecoregions were measured at less than 500 µS/cm, a finer resolution (subecoregional) analysis is

recommended to adequately protect these areas of Ecoregion 43. Specifically, because the more western parts of the ecoregion provide sources of freshwater and dilution to the rest of the ecoregion and ecoregions to the east, subdividing the ecoregion according to background SC and developing different SC criteria may help to protect regional water quality where geophysical and climatic conditions lead to higher natural SC regimes.

The weight-of-evidence method described in Appendix C could be used to evaluate subregions or stream classes that may have different background SC in this large ecoregion where natural background SC may range from <100 µS/cm to >1,000 µS/cm. For example, higher criteria may be appropriate for areas such as the Little Missouri Badlands (43b).

6.3. PROTECTION OF FEDERALLY-LISTED SPECIES AND OTHER HIGHLY VALUED TAXA

Although the example criteria were derived using the macroinvertebrate taxa represented in the data sets, the available evidence indicates that other taxa in the streams would likely be protected as well (see Section 2.6 and Appendix G). Hence, no adjustment was made for unanalyzed taxa. However, on a site-specific basis, the example criterion could be adjusted or recalculated to protect important species, highly valued aquatic communities, or specially protected waters.

7. CASE STUDY IV: EXAMPLE USING THE BACKGROUND TO CRITERION (B-C) REGRESSION METHOD FOR A REGION WITH LOW CONDUCTIVITY

This section presents an example calculation of an ecoregional CCC using the B-C method (see Section 3.7.2 and Appendix D). In this example, a CCC for the Cascades Level III Ecoregion 4 was calculated using SC data from the ecoregion and the B-C method because there were insufficient paired SC and biological data to accurately estimate the XC_{95} values for the XCD method in this ecoregion.

First, the water chemistry data set was screened for ionic composition to ensure samples were dominated by sulfate and bicarbonate anions and calcium and magnesium cations. Sampled sites were mapped to determine whether the geographic distribution of sites was representative of (dispersed throughout) the ecoregion. Minimally affected background SC of the new ecoregion was estimated at the 25th centile of probability samples (see Section 3.7.1.2; Cormier and Suter, 2013a). Least disturbed background SC was estimated at the 25th centile of a combined data set of targeted and probability samples. The CCC was calculated using the 25th centile least disturbed background SC as the independent variable (x) in the B-C regression model to yield an HC_{05} (y). Depending on available data and analytical results (see Figure 3-11), an HC_{05} may take the form of (1) the y-value at the mean of the regression line from the B-C model, (2) the y-value at the lower 50% PL of the regression line from the B-C model, or (3) an HC_{05} derived from a data set based on ≥200 paired SC and biological samples. In this example case for Ecoregion 4, the range of SC conditions was narrow with few sites exceeding 200 µS/cm and only two SC measurements exceeding 1,000 µS/cm, so any HC_{05} would be uncertain using paired SC and biological measurements. Therefore, an HC_{05} was not calculated using paired SC and biological measurements and the lower 50% PL was used to develop the example CCC.

7.1. DATA SET CHARACTERISTICS

7.1.1. Ecoregion Description

The Cascades (Ecoregion 4) is a mountainous ecoregion extending from the central portion of western Washington into Oregon and, after a separation by the Klamath River, another separate mountainous area in northern California (U.S. EPA, 2013d). The mountain ranges of

the Cascades continue northerly into the North Cascades (Ecoregion 77), and south into the Sierra Nevada (Ecoregion 5). To the east lies the Eastern Cascades Slopes and Foothills (Ecoregion 9). To the west in Washington state is the Puget Lowlands (Ecoregion 2) and in Oregon the fertile Willamette Valley (Ecoregion 3). To the west in southern Oregon and northern California, the Cascades are bounded by the Klamath Mountains/California High North Coast Range (Ecoregion 78).

Some peaks in Ecoregion 4 are snow-capped or glaciated year round. Both active and dormant volcanoes are located on the high plateau in the eastern part of the ecoregion. The highest strato-volcano is Mount Ranier with an elevation of 4,392 m (USGS, 2016). The western Cascades in Oregon and Washington are dissected by numerous, steep-sided stream valleys (U.S. EPA, 2013d).

This geologic area is underlain by Cenozoic volcanics that have been affected by alpine glaciation (U.S. EPA, 2013d). Soils are characterized by frigid temperature regimes and at lower elevations in the south. Some soils are mesic. Common soils include andisols, formed in volcanic ash containing high proportions of glass and amorphous colloidal materials, and inceptisols, nearly like the parent material and having little or no clay, iron, aluminum or organic matter. The mean annual precipitation ranges from 180 cm and ranges from 115 in the Southern Cascades to 360 cm on some of the highest peaks of the Cascades Subalpine/Alpine subecoregion (OWEB 2001, Wilkins et al. 2011). Two of the larger rivers include the Columbia and Klamath Rivers.

The Cascades have a moist, temperate climate that supports an extensive and highly productive coniferous forest that is intensively managed for logging. Conifers dominate except at the highest elevations where there are alpine meadows and rocky alpine zones.

7.1.2. General Data Set Description

Only preexisting water chemistry data were used for this example assessment (see Table 7-1). EPA-survey, State, and USGS data sets were combined to characterize ion concentrations and water chemistry and then calculate a provisional CCC. The USGS data set was also used to calculate the CMEC because this data set had many within-year samples at each site. The statistical package R, Version 2.12.1 (December 2010), was used for all statistical analyses (R Development Core Team, 2011).

Table 7-1. EPA and U.S. Geological Survey (USGS) chemistry data sets included in this study.
Years indicate the period during which the samples were collected. Western Environmental Monitoring and Assessment Program (EMAP) survey sites are included in the count of sites from the National Wadeable Streams Assessment (NWSA). Specific conductivity was not measured at all sites.

Survey	Years	# of sites	# of samples
EPA probability samples (sample size in parenthesis)			
NWSA, NRSA, Region 10 R-EMAP	1995–2009	152	152
Total		152	152
State data from EPA Region 10			
Oregon	1990–2014	418	2,511
Washington	1990–2015	121	562
Total (only 90 with SC)		539	3,073
State: subset ≥ six samples per year, January–December	1990–2015	19	1,111
USGS mixed sampling			
USGS: full data set	1958–2016	290	6,258
USGS: subset ≥ six samples per year, January–December	1959–2014	50	5,019

The B-C regression model was developed using biological data paired with SC data from 24 data sets with waters having ionic mixtures dominated by calcium, magnesium, sulfate and bicarbonate ions and where background SC did not exceed 626 µS/cm. Therefore, the model is most appropriate for waters with similar ionic characteristics.

Because the B-C regression model was developed with an ionic mixture dominated by bicarbonate and sulfate (i.e., $([HCO_3^-] + [SO_4^{2-}]) > [Cl^-]$ in mg/L), samples dominated by chloride (i.e., $([HCO_3^-] + [SO_4^{2-}]) \leq [Cl^-]$ in mg/L) should be removed from the data set prior to estimating background SC. In this case, no samples were dominated by chloride ions and so all samples in the EPA-survey data set were used. The State data set of 539 sites was used to verify ionic composition. Of 359 samples of the State data set with ionic measurements, all samples were dominated by sulfate plus bicarbonate. Therefore, none was removed from the final analysis. All sites in the combined EPA-USGS data set had pH data. Because none were <6 or >8.7, no sites were removed from the data set.

7.1.3. EPA-Survey Data Set

Data sources, sampling period, and number of samples used to estimate background SC in the new area (Ecoregion 4) are provided in Table 7-1. The NRSA 2008–2009 data set (U.S. EPA, 2013b), NWSA 2004 data set (U.S. EPA, 2006), R-EMAP 1999 data sets (U.S. EPA, 2013c), are based on single random (i.e., probability-based design) samples from June through September.

EPA-survey data sampling sites within the ecoregion are shown in Figure 7-1. Water quality parameters collected in Ecoregion 4 are included in Table 7-2. Most of the samples have reported SC, alkalinity, hardness, sulfate, chloride, bicarbonate, and pH, as well as other water quality parameters. When necessary, ionic concentrations in milliequivalents (meq/L) were converted to mg/L [(meq/L) × (ion MW)/(ionic charge)] (Hem, 1985).

Table 7-2. Summary of data for the example case for Cascades, Level III Ecoregion 4, from EPA-survey samples.
Calculated means are geometric except for pH values and ion ratios.

Parameter	*N*	Minimum	25th	50th	Mean	75th	Maximum
SC (µS/cm)	152	1.56	33.9	44.9	44.8	61.8	205.0
pH (SU)	144	6.17	7.3	7.5	7.5	7.7	9.0
Ca^{2+} (mg/L)	70	0.04	3.1	4.8	4.7	8.1	22.7
Mg^{2+}(mg/L)	70	0.03	0.7	1.3	1.2	1.9	8.8
Na^{+} (mg/L)	70	0.08	2.1	2.8	2.7	4.0	10.4
K^{+} (mg/L)	70	0.01	0.2	0.5	0.5	0.8	3.2
HCO_3^{-} (mg/L)	46	0.46	18.3	26.4	25.4	40.0	132.2
SO_4^{2-} (mg/L)	121	0.07	0.4	1.0	1.0	2.3	34.3
Cl^{-} (mg/L)	136	0.14	0.6	0.9	0.8	1.1	12.2
[a] $HCO_3^{-} + SO_4^{2-}/Cl^{-}$	46	3.88	24.5	32.3	50.4	58.4	211.1

[a]Ratio of mg/L $HCO_3^{-} + SO_4^{2-}/Cl^{-}$ greater than 1 indicates the mixture is dominated by $HCO_3^{-} + SO_4^{2-}$.

All samples were collected from first-through fourth-order streams as part of a probability-based design intended to estimate proportions of parameters for various stream classes. The probability-design sampling weights for stream order were not used in the

characterization. Analysis of water chemistry samples followed procedural and QA/QC protocols of EPA and EMAP (U.S. EPA, 2001, 1998b, 1994, 1987), Wadeable Streams Assessment (U.S. EPA 2006, 2004a, b), NRSA (U.S. EPA, 2009), and NAPAP (Drousé et al., 1986; U.S. EPA, 1987).

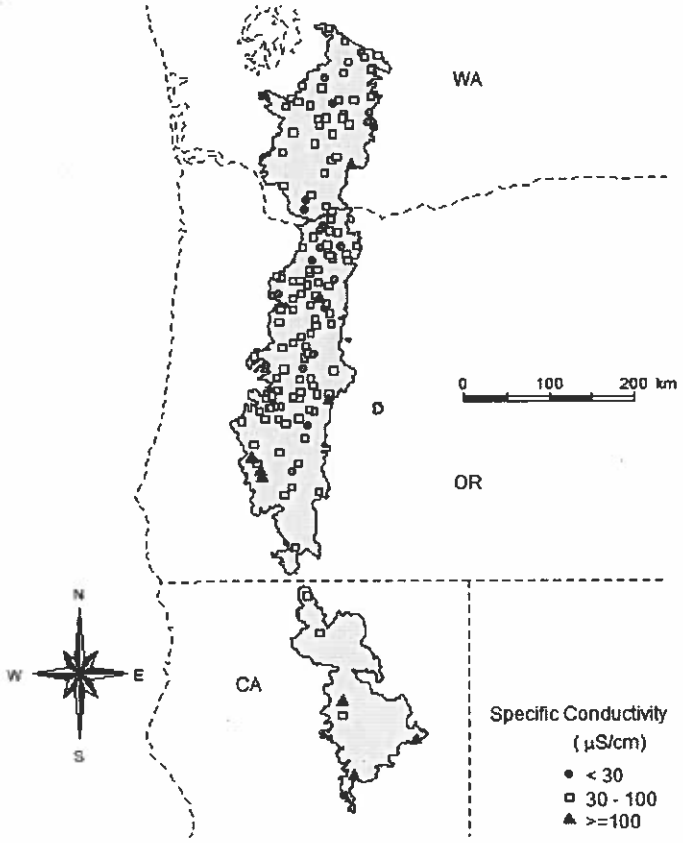


Figure 7-1. Sampling sites in the EPA survey data set that were used to estimate minimally affected background in Ecoregion 4.
For the purpose of demonstrating the background-to-criterion approach, Level III Ecoregion 4, is shaded gray. A total of 152 sites with specific conductivity measurements are depicted. Sampling locations are color coded by site-specific conductivity range: green diamonds <30 µS/cm, yellow squares 30−100 µS/cm, and red triangles ≥100 µS/cm. Geodetic reference system = North American Datum (NAD83).

7.1.4. State Data Set (EPA Region 10)

The State data set includes data from the Oregon DEQ 1990–2014 data set (Oregon DEQ, 2009) and the Washington Department of Ecology (WDE) 1990–2015 data set (WDE, 2014). Monthly sampling was performed throughout the year in many sites.

State sampling sites within the ecoregion are shown in Figure 7-2. Water quality parameters collected in Ecoregion 4 are included in Table 7-3. Most of the samples have reported SC, sulfate, chloride, and pH.

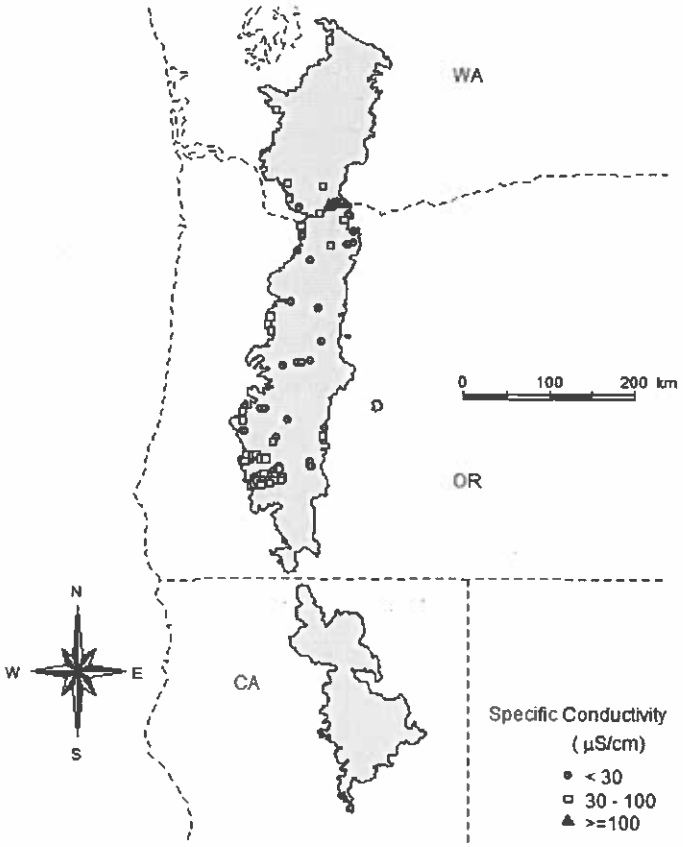


Figure 7-2. Sampling sites in State data set that were used to estimate minimally affected background in Ecoregion 4.
For the purpose of demonstrating the background-to-criterion approach, Level III Ecoregion 4 is shaded gray. A total of 539 sampling sites are in the state data set, but only 95 sites with conductivity measurements are shown here. Sampling locations are color coded by site-specific conductivity range: green diamonds <30 µS/cm, yellow squares 30–100 µS/cm, and red triangles ≥100 µS/cm. Geodetic reference system = North American Datum (NAD83).

Table 7-3. Summary of data for the example case for Cascades, Level III Ecoregion 4 from State Data from Oregon and Washington.
Calculated means are geometric except for pHs and ion ratios.

Parameter	*N*	Minimum	25th	50th	Mean	75th	Maximum
SC (µS/cm)	95	6.8	24.0	32.4	31.9	39.4	126
Ca^{2+} (mg/L)	78	1.0	2.3	3.0	3.7	4.3	1,100
HCO_3^- (mg/L)	300	7.7	19.9	25.8	27.5	38.0	3,966
SO_4^{2-} (mg/L)	252	0.1	0.3	0.6	0.8	1.7	36.2
Cl^- (mg/L)	315	0.3	0.7	1.0	1.1	1.5	250.0
[a]$HCO_3^- + SO_4^{2-}/Cl^-$	203	3.3	18.0	28.2	37.6	46.0	225.7

[a]ratio of mg/L $HCO_3^- + SO_4^{2-}/Cl^-$ greater than 1 indicates the mixture is dominated by $HCO_3^- + SO_4^{2-}$.

7.1.5. U.S. Geological Survey (USGS) Data Set

The USGS survey data set used in this example is composed of 6,258 water quality samples, from 290 stations within Ecoregion 4 (see Table 7-1; Figure 7-3). Some stations were sampled only once while others were sampled as many as 641 times. The data were collected between 1958 and 2016 during all seasons. Water quality parameters collected in Ecoregion 4 are included in Table 7-4. Most of the samples have reported SC, alkalinity, hardness, chloride, bicarbonate, and pH, as well as other water quality parameters. Analysis of water chemistry samples followed procedural and QA/QC protocols for USGS data sets (Mueller et al. 1997).

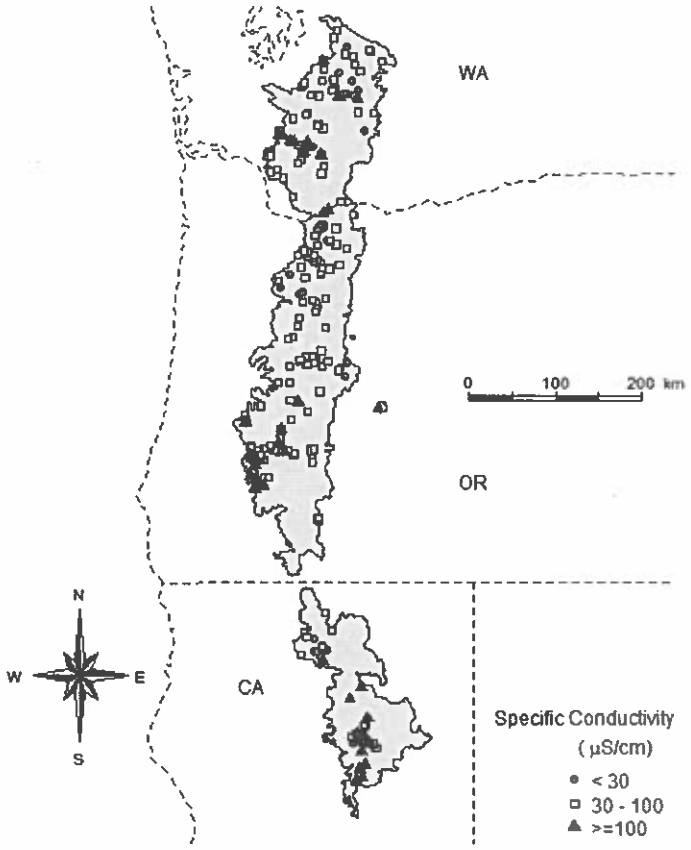


Figure 7-3. Sampling sites in the U.S. Geological Survey (USGS) data set in Ecoregion 4.

Ecoregion 4 is shaded gray. Geometric mean specific conductivity at 290 sampling locations is color-coded: green diamonds <30 µS/cm, yellow squares 30–100 µS/cm, and red triangles ≥100 µS/cm. Geodetic reference system = North American Datum (NAD83).

Table 7-4. Summary of data for the example case for Cascades, Level III Ecoregion 4 from the U.S. Geological Survey (USGS).
Calculated means are geometric except for pH.

Parameter	*N*	Minimum	25th	50th	Mean	75th	Maximum
SC (µS/cm)	282	3.50	38	53.9	53.6	78.3	370
pH (SU)	274	6.2	7.2	7.5	7.4	7.7	8.7
Ca^{2+} (mg/L)	5	1.6	1.7	2.1	2.9	5.6	15.7
Mg^{2+} (mg/L)	158	0.10	0.78	1.39	1.31	2.43	9.08
Na^{+} (mg/L)	5	1.2	1.2	1.3	1.7	2.5	5.6
K^{+} (mg/L)	5	0.1	0.2	0.2	0.3	0.5	1.3
HCO_3^{-} (mg/L)	57	3.0	29.8	35.0	37.0	51.3	122.0

All samples were collected from first-through fourth-order streams for various research purposes, and those targeted sampling designs may emphasize areas with increased anthropogenic disturbance. In this respect, the data may skew the background estimates. Background SC was not estimated from this data set alone because sampling stations were not randomly assigned.

Because the USGS and State data sets contained multiple measurements in a year from sampling locations, the data sets were used to estimate a CMEC and explore the variability of SC patterns within the region. Therefore, a second data set was selected by excluding stations with fewer than 6 SC measurements throughout the year. A minimum of one sample during the spring (March to June) and one in the summer (July to October) were also required so that at least one lower and one higher SC sample were included in the data set. The second USGS data set included 5,019 samples from 50 stations, while the second State data set include 1,111 samples from 19 stations. The USGS and State data sets were combined was used to calculate the variance near the CCC for the CMEC calculation.

7.1.6. Modeled Mean Base Flow Background Specific Conductivity (SC)

Predicted mean natural base-flow specific conductivity in catchments of Cascades, was also considered for comparison purposes (Olson and Hawkins, 2012). The stream length weighted, mean natural SC from the modeled base flow were calculated for the SC at base flow

for each ecoregion (see Appendix D). Figure 7-4 shows the predicted SC with 300 m resolution in order to emphasize the general trends across Ecoregion 4.

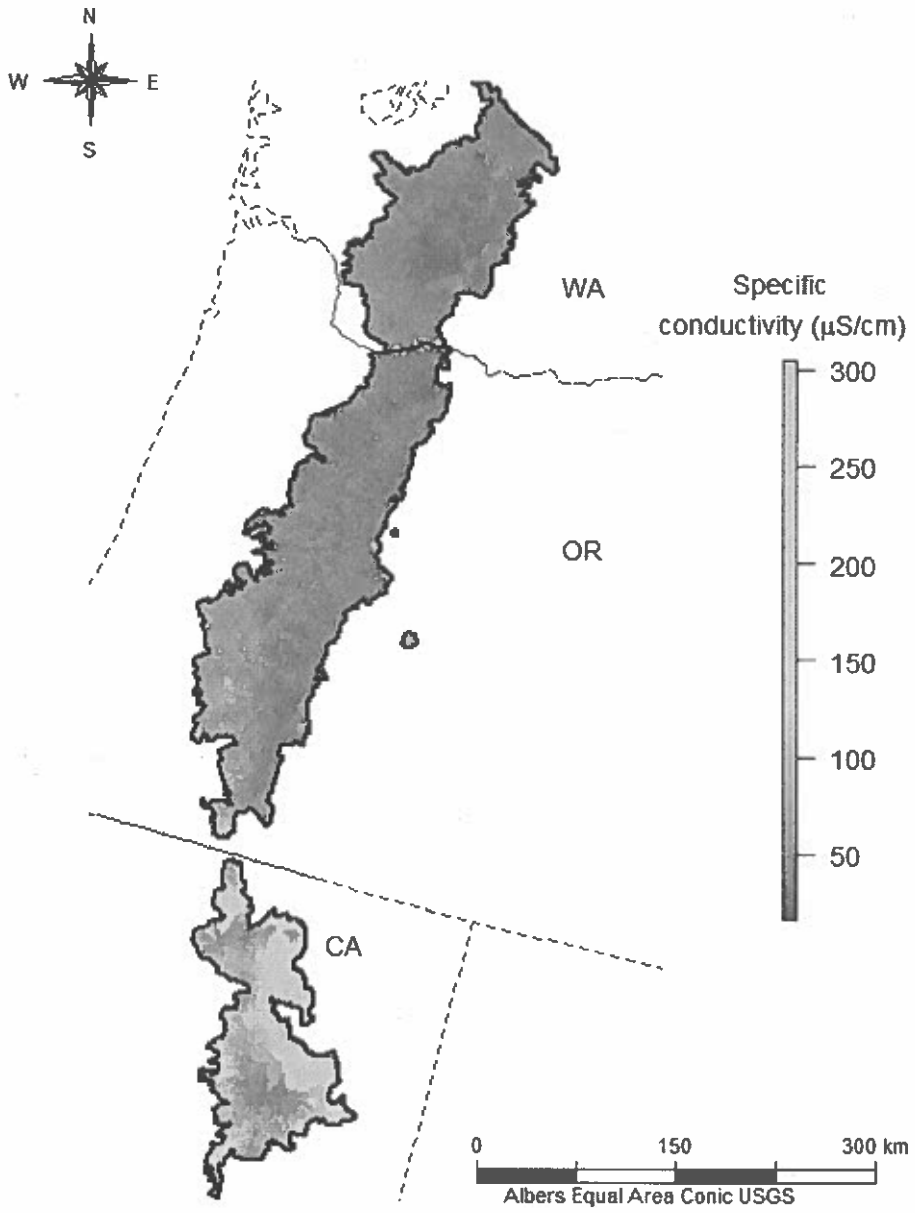


Figure 7-4. Predicted mean natural base-flow specific conductivity in catchments of the Cascades, Ecoregion 4, using the Olson-Hawkins model. Albers projection used for mapping.

7.1.7. Characterization of Ionic Matrices

7.1.7.1. *EPA-Survey Data Set Ionic Characteristics*

A summary of water quality ionic constituents including major ionic constituents from EPA-survey data for Ecoregion 4 is provided in Table 7-2. Centiles were calculated using each sample observation because most measurements were single grab samples. There were no chloride-dominated sites where $[Cl^-] \geq ([HCO_3^-] + [SO_4^{2-}])$ in mg/L in the EPA-survey data ($N = 152$); therefore, no sites were excluded from the data sets. Calcium plus magnesium were the dominant cations $([Ca^{2+}] + [Mg^{2+}]) > ([Na^+] + [K^+])$.

7.1.7.2. *State Data Set Ionic Characteristics*

A summary of water quality ionic constituents including major ionic constituents from State data for Ecoregion 4 is provided in Table 7-3. Centiles were calculated using each sample observation because most measurements were single grab samples. There were no chloride-dominated sites (where $[Cl^-] \geq ([HCO_3^-] + [SO_4^{2-}])$ in the state data ($N = 539$); therefore, no sites were excluded from the data sets. Likewise, calcium plus magnesium were the dominant cations, $([Ca^{2+}] + [Mg^{2+}]) > ([Na^+] + [K^+])$.

7.1.7.3. *U.S. Geological Survey (USGS) Data Set Ionic Characteristics*

Table 7-4 summarizes the water quality parameters including major ionic constituents for Ecoregion 4 in the USGS data set. Unlike the EPA-survey data set, the USGS data set are targeted sites of interest rather than probability samples. Also, in some cases, there are multiple measurements from the same site, and other sites are auto-correlated with downstream sampling locations. Therefore, the distribution of sites in this data set is not necessarily representative of Ecoregion 4 in its entirety; however, the data set can be used to define the overall pattern of SC for the ecoregion because it contains samples in areas not represented in the EPA-survey data set. Centiles were calculated using the geometric mean of site measurements (except pH and the ionic ratio) and were qualitatively compared to the probability-based EPA-survey data set. No sulfate measurements were found so $([HCO_3^-] + [SO_4^{2-}])/[Cl^-]$ ratios were not determined for this data set. Calcium plus magnesium were the dominant cations $([Ca^{2+}] + [Mg^{2+}]) > ([Na^+] + [K^+])$.

Two samples from the USGS data set were in the 1,000 µS/cm range and were associated with salt springs at Lake Paulina and Longmire Meadow mineral springs and were removed from the data set (Ingebritsen et al., 2014). Six sites (421−1,030 µS/cm) were sampled on the flanks of Mount St. Helen after the 1980 eruption; and, these were removed. These eight sites represent a small proportion of the data set, and the example criterion would not apply to these or similar areas with naturally higher background SC. The background SC was 39.5 µS/cm with these eight sites included and 38.2 µS/cm with them removed.

7.1.8. Comparison of Background Specific Conductivity (SC) Estimates

SC data from the three data sets, the combined data, and the Olson-Hawkins base flow model are summarized in Figure 7-5. The stream length weighted average predicted mean base flow SC from the Olson-Hawkins model in Ecoregion 4 is 65.7 µS/cm. The 25th centile of the EPA-survey data set is 33.9 µS/cm, of the State data set is 24 µS/cm, and of the USGS SC data set is 39.5 µS/cm. All three are less than the mean base flow SC (65.7 µS/cm), so these background SC are characterized as minimally affected (see Figure 7-5 and Tables 7-2, 7-3, and 7-4). When data are combined, the 25th centile (≈33 µS/cm) is still lower than the predicted mean base flow of 65.7 µS/cm (see Table 7-5, Figure 7-5). Therefore, this background SC estimated from the combined State-EPA-USGS data set also represents minimally affected background SC.

The 25th centile of the combined data set was used to calculate the HC_{05} following the decision tree described Section 3.7.2 and Figure 3-11.

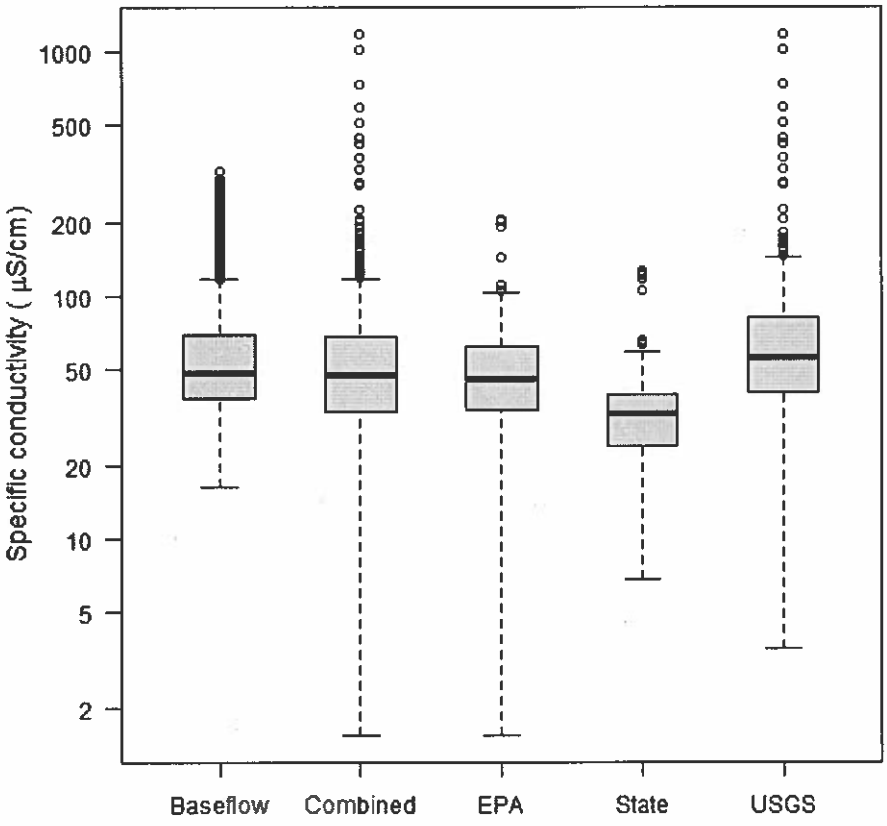


Figure 7-5. Box plots of specific conductivity (SC) distributions for EPA-survey, State, U.S. Geological Survey (USGS), and combined data sets, and the predicted base flow SC for all stream segments.
The State data set captures a slightly narrower range of values possibly owing to the targeted sampling. The USGS samples greater than 400 µS/cm include some samples from mineral springs and Mt. St. Helen ash flows which have been removed from the combined data set. The 25th centiles of the observed data sets are fairly similar to the 25th centile of predicted base-flow.

Table 7-5. Summary of data for the example case for Cascades, Level III Ecoregion 4 from the combined data set.
Calculated means for sampled sites are geometric for all variables except for pH and ion ratio.

Parameter	*N*	Minimum	25th	50th	Mean	75th	Maximum
SC (µS/cm)	529	1.56	32.7	46.4	46.4	66	370
pH (SU)	418	6.2	7.2	7.5	7.4	7.7	9.0
Ca^{2+} (mg/L)	153	0.04	2.51	3.59	4.06	6.36	1,100
Mg^{2+} (mg/L)	228	0.03	0.77	1.34	1.29	2.20	9.08
Na^{+} (mg/L)	75	0.08	2.03	2.76	2.59	3.96	10.45
K^{+} (mg/L)	75	0.01	0.22	0.49	0.44	0.77	3.17
HCO_3^{-} (mg/L)	403	0.46	20.4	28.0	28.4	40.2	3,966
SO_4^{2-} (mg/L)	373	0.07	0.34	0.78	0.85	2.17	36.2
Cl^{-} (mg/L)	451	0.14	0.63	1.00	1.00	1.40	250
$HCO_3^{-} + SO_4^{2-}/Cl^{-}$	249	3.29	18.3	28.6	40	48.5	226

[a]ratio in mg/L $HCO_3^{-} + SO_4^{2-}/Cl^{-}$ greater than 1 indicates the mixture is dominated by $HCO_3^{-} + SO_4^{2-}$.

7.2. CALCULATION OF THE CRITERION CONTINUOUS CONCENTRATION (CCC)

7.2.1. Calculation of the Ecoregion 4 mean Hazardous Concentration (HC_{05}) from Background

Because paired SC and biological data are available for <200 sites, the HC_{05} was estimated at the lower 50% PL of the B-C model (see Figure 7-6). The 25th centile of SC from the combined data set of Ecoregion 4 was used to identify the lower 50% PL using eqs 3-4 and 3-5. The B-C model development is described in Appendix D. The *x*-variable is the background SC in Ecoregion 4 which was log10 transformed. The calculated *y*-value is the predicted mean log10 HC_{05}. In this example case, the minimally affected background is 33 µS/cm (see Table 7-5). It was estimated at the 25th centile from the combined data set. The calculation of the predicted mean log10 of HC_{05} (*y*) is shown in eqs 7-1 and 7-2 and that value is used to estimate the lower 50% PL using eq 7-3.

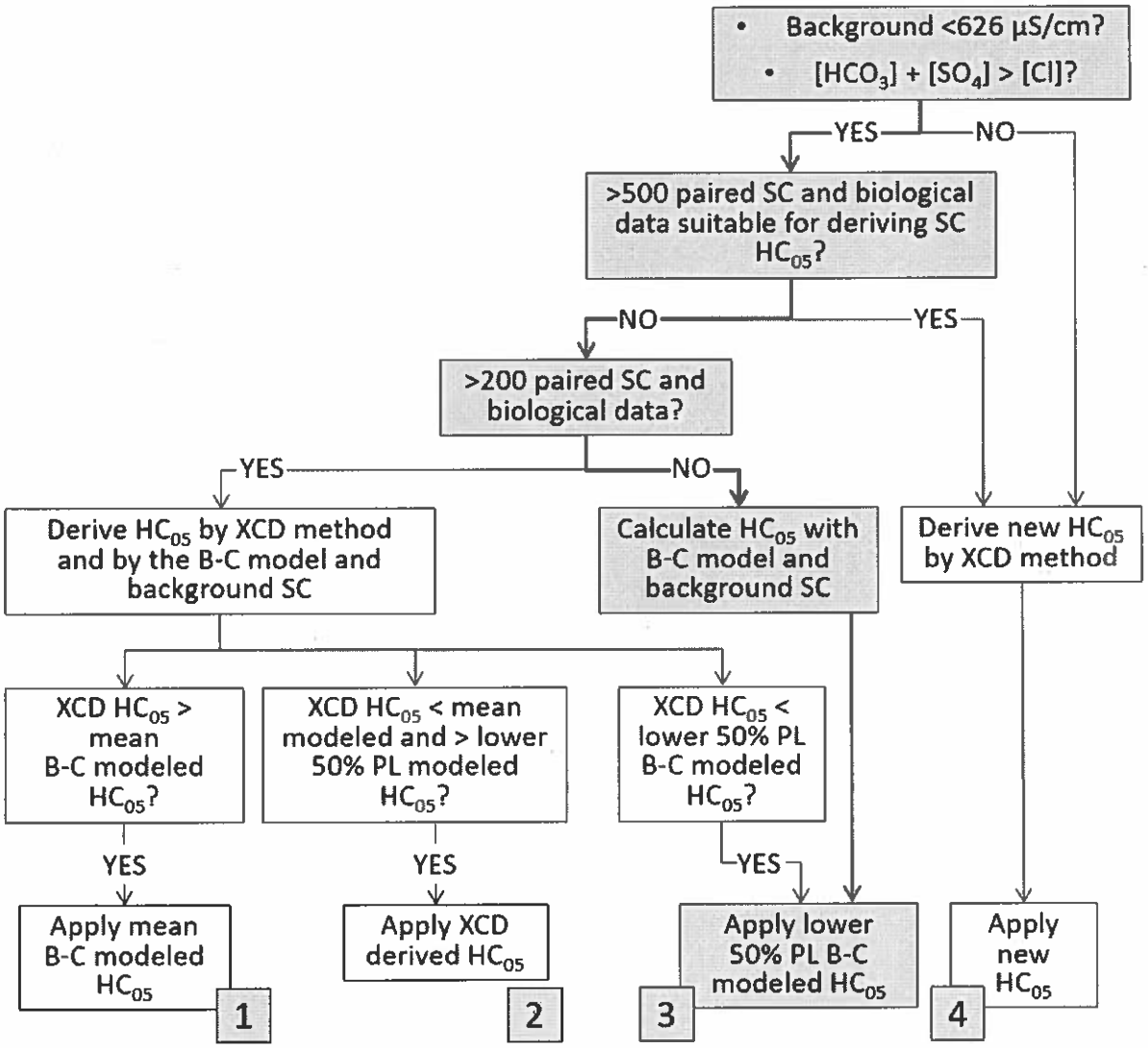


Figure 7-6. Process and decision path case example for Ecoregion 4. Decision path is highlighted in gray and connected by bold lines. Because there was no previously derived hazardous concentration at the 5th centile (HC_{05}) of a taxonomic extirpation concentration distribution (XCD) for Ecoregion 4, and the background was <33 µS/cm, and there were <200 paired specific conductivity (SC) measurements, the HC_{05} was calculated with the background-to-criterion (B-C) model at the lower 50% prediction limit (PL).

The B-C model is described by the following formula:

$$Y = 0.657X + 1.075 \quad (7\text{-}1)$$

Where:

X is the log10 of the ecoregional background SC
Y is the log10 of the predicted HC_{05}

The background for Ecoregion 4 (33 µS/cm) is converted to log10, replacing X in the formula with that value and Y is computed (see eq 7-2). The predicted value Y is converted from log10 to a number that is the mean modeled HC_{05} for that region. In Ecoregion 4 the mean modeled HC_{05} is 118 µS/cm after rounding to two significant figures.

$$\text{Log Predicted } HC_{05} = (0.657 \times 1.518\ \mu S/cm) + 1.075 = 2.072\ \mu S/cm \quad (7\text{-}2)$$

Then

$$\text{Predicted } HC_{05} = 10^{2.072}\ \mu S/cm = 118\ \mu S/cm$$

7.2.2. Calculation of the Lower 50% Prediction Limit

Because the available paired SC and biological data constitute <200 sites, the CCC was estimated at the lower 50% PL of the HC_{05} (see Figure 7-6). The 25th centile of background SC and the predicted mean HC_{05} of a region and variance of the B-C model is used to calculate the lower 50% PL (see eq 7-3). In this case example for Ecoregion 4, the background is 33 µS/cm and the mean modeled HC_{05} is 118 µS/cm. Both values are converted to log10 (x, y) as shown in eq 7-4. The prediction interval from the regression line for a mean predicted value $\hat{y}$ can be calculated as follows or more conveniently using statistical software thus avoiding rounding errors:

$$\hat{y} \pm t_{\alpha/2,n-2} S_y \sqrt{1 + \frac{1}{n} + \frac{(x^* - \bar{x})^2}{SS}} = \text{PL} \quad (7\text{-}3)$$

Symbol	Explanation	Example from the B-C model
$\hat{y}$	Log10 of mean predicted HC_{05}	2.072 µS/cm, log10 of 118 µS/cm
n	Number of samples in the model	$n = 24$
α	Alpha error rate for prediction interval (desired confidence level)	50% prediction interval ($\alpha = 0.5$)
t_{n-2}	t-value at specific level (alpha, α) and degrees of freedom ($n - 2$) of interval	For 50% prediction interval ($\alpha = 0.5$), $t_{(1-0.5)/2,24-2} = 0.686$
S_y	Residual standard error of prediction (standard deviation)	$S_y = 0.11$
SS	Sum of square of x deviation from their mean, $SS = \sum_{i=1}^{n}(x_i - \bar{x})^2$	$SS = 4.21$
$\bar{x}$	Mean x values used in the model generation	$\bar{x} = 2.15$
x°	x value for a new prediction interval	Log10 118 µS/cm = 2.072
PL	Upper and lower prediction limits of mean predicted $\hat{y}$	calculated in eq 6-4

Using x° = log10 (118) µS/cm and the mean predicted HC_{05} for Ecoregion 4 value, ($\hat{y} = 2.072$, the log10 of 118 µS/cm) the lower 50% PL is calculated as follows in eq 7-4. Note, the upper 50% PL is not calculated but is included in the formula because it may be used to estimate a CMEC where there are insufficient data to calculate a CMEC using the method described in Section 3.2.

$$log10\,(118)\ \pm 0.686 \times\ 0.11\sqrt{1 + \frac{1}{24} + \frac{(log_{10}(118) - 2.15)^2}{4.21}} \qquad (7\text{-}4)$$

So:

$$2.072 - 0.686\ \times 0.11\sqrt{\frac{25}{24} + \frac{(2.072 - 2.15)^2}{4.21}}$$

$$2.072 - 0.686\ \times 0.11 \times 1.02$$

$$\text{Log10}^{1.997} = 98\ \mu\text{S/cm}$$

The log of the lower calculated 50% PL is log10 1.997 which equals 98 µS/cm after back transformation and rounding to two significant figures yields a CCC of 98 µS/cm.

7.2.3. Example Criterion Maximum Exposure Concentration

At sites meeting the CCC of 98 µS/cm, 90% of the SC observations are estimated to occur below the CMEC (see Section 3.2). The CMEC was derived using a combined USGS (6,258 samples collected between 1959–2016) and State data sets (3,073 samples collected between 1990–2015). These data sets were used because they contained multiple measures of SC within a year whereas the EPA survey data set consisted of single measurements at each site. Of the 9,331 samples in this ecoregion, there are 6,130 samples in a year representing 312 station years, 69 unique stations, with at least 1 sample from March to June and one from July to October and at least 6 samples within a year. Note that inclusion of samples is not contingent on biological data.

Of the 312 station years (69 unique stations) with multiple SC measurements, the variability of within station SC was slightly differed for streams with different mean SC (see Figure 7-7). However, the LOWESS and confidence bounds for any detectable change points indicated that the average variability (residual standard deviation for a station) was relatively stable generally between 0.05 and 0.1 (see Figure 7-7); therefore, the entire data set was used to estimate the standard deviation components of the annual mean SC (98 µS/cm). The proposed CCC and standard deviation of this data set was determined, and the CMEC was calculated. The example calculation of the CMEC for Ecoregion 4 is shown below (see eq 7-5) using eq 3-2 from Section 3.2:

$$10^{\log10(98) + 1.28*0.234} = 196\ \mu S/cm \qquad (7\text{-}5)$$

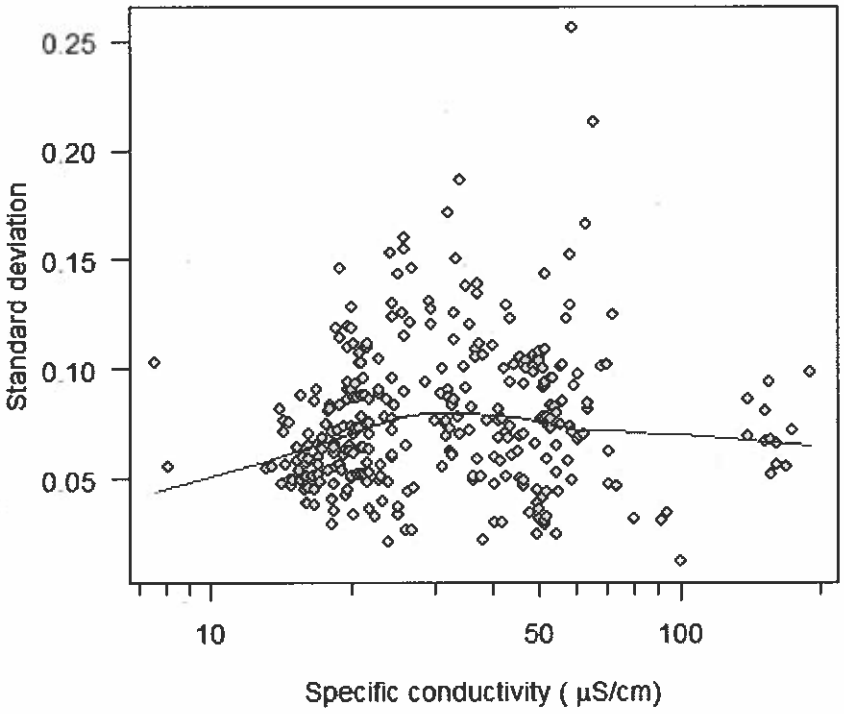


Figure 7-7. Illustration of within site variability (residual standard deviation for each station) along the specific conductivity gradient (station means) in Ecoregion 4.
The *x*-axis is log annual mean specific conductivity. Each dot represents a station. The fitted line is a locally weighted scatterplot smoothing spline (LOWESS, span = 0.75, linear polynomial model).

The example CMEC (see Table 7-6) rounded to two significant figures yields a CMEC of 200 µS/cm for Ecoregion 4. At this level, where the annual geometric mean SC <98 µS/cm, 90% of the observations are expected to be less than the CMEC.

Table 7-6. Summary data related to the calculation of the example criterion maximum exposure concentration (CMEC) for Ecoregion 4

Number of samples July to June prior to biological sampling	6,130
Number of unique stations/rotation year	69/312
CCC	98 µS/cm
CMEC	200 µS/cm

7.3. EXAMPLE CRITERION CHARACTERIZATION FOR ECOREGION 4 BASED ON A BACKGROUND-TO-CRITERION MODEL

The case example for Ecoregion 4 includes an annual geometric mean (i.e., CCC) and a 1-day mean (i.e., CMEC), not to be exceeded more than once in 3 years on average. Both of these distinct expressions of the example SC criteria would need to be met in order to adequately protect aquatic life. These values indicate that freshwater animals are protected if the annual geometric mean SC concentration in flowing waters does not exceed 98 µS/cm and the 1-day mean does not exceed 200 µS/cm more than once every 3 years on average. These example criteria would apply to all flowing freshwaters (ephemeral, intermittent, and perennial streams) in Ecoregion 4 inclusive of portions of Washington, Oregon, and California. On a site-by-site basis, these example ecoregional criteria apply if the ionic mixture is dominated by anions of bicarbonate and sulfate and cations calcium and magnesium. For streams crossing into Ecoregion 4 from ecoregions with either lower or higher background SC, professional judgment may be needed to assess the potential effect of different ionic composition or concentration. Professional judgment is recommended when applying to sites with a catchment area greater than 1,000 km^2 (386 mi^2) owing to lesser representation in the data set by this class of stream in the development of the B-C model. On a site by site basis, alternative SC criteria may be more appropriate if the natural background of a site is shown to be lower or higher than its regional background SC.

The Cascades ecoregion has less sources of ionic inputs and the igneous geology leads to very low stream SC (background SC of 33 µS/cm), which represents minimally affected conditions with respect to SC. Reference sites were not identified in the data sets so a comparison with the 75th centile SC in any data set was not possible. About 88% of the sampled sites (537) meet the CCC and more than 99% of all samples (7,855) meet the CMEC calculated for this example. Owing to the very low conductivity, there is very little difference between the lower 50% prediction interval or the mean modeled HC_{05}, 98 versus 118 µS/cm, respectively. Two samples from the USGS data set were in the 1,000 µS/cm range and were associated with salt springs at Lake Paulina and Longmire Meadow mineral springs and were removed from the data set (Ingebritsen et al., 2014). Six sites (421−1,030 µS/cm) were sampled on the flanks of Mount St. Helen after the 1980 eruption, and they were also removed before the analysis. The example criterion would not apply to these areas with naturally higher background SC. The

weight-of-evidence method described in Appendix C could be used to evaluate subregions or stream classes that may have different background SC in this large ecoregion. In particular, the isolated area in Northern California may have a naturally higher background SC based on the USGS measurements (see Figure 7-3) and the mean predicted baseflow (see Figure 7-4). Also, potential unique sources of salt such as fumaroles and salt springs may naturally raise SC.

7.4. PROTECTION OF FEDERALLY-LISTED SPECIES AND OTHER HIGHLY VALUED TAXA

Although the example criteria were derived using XC_{95} values for the macroinvertebrate taxa represented in the data sets used to develop the B-C model, the available evidence indicates that other taxa in the streams would likely be protected as well (see Section 2.6 and Appendix G). Hence, no adjustment was made for unanalyzed taxa. However, on a site-specific basis, the example criterion could be adjusted or recalculated to protect important species, highly valued aquatic communities, or specially protected waters.

8. REFERENCES

Allan, JD. (1981) Determinants of diet of brook trout (*Salvelinus fontinalis*) in a mountain stream. Can J Fish Aqua Sci 38:184–92.

Andersen, CB; Lewis, GP; Sargent, KA. (2004) Influence of wastewater treatment effluent on concentrations and fluxes of solutes in the Bush River South Carolina, during extreme drought conditions. Environ Geosci 11(1):28–41.

Anning, DW; Bauch, NJ; Gerner, SJ; Flynn, ME; Hamlin, SN; Moore, SJ; Schaefer, DH; Anderholm, SK; Spangler, LE. (2007) Dissolved solids in basin-fill aquifers and streams in the Southwestern United States. U.S.G.S. Scientific Investigations Report 2006-5315, version 1.1. Updated 2010. Denver, CO: USGS Information Services. Available online at http://pubs.usgs.gov/sir/2006/5315/.

Anning, DW; Flynn, ME. (2014) Dissolved-solids sources, loads, yields, and concentrations in streams of the conterminous United States: U. S. Geological Survey Scientific Investigations Report 2014-5012, 101 p. Available online at http://dx.doi.org/10.3133/sir20145012.

APHA (American Public Health Association) (1992) Standard methods for the examination of water and wastewater. 18th edition. Washington, DC: American Public Health Association.

Barbour, MT; Gerritsen, J; Snyder, BD; Stribling, JB. (1999) Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates, and fish. 2nd ed. EPA/841/B-99/002. Washington, DC: U.S. Environmental Protection Agency, Office of Water. Available online at http://www.epa.gov/owow/monitoring/rbp/wp61pdf/rbp.pdf.

Barlow, PM. (2003) Ground water in freshwater-saltwater environments of the Atlantic Coast. Circular 1262. Reston, VA: U.S. Geological Survey. Available online at: http://pubs.usgs.gov/circ/2003/circ1262/pdf/circ1262.pdf.

Barlow, PM; Reichard, EG. (2010) Saltwater intrusion in coastal regions of North America. Hydrogeo J 18:247–260.

Belli, NM; Faleiros, RO; Firmino, KCS; Masui, DC; Leone, FA; McNamara, JC; Furriel, RPM. (2009) Na,K-ATPase activity and epithelial interfaces of the freshwater shrimp *Macrobrachium amazonicum* (Decapoda, Palaemonidae). Comp Biochem Physiol A Mol Integr Physiol 152(3):431–439.

Bernhardt, ES; Lutz, BJ; King, R; Fay, J; Carter, CA; Helton, AM; Amos, J; Campagna, D. (2012) How many mountains can we mine? Examining the regional impact of surface mining on freshwater ecosystems of the Central Appalachians. Environ Sci Technol. 46:8115–8122.

Bernhardt, ES; Palmer, MA. (2011) The environmental costs of mountaintop mining valley fill operations for aquatic ecosystems of the Central Appalachians. Ann NY Acad Sci 1223:39–57Bernot, MJ; Tank, JL; Royer, TV; David, MB. (2006) Nutrient uptake in streams draining agricultural catchments of the Midwestern United States. Freshw Biol 51(3):499–509.

Bernot, MJ; Tank, JL; Royer, TV; David, MB. (2006) Nutrient uptake in streams draining agricultural catchments of the Midwestern United States. Freshw Biol 51(3):499–509.

Berra, TM. (2007) Freshwater fish distribution. Chicago: The University of Chicago Press.

Blasius, BJ; Merritt, RW. (2002) Field and laboratory investigations on the effects of road salt (NaCl) on stream macroinvertebrate communities. Environ Pollut 120(2):219–231.

Boelter, AM; Lamming, FN; Farag, AM; Bergman, HL. (1992) Environmental effects of saline oil-field discharges on surface waters. Environ Toxicol Chem 11(8):1187–1195.

Bos, DG; Cumming, BF; Watters, CE; Smol, JP. (1996) The relationship between zooplankton, SC and lake-water ionic composition in 111 lakes from the Interior Plateau of British Columbia, Canada. Int J Salt Lake Res 5(1): 1–15.

Bradley, TJ. (2009) Chapter 7. Hyper-regulators: life in fresh water. In: Animal osmoregulation. New York: Oxford University Press; pp 149–151.

Bringolf, RB; Cope, WG; Eads, CB; Lazaro, PR; Barnhart, MC; Shea, D. (2007) Acute and chronic toxicity of technical-grade pesticides to glochidia and juveniles of freshwater mussels (Unionidae). Environ Toxicol Chem 26(10):2086–2093.

Brinck, EL; Drever, JI; Frost, CD. (2008) The geochemical evolution of water coproduced with coalbed natural gas in the Powder River Basin, Wyoming. Environ Geosci 15(4):153–171.

Bringolf, RB; Cope, WG; Eads, CB; Lazaro, PR; Barnhart, MC; Shea, D. (2007) Acute and chronic toxicity of technical-grade pesticides to glochidia and juveniles of freshwater mussels (Unionidae). Environ Toxicol Chem 26(10):2086–2093.

Brittain, JE. (1982) Biology of mayflies. Ann Rev Entomol. 27:119–147.

Brittain, JE; Eikeland, TJ. (1988) Invertebrate drift – a review. Hydrobiologia 166:77–93.

Brock, TCM; Roessink, I; Belgers, JDN; Bransen, F; Maund, SJ. (2009) Impact of a benzoyl urea insecticide on aquatic macroinvertebrates in ditch mesocosms with and without nonsprayed sections. Environ Toxicol Chem 28(10):2191–2205.

Brown, RC; Davis, TP. (2002) Calcium Modulation of Adherens and Tight Junction Function A Potential Mechanism for Blood-Brain Barrier Disruption After Stroke. Stroke. 33(6):1706-11.

Bryant, G; McPhilliamy, S; Childers, H. (2002) A survey of the water quality of stream in the primary region of mountaintop/valley fill coal mining, October 1999 to January 2001. In: Draft programmatic environmental impact statement on mountaintop mining/valley fills in Appalachia—2003. Appendix D. Philadelphia, PA: U.S. Environmental Protection Agency, Region 3. Available online at http://www.cet.edu/pdf/mtmvfchemistry.pdf.

Burton, TM. (1976) An analysis of the feeding ecology of the salamanders (*Amphibia, Urodela*) of the Hubbard Brook Experimental Forest, New Hampshire. J Herpetol 10:187–204.

Cañeda-Argüelles, M; Kefford, BJ; Piscart, C; Prat, N; Schafer, RB; Schulz, C. (2013) Saliniation of rivers: an urgent ecological issue. Environ Pollut 173:157–167.

Caquet, T; Hanson, ML; Roucaute, M; Graham, DW; Lagadic, L. (2007) Influence of isolation on the recovery of pool mesocosms from the application of an insecticide II. Benthic macroinvertebrate responses. Environ Toxicol and Chem 26(6):1280–1290.

Cardinale, BJ. (2011) Biodiversity improves water quality through niche partitioning. Nature 472:86–89.

Carey, RO; Migliaccio, KW. (2009) Contribution of wastewater treatment plant effluents to nutrient dynamics in aquatic systems: A review. Environ Manage 44(2):205–217.

Carter, JL; Resh, VH; Hannaford, J; Myers, MJ. (2006) Macroinvertebrates as biotic indicators of environmental quality. In: Hauer, FR; Lamberti, GA; eds. Methods in stream ecology, 2nd edition. Burlington, MA: Academic Press. pp. 805–831.

Clare, EL; Barber, BR; Sweeney, BW; Herbert, PD; Fenton, MB. (2011) Eating local: Influence of habitat on the diet of little brown bats (*Myotis lucifugus*). Mol Ecol 20:1772–1780.

Clark, ML; Miller, KA; Brooks, MH. (2001) U.S. Geological Survey monitoring of Powder River Basin stream-water quantity and quality. Cheyenne, WY: U.S. Geological Survey, U.S. Department of the Interior, Cheyenne, WY. Available online at http://pubs.usgs.gov/wri/wri014279/.

Clements, WH; Kotalik, C; Cadmus, P. (2014) Effects of major ions on benthic communities: an experimental test of the proposed U.S. EPA aquatic life benchmark for conductivity. In: Joint Aquatic Sciences Meeting: Bridging genes to ecosystems: aquatic science at a time of rapid changes, Portland, Oregon, May 18−23, 2014. Available online at: http://www.sgmeet.com/jasm2014/viewabstract.asp?AbstractID=14814.

Clements, WH; Kotalik, C. (2016) Effects of major ions on natural benthic communities: an experimental assessment of the U.S. EPA aquatic life benchmark for conductivity. Freshw. Sci. 35(1):(126-138).). Available online at: http://www.journals.uchicago.edu/doi/pdfplus/10.1086/685085.

Clifford, HF. (1982) Life cycles of mayflies (Ephemeroptera), with special reference to voltinism. Quaest Entomol 18:15−90.

Coffey, DB; Cormier, SM; Harwood, J. (2014) Using field-based species sensitivity distributions to infer multiple causes. HERA 20(2):402−432.

Colwell, RK; Rangel, TF. (2009) Hutchinson's duality: The once and future niche. Proc Natl Acad Sci U.S.A. 106:19651−19658.

Cormier, SM; Coffey, DB; Griffith, M. (2012) Letter to the Editor in Chief concerning the article "Status of fish and macroinvertebrate communities in a watershed experiencing high rates of fossil fuel extraction: Tenmile Creek, a Major Monongahela River tributary" by Kimmel and Argent, 2012. Water Air Soil Pollut 223:4659−4662.

Cormier, SM; Suter, GW. (2013a) A method for deriving water-quality benchmarks using field data. Environ Toxicol Chem 32(2):255−262.

Cormier, SM; Suter, GW. (2013b) A method for assessing causation of field exposure-response relationships. Environ Toxicol Chem 32(2):272−276.

Cormier, SM; Suter, GW, II; Norton, SB. (2010) Causal characteristics for ecoepidemiology. HERA 16(1):53−73.

Cormier, SM; Suter, GW; Zheng, L. (2013a) Derivation of a benchmark for freshwater ionic strength. Environ Toxicol Chem 32(2):263−271.

Cormier, SM; Suter, GW; Zheng, L; Pond, GJ. (2013b) Assessing causation of the extirpation of stream macroinvertebrates by a mixture of ions. Environ Toxicol Chem 32(2):277−287.

Cormier, SM; Wilkes, SP; Zheng, L. (2013c) Relationship of land use and elevated ionic strength in Appalachian watersheds. Environ Toxicol Chem 32(2):296−303.

Coward, K; Bromage, NR; Hibbitt, O; Parrington, J. (2002) Gamete physiology, fertilization and egg activation in teleost fish. Rev Fish Biol Fish 12:33−58.

Crossland, NO; Mitchell, GC; Bennett, D; Maxted, J. (1991) An outdoor artificial stream system designed for ecotoxicological studies. Ecotox Environ Saf 22:175−183.

Dahm, KG; Guerra, KL; Xu, P; Drewes, JE. (2011) Composite geochemical database for coalbed methane produced water quality in the Rocky Mountain region. Environ Sci Technol 45(18):7655−7663.

Datry, T. (2012) Benthic and hyporheic invertebrate assemblages along a flow intermittence gradient: effects of duration of dry events. Freshw Biol (57)563−574.

De Jong, GD; Canton, SP. (2013) Presence of long-lived taxa and hydrologic permanence. J Freshw Ecol 28(2):277−282.

del Rosario RB, Resh VH (2000) Invertebrates in intermittent and perennial streams: is the hyporheic zone a refuge from drying? J N Am Benthol Soc 19:680–696.

Delucchi, CM. 1988. Comparison of community structure among streams with different temporal flow regimes. Can J Zool 66: 579–586.

Doeg, TJ; Milledge, GA. (1991) Effect of experimentally increasing concentration of suspended sediment on macroinvertebrate drift. Aust J Mare Freshw Res 42(5):519–526.

Drousé, SK; Hillman, DC; Creelman, LW; Potter, JF; Simon, SJ. (1986) National surface water survey, Eastern Lake survey – Phase I, quality assurance plan. EPA/600/4-86/008. Las Vegas, NV: U.S. Environmental Protection Agency, Office of Environmental Monioring and Quality Assurance.

Duncan, RA; Bethune, MG; Thayalakumaran, T; Christen, EW; McMahon, TA. (2008) Management of salt mobilization in the irrigated landscape—A review of selected irrigation regions. J Hydrol 351(1–2):238–252.

Dunlop, J; McGregor, G; Horrigan, N. (2005) Potential impacts of salinity and turbidity in riverine ecosystems. Characterization of impacts and a discussion of regional target setting for riverine ecosystems in Queensland. The National Action Plan for Salinity and Water Quality Water Quality State-level Investment Project. Available online at https://www.ehp.qld.gov.au/water/pdf/potential-impacts-sal-tur.pdf.

Dunlop, JE; Mann; RM; Hobbs, D; Smith, REW; Nanjappa, V; Vardy; Vink, S. (2015). Assessing the toxicity of saline waters: the importance of accommodating surface water ionic composition at the river basin scale. Australasian Bull Ecotoxicol Environ Chem 2: 1-15. Available online at http://australasia.setac.org/wp-content/uploads/ABEEC-v2-p1.pdf.

Echols, BS; Currie, RJ; Cherry, DS. (2009) Influence of SC dissipation on benthic macroinvertebrates in the North Fork Holston River, Virginia, downstream of a point-source brine discharge during severe low-flow conditions. Hum Ecol Risk Assess 15(1):170–184.

Echols, BS; Currie, RJ; Cherry, DS. (2010) Preliminary results of laboratory toxicity tests with the mayfly, *Isonychia bicolor* (Ephemeroptera: Isonychiidae) for development as a standard test organism for evaluating streams in the Appalachian coalfields of Virginia and West Virginia. Environ Monitor Assess 169(1–4):487–500.

Efron, B; Tibshirani, R. (1993) An introduction to bootstrap. Monographs on statistics and applied probability 57. Boca Raton, FL: Chapman & Hall/CRC Press.

El-Ashry, MT; van Schilfgaarde, J; Schiffman, S. (1985) Salinity pollution from irrigated agriculture. J Soil Water Conserv 40:48–52.

Entrekin, S; Evans-White, M; Johnson, B; Hagenbuch, E. (2011) Rapid expansion of natural gas development poses a threat to surface waters. Front Ecol Environ 9:503–511.

Environment Canada and Health Canada. (2001) Priority substances list assessment report: road salts. Canadian Environmental Protection Act, 1999. Available online at http://ww1.prweb.com/prfiles/2008/02/07/370423/EnvironmentCanadareport.pdf.

Environment Canada. (2012) Federal contaminated sites action plan (FCSAP) ecological risk assessment guidance. Prepared for U. Pott, Pacific and Yukon Environmental Stewardship Branch by Azimuth Consulting Vancouver, BC, Canada. Available at http://geoenvirologic.ca/Documents/20120631_ERAGuidance_Final_En.pdf.

Epanchin, PN; Knapp, RA; Lawler, SP. (2010) Non-native trout impact an alpine nesting bird by altering aquatic-insect subsidies. Ecology 91:2406–2415.

Erickson, RJ; Mount, DR; Highland, TL; Hockett, JR; Hoff, DJ; Jenson, CT; Norberg-King, TJ, Peterson, KN. (2016) The acute toxicity of major ion salts to Ceriodaphnia dubia. II. Empirical relationships in binary salt mixtures. Environ Toxicol Chem. 2016 Nov 1. doi: 10.1002/etc.3669. [Epub ahead of print].

Evans, DH. (2008a) Osmotic and ionic regulation: cells and animals. Boca Raton, FL: CRC Press. 606 pp.

Evans, DH. (2008b) Teleost fish osmoregulation: what have we learned since August Krogh, Homer Smith, and Ancel Keys? Am J Physiol Regul Intgr Comp Physiol 295(2):R704–R713.

Evans, DM; Zipper, CE; Donovan, PF; Daniels, WL. (2014) Long-term trends of specific conductance in waters discharged by coal-mine valley fills in central Appalachia, USA. J Am Water Res Assoc 50(6):1449–1460.

Evans, M; Frick, C. (2001) The effects of road salts on aquatic ecosystems. NWRI Contribution Series No. 02-308. Saskatoon, Saskatchewan: National Water Research Institute (NWRI).

Evans-White, MA; Stelzer, RS; Lambert, GA. (2005) Taxonomic and regional patterns of benthic macroinvertebrate elementals composition in streams. Freshw Biol 50:1786–1799.

Farag, AM; Harper, DD. (2012) The chronic toxicity of sodium bicarbonate defined under laboratory conditions. In: Farag, AM; Harper, DD; eds. The potential effects of sodium bicarbonate, a major constituent of produced waters from coalbed natural gas production, on aquatic life. Scientific Investigations Report 2012–5008; pp. 40–60. Reston, VA: U.S. Geological Survey.

Feminella, JW. (1996) Comparison of benthic macroinvertebrate assemblages in small streams along a gradient of flow permanence. J N Am Benthol Soc 15:651–669.

Findlay, SEG; Kelly, VR. (2011) Emerging indirect and long-term road salt effects on ecosystems. Ann NY Acad Sci 1223:58–68.

Fisher, SG; Gray, LJ; Grimm, NB; Busch, DE. (1982) Temporal succession in a desert stream ecosystem following flash flooding. Ecol Monogr 52:93–110.

Flotemersch, JE; Stribling, JB; Paul, MJ. (2006). Concepts and Approaches for the Bioassessment of Non-wadeable Streams and Rivers. EPA 600-R-06-127. US Environmental Protection Agency, Cincinnati, Ohio. https://www3.epa.gov/region1/npdes/merrimackstation/pdfs/ar/AR-1157.pdf.

Forman, RTT; Alexander, LE. (1998) Roads and their major ecological effects. Ann Rev Ecol Syst 29:207–31.

Fox, GA. (1991) Practical causal inference for ecoepidemiologist. J Toxicol Environ Health 33(4):359–374.

Fritz, KM; Fulton, S; Johnson, BR; Barton, CD; Jack, JD; Word, DA; Burke, RA. (2010) Structural and functional characteristics of natural and constructed channels draining a reclaimed mountaintop removal and valley fill coal mine. J N Am Benthol Soc 29:673–689.

Futuyma, DJ; Moreno, G. (1988) The evolution of ecological specialization. Ann Rev Ecol Syst 19:207–233.

Gaino, E; Bongiovanni, E. (1992) Comparative morphology of epithemata polar chorionic structures in the eggs of *Ephemerella ignita* Ephemeroptera Ephemerellidae. Trans Am Microscop Soc 111(3):255–265.

Geckler, JR; Horning, WB; Neiheisel, TM; Pickering, QH; Robinson, EL. (1976) Validity of laboratory tests for predicting copper toxicity in streams. EPA-600/3-76-116. Deluth MN: Environmental Research Laboratory. Available online at http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=496962.

Gerritsen, J; Burton, J; Barbour, MT. (2000) A stream condition index for West Virginia wadeable streams. Prepared by: Tetra Tech, Inc. Owing Mills, MD. Prepared for: U.S. EPA Region 3 Environmental Services Division, and U.S. EPA Office of Science and Technology, Office of Water. Available online at http://www.dep.wv.gov/WWE/watershed/bio_fish/Documents/WVSCI.pdf.

Gerritsen, J; Zheng, L; Burton, J; Boschen, C; Wilkes, S; Ludwig, J; Cormier, S. (2010) Inferring causes of biological impairment in the Clear Fork Watershed, West Virginia. EPA/600/R-08/146. Washington, DC: U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. Available online at http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=201963.

Gesser, H; Poupa, O. (1983) Acidosis and cardiac muscle contractility: comparative aspects. Comp Biochem Physiol A Comp Physiol 76(3):559-66.

Gibbs, RJ. (1970) Mechanisms controlling world water chemistry. Science 170:1088–1090.

Gillis, PL. (2011) Assessing the toxicity of sodium chloride to the glochidia of freshwater mussels: Implications for salinization of surface waters. Environ Pollut 159(6):1702–1708.

Goddard, MA; Mikhailova, EA; Post, CJ; Schlautman, MA. (2007) Atmospheric Mg^{2+} wet deposition within the continental United States and implications for soil inorganic carbon sequestration. Tellus. 59B:50–56.

Godwin KA; Hafner, SD; Buff, MF. (2003) Long-term trends in sodium and chloride in the Mohawk River, New York: The effect of fifty years of road-salt application. Environ Pollut 124(2):273–281.

Goldstein, JN; Woodward, DF; Farag, AM. (1999) Movement of adult Chinook salmon during spawning migration in a metals-contaminated system, Cour d'Alene River, Idaho. Trans Am Fish Soc 128:121–129.

Gonzalez, RJ; McDonald, DG. (1992) The relationship between oxygen consumption and ion loss in a freshwater fish. J Exp Biol 163(1):317-32.

Gray, LJ. (1993) Emergence production and export of aquatic insects in riparian habitats in a tallgrass prairie. Am Midl Nat 129:288–300.

Gregory, KB; Vidic, RD; Dzombak, DA. (2011) Water management challenges associated with the production of shale gas by hydraulic fracturing. Elements 7(3):181–186.

Griffith, MB. (2014) Natural variation and current reference for specific SC and major ions in wadeable streams of the coterminous U.S. Freshw Sci 33(1):1–17.

Griffith, MB. 2016. Toxicological perspective on the osmoregulation and ionoregulation physiology of major ions by freshwater animals: Teleost fish, crustacea, aquatic insects, and Mollusca: Osmoregulation and ionoregulation physiology of major ions. Environmental Toxicology and Chemistry. DOI: 10.1002/etc.3676.

Griffith, MB; Norton, SB; Alexander, LC; Polland, AL; LeDuc, SD. (2012) The effects of mountaintop mines and valley fills on the physicochemical quality of stream ecosystems in the central Appalachians: a review. Sci Total Environ 417–418:1–12.

Grubbs, SA. (2010) Influence of flow permanence on headwater macroinvertebrate communities in a Cumberland Plateau watershed, USA. Aqua Ecol 45:185–195.

Hall, RO, Jr; Peredney, CL; Meyer, JL. (1996) The effect of invertebrate consumption on bacterial transport in a mountain stream. Limnol Oceanogr 41:1180–1187.

Haluszczak, LO; Rose, AW; Kump, LR (2013) Geochemical evaluation of flowback brine from Marcellus gas wells in Pennsylvania, USA. Appl Geochem 28:55–61.

Hamburg, SP; Yanai, RD; Arthur, MA; Blum, JD; Siccama, TG. (2003) Biotic control of calcium cycling in northern hardwood forests: Acid rain and aging forests. Ecosystems 6(4):399–406.

Harper, DD; Farag, AM; Skaar, D; Selch, T. (2012) The acute toxicity of sodium bicarbonate defined under laboratory conditions. In: Farag, AM; Harper, DD; eds. The potential effects of sodium bicarbonate, a major constituent of produced waters from coalbed natural gas production, on aquatic life. Scientific Investigations Report 2012–5008. U.S. Geological Survey, Reston, VA; pp. 7–39.

Hastie, T; Tibshirani, R. (1986) Generalized additive models. Stat Sci 1(3):297–318.

Hawkins, CP; Cao, Y; Roper, B. (2010) Method of predicting reference condition biota affects the performance and interpretation of ecological indices. Freshw Biol 55(5):1066-85.

Heckman, CW. (1983) The recovery of the biotic community in a lotic freshwater habitat after extensive destruction by chlorine. Int Rev Gesamten Hydrobiol 68:207–226.

Hem, JD. (1985) Study and interpretation of the chemical characteristics of natural water. U.S. Geological Survey Water-Supply Paper 2254. Richmond, VA: USGS. Available online at http://pubs.usgs.gov/wsp/wsp2254/html/pdf.html.

Herlihy, AT; Paulsen, SG; Sickle, JV; Stoddard, JL; Hawkins, CP; Yuan, LL. (2008) Striving for consistency in a national assessment: the challenges of applying a reference-condition approach at a continental scale. J N Am Benthol Soc 27(4):860–877.

Higgins, CL; Wilde, GR. (2005) The role of salinity in structuring fish assemblages in a prairie stream system. Hydrobiologia 549:197–203.

Hill, AB. (1965) The environment and disease: Association or causation? Proc Royal Soc Med 58(5):295–300.

Hille, B. (2001) Ion channels of excitable membranes, 3rd edition. Sunderland, MA: Sinauer Associates, Inc.

Hitt, NP; Chambers, DB. (2014) Temporal changes in taxonomic and functional diversity of fish assemblages downstream from mountaintop mining. Freshw Sci 33(3):915–926. Available online at http://www.jstor.org/stable/10.1086/676997.

Hooper, DU; Chapin, FS, III; Ewel, JJ; Hector, A; Inchausti, P; Lavorell, S; Lawton, JH; Lodge, DM; Loreau, M; Naeem, S; Schmid, B; Setalia, H; Symstad, AJ; Vandermeer, J; Wardle, DA. (2005) Effect of biodiversity on ecosystem functioning: A consensus of current knowledge. Ecol Monogr 75:3–35.

Hopkins, RL, II; Roush, JC. (2013) Effects of mountaintop mining on fish distributions in central Appalachia. Ecol Freshw Fish 22(4):578–586.

Huntington, TG; Hooper, RP; Aulenbach, BT. (1994) Hydrologic processes controlling sulfate mobility in a small forested watershed. Water Res Res 30(2):283–295.

Huryn, AD; Wallace, JB. (2000) Life history and production of stream insects. Ann Rev Entomol 45:83–110.

Hynes, HBN. (1960) The biology of polluted waters. Liverpool, UK: Liverpool University Press.

Ingebritsen, SE; Gelwick, KD; Randolph-Flagg, NG; Crankshaw, IM; Lundstrom, EA; McCulloch, CL; Murveit, AM; Newman, AC; Mariner, RH; Bergfeld, D; Tucker, DS; Schmidt, ME; Spicer, KR; Mosbrucker, AR; Evans, WC. (2014) Hydrothermal monitoring data from the Cascade Range, northwestern United States: U.S. Geological Survey Data Set. Washington, DC: U.S. Department of the Interior, U.S. Geological Survey. doi:10.5066/F72N5088.

Jaffe, LF. (1991) The path of calcium in cytosolic calcium oscillations: A unifying hypothesis. Proc Natl Acad Sci USA. 88:9883–9887.

Jackson, RB; Jobbágy, EG. (2005) From icy roads to salty streams. Natl Acad Sci USA 102:14487-14488.

Jackson, RE; Reddy, KJ. (2007) Geochemistry of coalbed natural gas (CBNG) produced water in Powder River Basin, Wyoming: salinity and sodicity. Water Air Soil Poll 184:49–61.

Johnson, BR; Haas, A; Fritz, KM. (2010) Use of spatially explicit physiochemical data to measure downstream impacts of headwater streams. Water Res Res 46:WO9526.

Johnson, BL; Johnson, MK. (2015) An evaluation of a field-based aquatic life benchmark for specific conductance in northeast Minnesota. Prepared for Water Legacy. Available at http://waterlegacy.org/sites/default/files/u42412/Ex.16_JohnsonMNConductivityEvaluationRpt%26Attachments(Nov.%202015).pdf.

Johnson, BR; Weaver, PC; Nietch, CT; Lazorchak, JM; Struewing, KA; Funk, DH. (2015) Elevated major ion concentrations inhibit larval mayfly growth and development. Environ Toxicol Chem 34(1):167–72.

Johnson, RC; Jin, H-S; Carreiro, MM; Jack, JD. (2013) Macroinvertebrate community structure, secondary production and trophic-level dynamics in urban streams affected by non-point-source pollution. Freshw Biol 58:843–857.

Karatayev, AY; Miller, TD; Burlakova, LE. (2012) Long-term changes in unionid assemblages in the Rio Grande, one of the World's top 10 rivers at risk. Aqua Conserv: Mar Freshw Ecosyst 22:206–219.

Kattwinkel, M; Römbke, J; Liess, M. (2012) Ecological recovery of populations of vulnerable species driving the risk assessment of pesticides. Support Publ 2012: EN-338. 98 pp. Available online at: http://www.efsa.europa.eu/en/efsajournal/doc/338e.pdf.

Kaushal, SS; Groffman, PM; Likens, GE; Belt, KT; Stack, WP; Kelly, VR; Band, LE; Fisher, GT. (2005) Increased salinization of fresh water in the northeastern United States. Proc Natl Acad Sci USA 102(38):13517–13520.

Kaushal, SS; Likens, GE; Utz, RM; Pace, ML; Grese, M; Yespen, M. (2013) Increased river alkalinization in the Eastern U.S. Environ Sci Technol 17(18):10302–10311.

Kelly, VR; Lovett, GM; Weathers, KC; Findlay, SEG; Strayer, DL; Burns, DI; Likens, GE. (2008) Long-term sodium chloride retention in a rural watershed: legacy effects of road salt on streamwater concentration. Environ Sci Technol 42(2):410–415.

Kelting, DL; Laxson, CL; Yerger, EC. (2012) Regional analysis of paved roads on sodium and chloride in lakes. Water Res 46:2749–2758.

Kennedy, AJ; Cherry, DS; Currie, RJ. (2003) Field and laboratory assessment of a coal processing effluent in the Leading Creek watershed, Meigs County, Ohio. Arch Environ Contam Toxicol 44(3):324–331.

Kennedy, AJ; Cherry, DS; Currie, RJ. (2004) Evaluation of ecologically relevant bioassays for a lotic system impacted by a coal-mine effluent, using *Isonychia*. Environ Monit Assess 95(1–3):37–55.

Kennedy, AJ; Cherry, DS; Zipper, CE. (2005) Evaluation of ionic contribution to the toxicity of a coal-mine effluent using *Ceriodaphnia dubia*. Arch Environ Contam Toxicol 49(2):155–162.

Kimmel, WG; Argent, DG. (2010) Stream fish community responses to a gradient of SC. Water Air Soil Pollut 206(1–4):49–56.

Komnick, H. (1977) Chloride cells and chloride epithelia of aquatic insects. Int Rev Cytol 49:285–328.

Krug, EC; Frink, CR. (1983) Acid rain on acid soil: A new perspective. Science. 221:520–525.

Kunz, JL; Conley, JM; Buchwalter, DB; Norber-King, TJ; Kemble, NE; Wang, N; Ingersoll, CG. (2013) Use of reconstituted waters to evaluate effects of elevated major ions associated with mountaintop coal mining on freshwater invertebrates. Environ Toxicol Chem 32(12):2826–2835.

Larson, AG; Marti, PB. (1996) Relationship between ground water and surface water in the Quilceda Creek watershed. Environmental Information. Publication No. 96-333. Pp. 33. Olympia, WA: Washington State Department of Ecology. Available online at https://fortress.wa.gov/ecy/publications/documents/96333.pdf.

Lasier, PJ; Hardin, IR. (2010) Observed and prediction reproduction of *Ceriodaphnia dubia* exposed to chloride, sulfate, and bicarbonate. Environ Toxicol Chem 29(2):347–358.

Lefebvre, O; Moletta, R. (2006) Treatment of organic pollution in industrial saline wastewater: A literature review. Water Res 40(20):3671–3682.

Legendre, P. (1998) Model II regression user's guide, R edition. R Vignette. https://www.google.com/?gws_rd=ssl#q=model+II+regression.

Leland, HV; Brown, LR; Mueller, DK. (2001) Distribution of algae in the San Joaquin River, California, in relation to nutrient supply, salinity and other environmental factors. Freshw Biol 46:1139–1167.

Lenat, DR. (1984) Agriculture and stream water quality: A biological evaluation of erosion control practices. Environ Manage 8(4):333–343.

Lerotholi, S; Palmer, CG; Rowntree, K. (2004) Bioassessment of a river in a semi-arid, agricultural catchment, Eastern Cape. In: Proceedings of the 2004 Water Institute of Southern Africa (WISA) Biennial Conference, Cape Town, South Africa, pp. 338–344.

Liess, M; Beketov, M. (2011) Traits and stress: Key to identify community effects of low levels of toxicants in test systems. Ecotoxicology. 20(6):1328–1340.

Liess, M; Schulz, R. (1999) Linking insecticide contamination and population response in an agricultural stream. Environ Toxicol Chem 18(9):1948–1955.

Likens, GE; Driscoll, CT; Buso, DC; Siccama, TG; Johnson, CE; Lovett, GM; Fahey, TJ; Reiners, WA; Ryan, DF; Martin, CW; Bailey, SW. (1998) The biogeochemistry of calcium at Hubbard Brook. Biogeochemistry. 41:89–173.

Likens, GE; Bormann, FH; Johnson, NM; Fisher, DW; Pierce, RS. (1970) Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook watershed-ecosystem. Ecol Monogr 40(1):23–47.

Lindberg, TT; Bernhardt, ES; Bier, R; Helton, AM; Merola, RB; Vengosh, A; Di Giulio, LT. (2011) Cumulative impacts of mountaintop mining on an Appalachian watershed. Proc Natl Acad Sci 108(52):20929–20934.

Lynch, JA; Corbett, ES. (1989) Hydrologic control of sulfate mobility in a forested watershed. Water Res Res 25(7):1695–1703.

MacArthur, R; Levins, R. (1967) The limiting similarity, convergence, and divergence of coexisting species. Am Natural 101(921):377–385.

Marshall, WS. (2002) Na^+, Cl^-, Ca^{2+} and Zn^{2+} transport by fish gills: retrospective review and prospective synthesis. J Exp Zool 293:264–283.

Mayhugh, J; Ziemkiewicz, P. (2005) Treatment of chloride contaminated mine water in NW West Virginia. USGS West Virginia Water Resources Investigations Project Report WRI 54. Available from: http://water.usgs.gov/wrri/04grants/Progress%20Completion%20Reports/2003WV16B.pdf.

McCleskey, RB. (2011) Electrical conductivity of electrolytes found in natural waters from (5 to 90 °C). J Chem Engineer Data 56:317–327.

McNab, WH; Avers, PE. (1994) Ecological subregions of the United States. Washington, DC: USDA Forest Service.

Mebane, CA; Eakins, RJ; Fraser, BG; Adams, WJ. (2015) Recovery of a mining-damaged stream ecosystem. Elementa: Sci Anthrop. Pp. 34 Available on line at: https://www.elementascience.org/articles/42.

Merriam, ER; Petty, JT; Merovich, GT; Fulton, JB; Strager, MP. (2011) Additive effects of mining and residential development on stream conditions in a central Appalachian watershed. J N Am Benthol Soc 30(2):399–418.

Merricks, TC; Cherry, DS; Zipper, CE; Currie, RJ; Valenti, TW. (2007) Coal-mine hollow fill and settling pond influence on headwater streams in southern West Virginia, USA. Environ Monit Assess 129(1–3):359–378.

Merritt, RW; Cummins, KW. (1996) An introduction to the aquatic insects of North America. 3rd Edition. Dubuque, IA: Kendall/Hunt. 862 pp.

Meyer, JS; Sanchez, DA; Brookman, JA; McWorter, DB; Bergman, HL. (1985) Chemistry and aquatic toxicity of raw oil shale leachates from Piceance Basin, Colorado. Environ Toxicol Chem 4(4):559–572.

Micieli, MV; Risso, P; Achinelly, MF; Villar, MM; Muttis, E. (2012) Population dynamics between the mermithid Strelkovimermis spiculatus (Nematoda: Mermithidae) and the floodwater mosquito Ochlerotatus albifasciatus (Diptera: Culicidae) over time. Biol Contr 61:55–63.

Minshall, GW; Andrews, DA; Manuel-Faler, CY. (1983) Application of island biogeographic theory to streams: Macroinvertebrate recolonization of the Teton River, Idaho. In: Barnes, JR; Minshall, GW; eds. Stream ecology: application and testing of general ecological theory. Pp 279–297. New York: Plenum Press.

Molles, MC. (1985) Recovery of a stream invertebrate community from a flash flood in Tesque Creek, New Mexico. Southwest Nat 30:279–287.

Mount, DR; Erickson, RJ; Highland, TL; Hockett, JR; Hoff, DJ; Jenson, CT; Norberg-King, TJ; Peterson, KN; y M. Polaske,ZM; Wisniewskiz, S. (2016) The acute toxicity of major ion salts to Ceriodaphnia dubia: I. influence of background water chemistry. Environ Toxicol Chem 35(12):3039-3057.

Mount, DR; Gulley, DD; Hockett, JR; Garrison, TD; Evans, JM. (1997) Statistical models to predict the toxicity of major ions to *Ceriodaphnia dubia, Daphnia magna,* and *Pimephales promelas* (fathead minnows). Environ Toxicol Chem 16(10):2009–2019.

Mueller, DK; Martin, JD; Lopes, TJ. (1997) Quality-control design for surface-water sampling in the National Water-Quality Assessment Program. (Open-file report 97-223). Denver, CO: US Geological Survey. https://pubs.usgs.gov/of/1997/223/pdf/ofr97-223.pdf.

Mullins, GL; Hansen, DJ. (2006) Chapter 4: Basic soil fertility. In: Evanylo, G; ed. Mid-Atlantic nutrient management handbook. Mid-Atlantic Regional Water Program.

Mulrennan, ME; Woodroffe, CD. (1998) Saltwater intrusion into the coastal plains of the Lower May River, Northern Territory, Australia. J Environ Manage 54(3):169–188.

NADP (National Atmospheric Deposition Program) (2013) NADP maps and data. Available online at: http://nadp.sws.uiuc.edu/data/.

Nakano, S; Murakami, M. (2001) Reciprocal subsidies: Dynamic interdependence between terrestrial and aquatic food webs. Proc Natl Acad Sci 98:166–70.

NRC (National Research Council). (2010) Management and effects of coalbed methane produced water in the western United States. Committee on Management and Effects of Coalbed Methane Development and Produced Water in the Western United States. Washington, D.C.: National Academies Press.

Nelson, D; Cox, M. (2005) Lehninger principles of biochemistry. 4th edition. New York: W. H. Freeman & Co.; pp. 395–397.

Newbold, JD; Elwood, JW; O'Neill, RV; Sheldon, AL. (1983) Phosphorus dynamics in a woodland stream ecosystem: A study of nutrient spiraling. Ecology 64:1249–1263.

Newbold, JD; O'Neill, RV; Elwood, JW; van Winkle, W. (1982) Nutrient spiraling in streams: Implications for nutrient limitation and invertebrate activity. Am Natural 120:628–652.

Newman, MC; Ownby, DR; Mezin, LCA; Powell, DC; Christensen, TRL; Lerberg, SB; Anderson, B-A. (2000) Applying species sensitivity distributions in ecological risk assessment: Assumptions of distribution type and sufficient number of species. Environ Toxicol Chem 19(2):508–515.

Newman, MC; Ownby, DR; Mezin, LCA; Powell, DC; Christensen, TRL; Lerberg, SB; Anderson, B-A; Padma, TV. (2001) Species sensitivity distributions in ecological risk assessment: Distributional assumptions, alternative bootstrap techniques, and estimation of adequate number of species. In: Posthuma, L; Suter, GW, II; Traas, TP; eds. Species sensitivity distributions in ecotoxicology. pp 119–132. Boca Raton, FL: CRC Press, LLC.

Nezat, CA; Blum, JD; Yanai, RD; Park, BB. (2008) Mineral sources of calcium and phosphorus in soils of the Northeastern United States. Soil Sci Soc Am J 72:1786–1794.

Niemi, GJ; DeVore, P; Detenbeck, Taylor, D; Yount, JD; Lima, A; Pastor, J; Naiman, RJ. (1990) Overview of case studies on recovery of aquatic ecosystems from disturbance. Environ Manage 14:571–588.

Nietch, C; Lazorchak, J; Johnson, B; Allen, J. (2014) Evaluation of total dissolved solids and specific conductance water quality targets with paired single-species and mesocosm community exposures. Presented at Society of Environmental Toxicology and Chemistry North America 35th Annual Meeting, Vancouver, BC, CANADA, November 09–13, 2014. Available online at http://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=293057&CFID=17865572&CFTOKEN=51190896

Norton, SB; Cormier, SM; Suter, GW II. (2015) Ecological Causal Assessment. CRC Press, Taylor and Francis Group, Boca Raton, FL.

Novotny, EV; Murphy, D; Stefan, HG. (2008) Increase of urban lake salinity by road deicing salt. Sci Total Environ 406:131–144.

NRC (National Research Council). (2010) Management and effects of coalbed methane produced water in the western United States. Committee on Management and Effects of Coalbed Methane Development and Produced Water in the Western United States. Washington, D.C.: National Academies Press.

NYSDEC (New York State Department of Environment and Conservation). (2000). Memorandum from Scott Kisbaugh to Jay Bloomfield regarding reference lakes for nutrient criteria. September 26, 2000.

Olson, JR. (2012) The influence of geology and other environmental factors on stream water chemistry and benthic invertebrate assemblages. PhD Dissertation, Utah State University, Logan, Utah. Available at http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=2340&context=etd.

Olson, JR; Hawkins, CP. (2012) Predicting natural base-flow stream water chemistry in the western United States. Water Resour Res 48:W02504.

Omernik, JM. (1987) Ecoregions of the conterminous United States. Ann Assoc Am Geograph 77:118–125.

Omernik, JM. (1995) Ecoregions: a spatial framework for environmental management. In: Davis, WS; Simon, TP; (eds). Biological assessment and criteria: tools for water resource planning and decision making. [Pp 49–62]. Boca Raton, FL: Lewis Publishers.

Oregon DEQ (Department of Environmental Quality). (2009) Water monitoring and assessment mode of operations manual (MOMs). [DEQ03-LAB-0036-SOP]. Hillsboro, Oregon: Laboratory and Environmental Assessment Devision. Available online at http://www.deq.state.or.us/lab/techrpts/docs/DEQ03LAB0036SOP.pdf.

OWEB (Oregon Watershed Enhancement Board). (2001) Draft Oregon watershed assessment manual. Appendix A: Ecoregion descriptions. Salem, OR: OWEB. Available online at http://www.oregon.gov/OWEB/docs/pubs/wa_manual99/apdx1-ecoregions.pdf.

Palmer, MA; Bernhart, ES; Schlesinger, WH; Eshleman, KN; Fourfoula-Georgiou, E; Hendryx, MS; Lemly, AD; Likens, GE; Loucks, OL; Power, ME; White, PS; Wilcock, PR. (2010) Mountaintop mining consequences. Science 327:148–149.

Paul, MJ; Meyer, JL. (2001) Streams in the urban landscape. Ann Rev Ecol Syst 32:333–365.

Percival, E; Whitehead H. (1928) Observations on the ova and oviposition of certain Ephemeroptera and Plecoptera. Proc Leeds Phil Soc (Sci Sect) 1:271–288.

Peterson, AT, Soberon, J; Pearson, RG; Anderson, RP; Martinex-Meyer, E; Nakamura, M; Araujo, MB. (2011) Ecological niches and geographic distributions. Princeton, NJ: Princeton University Press.

Pond, GJ. (2004) Effects of surface mining and residential land use on headwater stream biotic integrity in the eastern Kentucky coalfield region. Kentucky Department of Environmental Protection, Division of Water, Frankfort, KY.

Pond, GJ. (2010) Patterns of Ephemeroptera taxa loss in Appalachian headwater streams (Kentucky, USA) Hydrobiologia 641(1):185–201.

Pond, GJ; Passmore, ME; Borsuk, FA; Reyolds, L; Rose, CJ. (2008) Downstream effects of mountaintop coal mining: comparing biological conditions using family- and genus-level macroinvertebrate bioassessment tools. J N Am Benthol Soc 27(3):717–737.

Pond, GJ; Passmore, ME; Pointon, ND; Felbinger, JK; Walker, CA; Krock, KJ; Fulton, JB; Nash, WL. (2014) Long-term impacts on macroinvertebrates downstream of reclaimed mountaintop mining valley fills in Central Appalachia. Environ Manage 54(4):919–933. Available online at http://www.ncbi.nlm.nih.gov/pubmed/24990807.

Posthuma, L; Suter GW, II; Traas, TP; eds. (2001) Species sensitivity distributions in ecotoxicology. Boca Raton, FL: Lewis Publishers.

Potapova, M. (2005) Relationships of soft-bodied algae to water-quality and habitat characteristics in the U.S. rivers: Analysis of the National Water-Quality Assessment (NAWQA) Program data set. Philadelphia, PA: The Academy of Natural Sciences. http://diatom.acnatsci.org/autecology/uploads/Report_October20.pdf.

Potapova, M. (2014) Autecology of freshwater algae datafiles and links to internet resources. Philadelphia, PA: The Academy of Natural Sciences of Drexel University. http://diatom.acnatsci.org/autecology/.

Potapova, M; Charles, DF. (2003) Distribution of benthic diatoms in U.S. rivers in relation to SC and ionic composition. Freshw Biol 48:1311–1328.

Price, JE; Zipper, CE; Jones, JW; Franck, CT. (2014) Water and sediment quality in the Clinch River, Virginia and Tennessee, USA, over nearly five decades. J Am Water Res Assoc 50(4):837–858. DOI: 10.1111/jawr.12219.

R Development Core Team (2011) R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Available online at http://www.R-project.org.

Remane, A. (1971) Ecology of brackish water. In: Remane A; Schlieper, C; eds. Biology of brackish water. New York, NY: John Wiley and Sons.

Resh, VH. (1995) Freshwater benthic macroinvertebrates and rapid assessment procedures for water quality monitoring in developing and newly industrialized countries. In: Davis, WS; Simon, TP; eds. Biological assessment and criteria. pp. 167–177. Boca Raton, FL: Lewis Publishers.

Richardson, JS. (1993) Limits of productivity of streams: Evidence from studies of macroinvertebrates. Can Spec Pub Fish Aqua Sci 118:9–15.

Rose, S. (2007). The effects of urbanization on the hydrochemistry of base flow within the Chattahoochee River Basin (Georgia, USA) J Hydrol 341:42–54.

Rubach, MN; Ashauer, R; Buchwalter, DB; DeLange, H; Hamer, M; Preuss, TG; Töpke, K; Maund, SJ. (2011) Framework for traits-based assessment in ecotoxicology. Integr Environ Assess Manag 7:172–186.

Ruhl, L; Vengosh, A; Dwyer, GS; Hsu-Kim, H; Schwartz, G; Romanski, A; Smith, SD. (2012) The impact of coal combustion residue effluent on water resources: A North Carolina example. Environ Sci Technol 46 (21):12226–12233.

Samarina, VP. (2007) Assessment of the impact of economic activity on the degree of overland flow contamination in the zone of the Kursk-Belgorod magnetic anomaly: Case study of the Oskol River. Water Resour 34(5):549–553.

Sams, JI; Beer, KM. (2000) Effects of coal-mine drainage on stream water quality in the Allegheny and Monongahela River basins – sulfate transport and trends. USGS Water Resources Investigations Report 99-4208. Lemoyne, PA: National Water-Quality Assessment Program. Available online at http://pa.water.usgs.gov/reports/wrir_99-4208.pdf.

Scanlon, BR; Stonestorm, DA; Reedy, R; Leaney, FW; Gates, JB; Cresswell, G. (2009) Inventories and mobilization of unsaturated zone sulfate, fluoride, and chloride related to land use change in semiarid regions, southwestern United States and Australia. Water Resour Res 45:W00A18.

Schlesinger, WH. (1997) Biogeochemistry, an analysis of global change, Second Edition. San Diego, CA: Academic Press. 588 pp.

Schofield, K; Ziegler, R. (2010) Detailed conceptual model diagram for ionic strength. (modified 7/10). U.S. Environmental Protection Agency, Causal Analysis/Diagnosis Decision Information System. Available online at: http://www.epa.gov/caddis/pdf/conceptual_model/ion_CD_det.pdf.

Sheehan, PJ; Winner, RW. (1984) Comparison of gradient studies in heavy-metal-polluted streams. In: Sheehan, PJ; Miller, DR; Butler, GC; Bourdeau, PJ; eds. Effects of pollutants at the ecosystem level. pp. 255–271. Oxford, England: John Wiley and Sons, Ltd.

Smith, DG. (2001) Pennak's freshwater Invertebrates of the United States: Porifera to Crustacea, 4th edition. New York, NY: John Wiley & Sons Inc. 648 pp.

Smith, JM; Dornish, M; Wood, EJ. (2005) Involvement of protein kinase C in chitosan glutamate-mediated tight junction disruption. Biomaterials. 26(16):3269-76.

Smith, RF; Alexander, LC; Lamp, WO. (2009) Dispersal by terrestrial stages of stream insects in urban watersheds: a synthesis of current knowledge. J N Am Benthol Soc 28(4):1022–1037.

Smithson, J. (2007) West Virginia stream/river survey design 2007—2111. Charleston, WV. West Virginia Department of Environmental Protection, Division of Water and Waste Management.

Soucek, DJ; Kennedy, AJ. (2005) Effects of hardness, chloride, and acclimation on the acute toxicity of sulfate to freshwater invertebrates. Environ Toxicol Chem 24(5):1204–1210.

Soucek, DJ; Dickinson, A. (2015) Full-life chronic toxicity of sodium salts to the mayfly Neocloeon triangulifer in tests with laboratory cultured food. Environ Toxicol Chem 34(9):2126-37.

Stallard, RF; Edmond, JM. (1987) Geochemistry of the Amazon. 3. Weathering chemistry and limits to dissolving inputs. J Geophys Res 92:8293–8302.

Stauffer, JR; Ferreri, CP. (2002) Characterization of stream fish assemblages in selected regions of mountain top removal/valley fill coal mining. In: Draft programmatic environmental impact statement on mountaintop mining/valley fills in Appalachia (2003) Appendix D. U.S. Environmental Protection Agency, Region 3, Philadelphia, PA.

Steffy, LU; McGinty, AL; Welty, C; Kilham, SS. (2004) Connecting ground water influxes with fish species diversity in an urbanized watershed. J Am Water Resour Assoc 40(5):1269–1275.

Stevens, DL; Olsen, AR. (2004) Spatially balanced sampling of natural resources. J Am Stat Assoc 99:262–278.

Stewart, MA; Bhatt, TN; Fennema, RJ; Fitterman, DV. (2002) The road to Flamingo: an evolution of flow pattern alterations and salinity instrusion into the Lower Glades, Everglades National Park. USGS Open-File Report 02-59. Denver, CO: U.S. Geological Survey. Available online at http://www.researchgate.net/publication/237232996_The_Road_to_Flamingo_an_Evaluation_of_Flow_Pattern_Alterations_and_Salinity_Intrusion_in_the_Lower_Glades_Everglades_National_Park.

Stoddard, JL; Larsen, DP; Hawkins, CP; Johnson, RK; Norris, RH. (2006) Setting expectations for the ecological condition of streams: The concept of reference condition. Ecol Appl 16(4):1267–1276.

Stout, B; Wallace, JB. (2003) A survey of eight major aquatic insect orders associated with small headwater streams subject to valley fills from mountaintop mining. Appendix in Mountaintop Mining/Valley Fills in Appalachia. Final Programmatic Environmental Impact Statement. Philadelphia, PA: U.S. Environmental Protection Agency.

Sutcliffe, DW. (1962) The composition of haemolymph in aquatic insects. Exp Biol 39:325–343.

Sutcliffe, DW. (1974) Sodium regulation and adaptation to fresh-water in isopod genus *Asellus*. J Exp Biol 61(3):719–736.

Suter, GW, II. (2007) Ecological risk assessment, 2nd edition. Boca Raton, FL: CRC Press.

Suter, GW, II; Cormier, SM. (2008) What is meant by risk-based environmental quality criteria? Integr Environ Assess Manag 4(4):486–489.

Suter, GW, II; Cormier, SM. (2013) A method for assessing the potential for confounding applied to ionic strength in Central Appalachian streams. Environ Toxicol Chem 32(2):288–295.

Suter, GW, II; Cormier, S.M. (2015) Why care about aquatic insects: uses, benefits and services. Integr Environ Assess Manage 11(2):188–194. http://onlinelibrary.wiley.com/doi/10.1002/ieam.16/pdf.

Suter, GW, II; Traas, T; Posthuma, L. (2001) Issues and practices in the derivation and use of species sensitivity distributions. In: Posthuma, L; Suter, GW, II; Traas, T; eds. Species sensitivity distributions in ecotoxicology. Boca Raton, FL: Lewis Publishers; pp. 437–474.

Sweka, JA; Hartman, KJ. (2008) Contribution of terrestrial invertebrates to yearly brook trout consumption and growth. Trans Am Fish Soc 137:224–235.

Svendsen, CR; Quinn, T; Kolbe, D. (2004) Review of macroinvertebrate drift in lotic ecosystems. Final report for Wildlife Research Program Environmental and Safety Division. Olympia, WA: Washington Department of Fish and Wildlife.

TDEC (Tennessee Department of Environment and Conservation) (2000) Letter to Geoff Grubbs containing comments on draft nutrient criteria recommendation. October 5, 2000.

Thomas, LP. (2002) Coal geology, 1st ed. West Sussex, England: John Wiley and Sons, Inc. 379 pp.

Thorp, JH; Covich, AP. (2001) Ecology and classification of North American freshwater invertebrates. New York, NY: Academic Press. 1056 pp.

Timpano, A; Schoenholtz, S; Zipper, C; Soucek, D. (2011) Levels of dissolved solids associated with aquatic life effects in headwater streams of Virginia's Central Appalachian coalfield region. Report prepared for the Virginia Department of Environmental Quality; Virginia Department of Mines, Minerals, and Energy; and the Powell River Project. Prepared by Virginia Tech. Blacksburg, VA. Available online at: http://www.prp.cses.vt.edu/Research_Results/Timpano_TDSReport_2011.pdf.

Timpano, AJ; Schoenholtz, SH; Soucek, DJ; Zipper, CE. (2014) Salinity as a limiting factor for biological condition in mining influenced Central Appalachian headwater streams. J Am Water Resour Assoc 51(1):240-250.

U.S. EPA (Environmental Protection Agency). (1982) Conductance (specific conductance, µmhos at 25°C) Method #: 120.1. Washington, DC: Office of Science and Technology. Available online at https://www.epa.gov/sites/production/files/2015-08/documents/method_120-1_1982.pdf.

U.S. EPA (Environmental Protection Agency). (1983) Water quality standards handbook. Washington, DC: Office of Water Regulations and Standards. EPA/823/R083/002. Available online at https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=2000UIPS.PDF

U.S. EPA (Environmental Protection Agency). (1985) Guidelines for deriving numeric National Water Quality Criteria for the protection of aquatic organisms and their uses. Washington, DC: Office of Research and Development, Environmental Research Laboratories. PB85-227049. Available online at http://water.epa.gov/scitech/swguidance/standards/upload/2009_01_13_criteria_85guidelines.pdf.

U.S. EPA (Environmental Protection Agency). (1987) Handbook of methods for acid deposition studies: Laboratory analyses for surface water chemistry. EPA/600/4-87/026. Washington, DC: U.S. Environmental Protection Agency, Office of Research and Development, Acid Deposition and Atmospheric Research Division. Available online at http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=30000TA0.txt.

U.S. EPA (Environmental Protection Agency). (1991) Technical support document for water quality-based toxics control. Washington, DC: Office of Science and Technology, Office of Water. EPA/505/2-90/001. Available online at https://www3.epa.gov/npdes/pubs/owm0264.pdf.

U.S. EPA (Environmental Protection Agency.) (1994) Water quality standards handbook: 2nd ed. EPA/823/B-94/005a,b. Washington, DC: Office of Water. Available online on http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20003QXV.TXT.

U.S. EPA (Environmental Protection Agency). (1998a) Guidelines for ecological risk assessment. EPA/630/R-95/002F. Washington DC: Risk Assessment Forum. Available online at http://www2.epa.gov/osa/guidelines-ecological-risk-assessment.

U.S. EPA (Environmental Protection Agency). (1998b) Environmental Monitoring and Assessment Program - surface waters: field operations and methods for measuring the ecological conditions of wadeable streams. EPA/620/R-94/004F. Research Triangle Park, NC: National Exposure Research Laboratory, National Health and Environmental Effects Research Laboratory. Available online at https://archive.epa.gov/emap/archive-emap/web/html/ws_abs.html.

U.S. EPA (Environmental Protection Agency). (2000a) Nutrient criteria technical guidance manual: Rivers and streams. EPA/822/B-00/002. Washington, DC: Office of Water. Available online at https://www.epa.gov/nutrient-policy-data/criteria-development-guidance-rivers-and-streams.

U.S. EPA (Environmental Protection Agency). (2000b) Stressor identification guidance document. EPA/822/B-00/025. Washington, DC: Office of Water. Available online at https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=20685.

U.S. EPA (Environmental Protection Agency). (2001) Laboratory methods for processing macroinvertebrate samples, macroinvertebrate indicator standard operating procedures (SOP#701). Cincinnati, OH: National Environmental Research Laboratory.

U.S. EPA (Environmental Protection Agency). (2002) Summary of biological assessment programs and biocriteria development for states, tribes, territories, and interstate commissions: streams and wadeable rivers. EPA/822/R-02/048. Washington, DC: Office of Water. Available at http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/biocriteria/upload/2002-Summary-BioAssess-Programs.pdf.

U.S. EPA (Environmental Protection Agency). (2003) Generic ecological assessment endpoints (GEAEs) for ecological risk assessment. EPA/630/P-02/004F. Washington, DC: Risk Assessment Forum. Available online at https://www.epa.gov/sites/production/files/2014-11/documents/generic_endpoinsts_2004.pdf.

U.S. EPA (Environmental Protection Agency). (2004a) Wadeable streams assessment: Quality assurance project plan. EPA/841/B-04/005. Washington, DC: U.S. Environmental Protection Agency, Office of Water and Office of Research and Development. Available online at http://www.epa.gov/owow/monitoring/wsa/QAPP-August18.pdf.

U.S. EPA (Environmental Protection Agency). (2004b) Wadeable streams assessment: Water chemistry laboratory manual. EPA/841/B-04/008. Washington, DC: U.S. Environmental Protection Agency, Office of Water and Office of Research and Development. Available online at http://www.epa.gov/owow/monitoring/wsa/WRS_lab_manual.pdf.

U.S. EPA (Environmental Protection Agency). (2006) Wadeable streams assessment: A collaborative survey of the nation's streams. EPA-841-B-06-002.Washington, DC: Office of Research and Development. Office of Water. Available online at: http://water.epa.gov/type/rsl/monitoring/streamsurvey/upload/2007_5_16_streamsurvey_WSA_Assessment_May2007.pdf

U.S. EPA (Environmental Protection Agency). (2009) National rivers and streams assessment: field operations manual. DC; EPA/841/B-07/009. Washington, DC: Office of Water. Available online at http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100AVOF.txt.

U.S. EPA (Environmental Protection Agency). (2010) Primary distinguishing characteristics of Level III Ecoregions of the Continental United States. Available online at: ftp://ftp.epa.gov/wed/ecoregions/us/Eco_Level_III_descriptions.doc.

U.S. EPA (Environmental Protection Agency). (2011a) A field-based aquatic life benchmark for conductivity in Central Appalachian streams. EPA/600/R-10/023F. Washington, DC: Office of Research and Development, National Center for Environmental Assessment. Available online at http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=233809.

U.S. EPA (Environmental Protection Agency). (2011b) The effects of mountaintop mines and valley fills on aquatic ecosystems of the Central Appalachian coalfields. EPA/600/R-09/138F. Washingon, DC: Office of Research and Development, National Center for Environmental Assessment. Available online at http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100E3KG.txt.

U.S. EPA (Environmental Protection Agency). (2011c) Review of field-based aquatic life benchmark for conductivity in Central Appalachian streams. Washington, DC: Science Advisory Board, Office of the Administrator. Available online at: http://yosemite.epa.gov/sab/sabproduct.nsf/0/EEDF20B88AD4C6388525785E007331F3/$File/EPA-SAB-11-006-unsigned.pdf.

U.S. EPA (Environmental Protection Agency). (2011d). A primer on using biological assessments to support water quality management. Office of Science and Technology Office of Water, Washington, DC EPA 810-R-11-01. Available online at http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=CD37911D739A54D92C380DB72D3B72CA?doi=10.1.1.644.3913&rep=rep1&type=pdf

U.S. EPA (Environmental Protection Agency). (2013a) Biological assessment program review: Assessing level of technical rigor to support water quality management. EPA/820/R-13/001. Washington, DC: Office of Science and Technology. Available online at: http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/biocriteria/upload/2013biological_assessment.pdf.

U.S. EPA (Environmental Protection Agency). (2013b) National rivers and streams assessment 2008−2009: A collaborative survey. Draft. EPA/841/D-13/001. Washington, DC: Office of Wetlands, Oceans, and Watersheds. Office of Research and Development. Available online at: http://water.epa.gov/type/rsl/monitoring/riverssurvey/upload/NRSA0809_Report_Final_508Compliant_130228.pdf Data available online at: http://water.epa.gov/type/rsl/monitoring/riverssurvey/index.cfm.

U.S. EPA (Environmental Protection Agency). (2013c) EMAP Data. Washington, DC: Environmental Monitoring & Assessment Program. Available online at: http://www.epa.gov/emap/html/data/index.html.

U.S. EPA (Environmental Protection Agency). (2013d) US Level III Ecoregions of the Continental United States. Available online at https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states.

USGS (United States Geological Survey). (2016). Mount Rainier. Washington, Pierce County: Volcano Hazards Program. Available online at: http://volcanoes.usgs.gov/volcanoes/mount_rainier/.

Vafai, SB; Mootha, VK. (2012) Mitochondrial disorders as windows into an ancient organelle. Nature 491(7424):374–383. doi:10.1038/nature11707.

van Dam, RA; Hogan, AC; McCullough, CD; Houston, MA; Humphrey, CL; Harford, AJ. (2010) Aquatic toxicity of magnesium sulfate, and the influence of calcium, in very low ionic concentration water. Environ Toxicol Chem 29:410–421.

Vander Laan, JJ; Hawkins, CP; Olson, JR; Hill, RA. (2013) Linking land use, in-stream stressors, and biological condition to infer causes of regional ecological impairment in streams. Freshw Sci 32(3):801–820.

Veil, JA; Puder, MG; Elcock, D; Redweik, RJ, Jr. (2004) A white paper describing produced water from production of crude oil, natural gas, and coal bed methane. Argonne, IL: U.S. Department of Energy, Argonne National Laboratory. Available on-line at: http://citeseerx.ist.psu.edu/viewdoc/download?rep=rep1&type=pdf&doi=10.1.1.211.8898.

Vesper, DJ; Moore, JE; Adams, JP. (2016) Inorganic carbon dynamics and CO_2 flux associated with coal-mine drainage sites in Blythedale PA and Lambert WV, USA. Environ Earth Sci 75(4):1-4.

Wallace, JB; Merritt, RW. (1980) Filter-feeding ecology of aquatic insects. Ann Rev Entomol 25:103–132.

Wallace, H; Wallace, BMN; Badaway, GMI. (1997) Lampbrush chromosomes and chiasmata of sex-reversed newts. Chronosoma 106:526–533.

Wallace, JB. (1990) Recovery of lotic macroinvertebrate communities from disturbance. Environ Manage 14(5):605–620.

Wallace, JB; Webster, JR. (1996) The role of macroinvertebrates in stream ecosystem function. Ann Rev Entomol 41:115–39.

Wang, N; Ingersoll, CG; Kunz, JL; Brumbaugh, WG; Kane, CM; Evans, RB; Alexander, S; Walker, C; Bakaletz, S. (2013) Toxicity of sediments potentially contaminated by coal mining and natural gas extraction to unionid mussels and commonly tested benthic invertebrates. Environ Toxicol Chem 32(1):207–221.

Wang, N; Dorman, RA; Ingersoll, CG; Hardest, DK; Brumbaugh, WG; Hammer, EJ; Bauer, CR; Mount, DR; (2016a) Acute and chronic toxicity of sodium sulfate to four freshwater organisms in water-only exposures. Environ Toxicol Chem 35:115–127.

Wang, N; Ivey, CD; Ingersoll, CG; Brumbaugh, WG; Alvarez, D; Hammer, EJ,;Bauer, CR; Augspurger, T; Raimondo, S; Barnhart, MC. (2016b). Acute sensitivity of a broad range of freshwater mussels to chemicals with different modes of toxic action. Environ Toxicol Chem doi:10.1002/etc.3642. [Epub ahead of print].

Waters, TF. (1966) Production rate, population density, and drift of a stream invertebrate. Ecology 47:595–604.

Waters, TF. (1972) The drift of stream insects. Ann Rev Entomol 17:253–267.

Waters, TF. (1995) Sediment in streams: sources, biological effects and control. Bethesda, Maryland: American Fisheries Society. 251 pp.

WDE (Washington State Department of Ecology. (2014) Standard Operating Procedures (SOPs) for sampling, auditing, and field methodology. Environmental Assessment Program. Available online at: http://www.ecy.wa.gov/programs/eap/quality.html#freshwater.

Wetzel, RG. (2001) Chapter 10. Salinity in inland waters. In: Limnology: lake and river ecosystems. 3rd Edition. San Diego, CA: Academic Press. 1006 pp.

Werner, AD; CT. Simmons. (2009) Impact of sea-level rise on sea water intrusion in coastal aquifers. Ground Water 47(2):197–204.

Whittier, TR; Hughes, RM; Stoddard, JL; Lomnicky, GA; Peck, DV; Herlihy, AT. (2007a) A structured approach to developing indices of biotic integrity: three examples from western USA streams and rivers. Trans Am Fish Soc 136:718–735.

Whittier, TR; Stoddard, JL; Larsen, DP; Herlihy, AT. (2007b) Selecting reference sites for stream biological assessments: best professional judgment or objective criteria. Journal of the North American Benthological Society. 2007 Jun;26(2):349-60.

Wichard, W; Tsui, PTP; Kommick, H. (1973) Effect of different salinities on the coniform chloride cells of mayfly larvae. J Insect Physiol 19:1825–1835.

Wiens, JJ. (2004) Speciation and ecology revisited: Phylogenetic niche conservatism and the origin of species. Evolution 58:193–197.

Williams D.D. 1996. Environmental constraints in temporary fresh waters and their consequences for the insect fauna. J N Am Benthol Soc 15:634–636.

Williams, DD; Hynes, HBN. (1976) The recolonization mechanisms of stream benthos. Oikos 27 (2):265–272.

Wood-Eggenschwiler, S; Barlocher, F. (1983) Aquatic hyphomycetes in sixteen streams in France, Germany and Switzerland. Trans Brit Mycol Soc 81:371–379.

Wood, CM; Shuttleworth, TJ. (2008) Cellular and molecular approaches to fish ionic regulation. Vol. 14: Fish Physiology. San Diego, CA: Academic Press, Inc.

Wood, PJ; Dykes, AP. (2002) The use of salt dilution gauging techniques: Ecological considerations and insights. Water Res 36:3054–3062.

Wood-Eggenschwiler, S; Barlocher, F. (1983) Aquatic hyphomycetes in sixteen streams in France, Germany and Switzerland. Trans Brit Mycol Soc 81:371–379.

Woods, AJ; Omernik, JM; Brown, DD. (1996) Level III and IV ecoregions of Pennsylvania and the Blue Ridge Mountains, the central Appalachian Ridge and Valley, and the central Appalachians of Virginia, West Virginia, and Maryland. EPA/600/R-96/077. Corvallis, OR: U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory. http://training.fws.gov/courses/csp/csp3200/resources/documents/epa_region_3_eco_desc.pdf.

Woods, AJ; Omernick, JM; Brown, DD. (1999) Level III and IV ecoregions of Delaware, Maryland, Pennsylvania, Virginia, and West Virginia. Corvallis, OR: U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory. 58 pp. Available online at: https://extension.umd.edu/sites/default/files/_docs/programs/master-gardeners/Natives/1999_Woods_Omernik_reg3_ecoregion_descriptions.pdf.

Woods, AJ; Omernik, JM; Nesser, JA; Shelden, J; Comstock, JA; Azevedo, SH. (2002) Ecoregions of Montana, 2nd edition (color poster with map, descriptive text, summary tables, and photographs) Map scale 1:1,500,000. U.S. Enviromental Protection Agency. Available online at http://www.epa.gov/wed/pages/ecoregions/mt_eco.htm.

Woodward, DF; Hansen, JA; Bergman, H; Little, E; DeLonay, AJ. (1995) Brown trout avoidance of metals in waters characteristic of the Clark Fork River, Montana. Can. J. Fish. Aquat. Sci. 52: 2013–2017.

Woodward, DF; Goldstein, JN; Farag, A; Brumbaugh, WG. (1997) Cutthroat trout avoidance of metals and conditions characteristic of a mining waste site: Couer d'Alene River, Idaho. Trans Am Fish Soc 126:699–706.

Wright, IA; Davies, PJ; Findlay, SJ; Jonasson, OJ. (2011) A new type of water pollution: concrete drainage infrastructure and geochemical contamination of urban waters. Mar Freshwr Res 62:1355−1361.

WVDEP (West Virginia Department of Environmental Protection). (2013) Watershed Assessment Branch 2013 standard operating procedures. Charleston, VA: West Virginia Department of Environmental Protection. 443 pp. Available online at: http://www.dep.wv.gov/WWE/watershed/Pages/WBSOPs.aspx.

WVDEP (West Virginia Department of Environmental Protection). (2008a) West Virginia integrated water quality monitoring and assessment report. Charleston, VA: West Virginia Department of Environmental Protection. Available online at: http://www.dep.wv.gov/WWE/watershed/IR/Documents/IR_2008_Documents/WV_IR_2008_Report_Only_EPA_Approved.pdf.

WVDEP (West Virginia Department of Environmental Protection). (2008b) 2008 Standard operating procedures.Vol. 1. Charleston, WV: Watershed Assessment Branch, WVDEP.

WVDEP (West Virginia Department of Environmental Protection). (2006) Quality assurance project plan for watershed branch monitoring activities. Charleston, WV: Division of Water and Waste Management, WVDEP. Available online at http://www.dep.wv.gov/WWE/watershed/Documents/2005_06_SOP_All.pdf.

Yasuno, M; Fukushima, S; Hasegawa, J; Shioyama, F; Hatakeyama, S. (1982) Changes in benthic fauna and flora after application of temephos to a stream on Mt. Tsukuba. Hydrobiologia 89:205−14.

Zaiontz, C. (2014) Real statistics using excel. Available online at http://www.real-statistics.com/regression/confidence-and-prediction-intervals/.

Zalizniak, L; Kefford, BJ; Nugegoda, D. (2006) Is all salinity the same? I. The effect of ionic compositions on the salinity tolerance of five species of freshwater invertebrates. Mar Freshw Res. 57(1):75−82.

Zhao, Q; Jia, X; Xia, R; Lin, J; Zhang, Y. (2016) A field-based method to derive macroinvertebrate benchmark for specific conductivity adapted for small data sets and demonstrated in the Hun-Tai River Basin, Northeast China. Environ Pollut 216: 902-910. http://dx.doi.org/10.1016/j.envpol.2016.06.065.

Zhichang, M; Huanting, S; Liu, JT; Eisma, D. (2001) Types of saltwater intrusion of the Changjiang Estuary. Sci China B 44(Suppl):105−157.

Ziegler, CR; Suter, GW, II; Kefford, BJ. (2010) Candidate cause: ionic strength. U.S. Environmental Protection Agency, CADDIS (The causal analysis/diagnosis decision information system). Available online at www.epa.gov/caddis.

Zhang, X; Wakamatsu, H. (2002) A new equivalent circuit different from the Hodgkin-Huxley model, and an equation for the resting membrane potential of a cell. Artif Life Robot 6:140-148.

Zielinski, RA; Otton, JK; Johnson, CA. (2001) Sources of salinity near a coal mine spoil pile, north central Colorado. J Environ Qual 30:1237−1248.

S. Twait

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

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BRUCE RAUNER, GOVERNOR ALEC MESSINA, ACTING DIRECTOR

Memorandum

IEPA-DIVISION OF RECORDS MANAGEMENT
RELEASABLE

AUG 02 2019

REVIEWER: SAB

DATE: 13 December 2016

TO: Iwona Ward

FROM: Scott Twait ST

SUBJECT: WQBELs
Williamson Energy, LLC – Pond Creek Mine
NPDES Permit No. IL007766 (Williamson County)

The subject facility discharges to the unnamed tributaries of Pond Creek through Outfalls 001 – 008 at a point where 0 cfs of flow exists upstream of the outfalls during critical 7Q10 low-flow conditions. The unnamed tributaries of Pond Creek are classified as a General Use Water. The unnamed tributaries of Pond Creek are not listed as a biologically significant streams in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor are they given an integrity rating in that document. The unnamed tributaries of Pond Creek, tributary to Waterbody Segment, NG-02, is not listed on the draft 2016 Illinois Integrated Water Quality Report and Section 303(d) List since they have not been assessed. The unnamed tributaries of Pond Creek are not subject to enhanced dissolved oxygen standards.

The subject facility proposes to discharge to Pond Creek through Outfall 009 at a point where 0 cfs of flow exists upstream of the outfalls during critical 7Q10 low-flow conditions. Pond Creek is classified as a General Use Water. Pond Creek is not listed as a biologically significant streams in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor is it given an integrity rating in that document. Pond Creek, Waterbody Segment, NG-02, is listed on the draft 2016 Illinois Integrated Water Quality Report and Section 303(d) List as impaired for aquatic life use with potential causes given as alteration in stream-side or littoral vegetative cover (non-pollutant), changes in stream depth and velocity patterns (non-pollutant), chlorides, loss of instream cover (non-pollutant), dissolved oxygen (non-pollutant), and sedimentation/siltation. Primary contact recreation and secondary contact uses are fully supported. Pond Creek is not subject to enhanced dissolved oxygen standards.

Outfalls 001 through 005 are alkaline mine drainage and outfalls 006 - 009 are acid mine drainage. The NPDES application did not indicate any watershed sizes or flow expected for mixing, however, Outfall 009 has mixing based on the stream flow and the stream chloride concentration.

Chloride should be regulated as a daily maximum at the water quality standard of 500 mg/L for all of the outfalls, except Outfall 009 which will be based on stream flow and chloride concentration as mentioned below.

Where appropriate, Manganese should be regulated as a daily maximum at the water quality standard of 1.0 mg/L.

The Sulfate limit is determined according to the water quality standards at 302.208(h)(2). The chloride and hardness data is from AWQMN station NG-02, Pond Creek, South edge of West Frankfort, downstream of the Williamson Energy, LLC – Pond Creek Mine No. 1 property, so this limit should be used for all outfalls. Flow data was not provided, so calculation of mixing was not completed. No mixing for sulfate in Outfall 009 is necessary. No mixing was used in the derivation of the effluent limit. The following table shows the results of downstream chloride and hardness.

Outfalls	Average Receiving Stream Chloride (mg/L)	Receiving Stream Critical Hardness (mg/L)	Sulfate Water Quality Standard (mg/L)
001-009	21.5	141	1250

The sulfate values in the far right column are applied as daily maximum permit limits.

Monitoring for chloride, sulfate and hardness should be periodically required at a downstream location from each outfall, or downstream of the mine property, during the course of the permit. This data will be used to recalculate sulfate limits for the next renewed or modified permit.

Cadmium, Chromium (Trivalent), Copper, Fluoride, Lead, Manganese, Nickel, and Zinc standards are based on hardness data collected at AWQMN station NG-02, Pond Creek, S edge of West Frankfort, with a critical hardness value of 141 mg/L as $CaCO_3$. Water quality standards identified in the table are expressed in units of mg/L except where noted. Dissolved metals standards have been converted to total metal except where noted. All data was provided by the discharger.

Outfall 001

Substance	Max. Eff. Conc.	No. of Samples	Multiply by	95% Potential	Acute Standard	302.208(g) standard	Further Analysis?
Arsenic	< 0.002	1	6.2	0.0124	0.3600	-	No RP*
Cadmium	0.018	1	6.2	0.1116	0.0144	-	Yes
Chromium (Total)	< 0.006	1	6.2	0.0372	2.3009	-	No RP*
Copper	< 0.003	1	6.2	0.0186	0.0245	-	No RP*
Lead	< 0.0075	1	6.2	0.0465	0.1482	-	No RP*
Nickel	0.067	1	6.2	0.4154	0.1104	-	Yes
Phenols	< 0.01	1	6.2	0.062	-	0.1	No RP*
Silver	< 0.002	1	6.2	0.0124	-	0.005	Yes
Zinc	0.025	1	6.2	0.155	0.1635	-	No RP*
Selenium	< 0.002	1	6.2	0.0124	-	1.0	No RP*
Mercury	< 0.002	1	6.2	0.0124	0.0026	-	Yes

* No RP = no reasonable potential to exceed water quality standards.

Further Analysis:

Under Agency policy, substances designated in the first table as being in need of further analysis, and for which five or fewer effluent results are available, will not be evaluated for reasonable potential to exceed standards per the USEPA *Technical Support Document for Water Quality Based Toxics Control.* Rather, these substances will be directly evaluated against the water quality standards applicable to the receiving stream. We do not believe that the USEPA procedure is valid when only a very small sample population exists due to the high multipliers applied. We believe that our approach is appropriate for facilities that have been previously identified through the pre-treatment program as having a low risk for high levels of metals and other industrial pollutants in their treated domestic waste effluents. For the Williamson Energy – Pond Creek Mine #1 Outfall 001, the parameters relevant to this policy are Cadmium, Nickel, Silver, and Mercury and have been evaluated as follows:

There is a reasonable potential to exceed the acute water quality standard for Cadmium. Cadmium should be regulated as a daily maximum in the NPDES permit at the acute water quality standard using the default metals translator.

The Nickel sample was reported less than the acute water quality standard. My conclusion is that no regulation of Nickel is necessary and that no monitoring beyond the routine requirements is needed.

The Williamson Energy – Pond Creek Mine #1 facility STP had no detections reported for Silver and Mercury. My conclusion is that no regulation of Silver and Mercury is necessary and that no monitoring beyond the routine requirements is needed.

Outfall 002

Substance	Max. Eff. Conc.	No. of Samples	Multiply by	95% Potential	Acute Standard	302.208(g) standard	Further Analysis?
Arsenic	< 0.002	1	6.2	0.0124	0.3600	-	No RP*
Cadmium	0.031	1	6.2	0.1922	0.0144	-	Yes
Chromium (Total)	< 0.006	1	6.2	0.0372	2.3009	-	No RP*
Copper	< 0.003	1	6.2	0.0186	0.0245	-	No RP*
Lead	< 0.0075	1	6.2	0.0465	0.1482	-	No RP*
Nickel	< 0.01	1	6.2	0.062	0.1104	-	No RP*
Phenols	< 0.001	1	6.2	0.0062	-	0.1	No RP*
Silver	< 0.002	1	6.2	0.0124	-	0.005	Yes
Zinc	< 0.001	1	6.2	0.0062	0.1635	-	No RP*
Selenium	< 0.002	1	6.2	0.0124	-	1.0	No RP*
Mercury	< 0.002	1	6.2	0.0124	0.0026	-	Yes

* No RP = no reasonable potential to exceed water quality standards.

Further Analysis:

Under Agency policy, substances designated in the first table as being in need of further analysis, and for which five or fewer effluent results are available, will not be evaluated for reasonable potential to exceed standards per the USEPA *Technical Support Document for Water Quality Based Toxics Control.* Rather, these substances will be directly evaluated against the water quality standards applicable to the receiving stream. We do not believe that the USEPA procedure is valid when only a very small sample population exists due to the high multipliers applied. We believe that our approach is appropriate for facilities that have been previously identified through the pre-treatment program as having a low risk for high levels of metals and other industrial pollutants in their treated domestic waste effluents. For the Williamson Energy – Pond Creek Mine #1 Outfall 002, the parameters relevant to this policy are Cadmium, Silver, and Mercury and have been evaluated as follows:

There is a reasonable potential to exceed the acute water quality standard for Cadmium. Cadmium should be regulated as a daily maximum in the NPDES permit at the acute water quality standard using the default metals translator.

The Williamson Energy – Pond Creek Mine #1 facility STP had no detections reported for Silver and Mercury. My conclusion is that no regulation of Silver and Mercury is necessary and that no monitoring beyond the routine requirements is needed.

Outfall 003

Substance	Max. Eff. Conc.	No. of Samples	Multiply by	95% Potential	Acute Standard	302.208(g) standard	Further Analysis?
Arsenic	< 0.002	1	6.2	0.0124	0.3600	-	No RP*
Cadmium	0.024	1	6.2	0.1488	0.0144	-	Yes
Chromium (Total)	< 0.006	1	6.2	0.0372	2.3009	-	No RP*
Copper	< 0.003	1	6.2	0.0186	0.0245	-	No RP*
Lead	< 0.0075	1	6.2	0.0465	0.1482	-	No RP*
Nickel	< 0.01	1	6.2	0.062	0.1104	-	No RP*
Phenols	< 0.01	1	6.2	0.062	-	0.1	No RP*
Silver	< 0.002	1	6.2	0.0124	-	0.005	Yes
Zinc	< 0.001	1	6.2	0.0062	0.1635	-	No RP*
Selenium	< 0.002	1	6.2	0.0124	-	1.0	No RP*
Mercury	< 0.002	1	6.2	0.0124	0.0026	-	Yes

* No RP = no reasonable potential to exceed water quality standards.

Further Analysis:

Under Agency policy, substances designated in the first table as being in need of further analysis, and for which five or fewer effluent results are available, will not be evaluated for reasonable potential to exceed standards per the USEPA *Technical Support Document for Water Quality Based Toxics Control.* Rather, these substances will be directly evaluated against the water quality standards applicable to the receiving stream. We do not believe that the USEPA procedure is valid when only a very small sample population exists due to the high multipliers applied. We believe that our approach is appropriate for facilities that have been previously identified through the pre-treatment program as having a low risk for high levels of metals and other industrial pollutants in their treated domestic waste effluents. For the Williamson Energy – Pond Creek Mine #1 Outfall 003, the parameters relevant to this policy are Cadmium, Silver, and Mercury and have been evaluated as follows:

There is a reasonable potential to exceed the acute water quality standard for Cadmium. Cadmium should be regulated as a daily maximum in the NPDES permit at the acute water quality standard using the default metals translator.

The Williamson Energy – Pond Creek Mine #1 facility STP had no detections reported for Silver and Mercury. My conclusion is that no regulation of Silver and Mercury is necessary and that no monitoring beyond the routine requirements is needed.

Outfall 004

Substance	Max. Eff. Conc.	No. of Samples	Multiply by	95% Potential	Acute Standard	302.208(g) standard	Further Analysis?
Arsenic	< 0.002	1	6.2	0.0124	0.3600	-	No RP*
Cadmium	0.024	1	6.2	0.1488	0.0144	-	Yes
Chromium (Total)	< 0.006	1	6.2	0.0372	2.3009	-	No RP*
Copper	< 0.003	1	6.2	0.0186	0.0245	-	No RP*
Lead	< 0.0075	1	6.2	0.0465	0.1482	-	No RP*
Nickel	< 0.01	1	6.2	0.062	0.1104	-	No RP*

Phenols	< 0.01	1	6.2	0.062	-	0.1	No RP*
Silver	< 0.002	1	6.2	0.0124	-	0.005	Yes
Zinc	< 0.001	1	6.2	0.0062	0.1635	-	No RP*
Selenium	< 0.002	1	6.2	0.0124	-	1.0	No RP*
Mercury	< 0.002	1	6.2	0.0124	0.0026	-	Yes

* No RP = no reasonable potential to exceed water quality standards.

Further Analysis:

Under Agency policy, substances designated in the first table as being in need of further analysis, and for which five or fewer effluent results are available, will not be evaluated for reasonable potential to exceed standards per the USEPA *Technical Support Document for Water Quality Based Toxics Control.* Rather, these substances will be directly evaluated against the water quality standards applicable to the receiving stream. We do not believe that the USEPA procedure is valid when only a very small sample population exists due to the high multipliers applied. We believe that our approach is appropriate for facilities that have been previously identified through the pre-treatment program as having a low risk for high levels of metals and other industrial pollutants in their treated domestic waste effluents. For the Williamson Energy – Pond Creek Mine #1 Outfall 004, the parameters relevant to this policy are Cadmium, Silver, and Mercury and have been evaluated as follows:

There is a reasonable potential to exceed the acute water quality standard for Cadmium. Cadmium should be regulated as a daily maximum in the NPDES permit at the acute water quality standard using the default metals translator.

The Williamson Energy – Pond Creek Mine #1 facility STP had no detections reported for Silver and Mercury. My conclusion is that no regulation of Silver and Mercury is necessary and that no monitoring beyond the routine requirements is needed.

Outfall 005

Substance	Max. Eff. Conc.	No. of Samples	Multiply by	95% Potential	Acute Standard	302.208(g) standard	Further Analysis?
Arsenic	< 0.002	1	6.2	0.0124	0.3600	-	No RP*
Cadmium	0.043	1	6.2	0.2666	0.0144	-	Yes
Chromium (Total)	< 0.006	1	6.2	0.0372	2.3009	-	No RP*
Copper	0.003	1	6.2	0.0186	0.0245	-	No RP*
Lead	< 0.0075	1	6.2	0.0465	0.1482	-	No RP*
Nickel	< 0.01	1	6.2	0.062	0.1104	-	No RP*
Phenols	< 0.01	1	6.2	0.062	-	0.1	No RP*
Silver	< 0.002	1	6.2	0.0124	-	0.005	Yes
Zinc	< 0.001	2	3.8	0.0038	0.1635	-	No RP*
Selenium	< 0.002	1	6.2	0.0124	-	1.0	No RP*
Mercury	< 0.002	1	6.2	0.0124	0.0026	-	Yes

* No RP = no reasonable potential to exceed water quality standards.

Further Analysis:

Under Agency policy, substances designated in the first table as being in need of further analysis, and for which five or fewer effluent results are available, will not be evaluated for reasonable potential to exceed standards per the USEPA *Technical Support Document for Water Quality Based Toxics Control.* Rather, these substances will be directly evaluated against the water quality standards applicable to the receiving stream. We do not believe that the USEPA procedure is valid when only a very small sample population exists due to the high multipliers applied. We believe that our approach is appropriate for facilities that have been previously identified through the pre-treatment program as having a low risk for high levels of metals and other industrial pollutants in their treated domestic waste effluents. For the Williamson Energy – Pond Creek Mine #1 Outfall 005, the parameters relevant to this policy are Cadmium, Silver, and Mercury and have been evaluated as follows:

There is a reasonable potential to exceed the acute water quality standard for Cadmium. Cadmium should be regulated as a daily maximum in the NPDES permit at the acute water quality standard using the default metals translator.

The Williamson Energy – Pond Creek Mine #1 facility STP had no detections reported for Silver and Mercury. My conclusion is that no regulation of Silver and Mercury is necessary and that no monitoring beyond the routine requirements is needed.

Outfall 006

Substance	Max. Eff. Conc.	No. of Samples	Multiply by	95% Potential	Acute Standard	302.208(g) standard	Further Analysis?
Arsenic	< 0.002	1	6.2	0.0124	0.3600	-	No RP*
Cadmium	0.03	1	6.2	0.186	0.0144	-	Yes
Chromium (Total)	< 0.006	1	6.2	0.0372	2.3009	-	No RP*
Copper	< 0.003	1	6.2	0.0186	0.0245	-	No RP*
Lead	< 0.0075	1	6.2	0.0465	0.1482	-	No RP*
Nickel	< 0.01	1	6.2	0.062	0.1104	-	No RP*
Phenols	< 0.01	1	6.2	0.062	-	0.1	No RP*
Silver	< 0.002	1	6.2	0.0124	-	0.005	Yes
Zinc	0.014	1	6.2	0.0868	0.1635	-	No RP*
Selenium	< 0.002	1	6.2	0.0124	-	1.0	No RP*
Mercury	< 0.002	1	6.2	0.0124	0.0026	-	Yes

* No RP = no reasonable potential to exceed water quality standards.

Further Analysis:

Under Agency policy, substances designated in the first table as being in need of further analysis, and for which five or fewer effluent results are available, will not be evaluated for reasonable potential to exceed standards per the USEPA *Technical Support Document for Water Quality Based Toxics Control.* Rather, these substances will be directly evaluated against the water quality standards applicable to the receiving stream. We do not believe that the USEPA procedure is valid when only a very small sample population exists due to the high multipliers applied. We believe that our approach is appropriate for facilities that have been previously identified through the pre-treatment program as having a low risk for high levels of metals and other industrial pollutants in their treated domestic waste effluents. For the Williamson Energy – Pond Creek Mine #1 Outfall 006, the parameters relevant to this policy are Cadmium, Silver, and Mercury and have been evaluated as follows:

There is a reasonable potential to exceed the acute water quality standard for Cadmium. Cadmium should be regulated as a daily maximum in the NPDES permit at the acute water quality standard using the default metals translator.

The Williamson Energy – Pond Creek Mine #1 facility STP had no detections reported for Silver and Mercury. My conclusion is that no regulation of Silver and Mercury is necessary and that no monitoring beyond the routine requirements is needed.

Outfall 007

Substance	Max. Eff. Conc.	No. of Samples	Multiply by	95% Potential	Acute Standard	302.208(g) standard	Further Analysis?
Arsenic	< 0.002	1	6.2	0.0124	0.3600	-	No RP*
Cadmium	0.044	1	6.2	0.2728	0.0144	-	Yes
Chromium (Total)	< 0.006	1	6.2	0.0372	2.3009	-	No RP*
Copper	< 0.003	1	6.2	0.0186	0.0245	-	No RP*
Lead	< 0.0075	1	6.2	0.0465	0.1482	-	No RP*
Nickel	< 0.01	1	6.2	0.062	0.1104	-	No RP*
Phenols	< 0.01	1	6.2	0.062	-	0.1	No RP*
Silver	< 0.002	1	6.2	0.0124	-	0.005	Yes
Zinc	0.028	1	6.2	0.1736	0.1635	-	Yes
Selenium	< 0.002	1	6.2	0.0124	-	1.0	No RP*
Mercury	< 0.002	1	6.2	0.0124	0.0026	-	Yes

* No RP = no reasonable potential to exceed water quality standards.

Further Analysis:

Under Agency policy, substances designated in the first table as being in need of further analysis, and for which five or fewer effluent results are available, will not be evaluated for reasonable potential to exceed standards per the USEPA *Technical Support Document for Water Quality Based Toxics Control.* Rather, these substances will be directly evaluated against the water quality standards applicable to the receiving stream. We do not believe that the USEPA procedure is valid when only a very small sample population exists due to the high multipliers applied. We believe that our approach is appropriate for facilities that have been previously identified through the pre-treatment program as having a low risk for high levels of metals and other industrial pollutants in their treated domestic waste effluents. For the Williamson Energy – Pond Creek Mine #1 Outfall 007, the parameters relevant to this policy are Cadmium, Silver, Zinc, and Mercury and have been evaluated as follows:

There is a reasonable potential to exceed the acute water quality standard for Cadmium. Cadmium should be regulated as a daily maximum in the NPDES permit at the acute water quality standard using the default metals translator.

The Zinc sample was reported less than the acute water quality standard. My conclusion is that no regulation of Zinc is necessary and that no monitoring beyond the routine requirements is needed.

The Williamson Energy – Pond Creek Mine #1 facility STP had no detections reported for Silver and Mercury. My conclusion is that no regulation of Silver and Mercury is necessary and that no monitoring beyond the routine requirements is needed.

Outfall 008

Substance	Max. Eff. Conc.	No. of Samples	Multiply by	95% Potential	Acute Standard	302.208(g) standard	Further Analysis?
Arsenic	< 0.002	1	6.2	0.0124	0.3600	-	No RP*
Cadmium	0.008	1	6.2	0.0496	0.0144	-	Yes
Chromium (Total)	< 0.006	1	6.2	0.0372	2.3009	-	No RP*
Copper	0.003	1	6.2	0.0186	0.0245	-	No RP*
Lead	< 0.0075	1	6.2	0.0465	0.1482	-	No RP*
Manganese	0.011	1	6.2	0.0682	5.51	-	No RP*
Nickel	< 0.01	1	6.2	0.062	0.1104	-	No RP*
Phenols	0.005	1	6.2	0.031	-	0.1	No RP*
Silver	< 0.002	1	6.2	0.0124	-	0.005	Yes
Zinc	< 0.001	1	6.2	0.0062	0.1635	-	No RP*
Selenium	< 0.002	1	6.2	0.0124	-	1.0	No RP*
Mercury	< 0.002	1	6.2	0.0124	0.0026	-	Yes

* No RP = no reasonable potential to exceed water quality standards.

Further Analysis:

Under Agency policy, substances designated in the first table as being in need of further analysis, and for which five or fewer effluent results are available, will not be evaluated for reasonable potential to exceed standards per the USEPA *Technical Support Document for Water Quality Based Toxics Control.* Rather, these substances will be directly evaluated against the water quality standards applicable to the receiving stream. We do not believe that the USEPA procedure is valid when only a very small sample population exists due to the high multipliers applied. We believe that our approach is appropriate for facilities that have been previously identified through the pre-treatment program as having a low risk for high levels of metals and other industrial pollutants in their treated domestic waste effluents. For the Williamson Energy – Pond Creek Mine #1 Outfall 008, the parameters relevant to this policy are Cadmium, Silver, and Mercury and have been evaluated as follows:

The Cadmium sample was reported less than the acute water quality standard. My conclusion is that no regulation of Cadmium is necessary and that no monitoring beyond the routine requirements is needed.

The Williamson Energy – Pond Creek Mine #1 facility STP had no detections reported for Silver and Mercury. My conclusion is that no regulation of Silver and Mercury is necessary and that no monitoring beyond the routine requirements is needed.

Outfall 009 (Pond Creek)

Substance	Max. Eff. Conc.	No. of Samples	Multiply by	95% Potential	Acute Standard	302.208(g) standard	Further Analysis?
Arsenic	0.002	9	1.8	0.0036	0.3600	-	No RP*
Cadmium	< 0.0002	9	1.8	0.0004	0.0144	-	No RP*
Chromium (Total)	0.008	9	1.8	0.0144	2.3009	-	No RP*
Cyanide (WAD)	< 0.002	9	1.8	0.0036	0.0220	-	No RP*
Copper	0.024	9	1.8	0.0432	0.0245	-	Yes

Iron (Dissolved)	0.419	9	1.8	0.7542	-	1.0	No RP*
Lead	< 0.001	9	1.8	0.0018	0.1482	-	No RP*
Manganese	0.21	9	1.8	0.378	5.51	-	No RP*
Mercury (ng/L)	< 0.002	9	1.8	0.0036	-	12.0	No RP*
Nickel	0.009	9	1.8	0.0162	0.1104	-	No RP*
Phenols	0.03	9	1.8	0.054	-	0.1	No RP*
Silver	< 0.001	9	1.8	0.0018	-	0.005	No RP*
Zinc	< 0.02	9	1.8	0.036	0.1635	-	No RP*
Selenium	0.011	9	1.8	0.0198	-	1.0	No RP*

* No RP = no reasonable potential to exceed water quality standards.

Further Analysis:

There is a reasonable potential to exceed the acute water quality standard for Copper. Copper should be regulated as a daily maximum in the NPDES permit at the acute water quality standard using the default metals translator.

Chloride should be limited in the NPDES permit at the limits described below. All other parameters will meet water quality standards at the end of the pipe. According to the effluent data received, Chloride needs mixing to allow water quality standards to be achieved at the edge of allowed mixing.

A mixing analysis was performed and detailed in a document by AquAeTer, Inc. titled "Williamson Energy Mine – Proposed Pond Creek Discharge Mixing Zone Analysis".

The permit only allows a discharge when the receiving stream is flowing. The permittee should use the following equation to demonstrate that water quality standards will be met downstream of the discharge.

$C_{DS} = [C_E Q_E + 0.25 C_{US} Q_{US}] / (0.25 Q_{US} + Q_E)$

Where:

C_E = Effluent concentration (mg/L)
Q_E = Effluent flow rate (cfs) for Outfall 017
Q_{US} = Upstream flow rate (cfs)
C_{US} = Upstream concentration (mg/L)
C_{DS} = Downstream concentration (mg/L)

The permittee has committed to install a gauging station and TDS monitor upstream of the discharge to determine an upstream flow (Q_{US}) and a chloride concentration (C_{US}) correlated to the TDS value. In addition, the permittee has agreed to install a continuous TDS monitor downstream to ensure that the chloride concentration (correlated to the TDS value) stays within the chloride water quality standard.

The "calculated" downstream concentration shall be less than 500 mg/L for chloride and reported on the discharge monitoring reports (DMRs).

If there is no upstream mixing available for Outfall 009, the NPDES permit should be regulated at 500 mg/L for chlorides and 1250 mg/L for sulfates.

Recommendations:

My evaluation of the metals and other substances given in the first table finds that water quality based permit limits are necessary for Cadmium in Outfalls 001, 002, 003, 004, 005, 006, and 007 at the limit below. Permit limits identified in the table are expressed in units of mg/L.

Substance	Daily Maximum
Cadmium	0.0144

My evaluation of the metals and other substances given in the first table finds that water quality based permit limits are necessary for Copper in Outfall 009 at the limit below. Permit limits identified in the table are expressed in units of mg/L.

Substance	Daily Maximum
Copper	0.0245

These recommendations reflect a water quality standards perspective only and should not be construed as being inclusive of all factors that must be taken into consideration by the permit writer.

Attachment

cc: Bob Mosher
FOS Region 7 Manager
Carol Selinger
Chron

NPDES Monitoring Data Download

Search Criteria:

Monitoring Period Range: 02/01/2016 to 01/01/2020

Facility ID: IL0077666

Outfall - Monitoring Location - Limit Set: 001 - 1 - 0

	Acidity, total (as CaCO3)	Alkalinity, total (as CaCO3)
	Mon mg/L	Mon mg/L
Mon Pd End Date:	DAILY MX	DAILY MX
02/29/2016	NODI: C	NODI: C
03/31/2016	NODI: C	NODI: C
04/30/2016	NODI: C	NODI: C
05/31/2016	NODI: C	NODI: C
06/30/2016	NODI: C	NODI: C
07/31/2016	NODI: C	NODI: C
08/31/2016	NODI: C	NODI: C
09/30/2016	NODI: C	NODI: C
10/31/2016	NODI: C	NODI: C
11/30/2016	NODI: C	NODI: C
12/31/2016	NODI: C	NODI: C
01/31/2017	NODI: C	NODI: C
02/28/2017	NODI: C	NODI: C
03/31/2017	NODI: C	NODI: C
04/30/2017	NODI: C	NODI: C
05/31/2017	NODI: C	NODI: C
06/30/2017	NODI: C	NODI: C
07/31/2017	NODI: C	NODI: C
08/31/2017	NODI: C	NODI: C
09/30/2017	NODI: C	NODI: C
10/31/2017	NODI: C	NODI: C
11/30/2017	NODI: C	NODI: C
12/31/2017	NODI: C	NODI: C
01/31/2018	NODI: C	NODI: C
02/28/2018	NODI: C	NODI: C
03/31/2018	NODI: C	NODI: C
04/30/2018	NODI: C	NODI: C
05/31/2018	NODI: C	NODI: C
06/30/2018	NODI: C	NODI: C
07/31/2018	NODI: C	NODI: C
08/31/2018	NODI: C	NODI: C
09/30/2018	NODI: C	NODI: C
10/31/2018	NODI: C	NODI: C
11/30/2018	NODI: C	NODI: C
12/31/2018	NODI: C	NODI: C
01/31/2019	NODI: C	NODI: C
02/28/2019	NODI: C	NODI: C

03/31/2019	NODI: C	NODI: C
04/30/2019	< 10	48
05/31/2019	NODI: C	NODI: C
06/30/2019	12	68
07/31/2019	NODI: C	NODI: C
08/31/2019	NODI: C	NODI: C
09/30/2019	NODI: C	NODI: C

Outfall - Monitoring Location - Limit Set: 001 - 1 - P

	Solids, settleable	pH
	.5 mL/L	6 SU
Mon Pd End Date:	QRTR MAX	QRTR MIN
03/31/2016	< .25	7.3
06/30/2016	< .25	7.4
09/30/2016	NODI: C	NODI: C
12/31/2016	NODI: C	NODI: C
03/31/2017	NODI: C	NODI: C
06/30/2017	< .25	7
09/30/2017	NODI: C	NODI: C
12/31/2017	NODI: C	NODI: C
03/31/2018	< .25	6.9
06/30/2018	NODI: C	NODI: C
09/30/2018	NODI: C	NODI: C
12/31/2018	NODI: C	NODI: C
03/31/2019	<= .25	>= 6.8
06/30/2019	.25	7
09/30/2019	NODI: C	NODI: C

Outfall - Monitoring Location - Limit Set: 002 - 1 - 0

	Acidity, total (as CaCO3)	Alkalinity, total (as CaCO3)
	Mon mg/L	Mon mg/L
Mon Pd End Date:	DAILY MX	DAILY MX
02/29/2016	NODI: C	NODI: C
03/31/2016	26	484
04/30/2016	60	592
05/31/2016	NODI: C	NODI: C
06/30/2016	16	556
07/31/2016	NODI: C	NODI: C
08/31/2016	NODI: C	NODI: C
09/30/2016	NODI: C	NODI: C
10/31/2016	NODI: C	NODI: C
11/30/2016	NODI: C	NODI: C
12/31/2016	NODI: C	NODI: C
01/31/2017	NODI: C	NODI: C
02/28/2017	NODI: C	NODI: C
03/31/2017	NODI: C	NODI: C
04/30/2017	NODI: C	NODI: C

05/31/2017	< 10	484
06/30/2017	NODI: C	NODI: C
07/31/2017	NODI: C	NODI: C
08/31/2017	NODI: C	NODI: C
09/30/2017	NODI: C	NODI: C
10/31/2017	NODI: C	NODI: C
11/30/2017	NODI: C	NODI: C
12/31/2017	NODI: C	NODI: C
01/31/2018	NODI: C	NODI: C
02/28/2018	NODI: C	NODI: C
03/31/2018	NODI: C	NODI: C
04/30/2018	NODI: C	NODI: C
05/31/2018	NODI: C	NODI: C
06/30/2018	NODI: C	NODI: C
07/31/2018	NODI: C	NODI: C
08/31/2018	NODI: C	NODI: C
09/30/2018	NODI: C	NODI: C
10/31/2018	NODI: C	NODI: C
11/30/2018	NODI: C	NODI: C
12/31/2018	NODI: C	NODI: C
01/31/2019	NODI: C	NODI: C
02/28/2019	NODI: C	NODI: C
03/31/2019	NODI: C	NODI: C
04/30/2019	< 10	68
05/31/2019	NODI: C	NODI: C
06/30/2019	10	296
07/31/2019	NODI: C	NODI: C
08/31/2019	NODI: C	NODI: C
09/30/2019	NODI: C	NODI: C

Outfall - Monitoring Location - Limit Set: 002 - 1 - P

	Solids, settleable	pH
	.5 mL/L	6 SU
Mon Pd End Date:	QRTR MAX	QRTR MIN
03/31/2016	< .25	6.7
06/30/2016	.25	6.8
09/30/2016	< .25	6.7
12/31/2016	< .25	7.3
03/31/2017	< .25	7.6
06/30/2017	< .25	6.9
09/30/2017	< .25	7
12/31/2017	< .25	7.4
03/31/2018	< .25	7.6
06/30/2018	< .25	7.7
09/30/2018	NODI: C	NODI: C
12/31/2018	NODI: C	NODI: C
03/31/2019	NODI: C	NODI: C

06/30/2019	.25	8.1
09/30/2019	< .25	8

Outfall - Monitoring Location - Limit Set: 003 - 1 - 0

	Acidity, total (as CaCO3)	Alkalinity, total (as CaCO3)
	Mon mg/L	Mon mg/L
Mon Pd End Date:	DAILY MX	DAILY MX
02/29/2016	NODI: C	NODI: C
03/31/2016	NODI: C	NODI: C
04/30/2016	NODI: C	NODI: C
05/31/2016	NODI: C	NODI: C
06/30/2016	NODI: C	NODI: C
07/31/2016	NODI: C	NODI: C
08/31/2016	NODI: C	NODI: C
09/30/2016	NODI: C	NODI: C
10/31/2016	NODI: C	NODI: C
11/30/2016	NODI: C	NODI: C
12/31/2016	NODI: C	NODI: C
01/31/2017	NODI: C	NODI: C
02/28/2017	NODI: C	NODI: C
03/31/2017	NODI: C	NODI: C
04/30/2017	NODI: C	NODI: C
05/31/2017	NODI: C	NODI: C
06/30/2017	NODI: C	NODI: C
07/31/2017	NODI: C	NODI: C
08/31/2017	NODI: C	NODI: C
09/30/2017	NODI: C	NODI: C
10/31/2017	NODI: C	NODI: C
11/30/2017	NODI: C	NODI: C
12/31/2017	NODI: C	NODI: C
01/31/2018	NODI: C	NODI: C
02/28/2018	NODI: C	NODI: C
03/31/2018	NODI: C	NODI: C
04/30/2018	NODI: C	NODI: C
05/31/2018	NODI: C	NODI: C
06/30/2018	NODI: C	NODI: C
07/31/2018	NODI: C	NODI: C
08/31/2018	NODI: C	NODI: C
09/30/2018	NODI: C	NODI: C
10/31/2018	NODI: C	NODI: C
11/30/2018	NODI: C	NODI: C
12/31/2018	NODI: C	NODI: C
01/31/2019	NODI: C	NODI: C
02/28/2019	NODI: C	NODI: C
03/31/2019	NODI: C	NODI: C
04/30/2019	NODI: C	NODI: C
05/31/2019	NODI: C	NODI: C

06/30/2019	NODI: C	NODI: C
07/31/2019	NODI: C	NODI: C
08/31/2019	NODI: C	NODI: C
09/30/2019	NODI: C	NODI: C

Outfall - Monitoring Location - Limit Set: 003 - 1 - P

	Solids, settleable	pH
	.5 mL/L	6 SU
Mon Pd End Date:	QRTR MAX	QRTR MIN
03/31/2016	< .25	7
06/30/2016	NODI: C	NODI: C
09/30/2016	< .25	7.1
12/31/2016	NODI: C	NODI: C
03/31/2017	NODI: C	NODI: C
06/30/2017	< .25	7
09/30/2017	NODI: C	NODI: C
12/31/2017	NODI: C	NODI: C
03/31/2018	< .25	7.4
06/30/2018	.25	7.2
09/30/2018	NODI: C	NODI: C
12/31/2018	NODI: C	NODI: C
03/31/2019	< .25	>= 7.1
06/30/2019	.25	7.1
09/30/2019	NODI: C	NODI: C

Outfall - Monitoring Location - Limit Set: 004 - 1 - 0

	Acidity, total (as CaCO3)	Alkalinity, total (as CaCO3)
	Mon mg/L	Mon mg/L
Mon Pd End Date:	DAILY MX	DAILY MX
02/29/2016	NODI: C	NODI: C
03/31/2016	NODI: C	NODI: C
04/30/2016	NODI: C	NODI: C
05/31/2016	NODI: C	NODI: C
06/30/2016	< 10	136
07/31/2016	NODI: C	NODI: C
08/31/2016	NODI: C	NODI: C
09/30/2016	NODI: C	NODI: C
10/31/2016	NODI: C	NODI: C
11/30/2016	NODI: C	NODI: C
12/31/2016	NODI: C	NODI: C
01/31/2017	NODI: C	NODI: C
02/28/2017	NODI: C	NODI: C
03/31/2017	NODI: C	NODI: C
04/30/2017	NODI: C	NODI: C
05/31/2017	NODI: C	NODI: C
06/30/2017	NODI: C	NODI: C
07/31/2017	NODI: C	NODI: C

08/31/2017	NODI: C	NODI: C
09/30/2017	NODI: C	NODI: C
10/31/2017	NODI: C	NODI: C
11/30/2017	NODI: C	NODI: C
12/31/2017	NODI: C	NODI: C
01/31/2018	NODI: C	NODI: C
02/28/2018	NODI: C	NODI: C
03/31/2018	NODI: C	NODI: C
04/30/2018	NODI: C	NODI: C
05/31/2018	NODI: C	NODI: C
06/30/2018	NODI: C	NODI: C
07/31/2018	NODI: C	NODI: C
08/31/2018	NODI: C	NODI: C
09/30/2018	NODI: C	NODI: C
10/31/2018	NODI: C	NODI: C
11/30/2018	NODI: C	NODI: C
12/31/2018	NODI: C	NODI: C
01/31/2019	NODI: C	NODI: C
02/28/2019	NODI: C	NODI: C
03/31/2019	NODI: C	NODI: C
04/30/2019	< 10	76
05/31/2019	NODI: C	NODI: C
06/30/2019	NODI: C	NODI: C
07/31/2019	NODI: C	NODI: C
08/31/2019	NODI: C	NODI: C
09/30/2019	NODI: C	NODI: C

Outfall - Monitoring Location - Limit Set: 004 - 1 - P

	Solids, settleable	pH
	.5 mL/L	6 SU
Mon Pd End Date:	QRTR MAX	QRTR MIN
03/31/2016	< .25	8
06/30/2016	NODI: C	NODI: C
09/30/2016	< .25	7.4
12/31/2016	NODI: C	NODI: C
03/31/2017	NODI: C	NODI: C
06/30/2017	< .25	7.9
09/30/2017	NODI: C	NODI: C
12/31/2017	< .25	7.7
03/31/2018	< .25	7.3
06/30/2018	.25	7.5
09/30/2018	.25	7.2
12/31/2018	NODI: C	NODI: C
03/31/2019	<= .25	>= 7.2
06/30/2019	.25	7.3
09/30/2019	NODI: C	NODI: C

Outfall - Monitoring Location - Limit Set: 005 - 1 - 0

	Acidity, total (as CaCO3)	Alkalinity, total (as CaCO3)
	Mon mg/L	Mon mg/L
Mon Pd End Date:	DAILY MX	DAILY MX
02/29/2016	NODI: C	NODI: C
03/31/2016	NODI: C	NODI: C
04/30/2016	NODI: C	NODI: C
05/31/2016	NODI: C	NODI: C
06/30/2016	NODI: C	NODI: C
07/31/2016	NODI: C	NODI: C
08/31/2016	NODI: C	NODI: C
09/30/2016	NODI: C	NODI: C
10/31/2016	NODI: C	NODI: C
11/30/2016	NODI: C	NODI: C
12/31/2016	NODI: C	NODI: C
01/31/2017	NODI: C	NODI: C
02/28/2017	NODI: C	NODI: C
03/31/2017	NODI: C	NODI: C
04/30/2017	NODI: C	NODI: C
05/31/2017	NODI: C	NODI: C
06/30/2017	NODI: C	NODI: C
07/31/2017	NODI: C	NODI: C
08/31/2017	NODI: C	NODI: C
09/30/2017	NODI: C	NODI: C
10/31/2017	NODI: C	NODI: C
11/30/2017	NODI: C	NODI: C
12/31/2017	NODI: C	NODI: C
01/31/2018	NODI: C	NODI: C
02/28/2018	NODI: C	NODI: C
03/31/2018	NODI: C	NODI: C
04/30/2018	NODI: C	NODI: C
05/31/2018	NODI: C	NODI: C
06/30/2018	NODI: C	NODI: C
07/31/2018	NODI: C	NODI: C
08/31/2018	NODI: C	NODI: C
09/30/2018	NODI: C	NODI: C
10/31/2018	NODI: C	NODI: C
11/30/2018	NODI: C	NODI: C
12/31/2018	NODI: C	NODI: C
01/31/2019	NODI: C	NODI: C
02/28/2019	NODI: C	NODI: C
03/31/2019	NODI: C	NODI: C
04/30/2019	< 10	64
05/31/2019	NODI: C	NODI: C
06/30/2019	NODI: C	NODI: C
07/31/2019	NODI: C	NODI: C
08/31/2019	NODI: C	NODI: C

09/30/2019	NODI: C	NODI: C

Outfall - Monitoring Location - Limit Set: 005 - 1 - P

	Solids, settleable	pH
	.5 mL/L	6 SU
Mon Pd End Date:	QRTR MAX	QRTR MIN
03/31/2016	.5	6.8
06/30/2016	< .25	6.8
09/30/2016	< .25	6.9
12/31/2016	NODI: C	NODI: C
03/31/2017	< .25	7.9
06/30/2017	< .25	7.3
09/30/2017	< .25	8.4
12/31/2017	< .25	7.9
03/31/2018	< .25	7.6
06/30/2018	.25	7.6
09/30/2018	NODI: C	NODI: C
12/31/2018	.25	6.7
03/31/2019	.25	>= 7.3
06/30/2019	.25	7.4
09/30/2019	< .25	8.1

Outfall - Monitoring Location - Limit Set: 006 - 1 - 0

	Acidity, total (as CaCO3)	Alkalinity, total (as CaCO3)
	Mon mg/L	Mon mg/L
Mon Pd End Date:	DAILY MX	DAILY MX
02/29/2016	NODI: C	NODI: C
03/31/2016	< 10	380
04/30/2016	NODI: C	NODI: C
05/31/2016	NODI: C	NODI: C
06/30/2016	NODI: C	NODI: C
07/31/2016	NODI: C	NODI: C
08/31/2016	NODI: C	NODI: C
09/30/2016	NODI: C	NODI: C
10/31/2016	NODI: C	NODI: C
11/30/2016	NODI: C	NODI: C
12/31/2016	NODI: C	NODI: C
01/31/2017	NODI: C	NODI: C
02/28/2017	NODI: C	NODI: C
03/31/2017	NODI: C	NODI: C
04/30/2017	NODI: C	NODI: C
05/31/2017	NODI: C	NODI: C
06/30/2017	NODI: C	NODI: C
07/31/2017	NODI: C	NODI: C
08/31/2017	NODI: C	NODI: C
09/30/2017	NODI: C	NODI: C
10/31/2017	NODI: C	NODI: C

11/30/2017	NODI: C	NODI: C
12/31/2017	NODI: C	NODI: C
01/31/2018	NODI: C	NODI: C
02/28/2018	NODI: C	NODI: C
03/31/2018	NODI: C	NODI: C
04/30/2018	NODI: C	NODI: C
05/31/2018	NODI: C	NODI: C
06/30/2018	NODI: C	NODI: C
07/31/2018	NODI: C	NODI: C
08/31/2018	< 10	512
09/30/2018	NODI: C	NODI: C
10/31/2018	NODI: C	NODI: C
11/30/2018	NODI: C	NODI: C
12/31/2018	NODI: C	NODI: C
01/31/2019	NODI: C	NODI: C
02/28/2019	NODI: C	NODI: C
03/31/2019	NODI: C	NODI: C
04/30/2019	NODI: C	NODI: C
05/31/2019	NODI: C	NODI: C
06/30/2019	NODI: C	NODI: C
07/31/2019	NODI: C	NODI: C
08/31/2019	NODI: C	NODI: C
09/30/2019	NODI: C	NODI: C

Outfall - Monitoring Location - Limit Set: 006 - 1 - P

	Solids, settleable	pH
	.5 mL/L	6 SU
Mon Pd End Date:	QRTR MAX	QRTR MIN
03/31/2016	< .25	6.9
06/30/2016	< .25	7.7
09/30/2016	< .25	6.9
12/31/2016	< .25	7.1
03/31/2017	< .25	7.8
06/30/2017	< .25	7.7
09/30/2017	< .25	7.7
12/31/2017	NODI: C	NODI: C
03/31/2018	< .25	8
06/30/2018	.25	7.5
09/30/2018	.25	7.7
12/31/2018	.25	6.9
03/31/2019	NODI: C	NODI: C
06/30/2019	.25	8
09/30/2019	< .25	>= 8.1

Outfall - Monitoring Location - Limit Set: 007 - 1 - 0

	Acidity, total (as CaCO3)	Alkalinity, total (as CaCO3)
	Mon mg/L	Mon mg/L

Mon Pd End Date:	DAILY MX	DAILY MX
02/29/2016	NODI: C	NODI: C
03/31/2016	< 10	496
04/30/2016	< 10	228
05/31/2016	< 10	276
06/30/2016	NODI: C	NODI: C
07/31/2016	NODI: C	NODI: C
08/31/2016	NODI: C	NODI: C
09/30/2016	NODI: C	NODI: C
10/31/2016	NODI: C	NODI: C
11/30/2016	NODI: C	NODI: C
12/31/2016	NODI: C	NODI: C
01/31/2017	NODI: C	NODI: C
02/28/2017	NODI: C	NODI: C
03/31/2017	NODI: C	NODI: C
04/30/2017	NODI: C	NODI: C
05/31/2017	NODI: C	NODI: C
06/30/2017	NODI: C	NODI: C
07/31/2017	NODI: C	NODI: C
08/31/2017	NODI: C	NODI: C
09/30/2017	NODI: C	NODI: C
10/31/2017	NODI: C	NODI: C
11/30/2017	NODI: C	NODI: C
12/31/2017	NODI: C	NODI: C
01/31/2018	NODI: C	NODI: C
02/28/2018	NODI: C	NODI: C
03/31/2018	NODI: C	NODI: C
04/30/2018	NODI: C	NODI: C
05/31/2018	NODI: C	NODI: C
06/30/2018	NODI: C	NODI: C
07/31/2018	NODI: C	NODI: C
08/31/2018	NODI: C	NODI: C
09/30/2018	NODI: C	NODI: C
10/31/2018	NODI: C	NODI: C
11/30/2018	NODI: C	NODI: C
12/31/2018	NODI: C	NODI: C
01/31/2019	NODI: C	NODI: C
02/28/2019	NODI: C	NODI: C
03/31/2019	NODI: C	NODI: C
04/30/2019	NODI: C	NODI: C
05/31/2019	NODI: C	NODI: C
06/30/2019	NODI: C	NODI: C
07/31/2019	NODI: C	NODI: C
08/31/2019	NODI: C	NODI: C
09/30/2019	NODI: C	NODI: C

Outfall - Monitoring Location - Limit Set: 007 - 1 - P

	Solids, settleable	pH
	.5 mL/L	6 SU
Mon Pd End Date:	QRTR MAX	QRTR MIN
03/31/2016	NODI: C	NODI: C
06/30/2016	.25	6.8
09/30/2016	< .25	3.3
12/31/2016	NODI: C	NODI: C
03/31/2017	NODI: C	NODI: C
06/30/2017	< .25	3.3
09/30/2017	NODI: C	NODI: C
12/31/2017	< .25	5.6
03/31/2018	< .25	3.3
06/30/2018	.25	6.7
09/30/2018	.25	7.5
12/31/2018	NODI: C	NODI: C
03/31/2019	NODI: C	NODI: C
06/30/2019	NODI: C	NODI: C
09/30/2019	NODI: C	NODI: C

Outfall - Monitoring Location - Limit Set: 008 - 1 - 0

	Acidity, total (as CaCO3)	Alkalinity, total (as CaCO3)
	Mon mg/L	Mon mg/L
Mon Pd End Date:	DAILY MX	DAILY MX
02/29/2016	NODI: C	NODI: C
03/31/2016	NODI: C	NODI: C
04/30/2016	NODI: C	NODI: C
05/31/2016	NODI: C	NODI: C
06/30/2016	NODI: C	NODI: C
07/31/2016	NODI: C	NODI: C
08/31/2016	NODI: C	NODI: C
09/30/2016	NODI: C	NODI: C
10/31/2016	NODI: C	NODI: C
11/30/2016	NODI: C	NODI: C
12/31/2016	NODI: C	NODI: C
01/31/2017	NODI: C	NODI: C
02/28/2017	NODI: C	NODI: C
03/31/2017	NODI: C	NODI: C
04/30/2017	NODI: C	NODI: C
05/31/2017	NODI: C	NODI: C
06/30/2017	NODI: C	NODI: C
07/31/2017	NODI: C	NODI: C
08/31/2017	NODI: C	NODI: C
09/30/2017	NODI: C	NODI: C
10/31/2017	NODI: C	NODI: C
11/30/2017	NODI: C	NODI: C
12/31/2017	NODI: C	NODI: C
01/31/2018	NODI: C	NODI: C

02/28/2018	NODI: C	NODI: C
03/31/2018	NODI: C	NODI: C
04/30/2018	NODI: C	NODI: C
05/31/2018	NODI: C	NODI: C
06/30/2018	NODI: C	NODI: C
07/31/2018	NODI: C	NODI: C
08/31/2018	NODI: C	NODI: C
09/30/2018	NODI: C	NODI: C
10/31/2018	NODI: C	NODI: C
11/30/2018	NODI: C	NODI: C
12/31/2018	NODI: C	NODI: C
01/31/2019	NODI: C	NODI: C
02/28/2019	NODI: C	NODI: C
03/31/2019	NODI: C	NODI: C
04/30/2019	NODI: C	NODI: C
05/31/2019	NODI: C	NODI: C
06/30/2019	NODI: C	NODI: C
07/31/2019	NODI: C	NODI: C
08/31/2019	NODI: C	NODI: C
09/30/2019	NODI: C	NODI: C

Outfall - Monitoring Location - Limit Set: 008 - 1 - P

	Solids, settleable	pH
	.5 mL/L	6 SU
Mon Pd End Date:	QRTR MAX	QRTR MIN
03/31/2016	NODI: C	NODI: C
06/30/2016	< .25	6.7
09/30/2016	< .25	3.3
12/31/2016	NODI: C	NODI: C
03/31/2017	NODI: C	NODI: C
06/30/2017	< .25	3.4
09/30/2017	NODI: C	NODI: C
12/31/2017	< .25	5.8
03/31/2018	NODI: C	NODI: C
06/30/2018	NODI: C	NODI: C
09/30/2018	NODI: C	NODI: C
12/31/2018	NODI: C	NODI: C
03/31/2019	NODI: C	NODI: C
06/30/2019	NODI: C	NODI: C
09/30/2019	NODI: C	NODI: C

[redacted]

Chloride (as Cl)	Chloride (as Cl)	Chloride (as Cl)
500 mg/L	Mon mg/L	Mon mg/L
DAILY MX	30DA AVG	MO MIN
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
28	28	28
NODI: C	NODI: C	NODI: C
32	32	32
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

pH
9 SU
QRTR MAX
7.3
7.4
NODI: C
NODI: C
NODI: C
7.5
NODI: C
NODI: C
6.9
NODI: C
NODI: C
NODI: C
<= 7.2
7.4
NODI: C

Chloride (as Cl)	Chloride (as Cl)	Chloride (as Cl)
500 mg/L	Mon mg/L	Mon mg/L
DAILY MX	30DA AVG	MO MIN
NODI: C	NODI: C	NODI: C
3500	2670	1840
3600	1638.67	246
NODI: C	NODI: C	NODI: C
2950	2950	2950
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

2333	2333	2333
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
62	62	62
NODI: C	NODI: C	NODI: C
690	690	690
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

pH
9 SU
QRTR MAX
6.7
8.3
8.1
8.1
8.2
8.1
8.2
8.3
8.2
8.1
NODI: C
NODI: C
NODI: C

8.2
8

Chloride (as Cl)	Chloride (as Cl)	Chloride (as Cl)
500 mg/L	Mon mg/L	Mon mg/L
DAILY MX	30DA AVG	MO MIN
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

pH
9 SU
QRTR MAX
7
NODI: C
7.1
NODI: C
NODI: C
7.6
NODI: C
NODI: C
7.4
7.4
NODI: C
NODI: C
<= 7.5
7.5
NODI: C

Chloride (as Cl)	Chloride (as Cl)	Chloride (as Cl)
500 mg/L	Mon mg/L	Mon mg/L
DAILY MX	30DA AVG	MO MIN
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
50	29	12
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
16	16	16
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

pH
9 SU
QRTR MAX
8
NODI: C
7.4
NODI: C
NODI: C
7.9
NODI: C
7.7
7.7
7.7
7.2
NODI: C
<= 8.1
8.2
NODI: C

Chloride (as Cl)	Chloride (as Cl)	Chloride (as Cl)
500 mg/L	Mon mg/L	Mon mg/L
DAILY MX	30DA AVG	MO MIN
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C

pH
9 SU
QRTR MAX
6.8
7.3
6.9
NODI: C
7.9
8.2
8.4
7.9
7.6
7.6
NODI: C
6.7
<= 7.5
7.9
8.1

Chloride (as Cl)	Chloride (as Cl)	Chloride (as Cl)
500 mg/L	Mon mg/L	Mon mg/L
DAILY MX	30DA AVG	MO MIN
NODI: C	NODI: C	NODI: C
2300	2300	2300
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
1600	1600	1600
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

pH
9 SU
QRTR MAX
6.9
8.7
7.8
7.9
7.8
7.7
7.7
NODI: C
8.1
8.4
8.4
8.4
NODI: C
8.4
<= 8.3

Chloride (as Cl)	Chloride (as Cl)	Chloride (as Cl)
500 mg/L	Mon mg/L	Mon mg/L

DAILY MX	30DA AVG	MO MIN
NODI: C	NODI: C	NODI: C
2450	2450	2450
930	930	930
3050	3050	3050
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

pH
9 SU
QRTR MAX
NODI: C
8.3
3.3
NODI: C
NODI: C
3.3
NODI: C
5.6
7.6
6.7
7.5
NODI: C
NODI: C
NODI: C
NODI: C

Chloride (as Cl)	Chloride (as Cl)	Chloride (as Cl)
500 mg/L	Mon mg/L	Mon mg/L
DAILY MX	30DA AVG	MO MIN
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

pH
9 SU
QRTR MAX
NODI: C
6.7
3.3
NODI: C
NODI: C
3.4
NODI: C
5.8
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C

[redacted]

Flow, in conduit or thru treatment plant
Mon MGD
30DA AVG
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
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NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C

NODI: C
.036
NODI: C
.036
NODI: C
NODI: C
NODI: C

Flow, in conduit or thru treatment plant
Mon MGD
30DA AVG
NODI: C
.432
.252
NODI: C
1.44
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C

.864
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
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NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
.0504
NODI: C
.05
NODI: C
NODI: C
NODI: C

Flow, in conduit or thru treatment plant
Mon MGD
30DA AVG
NODI: C
NODI: C
NODI: C

NODI: C
NODI: C
NODI: C
NODI: C

Flow, in conduit or thru treatment plant
Mon MGD
30DA AVG
NODI: C
NODI: C
NODI: C
NODI: C
.062
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
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NODI: C
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NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
.029
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C

Flow, in conduit or thru treatment plant
Mon MGD
30DA AVG
NODI: C
NODI: C
NODI: C

NODI: C

Flow, in conduit or thru treatment plant
Mon MGD
30DA AVG
NODI: C
.72
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
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NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
.36
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C

Flow, in conduit or thru treatment plant
Mon MGD

30DA AVG
NODI: C
1.332
1.728
.576
NODI: C
NODI: C
NODI: C

Flow, in conduit or thru treatment plant
Mon MGD
30DA AVG
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
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NODI: C
NODI: C

[redacted]

Flow, in conduit or thru treatment plant	Iron, total (as Fe)
Mon MGD	3 mg/L
DAILY MX	30DA AVG
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C

NODI: C
.036
NODI: C
.036
NODI: C
NODI: C
NODI: C

NODI: C
2.495
NODI: C
1.015
NODI: C
NODI: C
NODI: C

Flow, in conduit or thru treatment plant
Mon MGD
DAILY MX
NODI: C
.504
.432
NODI: C
1.44
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C

Iron, total (as Fe)
3 mg/L
30DA AVG
NODI: C
.816
.0318
NODI: C
.726
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C

.684
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
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NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
.0504
NODI: C
.05
NODI: C
NODI: C
NODI: C

.52
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
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NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
1.49
NODI: C
.181
NODI: C
NODI: C
NODI: C

Flow, in conduit or thru treatment plant	Iron, total (as Fe)
Mon MGD	3 mg/L
DAILY MX	30DA AVG
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C

NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C

Flow, in conduit or thru treatment plant	Iron, total (as Fe)
Mon MGD	3 mg/L
DAILY MX	30DA AVG
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
.072	.561
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C

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NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
.029
NODI: C
NODI: C
NODI: C
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NODI: C

NODI: C
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NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
.88
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C

Flow, in conduit or thru treatment plant	Iron, total (as Fe)
Mon MGD	3 mg/L
DAILY MX	30DA AVG
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C

NODI: C

NODI: C

Flow, in conduit or thru treatment plant
Mon MGD
DAILY MX
NODI: C
.72
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C

Iron, total (as Fe)
3 mg/L
30DA AVG
NODI: C
.07
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
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NODI: C
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NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C

NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
.36	1.119
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C
Flow, in conduit or thru treatment plant	Iron, total (as Fe)
Mon MGD	3 mg/L

DAILY MX	30DA AVG
NODI: C	NODI: C
1.656	.46
1.728	.356
.576	.149
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C

Flow, in conduit or thru treatment plant	Iron, total (as Fe)
Mon MGD	3 mg/L
DAILY MX	30DA AVG
NODI: C	NODI: C
NODI: C	NODI: C
NODI: C	NODI: C

NODI: C
NODI: C
NODI: C

[redacted]

Iron, total (as Fe)	Iron, total (as Fe)	Solids, total suspended
6 mg/L	Mon mg/L	35 mg/L
DAILY MX	MO MIN	30DA AVG
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
2.495	2.495	< 5
NODI: C	NODI: C	NODI: C
1.015	1.015	12
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Iron, total (as Fe)	Iron, total (as Fe)	Solids, total suspended
6 mg/L	Mon mg/L	35 mg/L
DAILY MX	MO MIN	30DA AVG
NODI: C	NODI: C	NODI: C
1.155	.476	30.5
.548	.031	9.67
NODI: C	NODI: C	NODI: C
.726	.726	23
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

.52	.52	9
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
1.49	1.49	14
NODI: C	NODI: C	NODI: C
.181	.181	11
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Iron, total (as Fe)	Iron, total (as Fe)	Solids, total suspended
6 mg/L	Mon mg/L	35 mg/L
DAILY MX	MO MIN	30DA AVG
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Iron, total (as Fe)	Iron, total (as Fe)	Solids, total suspended
6 mg/L	Mon mg/L	35 mg/L
DAILY MX	MO MIN	30DA AVG
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
1.036	.265	23
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
.88	.88	< 5
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Iron, total (as Fe)	Iron, total (as Fe)	Solids, total suspended
6 mg/L	Mon mg/L	35 mg/L
DAILY MX	MO MIN	30DA AVG
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C

Iron, total (as Fe)	Iron, total (as Fe)	Manganese, total (as Mn)
6 mg/L	Mon mg/L	1 mg/L
DAILY MX	MO MIN	DAILY MX
NODI: C	NODI: C	NODI: C
.07	.07	.074
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
1.119	1.119	.144
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Iron, total (as Fe) 6 mg/L	Iron, total (as Fe) Mon mg/L	Manganese, total (as Mn) 1 mg/L

DAILY MX	MO MIN	DAILY MX
NODI: C	NODI: C	NODI: C
.46	.46	.129
.356	.356	.959
.149	.149	.152
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Iron, total (as Fe)	Iron, total (as Fe)	Manganese, total (as Mn)
6 mg/L	Mon mg/L	1 mg/L
DAILY MX	MO MIN	DAILY MX
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

[redacted]

Solids, total suspended	Solids, total suspended	Sulfate, total (as SO4)
70 mg/L	Mon mg/L	500 mg/L
DAILY MX	MO MIN	DAILY MX
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
< 5	< 5	84
NODI: C	NODI: C	NODI: C
12	12	100
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Solids, total suspended	Solids, total suspended	Sulfate, total (as SO4)
70 mg/L	Mon mg/L	500 mg/L
DAILY MX	MO MIN	DAILY MX
NODI: C	NODI: C	NODI: C
45	16	2200
13	5	2650
NODI: C	NODI: C	NODI: C
23	23	2080
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

9
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
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14
NODI: C
11
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9
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14
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NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
NODI: C
155
NODI: C
1040
NODI: C
NODI: C
NODI: C

Solids, total suspended	Solids, total suspended	Sulfate, total (as SO4)
70 mg/L	Mon mg/L	500 mg/L
DAILY MX	MO MIN	DAILY MX
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Solids, total suspended	Solids, total suspended	Sulfate, total (as SO4)
70 mg/L	Mon mg/L	500 mg/L
DAILY MX	MO MIN	DAILY MX
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
31	18	93
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
< 5	< 5	54
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Solids, total suspended	Solids, total suspended	Sulfate, total (as SO4)
70 mg/L	Mon mg/L	500 mg/L
DAILY MX	MO MIN	DAILY MX
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C

Manganese, total (as Mn)	Manganese, total (as Mn)	Solids, total suspended
Mon mg/L	Mon mg/L	35 mg/L
30DA AVG	MO MIN	30DA AVG
NODI: C	NODI: C	NODI: C
.074	.074	88
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
.144	.144	< .25
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Manganese, total (as Mn) Mon mg/L	Manganese, total (as Mn) Mon mg/L	Solids, total suspended 35 mg/L

30DA AVG	MO MIN	30DA AVG
NODI: C	NODI: C	NODI: C
.129	.129	43
.959	.959	27
.152	.152	34
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Manganese, total (as Mn)	Manganese, total (as Mn)	Solids, total suspended
Mon mg/L	Mon mg/L	35 mg/L
30DA AVG	MO MIN	30DA AVG
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C
NODI: C
NODI: C

Sulfate, total (as SO4)	Sulfate, total (as SO4)	pH
Mon mg/L	Mon mg/L	6 SU
30DA AVG	MO MIN	MINIMUM
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
84	84	7.3
NODI: C	NODI: C	NODI: C
100	100	7.3
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Sulfate, total (as SO4)	Sulfate, total (as SO4)	pH
Mon mg/L	Mon mg/L	6 SU
30DA AVG	MO MIN	MINIMUM
NODI: C	NODI: C	NODI: C
1950	1700	737
2100	1200	7.7
NODI: C	NODI: C	NODI: C
2080	2080	7.7
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

2349
NODI: C
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NODI: C
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NODI: C
NODI: C
NODI: C
155
NODI: C
1040
NODI: C
NODI: C
NODI: C

2349
NODI: C
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155
NODI: C
1040
NODI: C
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NODI: C

7.5
NODI: C
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NODI: C
NODI: C
7.7
NODI: C
7.9
NODI: C
NODI: C
NODI: C

Sulfate, total (as SO4)	Sulfate, total (as SO4)	pH
Mon mg/L	Mon mg/L	6 SU
30DA AVG	MO MIN	MINIMUM
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Sulfate, total (as SO4)	Sulfate, total (as SO4)	pH
Mon mg/L	Mon mg/L	6 SU
30DA AVG	MO MIN	MINIMUM
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
92	90	7.4
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
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NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
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NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
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NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
54	54	7.5
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Sulfate, total (as SO4)	Sulfate, total (as SO4)	pH
Mon mg/L	Mon mg/L	6 SU
30DA AVG	MO MIN	MINIMUM
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

NODI: C	NODI: C	NODI: C

Solids, total suspended	Solids, total suspended	Sulfate, total (as SO4)
70 mg/L	Mon mg/L	500 mg/L
DAILY MX	MO MIN	DAILY MX
NODI: C	NODI: C	NODI: C
88	88	2050
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
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NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
< .25	< .25	1600
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Solids, total suspended	Solids, total suspended	Sulfate, total (as SO4)
70 mg/L	Mon mg/L	500 mg/L

DAILY MX	MO MIN	DAILY MX
NODI: C	NODI: C	NODI: C
43	43	1670
27	27	1250
34	34	2300
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C

Solids, total suspended	Solids, total suspended	Sulfate, total (as SO4)
70 mg/L	Mon mg/L	500 mg/L
DAILY MX	MO MIN	DAILY MX
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C
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pH
9 SU
MAXIMUM
NODI: C
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NODI: C
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pH
9 SU
MAXIMUM
NODI: C
8
8.1
NODI: C
7.7
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NODI: C
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7.5
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7.9
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pH
9 SU
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pH
9 SU
MAXIMUM
NODI: C
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7.8
NODI: C
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NODI: C
NODI: C
7.5
NODI: C
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pH
9 SU
MAXIMUM
NODI: C
NODI: C
NODI: C

NODI: C

Sulfate, total (as SO4)	Sulfate, total (as SO4)	pH	pH
Mon mg/L	Mon mg/L	6 SU	9 SU
30DA AVG	MO MIN	MINIMUM	MAXIMUM
NODI: C	NODI: C	NODI: C	NODI: C
2050	2050	8.4	8.4
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
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NODI: C	NODI: C	NODI: C	NODI: C
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NODI: C	NODI: C	NODI: C	NODI: C
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NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
1600	1600	8.2	8.2
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C

Sulfate, total (as SO4)	Sulfate, total (as SO4)	pH	pH
Mon mg/L	Mon mg/L	6 SU	9 SU

30DA AVG	MO MIN	MINIMUM	MAXIMUM
NODI: C	NODI: C	NODI: C	NODI: C
1670	1670	8.6	8.6
1250	1250	8.8	8.8
230	2300	8.6	8.6
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C

Sulfate, total (as SO4)	Sulfate, total (as SO4)	pH	pH
Mon mg/L	Mon mg/L	6 SU	9 SU
30DA AVG	MO MIN	MINIMUM	MAXIMUM
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
NODI: C	NODI: C	NODI: C	NODI: C
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Freshwater Mussels of the Big Muddy River

Diane K. Shasteen, Alison L. Price, Sarah A. Bales

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Illinois Department of Natural Resources: Office of Resource Conservation

U.S. Fish & Wildlife Service

Illinois Natural History Survey

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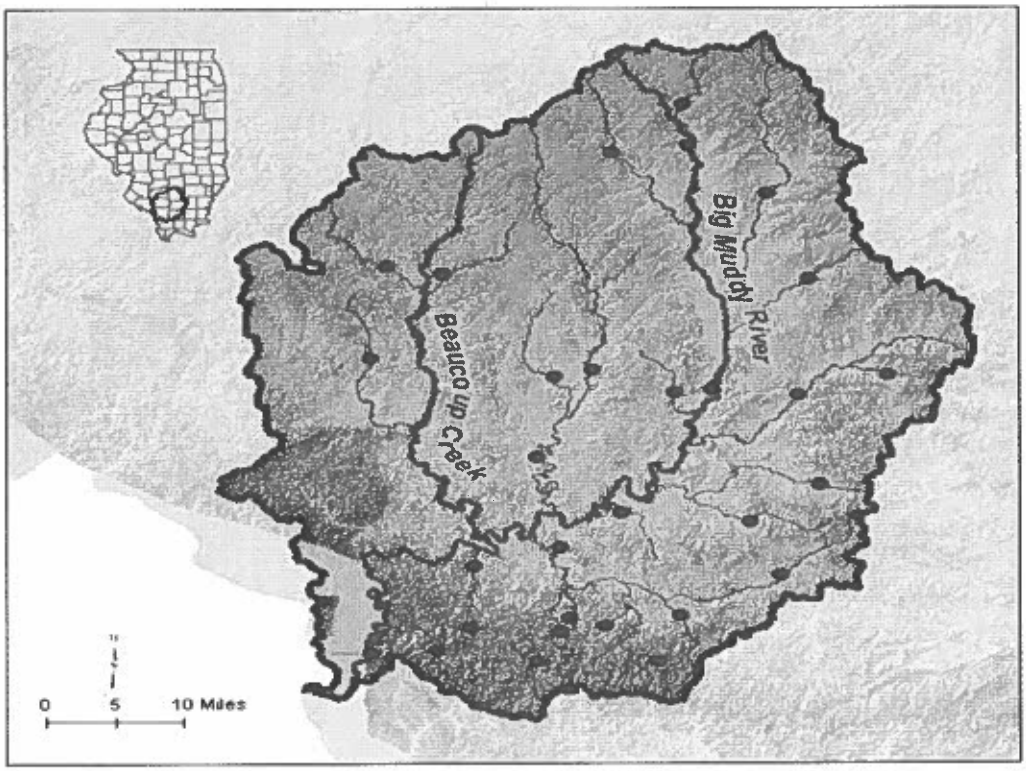
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Freshwater Mussels of the Big Muddy River



2012

Illinois Natural History Survey, Prairie Research Institute, University of Illinois
Illinois Department of Natural Resources

Diane Shasteen, Alison Price, Sarah Bales

Preface

While broad geographic information is available on the distribution and abundance of mussels in Illinois, systematically collected mussel-community data sets required to integrate mussels into aquatic community assessments do not exist. In 2009, a project funded by a US Fish and Wildlife Service State Wildlife Grant was undertaken to survey and assess the freshwater mussel populations at wadeable sites from 33 stream basins in conjunction with the Illinois Department of Natural Resources (IDNR)/Illinois Environmental Protection Agency (IEPA) basin surveys. Inclusion of mussels into these basin surveys contributes to the comprehensive basin monitoring programs that include water and sediment chemistry, instream habitat, macroinvertebrate, and fish, which reflect a broad spectrum of abiotic and biotic stream resources. These mussel surveys will provide reliable and repeatable techniques for assessing the freshwater mussel community in sampled streams. These surveys also provide data for future monitoring of freshwater mussel populations on a local, regional, and watershed basis.

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Introduction

Freshwater mussel populations have been declining for decades and are among the most seriously impacted aquatic animals worldwide (Bogan 1993, Williams et al. 1993). It is estimated that nearly 70% of the approximately 300 North American mussel taxa are extinct, federally-listed as endangered or threatened, or in need of conservation status (Williams et al. 1993, Strayer et al. 2004). In Illinois, 25 of the 62 extant species (44%) are listed as threatened or endangered (Illinois Endangered Species Protection Board 2011). While broad geographic information is available on the distribution and abundance of mussels in Illinois, systematically collected mussel-community data sets required to integrate mussels into aquatic community assessments do not exist. Sampling of mussels has been very sporadic and limited in the Big Muddy River basin and no known reports pertaining to mussel communities of the basin have been published. This report summarizes the mussel survey conducted in the Big Muddy River basin in 2009-2010 in conjunction with IDNR and IEPA basin surveys.

The Big Muddy River basin drains 3798 km^2 (2360 mi^2) in the southern part of Illinois and contains principal tributaries of Casey Fork, Middle Fork Big Muddy, Beaucoup Creek, Little Muddy River, and Crab Orchard Creek (Page et al. 1992). Originating near Cravat in Jefferson County, the Big Muddy River basin drains through the counties of Jefferson, Washington, Perry, Franklin, Williamson, and Jackson. The river mainstem forms the Jackson /Union county line and joins the Mississippi River south of Grand Tower (Figure 1). The Big Muddy River basin flows through four natural divisions, including the Lower Mississippi River Bottomlands, Ozark, Shawnee Hills, and Southern Till Plain (Schwegman 1973). The Southern Till Plain comprises the majority of the basin which is characterized by hilly upland topography and a broad flood plain (Forbes and Richardson 1908).

Land-use and Instream Habitat

In the Big Muddy River basin, land use varies slightly by county with approximately 50 to 75% of the area in agriculture. Forested lands account for 8 to nearly 25% of the landscape with the larger forested areas being located in Jackson and Williamson counties (IDA 2000). Three of the largest cities in southern Illinois with populations between 15,000 and 28,000 (Marion, Mt. Vernon, and Carbondale) are also located in this basin (IEPA 1996, US Census Bureau 2010). In 1965, the Big Muddy River was dammed near Benton and thus Rend Lake, the second largest inland impoundment in the state, was created (Page et al. 1992, USACE 2005). This reservoir provides over 15 million gallons of water per day to approximately 300,000 people in over 60 communities throughout the basin. It is also used extensively for recreational activities including boating, fishing, waterfowl hunting and camping (USACE 2005). These recreational activities are also popular in the Shawnee National Forest, Giant City State Park, Lake Kinkaid and Murphysboro, Crab Orchard National Wildlife Refuge, and LaRue Pine Hills Ecological Area,

which are all located within the Big Muddy River basin. In the southwestern part of this basin, especially near the Murphysboro area, strip mining for coal was prevalent during the early 20th century and pollution from the remaining spoil banks continues to be a problem in the basin (Page et al. 1992).

During glacial activity in the region, the Mississippi River exceeded its sediment transporting capacity thus closing off the mouths of its tributary streams, including the Big Muddy River. The Big Muddy River temporarily formed a lake; once the natural process of removing sediment returned to the Mississippi River a deeper channel emerged. As the Big Muddy River drained, soils typical of a lake bed were left behind (LeTellier 1971). Today, the soils of the Big Muddy basin consist of impervious clays, silt and fine sand. The substrates in all of the streams of this basin were dominated by some combination of sand, silt, and clay. Excessive siltation along with large woody debris was common at many sites within the basin (Figure 2 and 3). Most of the sites in the basin had wadeable water depths; however sampling sites were limited on the mainstem of the Big Muddy and on Beaucoup Creek due to non-wadeable water depths (e.g., depth>1m).

Methods

During the 2009/2010 surveys, freshwater mussel data were collected at 30 sites: 3 mainstem and 27 tributary sites in the Big Muddy River basin (Figure 1, Table 1). Locations of sampling sites are listed in Table 1 along with information regarding IDNR/IEPA sampling at the site. In most cases, mussel survey locations were the same as IDNR/IEPA sites.

Live mussels and shells were collected at each sample site to assess past and current freshwater mussel occurrences. Live mussels were surveyed by hand grabbing and visual detection (e.g. trails, siphons, exposed shell) when water conditions permitted. Efforts were made to cover all available habitat types present at a site including riffles, pools, slack water, and areas of differing substrates. A four-hour timed search method was implemented at each site. Live mussels were held in the stream until processing.

Following the timed search, all live mussels and shells were identified to species and recorded (Table 2). For each live individual, shell length (mm), gender, and an estimate of the number of growth rings were recorded. Shell material was classified as recent dead (periostracum present, nacre pearly, and soft tissue may be present) or relict (periostracum eroded, nacre faded, shell chalky) based on condition of the best shell found. A species was considered extant at a site if it was represented by live or recently dead shell material (Szafoni 2001). The nomenclature employed in this report (Appendix 1) follows Turgeon et al. (1998) except for recent taxonomic changes to the gender ending of lilliput (*Toxolasma parvum*), which follows Williams et al. (2008). Voucher specimens were retained and deposited in the Illinois Natural History Survey

Mollusk Collection. All non-vouchered live mussels were returned to the stream reach where they were collected.

Parameters recorded included extant and total species richness, presence of rare or listed species, and individuals collected, expressed as catch-per-unit-effort (CPUE; Table 2). A population was considered to indicate recent recruitment if individuals less than 30 mm in length or with 3 or fewer growth rings were recorded. Finally, mussel resources were classified as Unique, Highly Valued, Moderate, Limited, or Restricted (Table 2) based on the above parameters (Table 3) and following criteria outlined in Table 4 (Szafoni 2001).

Results

Species Richness

A total of 19 species of freshwater mussels were observed in the Big Muddy River basin, all of which were collected live (Table 2). Across all sites, the number of live species collected, the number of extant species collected (live + dead), and the total number of species collected (live + dead + relict) ranged from 0 to 13. The giant floater (*Pyganodon grandis*) had the most occurrences across sites sampled with live mussels present (11 of 30 sites; 37%; Figure 4). The lilliput (*Toxolasma parvum*), paper pondshell (*Utterbackia imbecillis*), pondhorn (*Uniomerus tetralasmus*) and white heelsplitter (*Lasmigona complanata*) were other commonly occurring species (Figure 4), occupying 17% of these sites. Site 6, the Big Muddy River near Benton, had the greatest species richness with 12 live species.

Abundance and Recruitment

A total of 358 individuals were collected across 30 sites. The number of live specimens collected at a given site ranged from 0 to 133, with an average of 16 mussels per site where live mussels were collected (22 of 30 sites; Table 2). A total of 120 collector-hours were spent sampling with an average of three mussels collected per hour. Nine sites yielded more than 10 live individuals and 2 of the 9 sites (sites 6 and 15) yielded more than 45 live individuals. The most common species collected in the Big Muddy basin were giant floater (*n*=131), mapleleaf (*Quadrula quadrula*; n=37), white heelsplitter (n=34), lilliput (n=24), and pink papershell (*Potamilus ohiensis;* n=20), which together comprised approximately 70% of the individuals collected.

Recruitment for each species was determined by the presence of individuals less than 30mm or with 3 or fewer growth rings. Smaller (i.e., younger) mussels are harder to locate by hand grab methods and large sample sizes can be needed to accurately assess population reproduction. However, a small sample size can provide evidence of recruitment if it includes individuals that are small or possess few growth rings. Alternatively, a sample consisting of very large (for the species) individuals with numerous growth rings suggests a senescent population.

Recruitment at individual sites ranged from none observed to high across the basin. Recruitment levels, referred to in Table 3 as Reproduction Factor, varied from one to five, and three of the sites in the Big Muddy River basin exhibited high to very high recruitment. Recruitment was over 50% at site 7, Andy Creek, and 30 to 50% at sites 1 and 9, Snow Creek and Middle Fork Big Muddy (Figure 5). Sites 2 and 29, Big Muddy River and Cedar Creek, exhibited recruitment from 1 to 30% of species collected. Recruitment may be occurring at site 30, Big Muddy mainstem, where dead shells of nearly all species collected were less than 3 years of age. All other sites in the Big Muddy River basin (24 of 30) exhibited no observed recruitment during this survey.

Mussel Community Classification

Based on the data collected in the 2009/2010 basin surveys, nearly 75% of the sites in the Big Muddy River basin have Restricted or Limited mussel communities using the current MCI classification system (Table 4, Figure 5). No sites are ranked as Unique or Highly Valued in the basin. Eight sites (sites 1, 2, 6, 7, 9, 15, 23, and 29) in the Big Muddy River basin were ranked as Moderate mussel resources.

Noteworthy Finds

According to historical records, 25 species are known from the Big Muddy River basin (Tiemann et al. 2007). All 19 species found during this survey had been recorded in the basin historically. However, three of these species had not been recorded live since 1969; these species included Wabash pigtoe (*Fusconaia flava*), pondmussel (*Ligumia subrostrata*), and deertoe (*Truncilla truncata*). Historic species not detected during this survey include creeper (*Strophitus undulatus*), spike (*Elliptio dilatata*), pimpleback (*Quadrula pustulosa*), plain pocketbook (*Lampsilis cardium*), pink heelsplitter (*Potamilus alatus*), and fawnsfoot (*Truncilla donaciformis*).

A possible range expansion may be occurring with the Louisiana fatmucket (*Lampsilis hydiana)* which occurs in the upper Arkansas, White and St. Francis rivers and in Louisiana and East Texas (NatureServe 2011). Specimens collected during this survey were classified as *Lampsilis siliquoidea* (*hydiana*) due to morphological features that resemble the Louisiana fatmucket (pers. comm. Kevin Cummings). Additional genetic testing would need to be conducted to correctly determine which species, *Lampsilis siliquoidea* or *Lampsilis hydiana*, exists in the Big Muddy basin.

Discussion

Our survey documented 19 species from the Big Muddy River basin, all were recorded live. No new species were found that had previously been undetected and six species previously detected were not found during our survey. Of these six species, only the plain pocketbook has

been documented as live in the basin. This species was found at three tributaries in the late 1990's to early 2000's; however these streams were not sampled during our survey. These sites would need to be surveyed to determine if this species is still present in the basin. Of the remaining five species not collected, deertoe and creeper have been documented only by relict shell, and the pink heelsplitter, pimpleback, and spike have not been documented since the late 1800's, early 1900's. All of these species were collected from the Big Muddy mainstem. These particular species, except for spike, are widespread and common throughout most of Illinois (Cummings and Mayer 1992) and all of these species are known from other major Mississippi River tributaries including the Rock, Illinois, and Kaskaskia Rivers (INHS Mollusk Collection Database). Sampling the mainstem of the Big Muddy was hindered by non-wadeable water depths; therefore additional sampling by alternative means would need to be conducted to determine if these species have indeed been extirpated from the basin.

Recruitment

Data collected during this survey indicate that very recent recruitment may not be occurring at most (25 of 30) sites in the Big Muddy basin. Only 3 of the 30 sites exhibited high to very high recruitment and 2 other sites had moderate recruitment noted. This finding suggests that most mussel communities of the Big Muddy may not be viable and self-maintaining. Although very few mussels collected during this basin survey fell into the category of 3 age rings or younger, many of them ranged from 4 to 10 years of age. This would indicate that the populations observed in most streams are within the age range thought to be reproductively active (Haag and Staton 2003). Therefore, we cannot conclusively state that the mussel communities of this system are void of recruitment. Recruitment may also be occurring on the Big Muddy mainstem near the Mississippi as nearly all of the dead shells found at site 30 were less than 3 years of age. Sampling methods to target juvenile mussels would be necessary to better assess the reproductive status of these populations.

Mussel community of the Big Muddy River basin

There is limited mussel community information relating to this basin from past surveys and reports. Nearly 90% of the sites sampled had no historical data available (Table 2), and there is no known intensive survey for mussels in this basin. Our surveys documented the existence of 19 species in the Big Muddy River basin from which 25 species were known historically. Additionally, our surveys found that all 19 species were represented by live individuals. Five of the six species not collected during this survey are represented by either relict shell or pre-1930 collections.

Other major Mississippi tributaries such as the Kaskaskia, Rock, and Illinois Rivers have a larger mussel fauna base according to historical records and recent surveys. Historically, these basins

contained 43, 47, and 49 species, respectively, while the Big Muddy has only 25 recorded species (Tiemann et al. 2007). Several theories could be offered on the disparity of species in this basin including the inability to conduct wadeable surveys, challenging diving conditions, lack of river access by vehicle, or the lack of suitable substrate composition for varying species. Substrates such as gravel, cobble, and boulder are practically nonexistent in the Big Muddy basin. As mentioned in the introduction, the substrate of the Big Muddy is predominately impervious clay, silt, and sand. The Big Muddy basin provides suitable substrates for many mussel species such as the giant floater, white heelsplitter, and other Anodontines. However, many species that occur in the other major Mississippi tributaries such as mucket (*Actinonaias ligamentina*), black sandshell (*Ligumia recta*), and threehorn wartyback (*Obliquaria reflexa*) prefer a mixture of substrate types including gravel, sand, and cobble (Cummings and Mayer 1992). Sedimentation and siltation of the streams in this basin may be another factor influencing the lack of these species. These factors are listed as impairments for aquatic life for many mainstem sites on the Big Muddy and several tributaries within the basin (IEPA 2010). With the lack of coarser substrates from the basin both today and historically, it may be safe to assume that many of these species have never existed in the basin. However, this statement cannot be made conclusively, due to a lack in historical information.

Living up to its name, sampling in the Big Muddy basin is challenging at best due to water depths (Big) and high turbidity (Muddy). The Big Muddy mainstem and many of its larger tributaries, such as Beaucoup and Drury Creeks, are not easily surveyed for freshwater mussels, thus it is difficult to accurately determine species richness of the basin. It is possible that the Big Muddy River provides a haven for the recruitment of many mussel species, based on the dead shells less than 3 years of age found at site 30, the nature of its substrates, and the river's connection with the Mississippi River. We are unable to conclusively state that the Big Muddy is serving as a source population for mussel species because of the lack of historical data and difficulty in sampling the basin. Additional sampling, either diving or boating to shallow areas on the lower portion of the mainstem and larger tributaries, would be needed to adequately determine the mussel fauna of this basin.

Literature Cited

Bogan, A.E. 1993. Freshwater bivalve extinctions (Mollusca: Unionoida): a search for causes. American Zoologist 33(6):599-609.

Cummings, K.S., and C. A. Mayer. 1992. Field Guide to Freshwater Mussels of the Midwest. Illinois Natural History Survey, Champaign. 194 pp.

Forbes, S.A., and R.E. Richardson. 1908. The fishes of Illinois. Illinois State Laboratory of Natural History, Danville. cxxxvi + 357 pp.

Haag, W. R. and J.L. Staton. 2003. Variation in fecundity and other reproductive traits in freshwater mussels. Freshwater Biology 48(12):2118-2130.

Illinois Endangered Species Protection Board. 2011. Checklist of endangered and threatened animals and plants of Illinois. http://dnr.state.il.us/ESPB/pdf/2011_Checklist.pdf

Illinois Department of Agriculture. 2000. Land Cover of Illinois Statistical Summary 1999-2000. http://www.agr.state.il.us/gis/stats/landcover99-00.html

Illinois Environmental Protection Agency. Illinois Water Quality Fact Sheet-1996. http://www.epa.state.il.us/water/water-quality/report-1996/fact-sheets/index.html

Illinois Environmental Protection Agency. 2010. Illinois Integrated Water Quality Report and Section 303(d) List. http://www.epa.state.il.us/water/tmdl/303d-list.html

NatureServe. 2011. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. http://www.natureserve.org/explorer/servlet/NatureServe?searchSciOrCommonName=lampsilis+hydiana.

Page, L.M., K.S. Cummings, C.A. Mayer, S.L. Post, and M.E. Retzer. 1992. Biologically significant Illinois streams, an evaluation of the streams of Illinois based on aquatic biodiversity. Technical Report. Illinois Department of Conservation and Illinois Department of Energy and Natural Resources, Springfield, Illinois. 498 pp.

Schwegman, J.E. 1973. Comprehensive plan for the Illinois nature preserves system. Part 2. The natural divisions of Illinois. Illinois Nature Preserves Commission, Springfield, Illinois.

Strayer, D.L., J.A. Downing, W.R. Haag, T.L. King, J.B. Layzer, T.J. Newton, and S.J. Nichols. 2004. Changing perspective on pearlymussels, North America's most imperiled animals. BioScience 54(5):429-439.

Szafoni, R. E. 2001. Protocol for integrating freshwater mussel surveys into IDNR / IEPA stream

basin surveys. Version 2.0. IDNR/ORC/Natural Heritage, Charleston, IL. 5pp.

Tiemann, J.S., K.S. Cummings, C.A. Mayer. 2007. Updates to the distributional checklist and status of Illinois freshwater mussels (Mollusca: Unionacea). Transactions of the Illinois State Academy of Science 100 (1):107-123.

Turgeon, D.D., A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P.M. Mikkelsen, J.F. Quinn, Jr., C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltema, M.J. Sweeney, F.G. Thompson, M. Vecchione, and J.D. Williams. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: Mollusks. 2nd Edition. American Fisheries Society, Special Publication 26:ix-526.

U. S. Army Corps of Engineers, St. Louis District, Rend Lake. 2005. History of Rend Lake. http://www.mvs.usace.army.mil//Rend/History/HistRL_05.html

Williams, J.D., M.L. Warren, Jr., K.S. Cummings, J.L. Harris, and R.J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18(9):6-22.

Williams, J.D., A.E. Bogan, and J.T. Garner. 2008. The freshwater mussels of Alabama and the Mobile Basin of Georgia, Mississippi, and Tennessee. University of Alabama Press, Tuscaloosa, Alabama. 908 pp.

Table1. 2009/2010 Big Muddy River Intensive Basin Survey. Types of samples include MU-mussel sampling, BE-boat electrofishing, ES-electric fish seine, SH-fish seine hauls, FF-fish flesh contaminate, H-habitat, M-macroinvertebrate, S-sediment, W-water chemistry. *Drury Creek Survey not completed due to water depth >3m.

Site Number	IEPA Code	Stream	Types of Samples	County	Location	Watershed Area (km^2)
1	NL-01	Snow Creek	MU, ES,H,M,S,W	Jefferson	6 mi NW Mt Vernon; Rd 1850N	49.60
2	N-05	Big Muddy River	MU, ES,H,M,S	Jefferson	1.5 mi NE Woodlawn Co Rd; 1450N	154.04
3	NK-02	Rayse Creek	MU	Jefferson	3.7 mi W Woodlawn; Rd 1400N	119.89
4	NJ-26	Casey Fork	MU	Jefferson	SE Mt Vernon; DNS Rt 142	196.87
5	NI-01	Gun Creek	MU, ES,H,M,S,W	Jefferson	3.3 mi E Ina	35.62
6	N-06	Big Muddy River	MU, BE,H,M,S,W	Franklin	Rt 14 Br; 3 mi W Benton	1287.86
7	NZN-15	Andy Creek	MU, ES,H,M,S,W	Franklin	Satch Road; 1.6 mi NE of Christopher	33.54
8	NHG-01	Akin Creek	MU, ES,H,M,S,W	Franklin	N Botail Road; 8.8 mi E of Benton	21.98
9	NH-23	Middle Fork	MU, BE,H,M,S	Franklin	2.2 mi SE Bent; Us Rt 34	329.47
10	NG-05	Pond Creek	MU, SH,H,M,S,W	Williamson	Liberty School Rd; 4.7 mi SE of West Frankfort	31.84
11	NGA-02	Lake Creek	MU, ES,H,M,S,W	Williamson	Co Rd 1200E; 0.3 mi S Johnston City	40.90
12	NF-01	Hurricane Creek	MU, ES,H,M,S,W	Williamson	4 mi WNW Herrin	60.67
13	NE-04	Little Muddy River	MU	Perry	Rt 14 Br; 2 mi E Old Duquoin	426.62
14	NEB-02	Reese Creek	MU, ES,H,M,S,W	Perry	2 mi E Duquoin on Park St	60.79
15	NE-05	Little Muddy River	MU, BE,H,M,S,W	Jackson	1.3 mi E of Elkville	684.39
16	ND-04	Crab Orchard Creek	MU, ES,H,M,S,W	Williamson	Rt 13 Br; E edge of Marion	82.52
17	NDJ-01	Wolf Creek	MU, ES,H,M,S,W	Williamson	E Rt 148; old railroad	44.74
18	NDD-03	Grassy Creek	MU, ES,H,M,S,W	Williamson	At Wolf Creek Rd	14.84
19	NDDA-01	Little Grassy	MU, ES,H,M,S,W	Williamson	6 mi SSW Carterville	47.11
20	NDC-99*	Drury Creek	ES,H,M,S,W	Jackson	0.2 mi US Makanda business dist	47.29
21	NDCB-01	Indian Creek	MU, ES,H,M,S,W	Jackson	2.5 mi NE Makanda	14.01
22	NDCA-01	Sycamore Creek	MU, ES,H,M,S,W	Jackson	2 mi E of Boskydell	5.27
23	ND-01	Crab Orchard Creek	MU, BE,H,M,S,W	Jackson	4 mi NE Carbondale	693.93
24	NCK-02	Swanwick Creek	MU, ES,H,M,S,W	Perry	Misty Road; 5.8 mi NW of Pinckneyville	117.41
25	NCI-01	Little Beaucoup Creek	MU, ES,H,M,S,W	Perry	6 mi NNE Pinckneyville	46.96
26	NCDB-01	Little Galum Creek	MU, SH,H,M,S,W	Perry	Galum Cr Rd; 0.5 mi N Pyramid St	30.47
27	NZL-01	Mud Creek	MU, ES,H,M,S,W	Jackson	West Lake Road; 2.1 mi SE of Muphysboro	25.54
28	NAC-02	Cave Creek	MU, ES,H,M,S,W	Jackson	Jerusalem Hill Road; 0.2 mi W of Ponoma	15.24
29	NA-03	Cedar Creek	MU, ES,H,M,S	Jackson	1 mi S Brewer School on Dutch Ridge	80.38
30	N-99	Big Muddy River	MU, BE,H,M,S	Jackson	5 mi E Grandtower at Rattlesnake Ferry	6064.97

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Table 2. Mussel data for sites sampled during 2009/2010 surveys (Table 1). Numbers in columns are live individuals collected; "D" and "R" indicates dead or relict shells collected. Shaded boxes are historic collections at the specific site location obtained from the INHS Mollusk Collection records. Species in bold are federally or state-listed species or species in Greatest Need of Conservation by IL DNR. Proportion of total is number of individuals of a species divided by total number of individuals at all sites. Extant species is live + dead shell and total species is live + dead + relict shell. NDA represents no historical data available. MCI scores and Resource Classification are based on values in Tables 3 and 4 (R= Restricted, L= Limited, M= Moderate, HV= Highly Valued, and U= Unique).
*Includes *Strophitus undulatus*, *Elliptio dilatata*, *Quadrula pustulosa*, *Lampsilis cardium*, *Potamilus alatus*, and *Truncilla donaciformis*, historical species not collected during this survey.

	Site Number																						Proportion of Total
	1	2	3	5	6	7	9	11	13	14	15	16	17	19	23	24	25	26	27	28	29	30	
Anodontinae																							
Anodonta suborbiculata					1		2				D												1%
Arcidens confragosus											4				D							D	1%
Lasmigona complanata					19					1	9				1						4		9%
Pyganodon grandis		12	1	R	30		23	2	2	21	19	R	D	12	D	D			1		8	D	37%
Strophitus undulatus																							0%
Utterbackia imbecillis	1	1			D		3				1										2	D	2%
Ambleminae																							
Amblema plicata		1			4				1		3												3%
Elliptio dilatata																							0%
Fusconaia flava					1																		0%
Megalonaias nervosa					16										1								5%
Quadrula pustulosa																							0%
Quadrula quadrula					26				2		6				3								10%
Tritogonia verrucosa					1																		0%
Uniomerus tetralasmus	1	R				2				1							2	D	R	1			2%
Lampsilinae																							
Lampsilis cardium																							0%
Lampsilis siliquoidea (hydiana)		3														D							1%
Lampsilis teres					4						4				1						5		4%
Leptodea fragilis					8				1	1	D				1							D	3%
Ligumia subrostrata	4	4	2									R		4									4%
Potamilus alatus																							0%
Potamilus ohiensis					19						1											D	6%
Toxolasma parvum	16	3	3											1							1		7%
Toxolasma texasiensis	1	5	D			4	D			D													3%
Truncilla donaciformis																							0%
Truncilla truncata					4										6								3%
																							Total
Individuals	23	29	6	0	133	6	28	2	6	24	47	0	0	17	13	0	2	0	1	1	20	0	358
Live Species	5	7	3	0	12	2	3	1	4	4	8	0	0	3	6	0	1	0	1	1	5	0	19
Extant Species	5	7	4	0	13	2	4	1	4	5	10	0	1	3	8	2	1	1	1	1	5	5	19
Total Species	5	9	4	1	13	2	4	1	4	5	10	2	1	3	8	2	1	1	2	1	5	5	19
Historical Species	NDA	NDA	NDA	NDA	NDA	NDA	NDA	NDA	NDA	NDA	NDA	NDA	NDA	2	NDA	NDA	NDA	1	NDA	NDA	1	6	25*
Catch per unit effort (CPUE)	5.76	7.02	1.50	0.00	33.33	1.50	6.97	0.50	1.50	6.00	11.78	0.00	0.00	4.25	3.25	0.00	0.50	0.00	0.25	0.25	5.00	0.00	
Mussel Community Index (MCI)	10	10	7	0	11	10	10	4	7	7	10	0	0	6	8	0	4	0	4	4	9	0	
Resource Classification	M	M	L	R	M	M	M	R	L	L	M	R	R	L	M	R	R	R	R	R	M	R	

R05129

Table 3. Mussel Community Index (MCI) parameters and scores.

Extant species in sample	Species Richness		Catch per Unit Effort (CPUE)	Abundance (AB) Factor
0	1		0	0
1-3	2		1-10	2
4-6	3		>10-30	3
7-9	4		>30-60	4
10+	5		>60	5
% live species with recent recruitment	Reproduction Factor		# of Intolerant species	Intolerant species Factor
0	1		0	1
1-30	3		1	3
>30-50	4		2+	5
>50	5			

Table 4. Freshwater mussel resource categories based on species richness, abundance, and population structure. MCI = Mussel Community Index Score

Unique Resource MCI ≥ 16	Very high species richness (10 + species) &/or abundance (CPUE > 80); intolerant species typically present; recruitment noted for most species
Highly Valued Resource MCI = 12- 15	High species richness (7-9 species) &/or abundance (CPUE 51-80); intolerant species likely present; recruitment noted for several species
Moderate Resource MCI = 8 - 11	Moderate species richness (4-6 species) &/or abundance (CPUE 11-50) typical for stream of given location and order; intolerant species likely not present; recruitment noted for a few species
Limited Resource MCI = 5 - 7	Low species richness (1-3 species) &/or abundance (CPUE 1-10); lack of intolerant species; no evidence of recent recruitment (all individuals old or large for the species)
Restricted Resource MCI = 0 - 4	No live mussels present; only weathered dead, sub-fossil, or no shell material found

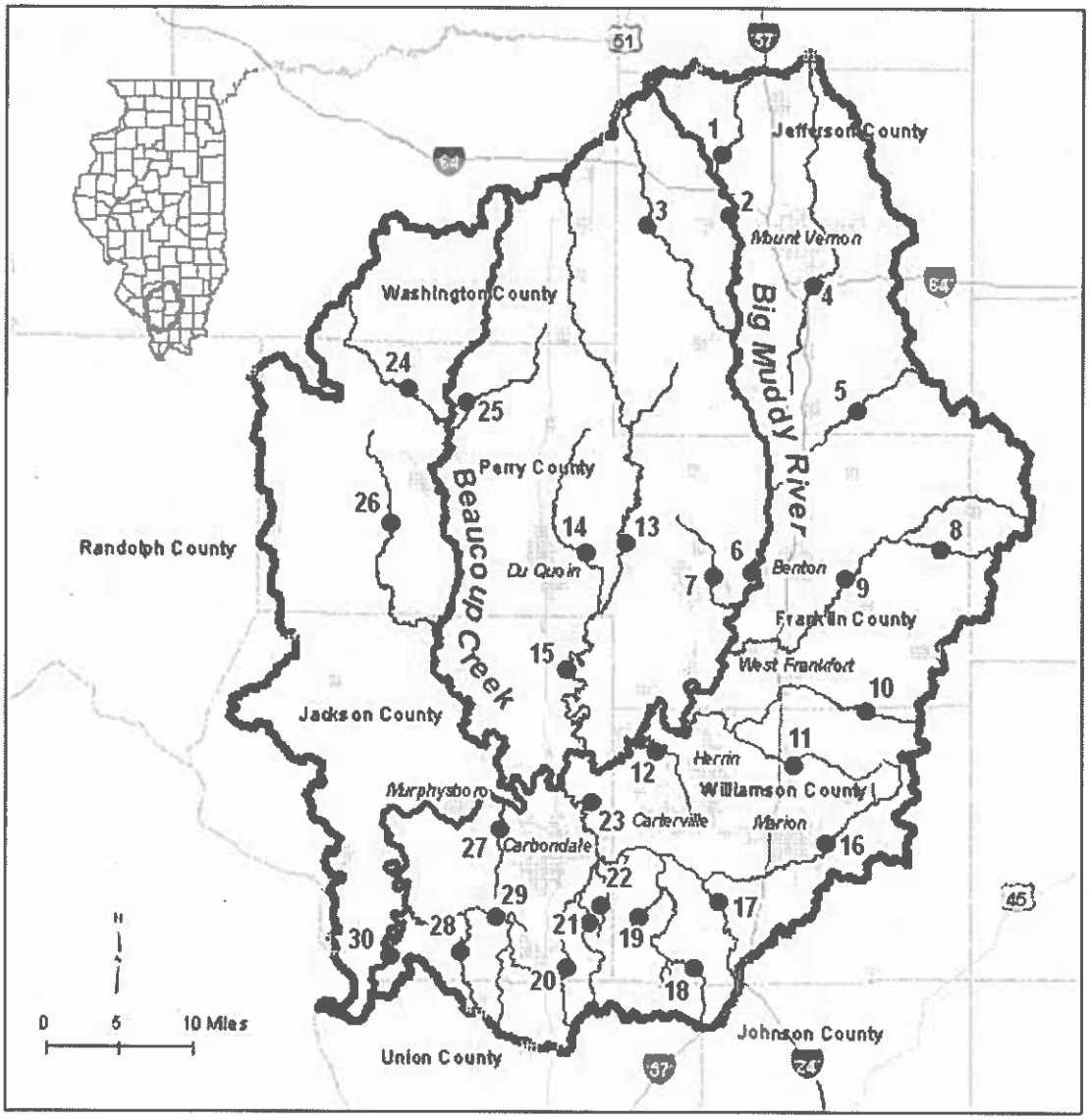


Figure 1. Sites sampled in the Upper and Lower Big Muddy River basin during 2009. Site codes referenced in Table 1.

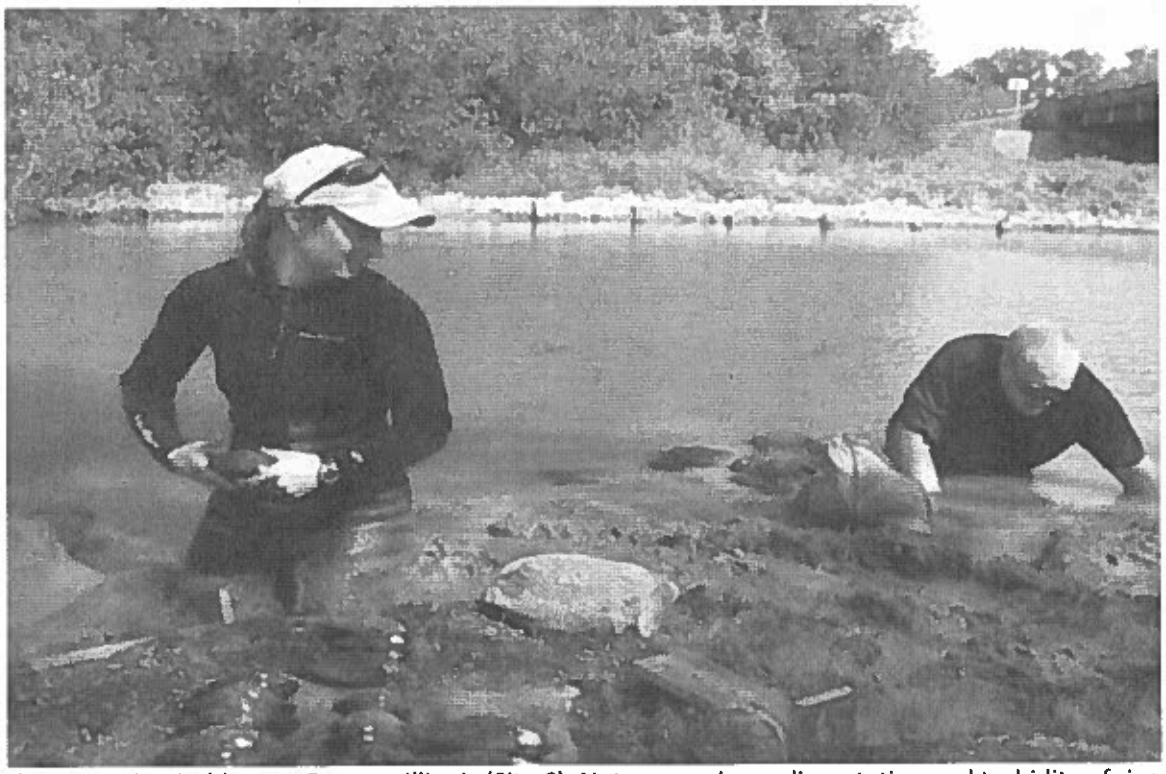


Figure 2. Big Muddy near Benton, Illinois (Site 6). Note excessive sedimentation and turbidity of river. Alison Price and A. J. Berger measuring mussels sunk up to thighs and waist in silt.



Figure 3. Casey Fork near Mt. Vernon, Illinois (Site 4). Note large woody debris in stream, silt/clay banks, and turbidity of river.

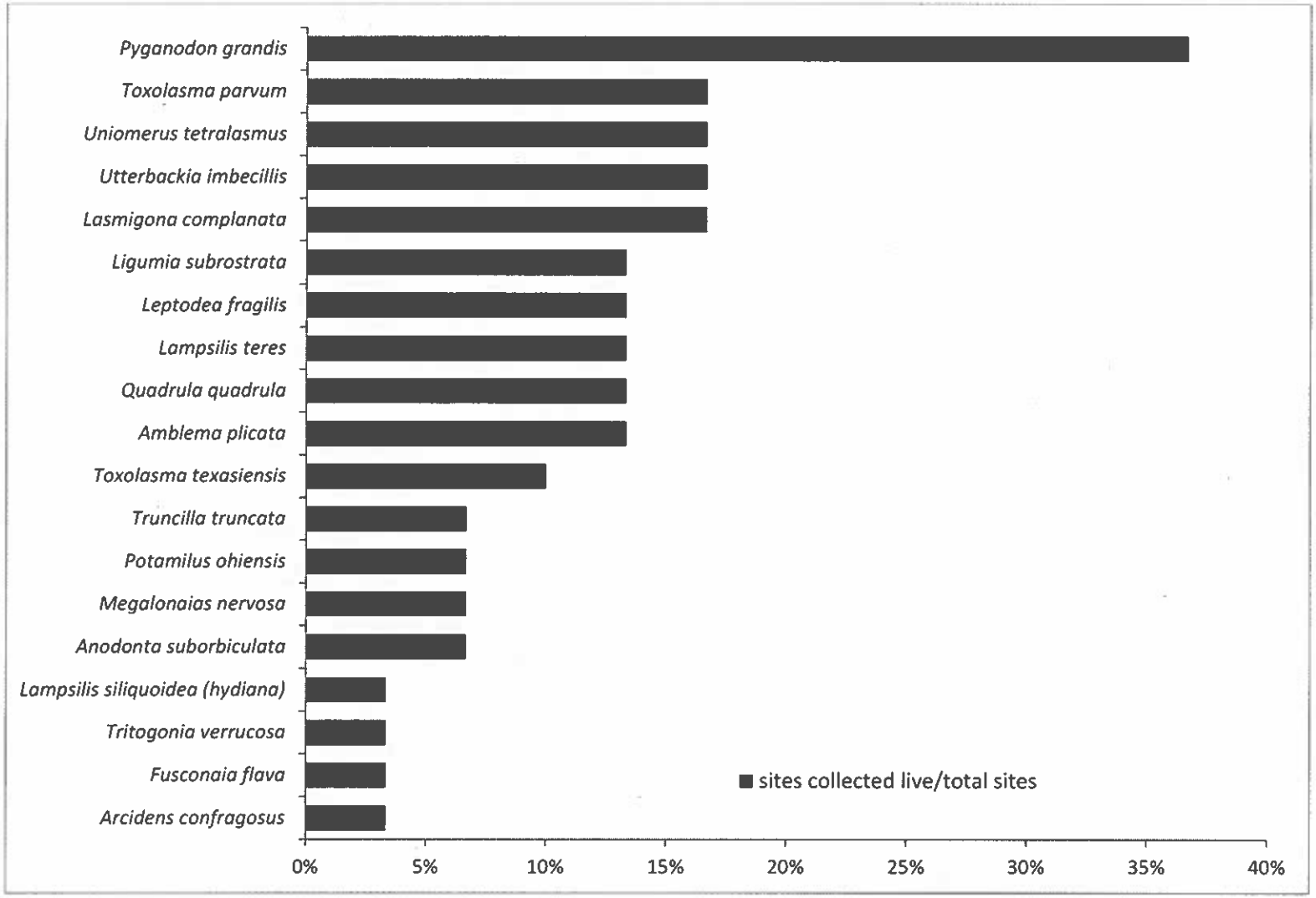


Figure 4. Number of sites where a species was collected live compared to the number of total sites sampled (30 total sites).

R05133

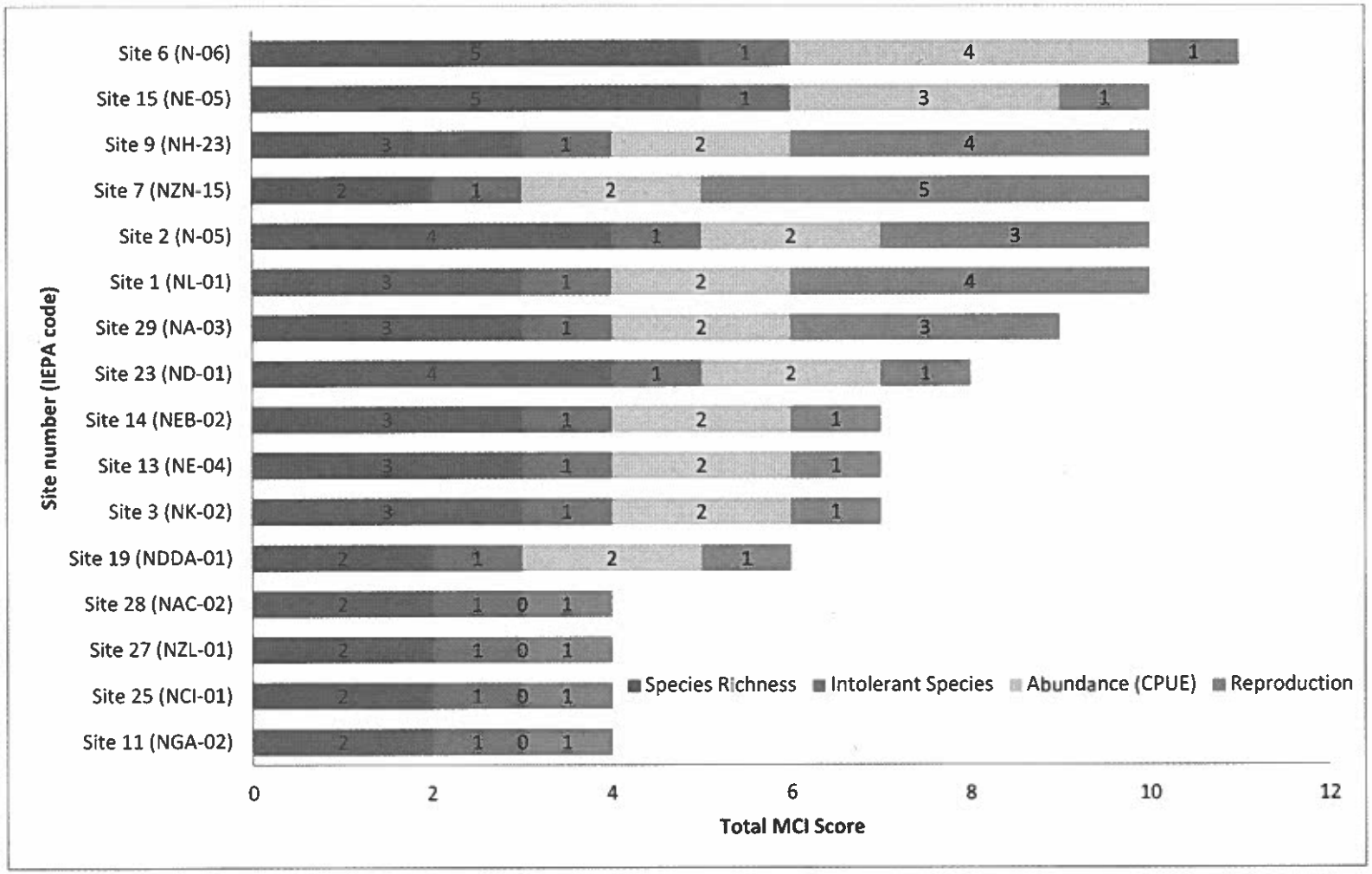


Figure 5. Comparison of Mussel Community Index (MCI) and MCI component scores for Big Muddy River basin sites based on factor values from Table 3.

R05134

Appendix 1. Scientific and common names of species. ST= state threatened.

Scientific Name	Common Name	Status
	Subfamily Anodontinae	
Anodonta suborbiculata	flat floater	
Arcidens confragosus	rock pocketbook	
Lasmigona complanata	white heelsplitter	
Pyganodon grandis	giant floater	
Strophitus undulatus	creeper	
Utterbackia imbecillis	paper pondshell	
	Subfamily Ambleminae	
Amblema plicata	threeridge	
Elliptio dilatata	spike	ST
Fusconaia flava	Wabash pigtoe	
Megalonaias nervosa	washboard	
Quadrula pustulosa	pimpleback	
Quadrula quadrula	mapleleaf	
Tritogonia verrucosa	pistolgrip	
Uniomerus tetralasmus	pondhorn	
	Subfamily Lampsilinae	
Lampsilis cardium	plain pocketbook	
Lampsilis siliquoidea hydiana	Louisiana fatmucket	
Lampsilis teres	yellow sandshell	
Leptodea fragilis	fragile papershell	
Ligumia subrostrata	pondmussel	
Potamilus alatus	pink heelsplitter	
Potamilus ohiensis	pink papershell	
Toxolasma parvum	lilliput	
Toxolasma texasiensis	Texas lilliput	
Truncilla donaciformis	fawnsfoot	
Truncilla truncata	deertoe	

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Seth Feaster, Karl Cates and Press Release December 10, 2019 Read More ...

IEEFA report: Dim future for Illinois Basin coal

Customer base eroding for domestic and export markets; Regional industry will be gone in 20 years

(https://ieefa.org/wp-content/uploads/2019/12/2019-12-10-IB-mine-map-sample-360x216.jpg)December 10, 2019 (IEEFA U.S.) – The Illinois Coal Basin, one of the most important coal-producing regions in the U.S., will likely see declining production and mine closures as the industry continues to contract in the wake of coal-fired power plant retirements and falling exports, concludes a report published today (https://ieefa.org/wp-content/uploads/2019/12/Dim-Future-for-Illinois-Basin-Coal_December-2019.pdf) by the Institute for Energy Economics and Financial Analysis.

The report, Dim Future for Illinois Basin Coal (https://ieefa.org/wp-content/uploads/2019/12/Dim-Future-for-Illinois-Basin-Coal_December-2019.pdf), details how coal companies in Illinois, Indiana, and Kentucky, which are already facing challenging prospects, will most likely fade away over the next two decades. A significant number of the coal-fired power plants supplied by the three-state Basin are already scheduled to be shut down by utilities while others are being run less and less often, trends that will likely continue.

By 2024, at least 15 U.S. plants that buy Illinois Basin coal will be fully or partially retired

"From the beginning of 2019 through 2024, at least 15 American plants that buy Illinois Basin coal—in Alabama, Florida, Georgia, Indiana, Kentucky, North Carolina and Tennessee—will be fully or partially retired," said Seth Feaster, an IEEFA data analyst and lead author of the report. "That number, which reflects formal announcements by utilities, is likely to grow as the economics of coal-fired generation continue to deteriorate relative to renewables and gas."

"Meanwhile, demand for Illinois Basin coal is shrinking in key overseas markets too, a trend driven by market forces similar to those at work in the U.S.: foreign competition, and increasingly attractive forms of alternative power generation," Feaster said.

THE REPORT OFFERS A COMPANY-BY-COMPANY OVERVIEW OF THE ILLINOIS BASIN COAL INDUSTRY, noting the coal-mining companies that stand to be affected include (in order of production level): Alliance Resource Partners, Murray Energy and its partner Foresight Energy, Peabody Energy, Hallador, Arch Coal and White Stallion.

IEEFA also notes that the rising number of mine idlings or closures in the past year or so by Alliance, Foresight/Murray, and Peabody may be insufficient to match falling demand from power plants or declines in exports in the wake of recent diminishing international market prices.

Report conclusions:

- The Illinois Basin's customer base in the U.S. continues to shrink as utilities move toward other forms of generation.
- Export-market demand is trending downwards and will continue to do so because the same policy and market forces at work in the U.S. are also transforming power-generation business models in other countries and regions.
- More Illinois Basin mines will close in the months and years ahead as the coal industry continues its structural and permanent decline.
- Communities and areas that prepare for and are proactive in embracing the energy transition will fare best.

THE REPORT URGES POLICYMAKERS IN ILLINOIS, INDIANA AND KENTUCKY TO PREPARE FOR IMPACTS on industry workers and local households, community tax bases, businesses and the regional economy as a whole, as well as provide leadership and sound policy initiatives to take advantage of the changes that are taking place in the energy industry.

Full report: Dim Future for Illinois Basin Coal: Market Forces and Shifting Preferences Are Eroding Customer Base Domestically and Abroad (https://ieefa.org/wp-content/uploads/2019/12/Dim-Future-for-Illinois-Basin-Coal_December-2019.pdf)

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About IEEFA

The Institute for Energy Economics and Financial Analysis (IEEFA) conducts global research and analyses on financial and economic issues related to energy and the environment. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy.

Posted in: Alliance Resource Partners, Arch Coal, Commentary, Energy Investment Trends, Energy Policy, Illinois, Illinois Basin Coal, Indiana, Kentucky, Natural Gas, Newsletter Daily, Peabody, Press Releases, Renewables, Stranded Assets, Transition, US Coal Markets, Utility trends

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Commercial Fishing in the Big Muddy River Memo
Prepared by PRN and SC
Information from the IDNR Division of Fisheries Annual Commercial Catch Reports (obtained via FOIA) for 2013 through 2018 (2017 most recent compilation provided)

Reported number of full-time and part-time commercial fishermen actively engaged in commercial fishing in the following years:

YEAR	Full-Time	Part-Time	Big Muddy River Reported Catch in Pounds
2013		3	11,179
2014	1	3	9,737
2015		2	7,210
2016		1	10,382
		*13	*4,983
2017		6	14,720
		*18	*8,884

*New Category of Recreational commercial fishermen actively engaged in commercial fishing

Exhibit 389C

From:	Andrew Rehn
To:	EPA.PublicHearingCom; Lieberoff, Barb
Cc:	Albert Ettinger; Cindy Skrukrud; Sabrina Hardenbergh; Jan thomas; Cameron J. Smith; Jane Cogie; Amanda Pankau; Jann.Stephen@epa.gov
Subject:	[External] (Exhibits 3/4) IL0077666 Pond Creek Mine Post-Hearing Comments from PRN, SC, SAFE
Date:	Friday, January 17, 2020 4:00:47 PM
Attachments:	Exhibit_N William 2018 pH 007.pdf Exhibit_L PCB 2007-135 George Strunk vs. Williamson Energy Pond Creek Mine Document-59512.pdf Exhibit_K PCB 2007-145 R Grant D Grant P Wallace vs Pond Creek Mine Document-57620.pdf Exhibit_M O2 2019 Groundwater Monitoring Pond Creek.pdf Exhibit_O Big Muddy Conductance, Temp, DO.pdf Exhibit_J Galloway Report 1994.pdf Exhibit_P Pond Creek Mine August 2019 IEPA Inspection Report.pdf

Please find the Exhibits J-P attached.

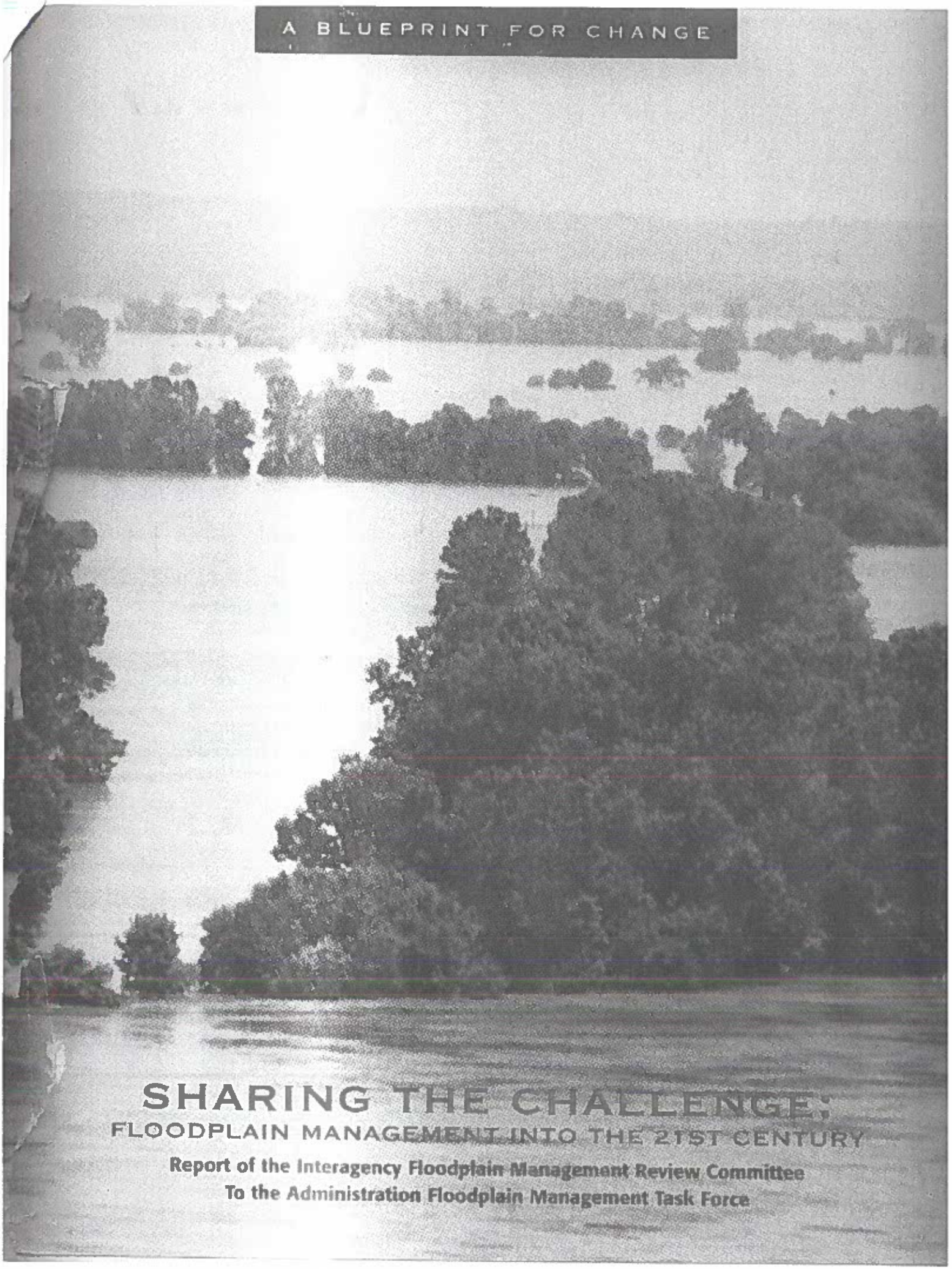
On Fri, Jan 17, 2020 at 3:56 PM Andrew Rehn <arehn@prairierivers.org> wrote:

> Dear Ms. Lieberoff and other Illinois EPA officials;
>
> On behalf of Prairie Rivers Network, Sierra Club and Southern Illinoisans Against Fracturing Our Environment, attached are post-hearing comments regarding the proposed NPDES Permit IL0077666 for the Pond Creek mine. As these comments will explain, the proposed permit plainly cannot be legally granted by the Illinois Environmental Protection Agency (IEPA) based on the current record. Please do not hesitate to reach out to us for further clarification.
>
> In 4 emails following this one, I will be including the exhibits to this comment letter. Please include those in the record with this submission.
>
> Thank you,
> Andrew
>
> --
> **Andrew Rehn**
> *Water Resources Engineer, Prairie Rivers Network*
> 1605 South State St, Suite 1, Champaign, IL 61820
>
> tel: 217.344.2371 x 8208
> www.prairierivers.org
> facebook | twitter

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A BLUEPRINT FOR CHANGE



SHARING THE CHALLENGE:
FLOODPLAIN MANAGEMENT INTO THE 21ST CENTURY

Report of the Interagency Floodplain Management Review Committee
To the Administration Floodplain Management Task Force

THE FLOOD

Then God, our Lord, hindered the work with a mighty flood of the great river, which at that time -- about the eighth or tenth of March [of 1543] -- began to come down with an enormous increase of water: Which in the beginning overflowed the wide level ground between the river and cliffs; then little by little it rose to the top of the cliffs. Soon it began to flow over the fields in an immense flood, and as the land was level without any hills there was nothing to stop the inundation.

...The flood was 40 days in reaching its greatest height, which was the 20th of April, and it was a beautiful thing to look upon the sea where there had been fields, for on each side of the river the water extended over twenty leagues of land, and all this area was navigated by canoes, and nothing was seen but the top of the tallest trees...

...By the end of May the river had returned within its banks.

Garciliaso de la Vega describing the DeSoto Expedition
On the banks of the Mississippi River near Tunica, Mississippi
History of Hernando DeSoto, Lisbon, 1605

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A BLUEPRINT FOR CHANGE

SHARING THE CHALLENGE: FLOODPLAIN MANAGEMENT INTO THE 21ST CENTURY

Report of the
Interagency Floodplain Management Review Committee

To the
Administration Floodplain Management Task Force

WASHINGTON, D.C.
JUNE 1994

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EXECUTIVE OFFICE OF THE PRESIDENT
INTERAGENCY FLOODPLAIN MANAGEMENT REVIEW COMMITTEE
WASHINGTON, D.C. 20503

June 30, 1994

TO: The Administration Floodplain Management Task Force
T. J. Glauthier, Associate Director, Office of Management and Budget
Kathleen McGinty, Director, White House Office of Environmental Policy
James R. Lyons, Assistant Secretary of Agriculture for Natural Resources

SUBJECT: Final Report

Forwarded herewith for your consideration is, *Sharing the Challenge: Floodplain Management into the 21st Century,* the final report of the Interagency floodplain Management Review Committee.

In January 1994 you assigned the Review Committee the mission to delineate the major causes and consequences of the 1993 Midwest flooding; to evaluate the performance of existing floodplain management and related watershed management programs. The Review Committee also was to make recommendations to the Task Force on changes in current policies, programs, and activities of the federal government that most effectively would achieve risk reduction, economic efficiency, and environmental enhancement in the floodplain and related watersheds.

The report provides the Review Committee's findings and recommendations for action. The thesis of the report is straightforward. Floods will continue to occur. The goals for floodplain management are clear. The means to carry out effective floodplain management exist today but need improvement and refocusing. It is now time to organize a national effort to conduct effective and efficient floodplain management. It is time to share responsibility and accountability for accomplishing floodplain management among all levels of government and with the citizens of the nation.

I would emphasize that the report represents the views of the Review Committee and is based on its research and interactions with federal, state and local officials, businesses, interest groups, and individuals in and outside the upper Mississippi River Basin. It does not necessarily represent the views of the agencies represented on the Review Committee or the views of the Administration. It is now up to the Administration to determine which of the recommendations and actions should be implemented on what schedule.

The Review Committee appreciates the support and guidance that you provided over the past six months as well as the opportunity to participate in such an interesting and important endeavor.

Gerald E. Galloway
Brigadier General, U.S. Army
Executive Director

Thanks

The Review Committee acknowledges with deep appreciation the assistance and thoughtful advice received from many federal, state, and local agencies, organizations, and individuals contacted during the course of this review. The collective wisdom, insights and experiences of these many people provided the Review Committee with an understanding of the problems and challenges of both living in and managing the floodplain. The Review Committee owes a debt of gratitude to those who set up and facilitated the public outreach sessions and the visits to flood affected areas. There will never be a substitute for seeing the problem area or talking to someone who has been through a flood.

Far too many people contributed to the effort to name them all individually. Because of their special contributions, however, the Review Committee would like to give special thanks to several groups and individuals. The leadership of the Administration Floodplain Management Task Force -- T. J. Glauthier, Associate Director, Office of Management and Budget; Kathleen McGinty Director, White House Office for Environmental Policy; James R. Lyons, Assistant Secretary of Agriculture for Natural Resources -- gave the Committee its charge and guided it along its path. Kathryn Way, White House Domestic Policy Council assisted in coordinating efforts with the states. Bruce Long, OMB, and Will Stelle, White House Office for Environmental Policy provided both expertise and day-to-day shepherding of committee activities, Mark Schaefer, White House Office of Science and Technology Policy, assisted with SAST. Ray Clark, Patti Leppert-Slack and Kathleen Gallagher, Council on Environmental Quality, provided substantive insights and moral and administrative support. The White House Council of Economic Advisors sponsored Economics Advisory Group with Erik Lichtenberg, Chair; Jon Goldstein, USFWS; Jim Schaub, USDA; Peter Kuch, EPA; Robert Stearns, Department of the Army; and Norm Starler, OMB, served as an invaluable sounding board. Margaret Siegel, the National Governors Association, facilitated contacts with the flood-affected and other interested states. Connie Hunt, the World Wildlife Fund, sponsored three in-basin workshops on use of the floodplain. Chris Brescia, MARC 2000, facilitated access to the agriculture and river communities. W. H. Klingner and John Rob, Upper Mississippi Flood Control Association, provided entry to the many levee and drainage districts of the basin. Tom Waters, the Missouri Levee and Drainage District Association, offered a steady stream of information about the Missouri River levee situation. The Universities Council on Water Resources, Duane Baumann, gathered a team of distinguished academicians -- Ray Burby, Shirley Laska, Luna Leopold, Mary Fran Myers, Leonard Shabman, and Gilbert White -- to provide their views on floodplain management. Doug Plasencia and Larry Larson, Association of State Floodplain Managers, and Jon Kusler, Association of State Wetland Managers, shared their experiences and opened their files and their membership to the Review Committee. The nine flood state governors and their representatives facilitated and guided the Committee's extensive contacts within the states: Al Grosoboll, Don Vonnahme and Marueen Cracker, Illinois; General Harold (Tommy) Thompson and LTC Tom Tucker, Iowa; Cindy Luxem, Kansas; Todd Johnson and Jim Franklin, Minnesota; Jerry Uhlman and Jill Friedman, Missoui; Dayle Williamson and Brian Dunnigan, Nebraska; Dave Sprynczynatyk and Jeff Klein, North Dakota; Gary Whitney, South Dakota; Lee Conner and Diane Kleiboer, Wisconsin. Holly Stoerker, Upper Mississippi River Basin

Association, and Richard Oppek, Missouri River Basin Association invited the Review Committee to participate in the meetings of the Associations and shared their years of experience.

Throughout the study process, the Review Committee benefited from the advice and information provided by many members of Congress, by their staff members, and by the key committee staffs.

The Review Committee would also like to thank the many Washington and basin based organizations that provided assistance and advice, especially the American Farm Bureau Federation, the American Society of Civil Engineers, the Association of State Flood and Stormwater Managers, the Association of American State Geologists, the Environmental Defense Fund, the Illinois Farm Bureau Federation, the McKnight Foundation, the National Association of Conservation Districts, the National Corn Growers Association, the National Waterways Conference, the National Wildlife Federation, the Natural Disaster Coalition, the Nature Conservancy, and the Sierra Club.

The individuals within federal agencies who served as advisors on agency activities and as focal points to facilitate information exchange with the Review Committee deserve special note: Army, John Zirschky; DOI, Michelle Altemus and Russ Earnest; USDA, Tom Hebert, Oleta Fitzgerald, and Eric Olsen; EPA, Dick Sanderson and David Davis; FEMA, Dick Moore, Dick Krimm, Jane Bullock, Morrie Goodman, and Martha Braddock; HHS, RADM Frank Young; HUD, Truman Goins; DOT, Susan Gaskins; DOL, Ed Flynn; NWS, Eugene Stallings; and USACE, MG Stan Genega, Hugh Wright, and Jerry Peterson.

During the preparation of any report, invaluable assistance is provided by the individuals who go beyond 'the call of duty.' The Review Committee would like to extend its thanks to Paul Alberti, Don Barnes, Whalen Blair, Patti Cogdell, Gary Dyhouse, Mary Lou East, Brian Hyde, George Johnson, Jim Kazel, Stuart Kasden, John Kerr, David Lawson, Andy Manale, Kermit Mann, David May, John McShane, Jeanne Melanson, Mark Merritt, Matt Miller, Marty Reuss, Kyle Schilling, Josephine Scott, Eugene Stakhiv, Kevin Tonat, Nancy Yeager, Chet Worm, Larry Zensinger, and Don Zochi.

Thanks are due to the National Park Service, the USACE, the USDA and the Missouri Department of Conservation for the photographs used in the report.

Wile the above groups and individuals have provided much valuable advice, the Review Committee bears sole responsibility for all views expressed in this report.

SHARING THE CHALLENGE: FLOODPLAIN MANAGEMENT INTO THE 21ST CENTURY

The Report of the Interagency Floodplain Management Review Committee

ABSTRACT

June 1994

The Midwest Flood of 1993 was a significant hydrometeorological event. In some areas it represented an unusual event; in most others, however, it was just another of the many that have been seen before and will be seen again. Flood flows similar to those experienced by most of the Midwest can occur at any time. During the decade ending in 1993, average annual flood damages in the United States exceed $3 billion. Flood damages are not a national problem.

Excessive rainfall, which produced standing water, saturated soils, and overland flow, caused major damages to upland agriculture and some communities. In turn, runoff from this rainfall created, throughout the basin, flood events that became a part of the nation's 1993 TV experience. Damages overall were extensive: between $12 billion and $16 billion that can be counted, and a large amount in unquantifiable impacts on the health and well-being of the population of the Midwest.

Human activities in the floodplains of the Midwest over the last three centuries have placed people and property at risk. Local and federal flood damage reduction projects were constructed to minimize the annual risk, and, during the 1993 flood, prevented nearly $20 billion in damages. Some of these programs, however, attracted people to high risk areas and created greater exposure to future damages. In addition, flood control, navigation, and agricultural activities severely reduced available floodplain habitat and compromised natural functions upon which fish and wildlife rely.

Over the last 30 years the nation has learned that effective floodplain management can reduce vulnerability to damages and create a balance among natural and human uses of floodplains and their related watersheds to meet both social and environmental goals. The nation, however, has not taken full advantage of this knowledge. The United States simply has lacked the focus and incentive to engage itself seriously in floodplain management. The 1993 flood has managed to focus attention on the floodplain and has provided the incentive for action.

The Interagency Floodplain Management Review Committee proposes a better way to manage the floodplains. It begins by establishing that all levels of government, all businesses and all citizens have a stake in properly managing the floodplain. All of those who support risky behavior, either directly or indirectly, must share in floodplain management and in the costs of reducing that risk. The federal government can lead by example; but state and local governments must manage their own floodplains. Individual citizens must adjust their actions to the risk they face and bear a greater share of the economic costs.

The Review Committee supports a floodplain management strategy of, sequentially, avoiding inappropriate use of the floodplain, minimizing vulnerability to damage through both structural and nonstructural means, and mitigating flood damages when they do occur.

By controlling runoff, managing ecosystems for all their benefits, planning the use of the land and identifying those areas at risk; many hazards can be avoided. Where the risk cannot be avoided, damage minimization approaches, such as elevation and relocation of buildings or construction of reservoirs or flood protection structures, are used only when they can be integrated into a systems approach to flood damage reduction in the basin. When floods occur, impacts on individuals and communities can be mitigated with a flood insurance program that is funded by those who are protected. Full disaster support for those in the floodplain is contingent on their participation in these self-help mitigation programs. Measures that internalize risks reduce the moral hazard associated with full government support.

To ensure a long-term, nationwide approach to floodplain management, the Review Committee proposes legislation

to develop and fund a national Floodplain Management Program with principal responsibility and accountability at the state level. It also proposes revitalization of the federal Water Resources Council to better coordinate federal activities, limited restoration of some basin commissions for basin-wide planning, and issuance of a Presidential Executive Order requiring federal agencies to follow floodplain management principles in the execution of their programs.

The upper Mississippi River Basin includes both individually authorized federal flood damage reduction projects and levees built by local groups and individuals. This pattern of development is unique and requires a unique approach. The Review Committee proposes a plan to identify and evaluate the needs of the basin, to ensure the integrity of a flood damage reduction system that meets the needs of the basin, and to restore natural floodplain functions on appropriate lands.

The nation knows where to go with floodplain management and how to get there. This report provides a map showing the shortest route to success. The nation now must take the actions required to do so.

REPORT OF THE INTERAGENCY FLOODPLAIN MANAGEMENT REVIEW COMMITTEE
to the
ADMINISTRATION FLOODPLAIN MANAGEMENT TASK FORCE

EXECUTIVE SUMMARY

The time has come to fact the fact that this Nation can no longer afford the high costs of natural disasters. We can no longer afford the economic costs to the American taxpayer, nor can we afford the social costs to our communities and individuals.

James L. Witt
Director, Federal Emergency Management Agency
Testimony before Congress, October 27, 1993

FLOODPLAINS AND THE NATION

The upper Mississippi and Missouri rivers and their tributaries have played a major role in the nation's history. Their existence was critical to the growth of the upper Midwest region of the United States and fostered the development of major cities and a transportation network linking the region to the rest of the world. The floodplains of these rivers provide some of the most productive farmland in the country. They offer diverse recreational opportunities and contain important ecological systems. While development of the region has produced significant benefits, it has not always been conducted in a wise manner. As a result, today the nation faces three major problems:

First, as the Midwest Flood of 1993 has shown, people and property remain at risk, not only in the floodplains of the upper Mississippi River Basin, but also throughout the nation. Many of those at risk do not fully understand the nature and the potential consequences of that risk; nor do they share fully in the fiscal implications of bearing that risk.

Second, only in recent years has the nation come to appreciate fully the significance of the fragile ecosystems of the upper Mississippi River Basin. Given the tremendous loss of habitat over the last two centuries, many suggest that the nation now face severe ecological consequences.

Third, the division of responsibilities for floodplain management among federal, state, tribal and local governments needs clear definition. Currently, attention to floodplain management varies widely among and within federal, state, tribal and local governments.

The Interagency Floodplain Management Review Committee proposes a better way to manage the nation's floodplains. This report not only describes the nature and extent of the 1993 flooding and government efforts to cope with the event but also presents a blueprint for change.

This blueprint is directed at both the upper Mississippi River Basin and the nation as a whole. Its foundation is a sharing of responsibilities and accountability among all levels of the government, business, and private citizens. It provides for a balance among the many competing uses of the rivers and their floodplains; it recognizes, however, that all existing activities in the floodplain simply cannot be discarded as inappropriate. Implementing this approach, the Review Committee believes, will bring about changes necessary to reduce flood vulnerability to both the infrequent major flood events and the more frequent smaller ones. Implementation also will reduce the environmental, social, and economic burdens imposed by current conditions on both public and private sectors.

SHARING THE CHALLENGE - FEDERAL, STATE, TRIBAL AND LOCAL GOVERNMENTS, BUSINESSES, CITIZENS

Since passage of the Flood Control Act of 1936, the federal government has dominated the nation's flood damage reduction efforts and as a result, the nation's floodplain management activity. Structural programs were deemed important and were also the principal sources of funds for any efforts to stem the rising tide of flood losses. In recent years, the federal government has begun to support nonstructural approaches. Many states, tribes, and local governments have developed and carried out floodplain management efforts that both reduced flood damages and enhanced the natural functions of floodplains. In carrying out these programs, however, they have been hampered by uncoordinated and conflicting federal programs, policies, regulations and guidelines that have hindered efficient floodplain management. Some state and local governments have not been as active in floodplain management. With the federal government assuming the dominant role and funding most ecosystem restoration, flood damage reduction, and flood recovery activities, the incentive has been limited for many state, tribal and local governments, businesses, and private citizens to share responsibility for making wise decisions concerning floodplain activity. Now is the time to:

- Share responsibility and accountability for accomplishing floodplain management among all levels government and with all citizens of the nation. The federal government cannot go it alone nor should it take a dominant role in the process.

- Establish, as goals for the future, the reduction of the vulnerability of the nation to the dangers and damages that result from floods and the concurrent and integrated preservation and enhancement of the natural resources and functions of floodplains. Such an approach seeks to avoid unwise use of the floodplain, to minimize vulnerability when floodplains must be used, and to mitigate damages when they do occur.

- Organize federal programs to provide the support and the tools necessary for all levels of government to carry out and participate in effective floodplain management.

COMMITTEE FINDINGS:

In conducting the review, the Committee divided its findings into two areas; the Midwest Flood of 1993, and Federal, State, Tribal, and Local Floodplain Management.

The Midwest Flood of 1993

In reviewing the Midwest Flood of 1993, the Committee found that:

- The Midwest Flood of 1993 was a hydrometeorological event unprecedented in recent times. It was caused by excessive rainfall that occurred throughout a significant section of the upper Mississippi River Basin. The damaging impacts of this rainfall and

related runoff were felt both in upland areas and in the floodplains. Pre-flood rainfall saturated the ground and swelled tributary rivers. Subsequent rains quickly filled surface areas, forcing runoff into the lower lands and creating flood conditions. The recurrence interval of the flood ranged from less than 100 years at many locations to near 500 years on segments of the Mississippi River from Keithsburg, Illinois, to above St. Louis, Missouri, and on segments of the Missouri River from Rulo, Nebraska, to above Hermann, Missouri. At 45 U.S. Geological Survey (USGS) gaging stations, the flow levels exceeded the 100-year mark. The duration of the flood added to its significance. Many areas were under water for months.

- Rainfall and floods like the 1993 event will continue to occur. Floods are natural repetitive phenomena. Considering the nation's short history of hydrologic record-keeping as well as the limited knowledge of long-term weather patterns, flood recurrence intervals are difficult to predict. Activities in the floodplain, even with levee protection, continue to remain at risk.

- The loss of the wetlands and upland cover and the modification of the landscape throughout the basin over the last century and a half significantly increased runoff. Most losses occurred prior to 1930, but some are related to more recent drainage, flood damage reduction, and navigation development. Although upland watershed treatment and restoration of upland and bottomland wetlands can reduce flood stages in more frequent floods (25 years and less) it is questionable whether they would have significantly altered the 1993 conditions.

- Human activity throughout the basin has caused significant loss of habitat and ecosystem diversity. Flood damage reduction and navigation works and land uses practices have altered bottomland habitat adversely.

- The costs to the nation from the flood were extensive. Thirty-eight deaths can be attributed directly to the flood and estimates of fiscal damages range from $12 billion to 16 billion. Agriculture accounted for over half of the damages. More than 70 percent of the crop disaster assistance payments were made to counties in upland areas where ground saturation prevented planting or killed the crop. Nearly 50 percent of the approximately 100,000 homes damaged, suffered losses due to groundwater or sewer backup as opposed to riverine flooding. Flood response and recovery operations cost the nation more than $6 billion. In addition many costs can not yet be quantified. Impacts on businesses in out of the basin have not been calculated. Tax losses to governments are unknown. The impacts of the flood on the population's physical and mental well-being are just being identified and are of concern.

- Flood damage reduction projects and floodplain management programs, where implemented, worked essentially as designed and significantly reduced the damages to population centers, agriculture, and industry. It is estimated that reservoirs and levees built by the U.S. Army Corps of Engineers (USACE), prevented more than $19 billion in potential damages. Large areas of Kansas City and St. Louis were spared the ravages of flood, although several suburbs suffered heavy damages. Watershed projects built by the Soil Conservation Service saved an estimated additional $400 million. Land use controls required by the National Flood Insurance Program (NFIP) and state floodplain management programs reduced the number of structures at risk throughout the basin.

- Many locally constructed levees breached and/or overtopped. Frequently, these events resulted in considerable damage to the land behind the levees through scour and deposition.

- Flooding during the 1993 event would have covered much of the floodplains of the main stem lower Missouri and upper Mississippi rivers whether or not levees were there. Levees can cause problems in some critical reaches by backing water up on other levees or lowlands. Locks and dams and other navigation related structures did not raise flood heights. For more frequent floods -- less flow -- navigation dikes may cause some minor increase in flood heights.

Federal, State, Tribal and Local Floodplain Management

The Review Committee examined the structure of current federal programs, relationships among federal, state, tribal and local governments, the performance of various programs during and after the flood, and the after action reports stemming from these activities. The Review Committee reached the following conclusions:

- The division of responsibilities floodplain management activities among and between federal, state, tribal, and local governments needs to be clearly defined. Within the federal system, water resources activities in general flood and floodplain management in particular need better coordination. State and local governments must have a fiscal stake in floodplain management; without this stake, few incentives exist for them to be fully involved in floodplain management. State governments must assist local governments in dealing with federal programs. The federal government must set the example in floodplain management activities.

- The National Flood Insurance Program (NFIP) needs improvement. Penetration of flood insurance into the target market -- floodplain occupants -- is very low, 20-30 percent. Communities choosing not to participate in the NFIP continue to receive substantial disaster assistance. Provision of major federal disaster assistance to those without insurance creates a perception with many floodplain residents that purchase of flood insurance is not a worthwhile investment. The mapping program is underfunded and needs greater accuracy and coverage. Some requirements within the program that vary from disaster to disaster need stabilization.

- The principal federal water resources planning document, *Principles and Guidelines,* is outdated and does not reflect a balance among the economic, social, and environmental goals of the nation. This lack of balance is exacerbated by a present inability to quantify, in monetary terms, some environmental and social impacts. As result, these impacts are frequently understated or omitted. Many critics of *Principles and Guidelines* see it as biased against nonstructural approaches.

- Existing federal programs designed to protect and enhance the floodplain and watershed environment are not as effective as they should be. They lack support, flexibility and funding, and are not well coordinated. As a result, progress in habitat improvement is slow.

- Federal pre-disaster, response, recovery and mitigation programs need streamlining but are making marked progress. The nation clearly recognized the aggressive and caring response of the government to the needs of flood victims, but coordination problems that developed need to be addressed. Buyouts of floodprone homes and damaged lands make considerable inroads in reducing future flood losses.

- The nation needs a coordinated strategy for effective management of the water resources of the upper Mississippi River Basin. Responsibility for integrated navigation, flood damage reduction and ecosystem management is divided among several federal programs.

- The current flood damage reduction system in the upper Mississippi River Basin represents a loose aggregation of federal, local, and individual levees and reservoirs. This aggregation does not ensure the desired reduction in the vulnerability of floodplain activities to damages. Many levees are poorly sited and will fail again in the future. Without change in current federal programs, source of these levees will remain eligible for post-disaster support. Levee restoration programs need greater flexibility to provide for concurrent environmental restoration.

- The nation is not using science and technology to full advantage in gathering and disseminating critical water resources management information. Opportunities exist to provide information needed to better plan the use of the floodplain and to operate during crisis conditions.

COMMITTEE RECOMMENDATIONS

The Review Committee developed recommendations in consonance with the proposed goals:

- To ensure that the floodplain management effort is organized for success, the President should:

  Propose enactment of a Floodplain Management Act which establishes a national model for floodplain management, clearly delineates federal, state, tribal, and local responsibilities, provides fiscal support for state and local floodplain management activities, and recognizes states as the nation's principal floodplain managers;

  Issue a revised Executive Order clearly defining the responsibility of federal agencies to exercise sound judgement in floodplain activities; and

  Activate the Water Resources Council to coordinate federal and federal-state-tribal activities in water resources; as appropriate, reestablish basin commissions to provide a forum for federal-state-tribal coordination on regional issues.

- To focus attention on comprehensive evaluation of all federal water project and program effects, the President should immediately establish environmental quality and national economic development as co-equal objectives of planning conducted under the *Principles and Guidelines*. *Principles and Guidelines* should be revised to accommodate the new objectives and to ensure full consideration of nonstructural alternatives.

- To enhance coordination of project development, to address multiple objective planning, and to increase customer service, the Administration should support collaborative efforts among federal agencies and across state, tribal, and local governments.

- To ensure continuing state, tribal and local interest in floodplain management success, the Administration should provide for federal, state, tribal, and/or local cost-sharing in pre-disaster, recovery, response, and mitigation activities.

- To provide for coordination of the multiple federal programs dealing with watershed management, the Administration should establish an Interagency Task Force to develop a coordination strategy to guide these actions.

- To take full advantage of existing federal programs which enhance the floodplain environment and provide for natural storage in bottomlands and uplands, the Administration should:

  Seek legislative authority to increase post-disaster flexibility in the execution of the land acquisition programs;

  Increase environmental attention in federal operation and maintenance and disaster recovery activities;

  Better coordinate the environmentally-related land interest acquisition activities of the federal government; and

  Fund, through existing authorities, programmatic acquisition of needed lands from willing sellers.

- To enhance the efficiency and effectiveness of the National Flood Insurance Program, the Administration should:

  Take vigorous steps to improve the marketing of flood insurance, enforce lender compliance rules, and seek state support of insurance marketing;

  Reduce the amount of post-disaster support to those who were eligible to buy insurance but did not to that level needed to provide for immediate health, safety, and welfare; provide a safety net for low income flood victims who were unable to afford flood insurance;

  Reduce repetitive loss outlays by adding a surcharge to flood insurance policies following each claim under a policy, providing for mitigation insurance riders, and supporting other mitigation activities;

Require those who are behind levees that provide protection against less than the standard project flood discharge to purchase actuarially based insurance;

Increase the waiting period for activation of flood insurance policies from 5 to 15 days to avoid purchases when flooding is imminent;

Leverage technology to improve the timeliness, coverage, and accuracy of flood insurance maps; support map development by levies on the policy base and from appropriated funds because the general taxpayer benefits from this program; and

Provide for the purchase of mitigation insurance to cover the cost of elevating, demolishing, or relocating substantially damaged buildings.

- To reduce the vulnerability to flood damages of those in the floodplain, the Administration should:

Give full consideration to all possible alternatives for vulnerability reduction, including permanent evacuation of floodprone areas, flood warning, floodproofing of structures remaining in the floodplain, creation of additional natural and artificial storage, and adequately sized and maintained levees and other structures;

Adopt flood damage reduction guidelines based on a revised *Principles and Guidelines* which would give full weight to social, economic, and environmental values and assure that all vulnerability reduction alternatives are given equal consideration; and

Where appropriate, reduce the vulnerability of population centers and critical infrastructure to the standard project flood discharge through use of floodplain management activities and programs.

- To ensure that existing federally constructed water resources projects continue to meet their intended purposes and are reflective of current national social and environmental goals, the Administration should require periodic review of completed projects.

- To provide for efficiency in operations and for consistency of standards, the Administration should assign principal responsibility for repair, rehabilitation, and construction of levees under federal programs to the U.S. Army Corps of Engineers.

- To ensure the integrity of levee and the environmental and hydraulic efficiencies of the floodplain, states and tribes should ensure proper siting, construction, and maintenance of non-federal levees.

- To capitalize on the successes in federal, state, tribal, and local pre-disaster, response, recovery, and mitigation efforts during and following the 1993 flood and to Streamline future efforts, the Administration should:

Through the NFIP Community Rating System encourage states and communities to develop and implement floodplain management and hazard mitigation plans;

Provide funding for programmatic buyouts of Structures at risk in the floodplain;

Provide states the option of receiving Section 404 Hazard Mitigation Grants as block grants;

Assign the Director of the Federal Emergency Management Agency responsibility for integrating federal disaster response and recovery operations; and

Encourage federal agencies to use non-disaster funding to support hazard mitigation activities on a routine basis.

- To provide integrated, hydrologic, hydraulic, and ecosystems management of the upper Mississippi River basin, the Administration should:

Establish upper Mississippi River Basin and Missouri River Basin commissions to deal with basin-level program coordination;

Assign responsibility, in consultation with the Congress, to the Mississippi River Commission (MRC), for integrated management of flood damage reduction, ecosystem management, and navigation on the upper Mississippi River and

tributaries; expand MRC membership to include representation from the Department of the Interior; assign MRC responsibility for development of a plan to provide long-term control an maintenance of sound federally built and federally supported levees along the main stems of Mississippi and Missouri rivers; this support would be contingent on meeting appropriate engineering, environmental, and social standards.

Seek authorization from the Congress to establish an Upper Mississippi River and Tributaries project for management of the federal flood damage reduction and navigation activities in the upper Mississippi River Basin;

Establish the upper Mississippi River Basin as an additional national cross-agency Ecosystem Management Demonstration Project; and Charge the Department of the Interior with conducting an ecosystem needs analysis of the upper Mississippi River Basin.

- To provide timely gathering and dissemination of the critical water resources information needed for floodplain management and disaster operations, the Administration should:

Establish an information clearing house at USGS to provide federal agencies and state and local activities the information already gathered by the federal government during and following the 1993 flood and to build on the pioneering nature of this effort; and

Exploit science and technology to support monitoring, analysis, modeling, and the development of decision support systems and geographic information systems for floodplain activities.

STRUCTURE OF THE REVIEW

Throughout the spring, summer, and fall of 1993, the people of the United States were faced each night with pictures of the devastation brought on the midwestern United States by the Great Flood of 1993. For nearly six decades, the nation had labored to reduce the impacts of floods, yet the toll in lives lost, homes damaged, and property destroyed was enormous. Why had this happened? What caused the flood? Had human intervention over time exacerbated the situation? What should the nation be doing to prevent a repetition? To answer these questions, the Administration Floodplain Management Task Force, part of the Administration Flood Recovery Task Force headed by Secretary of Agriculture Mike Espy, established the Interagency Floodplain Management Review Committee, a group of 31 professionals assigned to federal agencies with responsibilities in the water resources arena.

The Review Committee conducted its activity from January through June 1994 in Washington and throughout the Midwest. Working through the offices of the governors of the nine flood-affected states, the Review Committee met with state and local officials and visited over 60 locations. The Review Committee also made extensive contacts with federal agencies, interest groups, members of Congress and their staffs and numerous private citizens who expressed an interest in the flood. A part of the Review Committee, the Scientific Assessment and Strategy Team, chartered in November 1993 by the White House, conducted its activities at the EROS Data Center in Sioux Falls, South Dakota, where it developed a major database of flood and basin information.

The report of the Review Committee includes an action plan delineating proposed responsibilities and timelines for execution of the recommendations, a fiscal impact statement, and the preliminary report of the Scientific Assessment and Strategy Team.

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INTRODUCTION

The time has come to face the fact that this Nation can no longer afford the high costs of natural disaster. We can no longer afford the economic costs to the American taxpayer, nor can we afford the social costs to our communities and individuals.

James L. Witt
Director, Federal Emergency Management Agency
Testimony before Congress, October 27, 1993

Throughout the spring, summer, and fall of 1993, the people of the United State were faced with pictures of the devastation wrought on the Midwest by what became know as "The Great Flood of 1993." For nearly six decades, the nation had labored to reduce the impacts of floods, yet within a few months tens of thousands of homes were damaged, and the lives of hundreds of thousands of Americans disrupted. Acre upon acre of some of the nation's richest farmland lay fallow. Why did this happen? What caused the flood? Did human intervention over the years exacerbate the situation? What should the nation be doing to prevent a repetition of the 1993 event? The Administration Floodplain Management Task Force, a part of the Clinton Administration's flood Recovery Task Force, headed by Secretary of Agriculture Mike Espy, established the Interagency Floodplain Management Review Committee to seek answers to these questions and to make recommendations.

The charter of the Review Committee (see Appendix A) assigns it the mission to:

- Delineate the major causes and consequences of the 1993 flooding;

- Evaluate the performance of existing floodplain management and related watershed management programs; and

- Make recommendations to the Task force on changes in current policies, programs, and activities of the federal government that would most effectively achieve risk reduction, economic efficiency, and environmental enhancement in the floodplain and related watersheds.

The Review Committee consisted of federal engineers and physical, social, and biological scientists who contributed technical and institutional knowledge in the fields of flood damage-reduction and river basin ecosystem management. Of the 31 -member Review Committee, 15 members were located in Washington, D.C., and 16 formed the Scientific Assessment and Strategy Team (SAST), which operated from the Earth Resource Observation System (EROS) center at Sioux Falls, South Dakota. The SAST was chartered by the White House in November 1993 "to provide scientific advice and assistance to officials responsible for making decisions with respect to flood recovery in the upper Mississippi River Basin." It was incorporated into the Review Committee in January 1994 to serve as its research arm for scientific analysis. For a full listing of Review Committee members and their parent agencies, see Appendix B.

The Review Committee began its work in January 1994, focusing on federal agency briefings and consultations with other levels of government to gain a better understanding of the complex intergovernmental system of

WHAT IS A FLOODPLAIN?

Floodplains are the relatively low and periodically inundated areas adjacent to rivers, lakes, and oceans. Floodplain lands and adjacent waters combine to form a complex, dynamic physical and biological system that supports a multitude of water resources, living resources, water filtering processes, a wide variety of habitats for flora and fauna, places for recreation and scientific study, and historic and archeological sites. They are also the locus of a variety of human activities, including commerce, agriculture, residence, and infrastructure.

Estimates of the extent of the nation's floodplains vary according to the areas measured. In 1977 the U.S. Water Resources Council estimated that floodplains comprise about 7 percent, or 178.8 million acres of the total area of the United States and its territories.

During the 1993 flood, floodplains along the upper Mississippi and Missouri Rivers became part of the rivers when they were inundated by river stages exceeding channel capacity or the design elevations of flood-control levees or when the levees failed or overtopped.

Adapted, in part, from the draft 1994 Unified National Program for Floodplain Management

responsibilities and decision making in floodplain management. This initial effort was followed by discussions in the nine Midwest states most affected by the flood. Review Committee members met with the governors and their representatives, state flood recovery and mitigation task forces, staffs or relevant congressional committees, staffs of congressional members from the flood states, and interest groups at the national, regional, and local level. In March the Review Committee shifted its focus to outreach visits in the Midwest communities and areas affected by the flood. During this phase of review, the Review Committee visited over 60 communities where county, city, and other local officials and citizens assembled to provide information and insights. The Review committee asked those contacted to share their candid opinions about the best use of flood hazard areas, their visions of the future, and how that vision was changed by the 1993 flood. They were asked about hazard mitigation, floodplain management, and the emergency response plans of the flood-affected communities, with particular regard to whether such plans were useful during or after the flood. All were asked to critique the strengths and weaknesses of federal programs and policies as presently structured, and to discuss what federal and state roles should be in long-term management of floodplains.

Throughout the review process, a steady stream of letters arrived from organizations, interest groups, state and local officials, and from individuals offering information, personal viewpoints, and advice, all of which the Review Committee greatly appreciated.

Following visits to the Midwest, the Review Committee formulated an array of floodplain management options, briefs of which were presented to the Administration Floodplain Management Task force, congressional interests, federal agencies, state officials, and interest groups. Meetings to review the options were held in Washington, D.C.; Kansas City, Missouri; Springfield, Illinois; and Minneapolis, Minneapolis, Minnesota. The Review Committee then developed its recommendations.

FLOODPLAIN MANAGEMENT

Floodplain management is a decision making process whose goal is to achieve appropriate use of the nation's floodplains. Appropriate use is any activity or set of activities compatible with the risk to natural resources (natural and beneficial functions of floodplains) and human resources (life and property).

The history of the nation's floodplain activity is as old as the nation itself and is well chronicled in *An Assessment Report: Floodplain Management in the United States,* prepared in 1992 for the Federal Interagency Floodplain Management Task Force

GOOD NEWS

Although the flood of 1993 ultimately caused major damages throughout the upper Mississippi river basin, many elements of structural and nonstructural flood damage reduction systems put in place by federal, state, and local governments over the years did work and prevented billions of dollars in damages.

During the flood the outreach from all over the country and the world to those suffering the effects of the flooding was most impressive. Thousands filled and stacked sandbags to hold weakening levees; others worked day after day to help clean the homes and businesses of people they had never met. Dry communities adopted those in need. Contributions to assist flood victims poured in from people in many nations. Federal, state, and local disaster teams worked around the clock, month after month, to Mitigate damages and suffering. Those who were recipients of this assistance will never forget this demonstration of true caring. While the Review Committee report will not address all of these successes, they should not be forgotten.

SHARING THE CHALLENGE

Today the nation faces three major problems in floodplain management:

- As the Midwest Flood of 1993 has shown, people and property remain at risk, not only in the floodplains of the upper Mississippi River Basin but also throughout the nation. Many of those at risk neither fully understand the nature and the potential consequences of that risk nor share fully in the fiscal implications of bearing that risk. Over the last thirty years, average annual riverine flood damages have exceeded $2 billion. Over the last ten, they have been over $3 billion. Between 1988 and 1992, the Federal Emergency Management Agency has expended nearly $200 million each year in flood recovery activities.

- Only in recent years has the nation come to appreciate fully the significance of the fragile ecosystems of the upper Mississippi River Basin. Given the tremendous loss of habitat over the last two centuries, many suggest that we now face severe ecological consequences.

A lot of great things have been done that prevented damages and mitigated the damages that did occur... we can't lose sight of this.

Terry Brandstad
Governor Of Iowa
February 16, 1994

∑ The division of responsibilities for floodplain management among federal, state, tribal, and local governments is not clearly defined. As a result, attention to floodplain management varies widely among and within federal, state, tribal, and local governments.

This report provides the Review Committee's findings and recommendations for action. Part I (Chapters 1-3) discusses the flood event and its impacts as well as the effects of human intervention, over time, on the nature of this flood. It also provides insights into the potential for recurrence of the event. Part II (Chapters 4-9) provides a blueprint for the future -- a consensus view of floodplain management for the 21st century. Part III addresses the residual problems with floodplain management in the upper Mississippi River Basin. Part IV (Chapters 11-15) highlights needs in the fields of research, science, and technology; discusses the economic impacts of the report's findings and recommendations; converts the general actions proposed in Chapters 5 to 11 into specific tasks for accomplishment and summarizes the report.

The report contains conclusions, actions, and recommendations. Conclusions represent the Committee's evaluation of its research or analysis related to the Flood of 1993 and its consequences. The Review Committee identified specific approaches required to move forward in floodplain management as actions. Actions may involve resource commitments beyond an agency's baseline posture. Recommendations address problems that the Review Committee believes merit attention; however, the solutions to these problems can be accomplished within agency resources, existing programs, or cooperative efforts.

The thesis of this report is straightforward. The tools to carry out effective floodplain management exist today but need improvement. The goals are clear. It is now time to organize a national effort to conduct effective and efficient floodplain management. It is time to share responsibility and accountability for accomplishing floodplain management among all levels of government and with the citizens of the nation. Working together, the nation's public and private sectors can accomplish the mission.

A MESSAGE FROM ELIZABETH

Dear General Galloway:

My name is Elizabeth Darabcsek. I am eleven years old and in the 5th grade at Christ Prince of Peace School.

I read your article in the newspaper and was interested. I thought I could help.

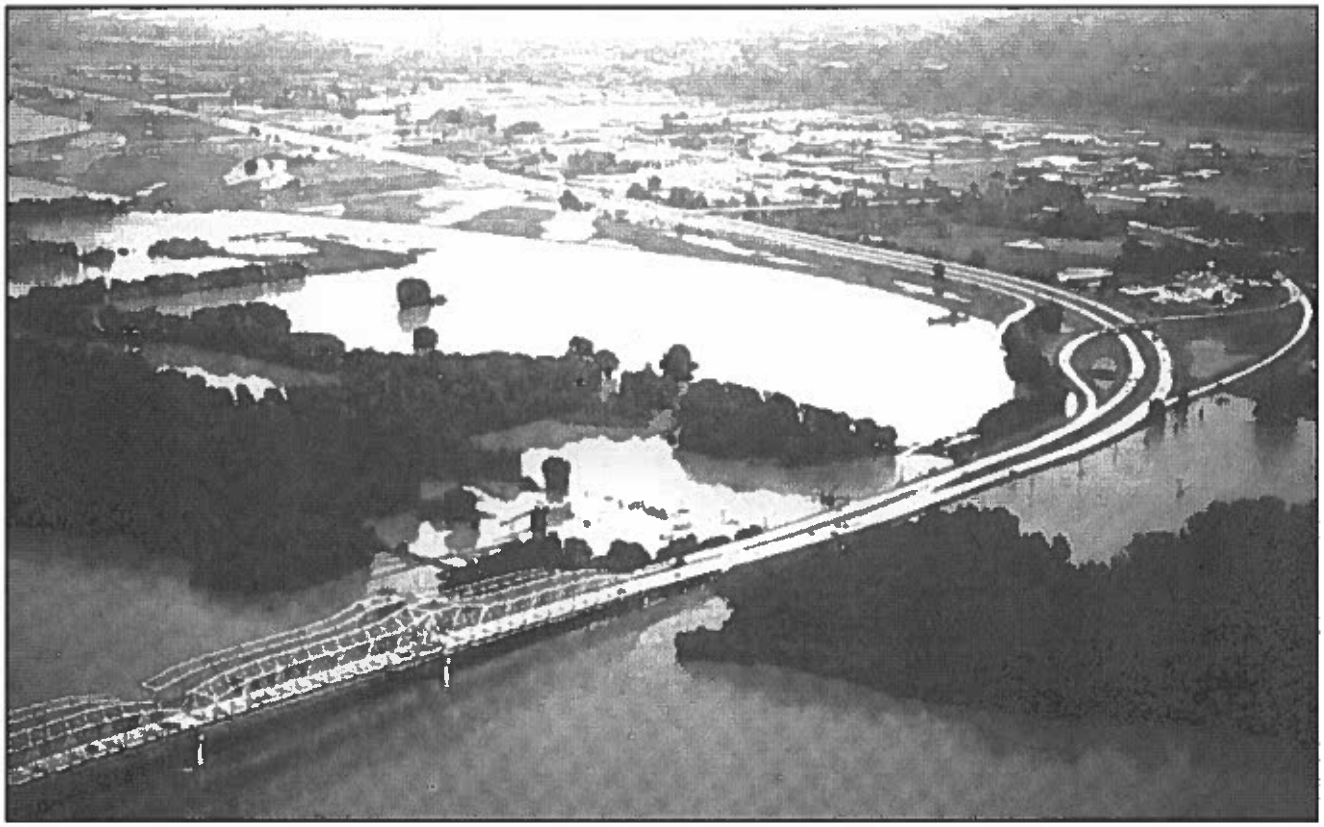
I did a science fair project on floods. I tested levees, back to nature and something I made up, it was a small levee by the river and a larger one a little farther back. The little one held most of the water but not all. The water that was not held back from the small levee would then stay in the space between the big and little levee. The land between the two levees could be used as farm land or other things that could not be badly damaged by a big flood. The damaged levee could be used as the levee in the front (the smaller levee). Therefore, we would only have to build one new levee. This information may not help you, but I wanted you to know that I am trying to help protect our cities too.

Sincerely,
Elizabeth Darabcsek

P.S. Just to tell you, I won first place for my project out of the whole 5th grade.

ENDNOTE

1. Federal Interagency Floodplain Management Task Force. *Floodplain Management in the United States: An Assessment Report.* (Washington, DC: FIFMTF, 1992. USACE and NWS. U.S. Army Corps of Engineers, *Annual Flood Damage Report to Congress for Fiscal Year 1993,* Prepared by the USACE Engineering Division in cooperation with the National Weather Service Office of Hydrology, (Washington, DC: USACE, April 1994); Federal Emergency Management Agency, "Disaster Payment Report," (Washington, DC: FEMA, May 1994).



Part I

THE FLOOD



Chapter 1

THE FLOOD OF 1993

I have visited the Midwest states affected by the '93 Flood many times. Each time I have come away saddened by the enormous loss. I have never seen such devastation. On the other hand, I have never witnessed such tremendous courage as that displayed by individuals who are beginning to rebuild their lives.

Mike Espy
Secretary of Agriculture
Chair, Flood Recovery Task Force
November 10, 1993

Floods are a function of the location, intensity, volume, and duration of rainfall and snowmelt. Other factors include the characteristics of a region's topography, its land-cover conditions, and the capacity of its floodplain to convey or store water. In 1993 a singular combination of these factors resulted in one of the most costly flood disasters in U.S. history. This chapter surveys the damages prevented and the record damages reported in the 1993 flooding of the upper Mississippi River Basin. It also addresses the response and recovery costs for affected towns, cities, and states and for the nation.

THE BASIN

The upper Mississippi River Basin is physiographically, ecologically, and climatologically diverse. Physiographically it ranges from the Rocky Mountains to the Ozark Plateau to the Glaciated Plains and central lowlands. Climatologically it ranges from the semi-arid basins and plains of eastern Colorado and Wyoming to the humid-temperate margins of the Great lakes. Geographic analysis divides this region into 70 terrain units defined by distinct combinations of physical, geologic, soil, ecological, climate, and land-use characteristics. Each unit is subject to different combinations and intensities of hydrologic and geomorphic processes. Individual areas respond differently to storm events and land treatments. The Mississippi River rises at the outlet of Lake Itasca in the lake and forest country of north-central Minnesota and empties into the Gulf of Mexico in the marshy delta just below Head-of-Passes, Louisiana. Over its journey of 2,320 miles, the Mississippi River falls 1,463 feet and drains 1.25 million square miles (sq. mi.) or 41 percent of the land area of the 48 contiguous United States. That portion of the Mississippi River drainage lying above its confluence with the Ohio River and referred to as the upper Mississippi River Basin is the focus of this report. It is in this basin where the deluge of rain and consequent record flooding occurred during the spring, summer and fall of 1993.

Draining all or part of 13 states, the upper Mississippi River Basin encompasses approximately 714,000 square miles. It comprises 57 percent of the total Mississippi River Basin and 23 percent of the area in the contiguous United States. From its source at Lake Itaska, Minnesota, to its confluence with Ohio River at Cairo, Illinois, the Mississippi River courses a distance of 1,366 miles. Its principal tributary is the Missouri River, which drains 529,300 sq. mi. above its mouth at St Louis, Missouri, including 9700 sq. mi. in Canada.

UPPER, LOWER, MIDDLE?

Lending confusion to a discussion of the Mississippi River and its drainage basin is the fact that hydrologists divide the basin, including tributary basins, into two parts: the upper and the lower; and the river into three reaches -- the upper, middle, and lower. Division between the upper basin and lower basin is at Cairo (above the mouth of the Ohio River). For the Mississippi River itself, the reach upstream from St. Louis is called the upper Mississippi River (upper Miss.), the reach between St. Louis and Cairo is the middle Mississippi River (middle Miss.), and the reach downstream from Cairo is called the lower Mississippi River (lower Miss.).

Other major tributaries include the Minnesota, Wisconsin, Iowa, Des Moines, and Illinois rivers, all of which drain watersheds greater than 10,000 sq. mi. in area (Figure 1.1).

The Missouri River, which drains all or part of ten states and 74 percent of the upper Mississippi River Basin, contributes only 42 percent of the long-term average annual flow of the Mississippi River at St. Louis. The Missouri River does contribute the most sediment in the upper Mississippi River Basin. Hydrologically the Missouri River Basin is divided into upper and lower portions with demarcation at Sioux City, Iowa. The upper and lower basins contain 314,600 sq. mi. and 214,700 sq. mi. respectively.

Runoff from the upper basin is controlled in great measure by regulation of six large dam and reservoir projects on the main stem Missouri River operated by the U.S. Army Corps of Engineers (USACE). The drainage area (279,400 sq. mi.) above Gavins Point Dam, the dam furthest downstream, encompasses about 90 percent of the upper Missouri River Basin and over 50 percent of the total Missouri River Basin area. The amount of water that runs off the upper basin annually averages 24.6 million acre-feet.[1]

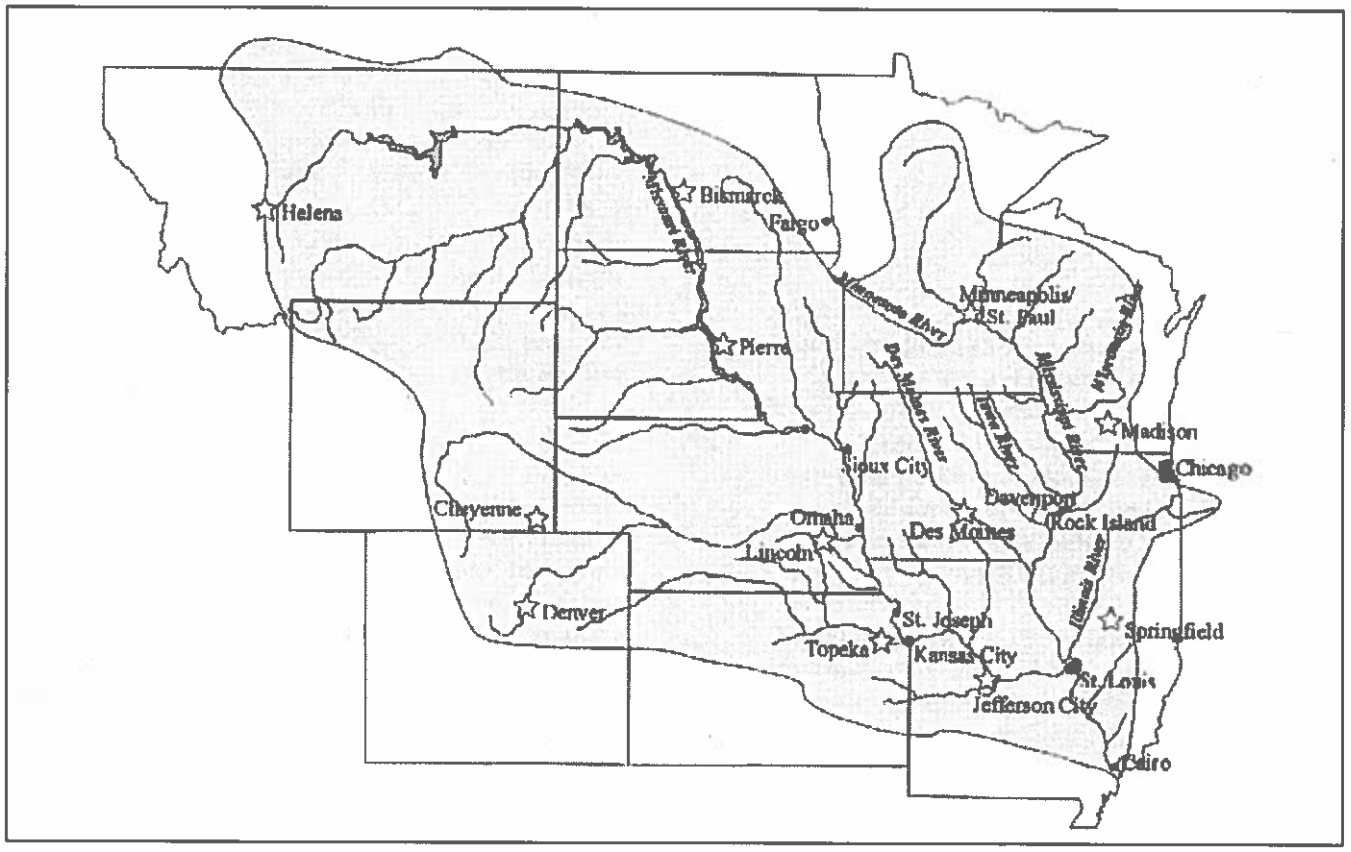
History of Development

The upper Mississippi River valley was settled by European immigrants during the 18th and 19th centuries. By 1824 early steamboat travel and commerce created a demand for navigation improvements. Urban and rural populations continued to grow, creating an increased demand for forest lumber resources and agricultural products. Most early urban settlements were located on or near rivers to be close to water supplies and transportation arteries. By the late 1800s, settlers had cleared and drained many wetlands for agriculture and planted higher floodplain areas to crops.[2]

VOLUMES OF WATER

When quantifying large volumes of water, a measuring unit as small as a gallon results in numbers in the billions or trillions and makes perception difficult. Water engineers and scientists have adopted a larger unit and, therefore, employ smaller, somewhat more readily envisioned numbers. That unit is the acre-foot and represents the volume of water standing one foot deep over an area of one acre. Thus the mean annual volume of water that runs off the upper Missouri River Basin can be expressed as 25 million acre-feet rather than 8,145,720,000,000 gallons.

Figure 1.1 Upper Mississippi River Basin



Some areas were protected with agricultural levees.



Early development of the basin was closely tied to the river system, and many navigation and local flood-control efforts were installed without federal assistance. By the early 1900s, the basin's fisheries resources were declining as a result of various environmental perturbations, sedimentation, pollution, and water-leverl fluctuations caursed by deforestation and agricultural development. Between 1930 and 1950, extensive modification continued on tmain rivers, while upland areas continued to be drained for agricultural purposes. Major urban areas such as St. Louis, Kansas City, and Minneapolis/St. Paul developed as business and industry centers.

The Midwest Flood of 1993, one of the most costly flood events in this nation's history, flooded over 6.6 million acres in the 419 counties in the study area.[3] The damages experienced reflected the land-use and settlement patterns within and adjacent to the floodplain. The floodplains

along the main stem Mississippi and Missouri rivers and the major tributaries that were inundated generally are used for agriculture, and most areas are sparsely populated. Throughout most of the area, river towns are protected by urban levees, or they are located primarily on a bluff. Floodwaters thus inundated neighborhoods rather than entire communities. Residences, businesses, and industries did receive extensive damages in bottomland areas and along tributaries near Kansas and St. Louis. Development in these urban areas, however, is largely in the uplands or protected by urban levees that provided flood protection. As a point of comparison, significantly fewer people were impacted by the Midwest Flood of 1993 than were impacted by the 1927 flood on the lower Mississippi River.

Floodplain land-use patterns. Above Rock Island, Illinois, the Mississippi River valley is relatively narrow and bottomlands are filled to a large extend by navigation pools -- the slack water pools that form behind navigation dams. Most of the remaining floodplain in this area is contained in wildlife refuges with limited agriculture. Along this reach of the river are scattered towns settled during the steamboat era that have developed as market centers and service areas for agricultural hinterlands. Industries were established in many of these towns to take advantage of river navigation and the railroads that later followed the river valleys. Such towns generally have been protected b urban levees or are largely out of the floodplain. Below Rock Island the valley widens out to as much as six miles. The extensive bottomlands in these areas are protected by agricultural levees and used for crops. The leveed areas include farmsteads and a few small farm communities entirely within the floodplain.

Missouri River bottomlands, used predominantly for agriculture, are protected to varying degrees by levees. On the fringes of the bottomlands are small farm communities. In the adjoining uplands a number of larger communities are located on the bluffs above the valley.

Developed floodplains with larger urban areas such as Omaha/Council Bluffs, Kansas City, and St. Louis are largely protected by levees. Near Kansas City and St. Louis, several residential, industrial, and commercial areas are built on floodplains behind levees that overtopped or failed in 1993. Other residential, industrial, or commercial areas were flooded along the larger tributary streams in these urban areas. Rural subdivisions are scattered along the river, many of which began as hunting and fishing camps and evolved into year-around communities. These subdivisions provide inexpensive housing in part because of cheap land, lack of services such as sewer and water, limited land-use controls, and few building requirements.

On the major tributaries, the patterns of development are much the same as along the Mississippi and Missouri main stems, although the bottomlands are narrower with fewer farmsteads. The small towns along these tributaries often have floodprone neighborhoods, but most of the population lives in the adjoining uplands. Table 1.1 includes information on land use and land cover categories for the floodplain and the flood extent for the study area. The estimates of land use and land cover were developed using satellite imagery.

Population trends. In general rural counties declared disaster areas in the nine states affected by the 1993 flood are losing population. No data are available on gain or loss of floodplain populations during this period. The only comparable data from the 1980 Census and the 1990 Census are aggregated by county or community. Population increases that have occurred are generally in the suburban counties of major urban areas such as Minneapolis/St. Paul, Des Moines, Kansas City, and St. Louis. Loss of population in rural areas is the result of farm consolidation, lack of employment opportunities, and improvements in transportation. Fewer farmers mean a lower demand for local goods and services, which has a ripple effect on the local economy. Those who remain on the land drive to larger communities to shop and for many of the services previously provided by farm towns. Such trends, not unlike those occurring throughout the nation, are limiting development pressure within the floodplain. Figure 1.2 shows the population gain or loss by county in the flood-affected 9-state region between 1980 and 1990.

Table 1.1 Land Use and Land Cover in the Floodplain and Areal Extent of Flooding in 1993.

Land use/cover category	Floodplain (acres)	Use in floodplain (%)	Flood extent (acres)	Use in flood extent (%)
Urban built-u	518,891	5.0	165,980	2.5
Agriculture	7,073,696	68.8	4,155,830	63.4
Water	933,085	9.1	956,983	14.6
Wetland/forested wetland	1,435,411	13.9	882,174	13.5
Other	321,906	3.1	394,109	6.0
Total	10,282,989		6,555,076	

Source: Federal Emergency Management Agency contract with Earth Satellite Corporation, April 1994.

Note: The land use and land cover categories in the table are Anderson Level One used by the U.S. Geologic Survey (Anderson, James R., Ernest E. Hardy, John T. roach, and Richard E. Witmer, U.S. Geological Survey Professional Paper No. 964, 1976). The floodplain was identified using landform analysis and includes areas protected by levees and areas above the elevation of the 1993 flood. The flood extent is the area flooded and includes some ponding in upland areas not in the geomorphologic floodplain.

Population characteristics. The Review Committee found during visits to over 60 communities in the flood-affected region that the floodplain neighborhoods and rural subdivisions tended to be lower income neighborhoods of the community. These neighborhoods appear to have a higher percentage of rental properties, more elderly residents, more young families more people on assistance, and lower value housing. It is common to find homes in the floodplains of these communities that have market values of less than $25,000 and often as low as $10,000 or $5,000.

In part these neighborhoods may be low-income because they contain older housing and because they are floodprone. In many of these communities these floodplain neighborhoods are an important source of affordable housing for low and moderate income families. The U.S. Census data shown in Table 1.2 tend to confirm these observations.[4] The data for the study area, however, is available only by community and by Census Block Group. These geographic areas will generally include both floodplain and upland areas. Demographic differences



must be recognized and floodplain policies must be carefully designed to prevent inequities.[5]

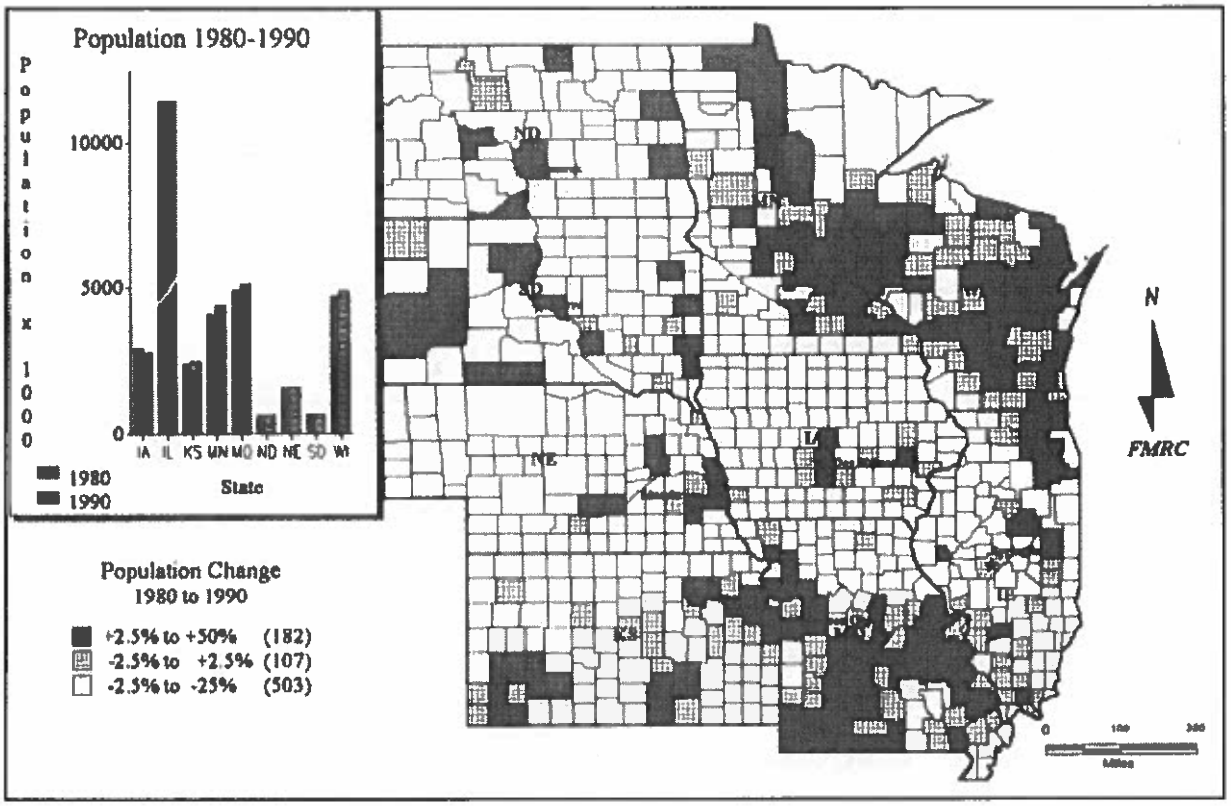


Figure 1.2 Population Change, Nine Midwest States, 1980-1990.

Source: U.S. Bureau of the Census

THE FLOOD EVENT

The National Weather Service (NWS) reported that the Flood of 1993 caused at least 38 deaths, severe damages, and extreme hardship for the people of the Midwest. Agricultural damages exceeded 50 percent of the total, but less than 30 percent of such damages were in the floodplains of the main stem rivers. The majority of agricultural damages were in the uplands where the cause was wet soil conditions rather than inundation. The duration of flooding caused people to be driven from their homes and businesses for an extended period. In the major cities, such as St. Louis and Kansas City, damages were prevented by flood-control improvements. In many areas past policies of federal, state, and local governments avoided potential damage by preventing development in the floodplain.

The Flood of 1993 in the Midwest was a hydrometeorological event without precedent in modern times. In terms of precipitation amounts, record river levels, flood duration, area of flooding, and economic losses, it surpassed all previous floods in the United States. During the period from June through September, record and near record precipitation fell on soil already saturated by previous seasonal rainfall and spring snowmelt, resulting in flooding along major rivers and their tributaries in the upper Mississippi River Basin.

Table 1.2 Papulation Characteristics of the Study Area.

	Upland CBGs	Flood Extent/Floodplain CGBs in MSAs	Flood Extent/Floodplain CBGs in non-MSAs
Age Over 65	13.4 %	10.8 %	16.7 %
Public Assistance	5.9 %	5.7 %	6.7 %
Per Capita Income	$12,636	$10,635	$10,542
Median Household Income	$27,953	$22,629	$21,249
Mobile Homes	4.8 %	10.8 %	12.3 %

Source: U.S. Bureau of Census, 1990.

Notes: (1) CBGs = Census Block Groups; MSAs = Metropolitan Statistical Areas.
(2) Per capita and median household income are lower for CBGs within the flood extent. Mobile homes represent a considerably higher percentage of the housing units, another indication of a lower income population.

River levels exceeded flood stage at approximately 500 NWS river forecast points and record flooding occurred at 95 forecast points throughout the flood-affected region.6 At 45 U.S. Geological Survey (USGS) streamflow gaging stations, the peak discharge rate (flowrate) exceeded that of the 1-percent annual-chance (100-year) flood value. 7 Not only extensive in magnitude and area, the 1993 flood was prolonged in time as evidenced by many locations that remained above flood stage for weeks, with some remaining for as long as five straight months.

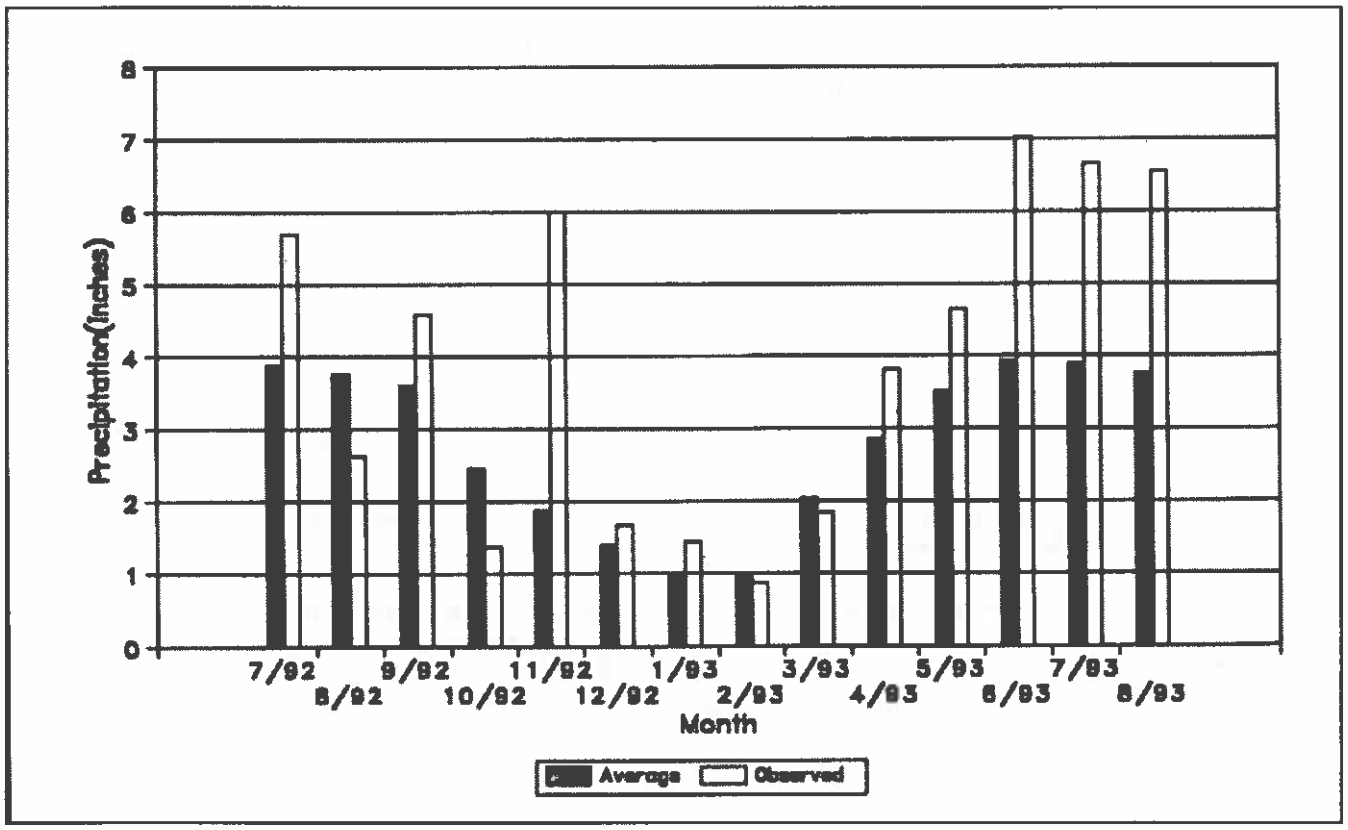
Soil Conditions Prior to the 1993 Flood

The antecedent conditions that gave rise to the Flood of 1993 include, in addition to record rainfalls, wet soil conditions that began in the central Great Plains during the summer of 1992 and rose rapidly with the increasing precipitation and cooling air temperatures of late 1992. July, September, and especially November 1992 were much wetter than normal over the upper Mississippi River Basin. That winter precipitation was near normal, but a wet spring followed. By late March, extremely moist conditions covered much of the region as a result of the wet fall and spring snowmelt runoff.8 Iowa, which was centrally located in the area of heaviest flooding, experienced the second wettest November -- April period in 121 years of record. This period was followed by above-normal precipitation over the upper Mississippi River Basin during April and May (Figure 1.3). The April -- June period was the wettest observed in the upper Mississippi River Basin in the last 99 years. Consequently even before the onset of the heavy summer rains, most upper basin soils were saturated, and many streams and rivers were flowing at well above seasonal normal levels.

Rainfall

During much of the summer of 1993, a persistent atmospheric pattern of excessive rainfall occurred across much of the upper Mississippi River Basin.9 The major river flooding resulted primarily from numerous series of heavy rainfall events from June through late July. The recurrence of heavy rainfall was the direct result of a stable upper-level atmospheric circulation pattern with a deep trough to the west of the upper Mississippi valley and a strong ridge along the East Coast (Figure 1.4). In late July and early August, a change in the upper air circulation pattern brought drier conditions to the Midwest as the trough shifted eastward. Locally heavy thunderstorms generated some additional flooding in parts of the soaked upper Mississippi River Basin during mid-August;

Figure 1.3 Average and Observed Monthly Precipitation Totals for the Upper Mississippi River Basin



Source: U.S. Department of commerce, NOAA, National Weather Service.*

however, these rains were associated with a typical summertime pattern and not a return to the anomalous and persistent June and July atmospheric conditions.

During the June-August 1993 period, rainfall totals surpassed 12 inches across the eastern Dakotas, southern Minnesota, eastern Nebraska, and most of Wisconsin, Kansas Iowa, Missouri, Illinois, and Indiana. Over 24 inches of rain fell on central and northeastern Kansas, northern and central Missouri, most of Iowa, southern Minnesota, and southeastern Nebraska. Up to 38.4 inches fell in east-central Iowa. Generally precipitation amounts were 200 to 350 percent of normal from the northern plains southeastward into the central Corn Belt.

Rainfall amounts over the upper Mississippi River Basin during the May-August 1993 period are unmatched in the historical records of the central United States. In July broad areas in the lower Missouri River Basin experienced rainfall amounting to four times normal. The series of storms producing these record rainfalls were remarkable not only in their magnitude but also for their broad regional extent; record wetness existed over 26,000 sq. mi. of the upper Mississippi River Basin. Seasonal rainfall records were shattered in all rainfall amounts equaled those computed for storm frequencies having 75-year to 300-year recurrence intervals. Figure 1.4 shows the weather pattern that existed in 1993.

INCREDIENTS FOR A MAJOR FLOOD

The following weather facts tell why Iowa flooded in 1993:

Wettest period. Precipitation from January through September 1993 was the greatest amount, 44.5 inches, in 121 years of record; the previous record was 44.2 inches in 1881.

Wettest 12 months. Precipitation from September 1992 through August 1993 was the greatest amount in history, 54 inches; previous record was 49 inches in 1881

Unusual persistence of rainfall. The Midwest had no previous record for such a sustained period of precipitation.

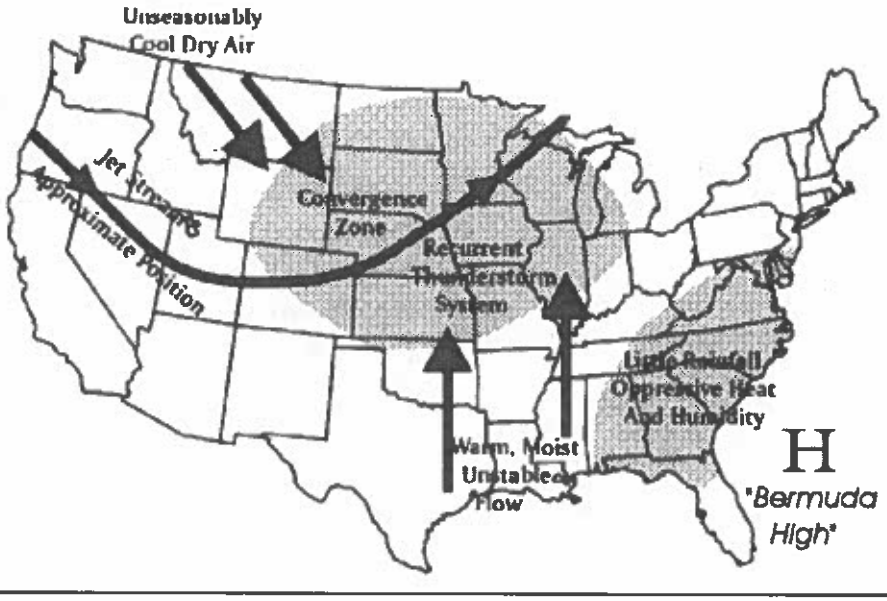
Highest soil moisture. Soil moisture readings in August 1993 were the highest in history.

Cloudiest period. Cloud cover from November 1992 through August 1993 was the greatest for that time period on record.

Lowest evaporation. Evaporation was the lowest in history.

Source: Hillaker, Harry, Iowa State Climatologist, Iowa Department of Agriculture, *Special Summary, Great Iowa Floods, 1993* (Des Moines, Iowa, September 7, 1993).

Figure 1.4 Weather Pattern, June-July 1993.



Source: U.S. Department of Commerce, NOAA, National Weather Service.*

River Flow

The deluge across the upper Mississippi River Basin produced record setting peak flow rates and water levels in many tributaries and in the main stem rivers, including a large reach of the upper Mississippi, over the full reach of the middle Mississippi, and over much of the length of the lower Missouri River. Flooding began in the northern portion of the upper Mississippi River Basin in June and then moved southward with the shifting of the storm-producing weather pattern and the travel of the flood flows downstream as summer progressed.

Rainfall was particularly heavy between June 17 and 20 in southwest Minnesota and northwest Iowa, causing record flooding on the Minnesota River. The next major pulse of precipitation occurred from June 23-25. Runoff from these rains combined with flood flows from the Minnesota River to initiate the first flood crest that moved down the upper Mississippi River.

Following a short, dry period, a prolonged siege of heavy precipitation occurred from June 30 to July 11. This included extreme amounts of rainfall on July 9 in Iowa, which produced record flooding on the Raccoon and Des Moines rivers. Just as the crests from these two rivers reached Des Moines, a relatively small, convective pocket dumped several inches of rain on the crests rapidly boosting the river levels and flooding the city's water treatment plant. The intense rainfall during this period also led to record flooding on portions of the lower Missouri River and combined with the crest already rolling down the Mississippi to establish record river stages from the Quad Cities area on the upper Mississippi River downstream to Thebes, Illinois, on the middle Mississippi River.

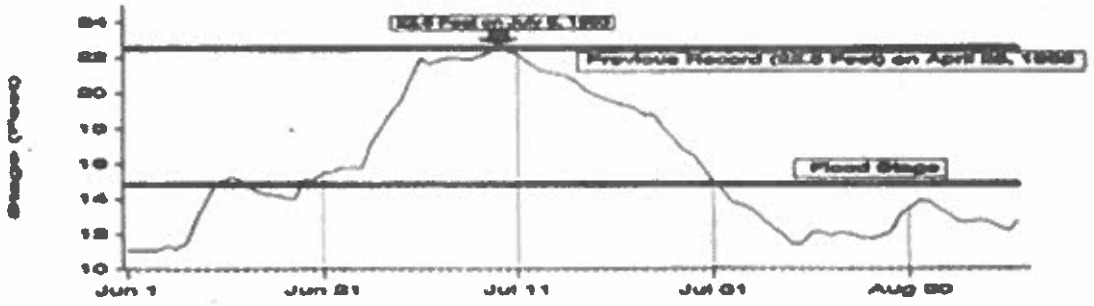
Another major precipitation event occurred from July 21-25. The heaviest rains were focused farther south than the earlier events, with especially heavy rain falling over eastern Nebraska and Kansas, leading to the second major crests on both the Missouri and Mississippi rivers. Hydrographs, of river stages (elevations) over time for the Missouri River at Kansas City and the upper Mississippi River at the Quad Cities are shown in Figure 1.5.

The Kansas City graph shows two flood peaks, one caused by the June 30 to July 11 rainfall and the other by rain falling from July 21-25. The Quad Cities graph shows only the single peak from the earlier period. This comparison demonstrates the generally southern focus of this second event. Both peaks are evident on the hydrograph for the Mississippi River at St. Louis (Figure 1.5). While flooding from the latter rainfall period did not extend as far upstream on the Mississippi River, new record river levels occurred at many locations downstream and on much of that portion of the Missouri River that flows through Missouri. Figure 1.6 shows those reaches of main stem and tributary rivers where peak stages exceeded previous record levels and where they reached unusually high but not record levels.

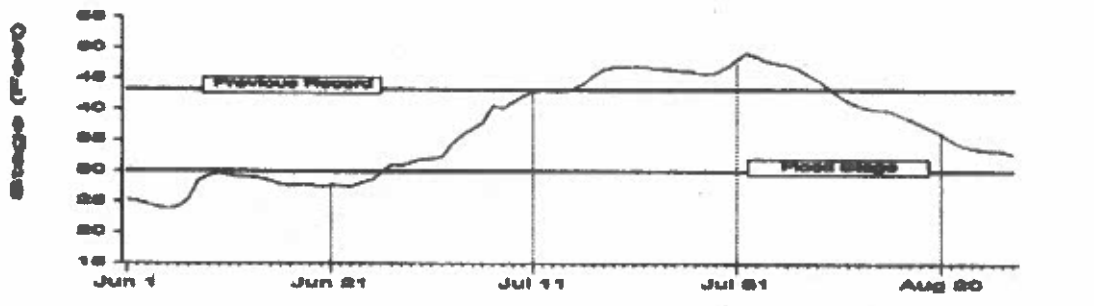
Above normal rains continued to occur over pats of the flood-affected region during August, especially over Iowa where accumulations were twice the normal monthly amount over much of the state. By mid-September, however, rainfall began to diminish and rivers began to recede. Then, at the end of September, a strong system of thunderstorms deposited 1 to 3 inches of rain over the State of Missouri and 7 inches or more from the central part of the state eastward. The consequence was major flash flooding on many tributaries and new flood crests on the lower Missouri and middle Mississippi rivers. Farmlands behind previously breached levees were reflooded and two people drowned in separate incidents. Many roads were washed out and there was much damage to property in Missouri.

Conclusion: ***Wet antecedent soil and swollen river conditions, record rainfall, and significant upland runoff resulted in 1993 flood flows that ranged from below the 100- year up to the 500-year recurrence interval magnitude at many locations.***

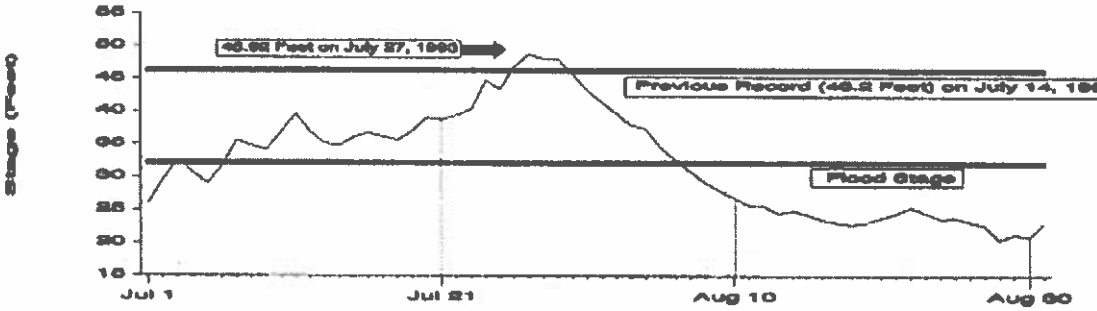
Figure 1.5 Hydrographs for the Mississippi and Missouri Rivers.



Hydrograph for the Mississippi River at Quad Cities.

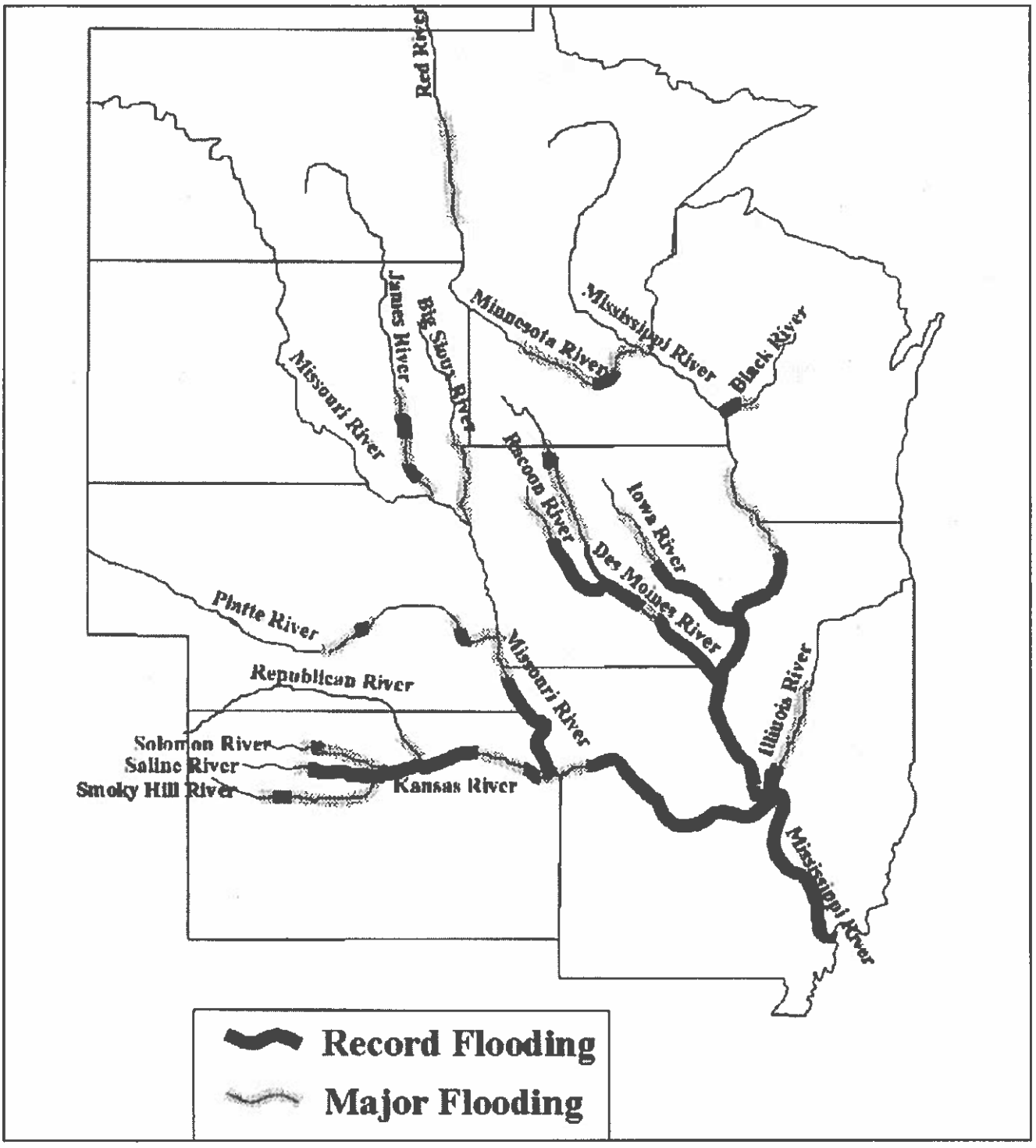


Hydrograph for the Mississippi River at St. Louis.



Hydrograph for Missouri River at Kansas City.

Figure 1.6 Areas Flooded in 1993



Source: U.S. Department of Commerce, NOAA, National Weather Service.

DAMAGES REPORTED

Estimates of total damages in the Midwest from weather events during 1993 range between $12 billion and $16 billion. Over half of these were agricultural damages to crops, livestock, fields, levees, farm buildings, and equipment. The remaining damages were primarily to residences, businesses, public facilities, or transportation. Much of the agricultural damage occurred in upland areas as the result of wet fields and a short growing season rather than inundation by floodwaters. Similarly a portion of residential and business damages was caused by basement flooding due to high groundwater and sewer back-up in areas outside the floodplain.

The NWS has estimated damages for the Midwest flood at $15.7 billion based on information provided by its field offices.[10] This estimate was based on totals by state, but did not include breakdowns of damage by type. In August 1993 The New York Times published an estimate of nearly $12 billion in damages based on information it obtained from state and federal officials.[11] State and federal officials could not assess all damages until floodwaters receded, and the full extent of agricultural damages was not known until after the end of the growing season. Most of the affected states have updated their damage estimates, and the total ranges from $12 billion to $13 billion. The available estimates are summarized in Table 1.3.

The Review Committee developed an estimate of flood damages using federal payments and making assumptions as to what percentage of damages those payments represent. This information indicates that total damages were ore than $12 billion with as much as $4 billion to $5 billion of that total being agricultural damages in upland areas.

Table 1.3 Damage Estimates for 1993 Midwest Flooding, in Millions of Dollars

State	NWS Totals	State Totals	State Agriculture	NY Times Totals	NY Times Agriculture
Illinois	2,640	1,000-2,000	565	1,535	605
Iowa	5,740	>3,400	na	2,200	1,200
Kansas	551	>500	441	574	434
Minnesota	964	1,700	1,500	1,023	800
Missouri	3,430	3,000	1,790	3,000	1,800
Nebraska	295	na	na	347	292
North Dakota	414	600	500	1,500	705
South Dakota	763	596	572	595	595
Wisconsin	904	930	800	909	800
Total	15,701	12,000-13,000	na	11,683	7,231

Sources [12]
Note: "na" means not available

Damage estimates for the Midwest flood show marked inconsistencies. No federal agency is responsible for developing accurate assessments of flood damages, nor is funded to do so. The affected states and the Federal Emergency Management Agency (FEMA) conduct preliminary damage assessments to determine if a Presidential disaster declaration is warranted and to estimate the resources necessary for response and recovery. Once sufficient damage has been identified that justifies a declaration on once FEMA has a general idea of how resources should be allocated, federal agencies have little incentive to expend resources updating preliminary assessments. Resources are instead focused on tracking and projecting expenditures. The NWS is not funded to estimate total damages but does so to support other missions. The USACE, which in the past estimated flood damages, is no longer funded to do so. The Review Committee is concerned that decisions involving hundreds of millions of dollars often are being made without systematic assessments of flood damages and without a clear understanding of the nature and extent of those damages.

Agriculture

Agricultural damages from the Flood of 1993 had two primary causes: excessive moisture that prevented planting and reduced yields in upland and floodplain areas and actual flooding that destroyed crops and severely damaged many acres of fertile floodplain cropland. It is difficult to separate the factors that influenced crop production during the 1993 growing season in the 9-state region. They included rain, low temperatures, early frost, and floods. More then 70 percent of the crop disaster assistance payments, however, were made to counties in upland areas -- not in main stem river floodplains.[13]

Agricultural damages directly attributed to actual flooding totaled more than $2.5 billion, with an estimated $1.4 billion in lost corn and soybean sales. Most of these losses were restricted to 1993 as the productive capacity of the land was unchanged. There were, however, damages to field fertility and farm infrastructure of at least $100 million.

Each state suffered different types of losses. For example, Missouri with 34 percent of its cropland (5.1 million acres) in the floodplain , had crop damages from flooding on 3.1 million acres causing $247 million in lost sales.[14]



In Illinois, only 3 percent of the state's corn and soybean acreage (312,000 and 276,000 acres respectively) were lost to flooding with a loss in sales of $153.4 million.[15] Minnesota farmers lost $500 million in crop sales, but most of the damage was caused by wet conditions rather than riverine flooding. [16]

Damage from scour and deposition affected 455,000 acres on the Missouri River floodplain representing 20 percent of the flooded cropland along the Missouri and Mississippi rivers. [17] Drainage ditches were filled with sediments, and other agricultural infrastructure was destroyed. Almost 60,000 acres have sand deposition more than 24 inches thick and reclamation costs to restore fertility to damaged cropland are approximately $190/acre.[18] If cropland restoration requires removal of sand, it would cost approximately $3,200 to remove each acre-foot of sand. [19] It will cost $10.8 million to remove sediment and debris from ditches.[20]

Secondary impacts of agricultural losses to a local economy vary substantially with the dependence of that economy on the agricultural sector. Immediate losses are due to lost sales and unemployment. In the long run, the assessed value of land that sustained long-term damage may be reduced which will affect the property tax base of affected communities.

Another secondary effect was a reduction in crop-support payments after prices adjusted to the reduced production caused by wet weather in the Midwest and drought in the Southeast in 1993. This loss to farmers was a gain for

taxpayers since subsidies represent transfer payments. For corn, these deficiency payments were reduced by more than $2.6 billion.[21] These price effects and subsequent reduction in deficiency payments will be temporary, if the 1994 crop supply returns to past levels.

Conclusion: ***The majority of 1993 agricultural damages in the Midwest were caused by wet soil conditions and inundation in upland areas. Damage to inundated cropland in the floodplain was significant with almost complete crop losses behind failed levees. Areas affected***



by severe erosion and deposition may suffer long-term loss of productivity.

Residences and Businesses

Estimates vary on the number of homes flooded and families impacted by the Midwest flood. Surveys made by Red Cross workers immediately after the floods identified more than 55,000 flooded residences.[22] FEMA subsequently verified these damages with Red Cross chapters and developed an updated estimate of 70,545 residences.[23] The New York Times estimated that more than 84,000 residences were damaged.[24] As of April 11, 1994, the federal government had received 167,224 registrations for individual assistance and 112,042 applications for the Disaster Housing Program. Among this latter group, 89,734 applications have been approved. The Disaster Housing Program data indicates that more than 100,000 residences were flooded. [25]

The fluctuating numbers illustrate an overlooked characteristic of this flood. While the media focused on flooding of communities along the main stem Mississippi and Missouri rivers and their major tributaries, at least as many families were impacted by flooded basements due to high groundwater, overloaded storm sewer systems, or sewer back-up. Many of the homes with flooded basements were not in the 100-year floodplain or behind levees that overtopped or failed. In Cook County, Illinois, for instance, large numbers of homes on the south and west sides of Chicago had basement flooding due to storm water and sewer back-up caused by heavy rainfall which overwhelmed the city's combined storm and sanitary sewer system. The county was eventually added to the Illinois disaster declaration even though this type of damage generally does not warrant inclusion. Over half of the 60,448 registrations for individual disaster assistance in Illinois and 20 Percent of the registrations for the entire 9-state region were in Cook County.[26]

Businesses sustained significant physical damages particularly in urban areas such as St. Louis County and the Kansas City areas of Missouri. Much of this damage occurred behind levees that failed or were overtopped. The 1996 National Flood Insurance Program (NFIP) claims payments made to small businesses26 and the 4,667 Small Business Administration (SBA) loans for



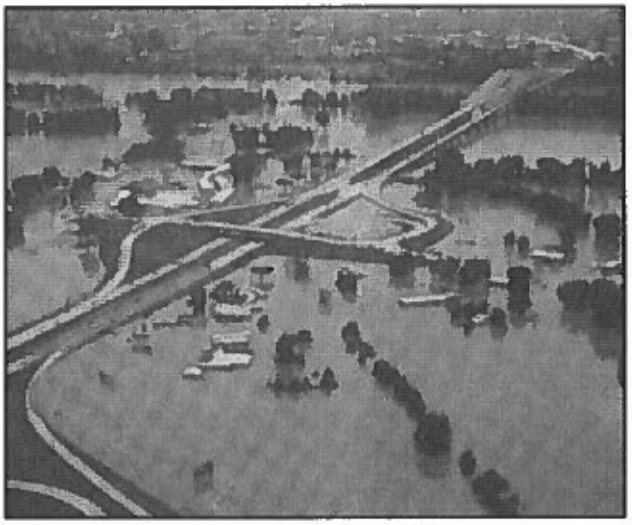
damages to businesses26 indicate that in excess of 5,000 individual businesses were damaged. No overall damage estimates for businesses are available, but a measure of this damages, SBA loans to businesses, exceeded $334 million for physical damage29 and economic injury. Add to these loans NFIP flood insurance payments for small businesses and other non-residential buildings that exceed $94 million, 30 and the total exceeds $431 million. In addition to physical damage to buildings and their contents, lost profits and wages from businesses closed by the flood had local and regional impacts. For example, an American Cyanamid Plant near Hannibal, Missouri, was protected by its own levee and not damaged by floodwaters, but the plant was shut down for nearly three month because its access road was inundated when an agricultural levee failed.

Transportation Systems

Rivers and river valleys historically have been major transportation routes, particularly in the area impacted by the 1993 flood. In the Midwest, transcontinental railroads, interstate highways, and other road systems either follow river valleys or cross them. As a result, physical damages to transportation systems form a significant percentage of total flood damages. In addition to direct damages, indirect costs accrue when transportation routes are inundated by floodwaters, and traffic is halted or detoured.

A major portion of flood damages to public facilities I n1993 involved roads and bridges. These damages ranged from blown culverts and wash-outs on rural roads and city streets to loss of bridges and damages to interstate highways inundated by floodwaters. The repair of flood-damaged roads and bridges generally is funded through the FEMA Public Assistance Program or the Department of Transportation. Funds expended by those agencies when added to the state/local cost share for public assistance indicated that total physical damages to roads and bridge exceeded $250 million. [31]

Road and bridge flooding caused indirect losses related to increased transportation costs. In extreme cases, detours of 100 miles were required to travel between adjoining



communities that had been connected by a bridge. Often bridges were elevated high above the river to allow for navigation or to minimize hydraulic impacts of floods, but bridge approaches built at or near the natural elevation of the floodplain were inundated by floodwaters. Even though the bridge was undamaged and the approach damage was minimal, the economic impacts on the communities served by the bridge could be extreme, particularly for a long duration flood such as occurred in 1993. For example, Keokuk, Iowa, was cut off from market areas in Illinois and Missouri for several weeks when the approaches to bridges over the Mississippi and Des Moines rivers were inundated. This resulted in serious economic impacts on local businesses. Flooding of the approaches to the bridge over the Mississippi River at Quincy, Illinois, for 73 days resulted in an estimated $30 million in lost business to Quincy merchants.[32] In addition, many people who lived in Missouri and could not commute to work in Illinois were temporarily unemployed. Ferries were eventually established to address part of this problem. The full magnitude of these losses are reflected in over 36,000 claims approved for a total of $92 million in Disaster Unemployment Assistance.[33]

Historically railroads were built in floodplains and river valleys to minimize construction and fuel costs. Main lines continue to parallel both the Missouri and

Mississippi rivers. Although generally tracks are elevated on embankments above the elevation of most floods or are located behind levees, they remain subject to major flood events. In 1993 over 800 miles of track were flooded and several main lines were inundated for varying periods of time, but most trains were routed around flooded areas. The Association of American Railroads estimates that railroad damages totaled $182 million, including $131 million in physical damages to tracks, bridges, signals, communication lines, switches, locomotives, rolling stock, and buildings. Additional cost of $51 million resulted from detouring trains around sections of flooded track.[34] Repair costs are generally borne by the railroads themselves although $21 million was distributed to railroads through the Supplemental Appropriation for Local Rail Freight Assistance.[35]

Airports often are located in floodplains because of the flat terrain and close proximity to urban areas. The Federal Aviation Administration (FAA) has identified 33 airports with varying degrees of flood damages. Estimated repair costs exceed $5.4 million. The airports range in size from the Spirit of St. Louis Airport in St. Louis Country, Missouri, to airports that are little more than grass landing strips with a few hangars for private aviation. Most of the flooded airports were in Missouri (16) and Iowa (12). The Spirit of St. Louis Airport, and alternate for Lambert-St. Louis Airport, sustained $1.7 million in damages when the Monarch-Chesterfield Levee failed. Other major airports that were flooded included those at Creve Couer and Jefferson City and the Kansas City Downtown Airport. Several smaller airports remain closed and may not reopen.[36]

Navigation

Most of the main stem rivers were closed to barge traffic from July 11 until August 15, 1993, and severe limitations on barge traffic continued through September, October, and November. The Maritime Administration estimated that losses of revenue to the navigation industry were $300 million per month.[37] More than $165 million were lost in Illinois alone. Regional impacts on jobs from barge and port disruptions were also greatest in Illinois.[38]

Public Facilities

The Midwest flood caused extensive damages to water and wastewater treatment plants and other public facilities. Damages to utilities, including water and wastewater treatment facilities and storm sewer systems, exceeded $84 million. [39] Water treatment plants often are located in floodplains to be near well fields or the surface water that supplies the system. In addition, water supply lines must cross floodplains to serve floodplain residents. The EPA has identified 200 municipal water systems impacted to some degree by the flood.[40] The most prominent example is the Des Moines Water Works that serves the City of Des Moines and adjoining communities. The plant was flooded and remained out of operation for 12 days, and water from it was not safe to drink for another seven days. In addition to physical damages of $12 million, significant impacts were felt in the service area.[41] Businesses and government offices closed because of lack of fire protection, and bottled water and portable toilets had to be provided for residents. The economic impact of the shutdown may far exceed thee cost repair of the physical damage.

Wastewater treatment plants tend to be located in floodplains which are generally the lowest point in a community and offer the advantage of gravity flow. Furthermore the effluent from these plants is discharged into major rivers or streams. The impact of flooding ranges from temporary plant shutdown and the discharge of raw sewage into the river during the flood to physical damage that results in extended plant shutdowns and continued discharges of raw sewage or partially treated effluent until such time as the plant can be repaired. A total of 388 wastewater facilities were impacted by the flood. [42]

Damages to public buildings exceeded $27 million. Water control facilities had more than $20 million in damages, and facilities such as parks and other recreation facilities

recorded more than $22 million. These estimates are based on FEMA projections of infrastructure spending that include a 10-percent local cost share. [43]

DAMAGES PREVENTED

Management and structural practices prevented damages from being worse than they were. These practices involved nonstructural solutions, upland conservation treatment, and major flood control projects.

Nonstructural Flood Protection



The term "nonstructural measures" is used to describe techniques that "modify susceptibility to flooding (such as regulation, floodplain acquisition, and flood proofing techniques)."[44] A nonstructural approach to flood damage prevention was effective in the town of Prairie Du Chein, Wisconsin where the flood was a 40- to 50- year event. Prairie du Chein was the site of the first relocation project undertaken by the USACE and carried out between 1978 and 1984. A measure of the project's success was reported by the Red Cross workers came to town but left within two weeks because no one needed their help.[45] Relocation had freed citizens of anxiety about the risk of flood damage to their home and businesses. Nonstructural land management applications such as the Minnesota Valley National Wildlife Refuge and the Upper Mississippi River Wildlife and Fish Refuge provided for storage and conveyance of a portion of the 1993 floodwaters within the floodplains of the lower Minnesota and upper Mississippi River valleys. Refuges, parklands, green ways, and agriculture are examples of appropriate floodplain uses that reduce flood damages by minimizing the number of structures at risk.

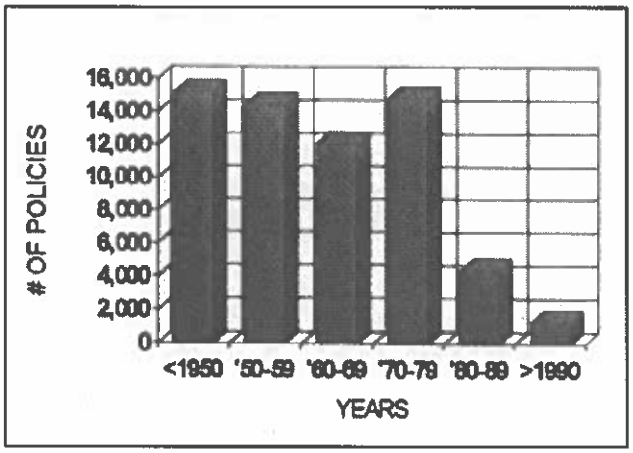
The National Flood Insurance Program. The NFIP has not encouraged floodplain development in the Midwest and, in combination with state and local floodplain management programs, appears to have discouraged it. The NFIP has discouraged floodplain development by (1) increasing awareness of flooding by identifying and mapping the flood hazard, (2) internalizing the cost of floodplain occupancy, making development in the floodplain more costly (i.e., added cost of protecting buildings from flooding and the added cost of the NFIP flood insurance premium), and (3) requiring additional permitting and engineering studies that developers and individuals may choose to avoid.

The Review Committee met with a number of communities in the Midwest, large and small, that actively discourage development in their floodplains even if permitted by federal or state regulations. This "steering" of development to flood-free locations has deterred new floodplain development in these communities.

Approximately 93 percent of the properties which are located in the 100-year floodplain in the flooded area and are currently insured by the NFIP were constructed before the issuance of a Flood Insurance Rate Map (FIRM) for the community and conversion of the community to the Regular Program of the NFIP, [46] i.e., between December 31, 1974 and the early to mid-1980's. Floodplain management regulations appear to have prevented or reduced damages to new construction (post-FIRM construction). These buildings sustained proportionally fewer losses than older buildings even though the flood elevations exceeded the 100-year design standard in many locations. These new buildings comprise 6.4 percent of the insured floodplain buildings in the declared counties, but account for only 3.2 percent of the losses.[47]

Figure 1.7 indicates a significant reduction in the number of buildings built in the floodplain after 1980. Since insured buildings tend to include newer, more expensive buildings with mortgages subject to the mandatory flood insurance purchase requirement, the percentage and numbers of all buildings built prior to enactment of the NFIP are likely to be even higher.

Figure 1.7 Construction Dates NFIP Insured Buildings in the Nine Midwest States



Source: Federal Emergency Management Agency, Federal Insurance Administration. Computer Printout, March 28, 1994.

Acquisition and relocation. Acquisition or relocation of floodprone building through federal programs or state and local initiatives continues to be an important strategy for reducing potential flood damages. Successful buy-out programs normally are a response to a flood or series of floods. Implementation occurs over a multi-year period, as funding becomes available. The Review Committee identified more than 600 buildings in the upper Mississippi River Basin which have been acquired and relocated out of floodprone areas over the past 20 years. Most of these buildings had been damaged previously by floods and would have been severely damaged by the higher waters of the Flood of 1993.

Upland Watershed Treatment

The Flood of 1993 demonstrated the value of f installing flood-prevention measures and of improving land treatment practices on agricultural lands throughout the watershed. In upland watershed areas, the Soil Conservation Service (SCS) small watershed projects prevented damages estimated at $400 million. Crop losses to landowners were lower in areas with upland watershed treatment. An example is the SCS project on the Grindstone-lost Muddy Watershed Project that protects approximately 60 percent of Dekalb County and portions of Clinton, Gentry, and Davies counties in Missouri. Flood protection on the 326-sq. mi. watershed includes land treatment, flood prevention, multi-purpose flood control reservoirs, and erosion grade control structures. The project area recorded two storms exceeding the 1-percent chance of occurrence in July and September 1993. Estimated agricultural benefits accrued were $915,900 for the July storm and $989,700 for September storm with road and bridge benefits of $66,000 and $70,000. Agricultural disaster payments per acre in Dekalb County were less than half those paid in neighboring counties. Since the storm, local people have donated $2,000 to purchase landrights for construction of remaining flood control reservoirs.

Flood Damage Reduction Projects

The USACE estimates that flood-control facilities in place during the 1993 flood prevented $19.1 billion in damages.[48] Of that total, $11.5 billion in damages were prevented along the Missouri River. Damages prevented by the water control management of flood storage reservoirs amounted to $7.4 billion in the Missouri River Basin; $4.0 billion by the storage of flood water in the six main stem Missouri River reservoirs on the tributaries. The other 4.1 billion in damages prevented along Missouri River is attributed to levee projects. USACE and Bureau of Reclamation flood control reservoirs on the main stem and tributaries in the Missouri River Basin reduced peak discharges on the Missouri River by storing over 17 million acre-feet of flood water between June and August.[49] In the St. Louis metropolitan area, a combination of upstream reservoirs, levees, and floodwall prevented damages of approximately $3 billion. Upstream reservoirs and levees also prevented damages of about 5.6 billion at Kansas City.

Conclusion: ***Damages from the 1993 flood were reduced significantly through use of non-structural and structural measures.***

RESPONSE AND RECOVERY COSTS

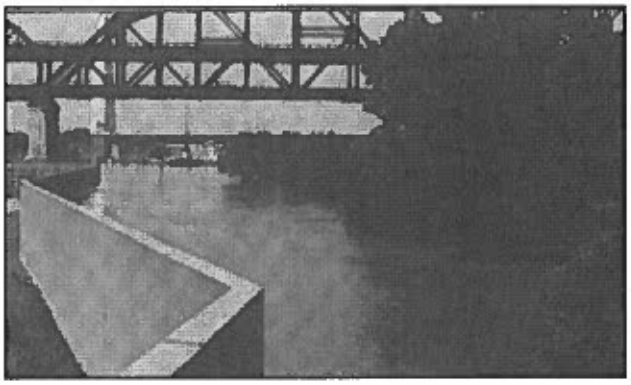
By the end of the flood, nine state disaster declarations included more than 525 counties. Current estimated federal response and recovery cost include 4.2 billion in direct federal expenditures, $1.3 billion in payments from federal insurance programs, and more that $621 million in federal loans to individuals, businesses, and communities.

A review of the types and amounts of federal response and recovery cost by state illustrate again the differences in types of damages among the nine states.

In the upper basin states of Minnesota, Nebraska, North Dakota, and South Dakota and in Wisconsin and northern Iowa, the losses were primarily to agriculture, much of it in upland areas. Along the main stems of the Mississippi and Missouri rivers and their major tributaries in Missouri, Illinois, and central Iowa, significant losses occurred in agriculture as a result of bottomland flooding, but urban areas also recorded damages.

Federal Expenditures

Federal expenditures represent disaster response and recovery cost borne by the federal government. Among these are disaster assistance payments to individuals and farmers, costs to repair levees and other infrastructure, costs to provide health and social services; and cost associated with hazard mitigation, housing, and community development. Å summary of federal expenditures for the Midwest flood is included in Table 1.4



Crop disaster payments. Disaster payments are made for production and quality losses of most commercially grown crops when losses are caused by damaging weather and related condition. Production losses related to prevented planting and low yield are eligible for compensation. The Agricultural Stabilization and Conservation Service of USDA can authorize crop disaster payments without a Presidential Disaster Declaration. Participation in price-support programs does not affect eligibility or payment levels. Producers with crop insurance qualify if losses are greater than 35 percent of expected production; and those without crop insurance qualify if losses are greater than 40 percent. For most crops grown in the 9-state region, payments are calculated by determining the eligible amount of loss and multiplying it by 65 percent. As a general rule of thumb, farmers can expect disaster payments to cover 40 percent of expected cash receipts. 50 For 1993, yields less than 9 bushels an acre of corn or 4 bushels per acre of wheat counted as total losses for calculation of disaster payments. Figure 1.8 shows the location of crop disaster payments in the 9-state region. More than 70 percent (1.02 billion) went to the prairie pothole

Table 1.4 Summary of Federal Expenditures by State for the Midwest Flood of 1993 in Millions of Dollars.[51]

Programs	Total	IL	IA	KS	MN	MO	NE	ND	SD	WI
Crop Loss Payments	1,463.	49.2	351.1	65.5	442.5	121.12	76.0	99.5	151.1	107.2
Emergency Conservation Program	2.7	. 0.1	1.5	-	.01	0.7	0.1	-	0.2	-
Emergency Watershed Program	57.2	9.5	13.8	4.0	1.1	11.9	1.0	.0.9	3.5	1.0
Food Stamps and Commodities	10.9	2.1	2.4	-	-	6.4	-	-	-	-
FmHA Loans and Grants	15.8	2.4	7.4	0.2	2.5	1.4	0.1	0.2	0.9	0.8
SCS Supplemental 1994	150.0	-	-	-	-	-	-	-	-	-
USDA Subtotal	1699.9	63.3	376.2	69.7	46.2	141.6	77.2	100.6	155.7	109.0
Infrastructure (proj.)	424.4	92.8	99.6	31.2	27.5	94.9	41.8	8.2	9.9	18.5
Human Services (proj)	449.1	59.7	54.9	56.5	24.4	125.9	3.5	22.7	20.04	18.0
Hazard Mitigation (proj.)	134.9	26.3	27.0	15.2	9.7	30.0	10.0	4.2	4.5	8.0
Admin (proj.)	89.6	18.7	8.3	8.8	1.3	40.7	3.5	2.0	2.1	1.9
FEMA Subtotal	1098.0	197.5	189.80	111.7	62.90	291.5	58.80	37.10	36.90	46.40
CDBG 1993 Allocation	200.0	35.9	43.1	18.8	13.5	57.2	7.8	11.9	6.0	5.9
Home 1993 Allocations	50.0	10.8	11.4	3.4	2.7	15.3	1.3	2.6	1.30	1.30
CDBG 1994 Allocations	250.0	48.2	53.2	18.4	13.6	79.6	15.3	7.7	6.8	7.2
Hud Subtotal	500.0	94.9	107.7	40.6	29.8	152.1	24.4	22.2	14.1	14.4
EDA Assistance Programs *	200.0	8.3	48.4	17.9	7.4	51.7	0.6	2.9	1.6	0.7
NOAA Expenses	1.0	0.1	0.1	-	0.5	0.2	-	-	-	0.1
Legal Services Corporation	0.3	-	-	-	-	-	-	-	-	-
Commerce Subtotal	201.3	8.4	48.5	17.9	7.9	51.9	0.6	2.9	1.6	0.8

Table 1.4 Summary of Federal Expenditures by State for the Midwest Flood of 1993 in Millions of Dollars (cont'd).

Program	Total	IL	IA	KS	MN	MO	NE	ND	SD	WI
Flood Control Emergency	218.0	70.0	7.0	11.0	0.3	128.0	1.0	-	-	-
Emergency Operations and Contingencies	31.4	-	-	-	-	-	-	-	-	-
Operation and Maintenance	3.7	0.3	2.7	-	-	0.7	-	-	-	-
USACE Subtotal	253.1	70.3	9.7	11.0	0.3	128.7	1.0	0.0	0.0	0.0
HHHS Subtotal	75.0	7.4	22.8	4.2	4.0	19.3	2.3	2.2	2.6	3.9
Impact Aid 70.0	-	-	-	-	-	-	-	-	-	
Student Financial Assistance 30.0	1.4	11.1	0.2	0.8	4.5	0.4	0.8	0.5	0.3	
Education Subtotal	100.0	1.4	11.1	0.2	0.8	4.5	0.4	0.8	0.5	0.3
Labor Subtotal	64.6	1.0	15.0	10.0	5.0	15.0	3.0	2.0	3.1	1.5
National Community Service Subtotal	4.0	0.4	1.2	0.4	0.7	1.0	-	-	-	0.3
Coast Guard Operation	10.0	-	-	-	-	-	-	-	-	-
Federal Highway Administration	152.1	32.4	16.7	19.8	4.6	66.4	3.0	3.6	2.5	2.8
Local Rail Freight Assistance	21.0	0.6	5.4	3.8	2.7	7.1	-	-	1.4	-
DOT Subtotal	146.7	33.3	22.1	23.6	7.3	73.5	3.0	3.6	3.9	2.8
Abatement, Control, and Compliance	24.3	3.4	3.4	1.9	0.8	6.9	1.5	0.9	0.7	0.9
Program and Research Operations	1.0	0.2	-	0.1	-	-	-	-	-	-
Underground Storage Tanks	8.0	1.4	1.2	0.7	1.4	0.7	0.5	0.3	3	1.5
Oil Spill Response	0.7	0.3		0.4						
EPA Subtotal	3.4	5.3	4.6	3.1	2.2	7.6	2.0	1.2	3.7	2.4

Table 1.4 Summary of Federal Expenditures by State for the Midwest Flood of 1993 in Millions of Dollars (cont'd).

Programs	Total	IL	IA	KS	MN	MO	NE	ND	SD	WI
FWS Construction	30.0	10.5	0.2	0.7	5.2	2.7	-	0.4	-	4.3
Historic Preservation	5.0	1.0	1.0	0.2	0.3	1.0	0.3	0.2	0.2	0.2
NPS Construction	0.9	-	0.3	0.1	0.1	0.2	0.1	-	-	0.1
USGS Survey	1.4	0.32	0.6	0.3	0.3	1.2	0.1	0.2	0.3	0.2
BIA Programs	3.9	-	-	-	-0.1	-	-	-	0.4	-
DOI Subtotal	41.2	11.8	2.1	1.3	6.0	5.1	0.5	0.8	0.9	4.8
Total	4,254.2	520.8	810.8	2941	573.5	910.4	173.2	173.4	203.4	186.1

*Includes $18M for Levees
Sources[52]

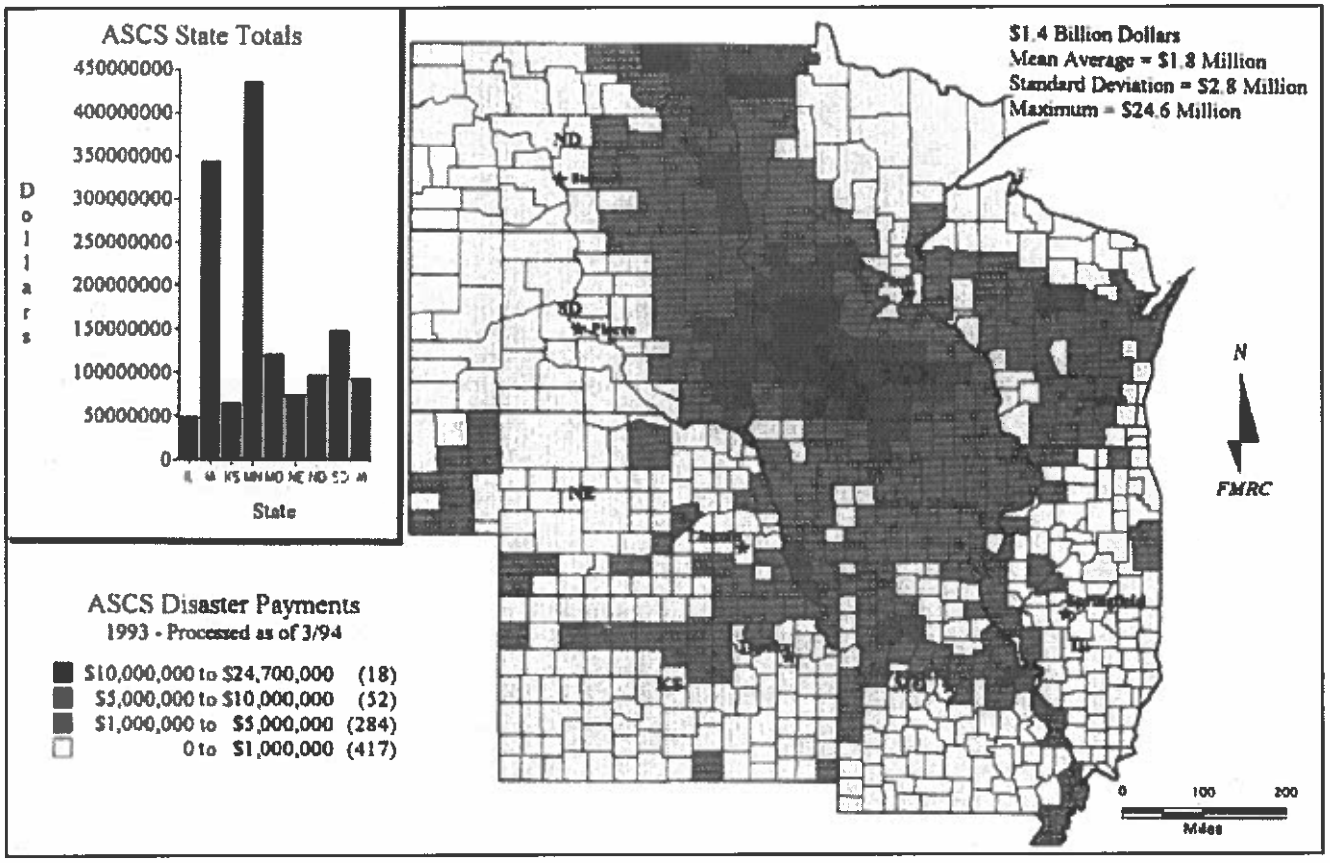
Table 1.5 U.S. Department of Agriculture ASCS Disaster Payments, 1993.

States	Programs Crops ($)	Non-Program Crops ($)	Total Payments ($)
Illinois	42,662,617	7,445,761	50,108,378
Iowa	342,849,940	12,910,334	355,760,274
Kansas	42,662,617	4,823,055	65,562,624
Minnesota	414,574,259	30,983,156	445,557,415
Missouri	113,812,607	8,290,327	122,102,934
Nebraska	64,123,698	13,233,694	77,357,392
N. Dakota	67,127,874	34,760,511	101,888,385
S. Dakota	142,318,846	1,299,410	153,618,256
Wisconsin	82,468,812	18,377,402	100,846,214
9-State Total	1,330,678,222	142,123,650	1,472,801,872

Source: Agricultural Stabilization and Conservation Service, April 15, 1994

Note: Program crops that received 1993 disaster payments within the 9-state region include those within the Commodity Program (barley, corn upland cotton, oats, rice, sorghum, sugar beets, wheat) plus those in special programs (soybeans and tobacco).

Figure 1.8 Crop Disaster Payments, 1993



Source: U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, March 1994

region of the Dakotas, Minnesota, Wisconsin, and northern Iowa. [53] Cropland in this area of hydric soils and excessive rainfall does not drain well. The majority of payments went to farmers participating in commodity programs (Table 1.5), but damages would have been higher without farmer enrollment because the 6 million acres of land set aside (the 1993 requirement for program participation) would have incurred crop losses if production has been allowed.

Federal Insurance Programs

The federal government operates two insurance programs that provided claims payments to those impacted by the Midwest flood; the National Flood Insurance Program (NFIP) and the Federal Crop Insurance Program. Claims payments by federal insurance programs are distinct from federal expenditures. Table 1.6 summarizes claims payments from these programs by state. Under both programs, individuals pay an annual insurance premium to the government and the government provides insurance coverage. Tables showing insurance payments from the NFIP and the Federal Crop Insurance Corporation (FCIC) follow.

National Flood Insurance Program. Flood Insurance coverage on buildings and their contents is available through the NFIP participating communities. Under

Table 1.6 Summary of Federal Insurance Claims Payments by State for the 1993 Midwest Floods in Millions of Dollars

Program	Total	IL	IA	KS	MS	MO	NE	ND	SD	WI
Federal Crop Insurance Program Claims Payments	1017.0	25.4	281.2	40.4	353.9	27.7	49.0	139.3	54.1	46.0
National Flood Insurance Program Claims Payments	297.3	61.4	23.4	10.7	1.7	192.3	4.8	0.3	0.8	2.0
Total Claims	1,314.	86.8	86.8	51.1	355.6	220.	53.8	139.6	54.9	48.0

Sources: U.S. Department of Agriculture, Flood Information Center, "USDA Emergency Assistance Paid to Flood States," April 4, 1994; Federal Emergency Management Agency, Federal Insurance Administration, computer print-out, March 16, 1994.

the NFIP insurance premiums for buildings that predate the identification of the flood hazard in a particular community are subsidized, but for buildings built after that date, premiums are based on full actuarial rates. All costs of administering the program, including the costs of floodplain mapping and salaries of federal employees are charged to policyholders. The Midwest flood was the third most costly in terms of NFIP payments, exceeded only by Hurricane Hugo and the December 1992 coastal storm that struck New York, New Jersey, Massachusetts, Delaware, and Connecticut. In 1993, over half of the losses and two thirds of the payments were in Missouri. States in the upper basin had lower average payments since buildings were generally subjects to shallow flooding along tributaries which flooded basements and some first floors. States in the lower basin had much higher average losses reflecting the deep flooding in the bottoms along the main stems of the Mississippi and Missouri rivers (Table 1.7 and Figure 1.9). High average payments in Missouri also reflect large payments to small businesses and other non-residential building, particularly in Chesterfield and elsewhere in St. Louis County. Even in the counties with disaster status, in excess of 80,000 insured properties did not overtop or fail, but most were on tributaries that did not flood or where flooding was of less than 100 year frequency.

Federal Crop Insurance Program. Farmers can protect themselves from actual crop losses or prevented planting caused by uncontrollable natural events through purchase of crop insurance from the FCIC. This government corporation within the USDA provides coverage for 51 crops in the event of loss from drought, excess soil moisture, flood, frost, hail, wind, insects, and other natural perils. Historically drought has been the major cause of crop loss (55 percent) while floods represent only two percent of claims. Excess soil moisture, however, represents 16 percent of losses.

Farmers must purchase the insurance early in the crop year. For example, a policy to cover a corn crop planted in 1994 in the Midwest would have to be purchased by April 15. Farmers can choose the level of insurance that they wish to purchase, but they are not able to insure their crop for the full value. Maximum coverage is 75 percent of expected crop yield.[54] To encourage participation, the federal government subsidizes crop insurance premiums up to 30 percent and pays administrative, actuarial, underwriting, and selling expenses.

Table 1.8 shows the participation rate for crop insurance purchases in the 9-state area for 1993 as well as the indemnities paid to policyholders. Participation is lowest in the corn/soybean region and highest where

Table 1.7 NFIP Flood Insurance Losses for the Period from April 1 Through September 30, 1993 by State for the 1993 Midwest Floods.

State	Policies 1/31/94	Loss Count	Total Payments ($)	Average Payment ($)	Losses (%)	Payments (%)
Illinois	36,844	3,624	61,389,123	16,939.60	22	21
Iowa	8,689	1,390	23,378,415	13,833.38	10	8
Kansas	11065	1,071	10,702,780	9,993.26	7	4
Minnesota	3,472	372	1,712,960	4,604.73	2	>1
Missouri	20,981	8,271	192,296,740	23,249.52	5	65
Nebraska	6,652	503	4,833,133	9,608.61	3	2
North Dakota	3,008	198	285,572	1,442.28	1	>1
South Dakota	1,313	115	745,309	6,408.95	2	>1
Wisconsin	7,096	323	1,999,654	6,190.88	2	>1
Total	99,120	16,167	297,343,686	18,392.01		

Source: Federal Emergency Management Agency, Federal Insurance Administration, Computer print-out, March 16, 1994.

wheat is the principal crop. The largest claims were in the prairie pothole region (as were the bulk of the crop disaster payments) rather than in the floodplains. The probability of participation in the crop insurance program is lower for floodplain farmers than for those in the upland because flood damage is, in general, more localized than drought which is the primary hazard in the Midwest.

Loans. Federal agencies have approved $623 million in loans to individuals, businesses, and communities impacted by the Midwest flood. These loans, which must be repaid, as a federal expenditure only to the degree that interest rates are subsidized, borrowers default on loans, and administrative costs are incurred (See Table 1.9). The primary source of the loans is the Small Business Administration (SBA) Disaster Loan Program, which provided $597 million in loans to flood-affected homeowners and renters, businesses of all sizes, and non-profit organizations. Interest subsidies, defaults, and administrative costs amount to approximately 30 percent of the loans.[55] Farmers Home Administration (FmHA) is the source of agricultural loans because SBA is prohibited from making loans to farmers.

Federal income tax deductions. Uninsured and otherwise unreimbursed losses resulting from casualties such as a flood are deductible for Federal Income Tax purposes to the extent that they exceed 10 percent of Federal Adjusted Gross Income plus 100. ˇHis deduction results in decreased tax revenue to the federal government. The Internal Revenue Service provides tax counseling to disaster victims to assist them in applying for refunds by amending their previous years tax return when a major disaster is declared. The loss of tax revenue has not been quantified for the Midwest flood. Due to the amount of insurance and disaster assistance payments, the income levels of many of the flood victims, and requirement that the loss exceed 10 percent of adjusted gross income, the loss may not be substantial. The casualty loss deduction, however, does act as an additional mechanism for transferring the costs of flood damage from the private sector to the federal government.

Figure 1.9 National Flood Insurance Claims, 1993

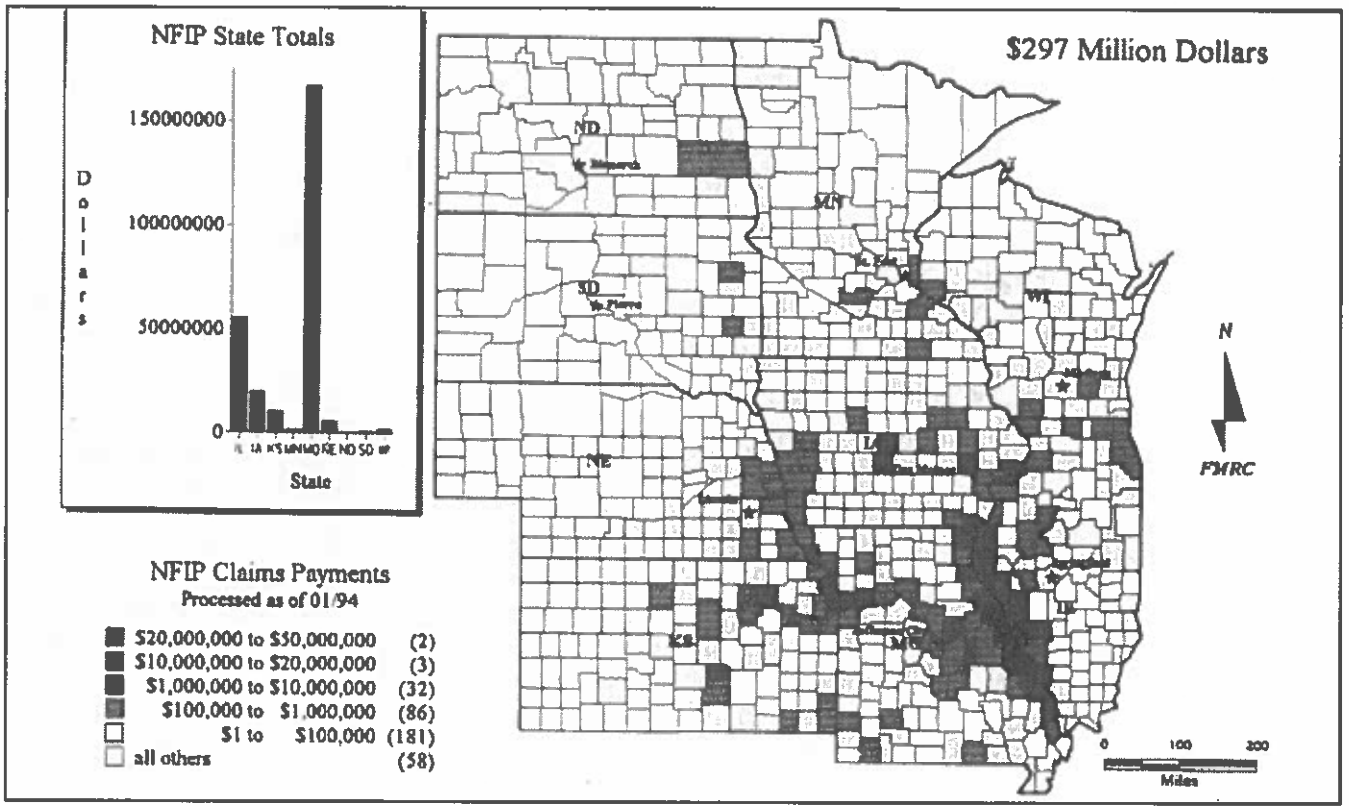


Table 1.8 Federal Crop Insurance Participation and Payments, 1993

State	Participation	Payments
	(%)	$(million)
Illinois	44.4	25.4
Iowa	60.2	281.02
Kansas	76.4	40.02
Minnesota	52.4	353.9
Missouri	24.0	27.07
Nebraska	56.1	49.0
N. Dakota	93.4	139.3
S. Dakota	47.0	54.1
Wisconsin	11.3	46.0
Total		1,017.0

Source: U.S. Department of Agriculture, Federal Crop Insurance Corporation, April 15, 1994

State and Local Costs

The Midwest flood was also costly for state and local governments. Because the FEMA provided assistance at a 90/10 cost share, the state/local share was approximately $42 million for Public Assistance and nearly the same amount for assistance to indivuduals.56 States and communities also had unreimbursed expenses associated with response and recovery. State and local costs for the restoration of damaged levees and watershed exceeded 130 million. These expenditures were part of the USACE 80/20 and the SCS 75/25 required cost shares.

Of greater concern to some communities is the short and long-term reductions in real estate tax revenues as properties are reassessed to reflect flood damages to building and agricultural lands or losses in market value due to the increased awareness of the flood hazard. In those areas, where homes are not being rebuilt and fields are not being restored, these losses will be permanent. Impact aid from the U.S. Department of Education, currently budgeted at $70 million, will replace a part of the lost tax revenues that would have gone to schools.[57] At the state level, losses in tax revenue may result from lost profits and wages. Partial compensation for these losses may come in part from the increased economic activity of the recovery effort and from federal assistance.

Non-Quantifiable Costs

The EPA determined that 59 Superfund sites experienced flooding; however, impacts to the sites were minimal and corrective measures have been completed on sites requiring them.[58] In addition, 73 solid waste treatment,[59] storage, and disposal sites were also flooded,[60] and large propane tanks that were dislodged floated downriver creating the potential for massive explosions. Besides the large propane tanks, the states collected over 18,000 orphaned drums[61] -- each with a potential hazardous or toxic substance -- and a large amount of household hazardous wastes whose disposal was necessitated by the flooding. Daily loads of agricultural chemicals (herbicides and Nitrates) transported by the Mississippi River were large relative to previous years; record flooding did not dilute the concentrations of herbicides.[62] Concentrations of two herbicides (altrazine and cyanazine) in some samples from the Mississippi River exceeded health-based limits for drinking water; however, the annual concentration was not expected to exceed those limits for 1993.[63] The cumulative impact of any flood-related releases of hazardous materials, including pesticides, herbicides, and other toxic materials has not been established.

The effects of flooding on groundwater hydrology and groundwater quality have yet to be determined. In response to concerns regarding the safety of private wells, the Administration established a well-water contamination survey in coordination with the nine-flood states.[64] The EPA performed floodwater quality sampling around major metropolitan areas on the Missouri River. In some cases, drinking water standards were exceeded, but the majority of the readings posed no health risk.[65] Results from sampling of treated drinking water revealed three location where Maximum Contaminant Levels were exceeded although results from a single sample do not necessarily indicate a problem.[66] USGS and National Oceanic and Atmospheric (NOAA) have not found significant changes in water chemistry since the 1993 flood.[67]

Impacts of the flooding on the distribution of contaminated river sediments is also unknown. Studies are underway to determine sediment chemistry and characterize sediment deposition patterns in rivers and streams.[68]

Effects of the flood on public and mental health are largely anecdotal. Some communities noted increases in spousal and child abuse and numbers of calls for police response. Mental health effects of community and individual buyout/relocation are poorly understood. Several studies are currently being completed to assess the human response to the 1993 flood and to evaluate the factors that strain the ability of families to function adaptively to the event.[69] Experience with other floods indicates that out breaks of Equine, Western, and St. Louis encephalitidies can be expected two years after flooding event (due to the lag time in amplification of disease vectors).[70] The length of time between the flood event and the appearance of disease adds to the problem of attributing costs.

The flood took its toll on historic and cultural resources

Table 1.9 Summary of Amount of Federal Loans by State for the 1993 Midwest Flood in Millions of Dollars

Program	Total	IL	IA	KS	MN	MO	NE	ND	SE	WI
Small Business Administration Disaster Loans	597.3	134.7	108.55	31.6	27.4	235.3	14.2	16.1	16.7	12.8
Rural Development Administration Loans	9.3	----	6.7	1.2	----	0.7	0.1	---	0.6	---
Farmers Home Administration Emergency Disaster Loans	14.7	2.1	7.3	0.1	2.4	0.9	0.1	0.2	0.9	0.8
Total Amount Approved	621.3	136.8	122.5	32.9	29.8	236.9	14.4	16.3	18.2	13.6

Source: Kuilik, Bernard, Associate Administrator for Disaster Assistance, U.S. Small Business Administration, personal communication, May 3, 1994; U.S. Department of Agriculture, Flood Information Center, "USDA Emercency Assistance Paid to Flood States," April 4, 1994.

in the area. Historic homes in Grafton, Illinois and Ste. Genevieve, Missouri and a church in Portage des Sioux were damaged. A cemetery in Hardin, Missouri was inundated which disinterred over 500 bodies. There were several American Indian tribes affected by the Flood of 1993. The SAC and Fox of the Mississippi in Iowa (Mesquakie) lost 10 homes and the ceremonial area of their Pow-wow grounds.[71] The Kickapoo Tribe in Kansas had damages to their crops, bridges, roads, and water systems.[72] Indian lands in the prairie pothole are were saturated by frequent rains. Local lakes flooded homes on the shore and contaminated drinking water wells. Well and lake water continue to be monitored for pesticides, animal wastes, and other pollutants potentially carried by runoff to the upland lakes.[73] Preliminary field investigations by state and federal forestry staff in Mississippi River navigation pools 25 and 26 revealed that all hackberry and sugarberry and a large percentage of sycamore appeared to be dead or dying at those locations. Similar effects might be expected elsewhere in the Basin's floodplain where flood duration coincided with the entire growing season. Hackberry and sugarberry are important mast-producing trees, and mature sycamore are frequently selected by species of colonial nesting birds.[74] The full effects on forest canopy and subcanopy structure will not be know for years to come.

Conclusion: ***Not all costs of the Flood of 1993 can be quantified in monetary terms, but bot quantifiable and non-quantifiable costs were significant in magnitude and importance.***

BENEFICIAL EFFECTS

Flooding is a natural phenomenon of every river. Historically, floodwater enriched bottomlands and provided spawning habitats for native fish. The ecological value of maintaining connections between the river and its floodplain and the flood-pulse advantage are among the benefits conveyed by a flood.[75] The 1993 flood connected many midwestern rivers with their floodplains, and for the first time in decades this flood coincided with the natural spawning period of riverine fishes. The benefits of this inundation to fisheries and aquatic resources was evidenced anecdotally in reports of fishermen utilizing newly created scour holes, and empirically in fisheries samples collected as part of the fall fish sampling for the cooperative interagency (USACE, FWS, and 5 states) upper Mississippi River System Long Term Resource Monitoring Program (LTRMP). Catches of young-of-the-year fish in fall 1993 samples (after the flood) were greater than numbers of such fish collected in all samples for the entire 1992 samplings year (before the flood).[76]

ENDNOTES

1. U.S. Army Corps of Engineers, Missouri River Division, Reservoir Control Center, *1993-1994 Missouri River Mianstem Reservoirs Annual Operating Plan,* December 1994.

2. U.S. Arm Corps of Engineers, Kansas City District, maps of the Missouri River from Rulo, Nebreska to St. Louis, Missouri 1879-1954.

3. The Fema study area was selected in the early phases of the response and recovery effort and included 419 contiguous counties in the upper Mississippi and Missouri River basins believed at the time to be most severely impacted by the 1993 flood.

4. The analysis was based on those Census Block Groups (CBGs) whose centroids were in the flood extent and the floodplain as mapped by the SAST team. These CBGs then were compared to CBGs with their centroids in uplands. Although most of the CBGs with centroids within the flood extent and floodplain contain extensive upland areas, the data are an indicator that areas inundated by the Midwest flood differ from the upland areas. The data were developed for both CBGs within Metropolitan Statistical Areas (MSA) and those outside of those areas.

5. The Executive Order on Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (EO 128-98, February 11, 1994) requires agencies to conduct activities related to human health and the environment in a manner that does not have the effect of discriminating against low-income and minority populations.

6. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, *Natural Disaster Survey Report, The Great Flood, 1993,* (Silver Springs, MD : DOC, February 1994).

7. Parrett, Charles, Nick B. Melcher, and Robert W. James, Jr., Flood Discharges in *The Upper Mississippi River Basin, 1993,* U.S. Geological Survey Circular 1120-A, Second printing (with revisions), September 24, 1993.

8. *Natural Disaster Survey Report, The Great Flood of 1993.*

9. The primary source for information in the Rainfall and River Flow sections was *Natural Disaster Survey Report, The Great Flood of 1993.*

10. U.S. Army Corps of Engineers, *Annual Flood Damage Report to Congress for Fiscal Year 1993,* Prepared by USACE Engineering Division in Cooperation with the National Weather Service Office of Hydrology, (Washington, DC: USACE, April 1994). The NWS supporting report, *Water Year '93 Food Damage Report,* includes several pages of discussions on the problems and limitations of current methods of estimating flood damages.

11. Ayres, B. Drummond, Jr., "What's Left from the Great Flood of '93," *The New York Times,* (August 10, 1993).

12. NWS Totals: "Water Year '93 Flood Damage Report," Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, 1994. NY Times Totals: Ayres, B. Drummond, Jr., "What's Left from the Great Flood of '93," New York Times, August 10, 1993. Illinois: Bhowmik, Nani G., editor, *The 1993 Flood on the Mississippi River in Illinois,* (Illinois, State Water Survey Misc. Publication No. 151. 1993). Iowa: Ostendorf, Jerry, Iowa Department of Public Defense, Emergency Management Division, personal communication, April 1, 1994. Kansas: Region VII Interagency Hazard Mitigation Team, Interagency Hazard Mitigation Team Report for FEMA-DR01000-KS, 1993. Minnesota: McCright, Kathee, Director, State of Minnesota, Washington Office, letter, April 14, 1994. Missouri: Governors Task Force on Floodplain Management, *Draft Recommendations and Updates,* February 1994. North Dakota: North Dakota Governor's Office, personal communication, March 29, 1994. South Dakota: Interagency Hazard Mitigation Team, *Hazard Mitigation Opportunities for South Dakota,* FEMA 999-DR-SC, August 1993. Wisconsin: Wisconsin Department of Natural Resources, *The Floods of 1993, The Wisconsin Experience, December 1993.*

13. Derived from USDA/ASCS and USDA/FCIC data, April 1994.

14. Cassidy, Dan, and Rickert Althaus, "The Flood of 1993: The Economic Aftermath," *Choices* (First Quarter 1994), pages 29-31.

15. Bhowmik, Nani G., (ed.), *The 1993 Flood on the Mississippi River in Illinois,* (Illinois State Water Survey Misc. Publication No. 151, 1993).

16. Taff, StevenJ., and Wilbur Maki, University of Minnesota Department of Agricultural and Applied Economics, (Letter Report, October 25, 1993).

17. U.S. Department of Agriculture, Soil Conservation Service data sheet, (Columbia, MO: USDA, October 1993).

18. Ibid.

19. "The Flood of 1993: The Economic Aftermath."

20. USDA, data sheet, October 1993.

21. Ibid; also see Table 1.5, that shows total crop disaster payments for the 9-state area were $1.46 billion and crop insurance payments were $1.02 billion.

22. American Red Cross National Headquarters, "Mid-West Floods 1993 American Red Cross Disaster Relief Operations Statistical and Cost Report,' (ARC, 1993).

23. Shepard, Bonnie, Federal Emergency Management Agency, Federal Insurance Administration, personal communication April 14, 1994.

24. "What's Left from the Great Flood of '93."

25. Federal Emergency Management Agency, "Status of Individual Assistance Activities for Major Disasters in the Midwest", (Washington, DC: FEMA, April 13, 1994).

26. Federal Emergency Management Agency, computer tape data of individual assistance for the Midwest disasters, (Washington, DC: FEMA, April, 1994).

27. Federal Emergency Management Agency, Federal Insurance Administrations, computer print-out (Washington, DC: March 16, 1994).

28. Kulik, Bernard, Associate Administrator for Disaster Assistance, Small Business Administration, personal communication, May 3, 1994.

29. Ibid.

30. FEMA, computer print-out March 26, 1994.

31. Federal Emergency Management Agency, "Big Disasters 1989-1994 -- Projected Infrastructure Funding (formerly Public Assistance)," (Washington, DC: FEMA, April 1, 1994).

32. *The 1993 Flood on the Mississippi River in Illinois.*

33. "Status of Individual Assistance Activities for Major Disasters in the Midwest."

34. Harper, Edwin L., President and Chief Executive Officer, Association of American Railroads, testimony before the Subcommittee on Transportation and Hazardous Materials, Committee on Energy and Commerce, U.S. House of Representatives, September 23, 1993.

35. U.S. Congress, PL 103-75, emergency supplemental appropriations for relief from the major, widespread flooding in the Midwest for the fiscal year ending September 30, 1993, and for other purposes, (Washington, DC, August 11, 1993).

36. Trilling, Donald R., Director, Office of Transportation Regulatory Affairs, U.S. Department of Transportation, personal communication, February 16, 1994.

37. U.S. Department of Transportation, Maritime Administration (MARAD), data sheet, August 17, 1993.

38. Ibid.

39. "Big Disasters 1989-1994 -- Projected Infrastructure Funding."

40. Knight, D. Karen, U.S. Environmental Protection Agency, Headquarters Emergency Operation Center, personal communication, August 25, 1993.

41. On March 4, 1994, members of the FMRC met with representatives of the Des Moines Water Works in Des Moines, Iowa.

42. Knight, personal communication.

43. "Big Disasters 1989-1994 -- Projected Infrastructure Funding."

44. Federal Interagency Floodplain Management Task Force, *Floodplain Management in the United States: An Assessment Report, Volume 2,* (Washington, DC: FIFMTF, 1992), pages 9-8.

45. Klemme, Dale, Relocation Coordinator, Prairie du Chein, WI, personal communication, 1994.

46. FEMA, computer print-out, March 16, 1994

47. Ibid.

48. *Annual Flood Damage Report to Congress for Fiscal Year 1993.*

49. The 1993 flood occurred after a six-year drought which resulted in lower than normal elevations in the reservoirs. If the Reservoirs had been at normal pool elevations, however, the same flood damage reduction benefits would have been provided.

50. "The Flood of 1993: The Economic Aftermath."

51. National totals may not equal cumulative state totals for some programs because funds have not been fully allocated, obligated, or expended.

52. PL 103-75, Making emergency supplemental appropriations for relief from the major, widespread flooding in the Midwest for the fiscal year ending September 30, 1993 and for other purposes. P.L. 103-211, Making emergency supplemental appropriations for the fiscal year ending September 30, 1994 and for other purposes. "USDA Emergency Assistance Paid to Flood States, "U.S. Department of Agriculture Flood Information Center, Report Date: April 4, 1994. "Big Disasters 1989-1994 -- Projected Infrastructure Funding" and "Big Disasters 1989-1994, Projected Costs for Human Services, Hazard Mitigation, Administration," Federal Emergency Management Agency, Data as of April 1, 1994. HUD 1993 CDGB and HOME allocations-Meeting with Dan Patch, U.S. Department of Housing and Urban Development, January 12, 1994. HUD 1994 CDGB allocations -- Personal communication, Phyllis Amon, U.S. Department of Housing and Urban Development, April 22, 1994. EDA data for states is grants awarded and applications invited-Personal communication, Dave McIlwain, Economic Development Administration, April 15, 1994. USACE data-Personal communication, Capt. Ken Young, U.S. Army Corps of Engineers, Readiness Branch, April 20, 1994. EPA data-Personal communication, Kathy Jones, Environmental Protection Agency, Office of Solid Waste and Emergency Response, April 21, 1994. DOT data for highways and railroads -- Personal communication, Susan D. Gaskins, U.S. Department of Transportation, Office of the Secretary, May 6, 1994. NOAA, student financial assistance, National Community Service, and DOI data -- "Federal Spending on the MidWest Flood Recovery," Office of Management and Budget, April 8, 1994. Labor data-Personal communication, Tom Edwards, ETA Public Affairs, May 13, 1994.

53. FMRC analysis of USDA/ASCS count-level data.

54. The amount paid for a claim is based on loss below the coverage amount. For example, a farmer with a 65 percent level of crop insurance who lost half of his or her crop would be compensated for 15 percent of the crop value (65% - 50% = %15). A farmer with a 35 percent level (the minimum) would get no compensation. The price paid per unit of eligible crop loss can be selected as the market price or as a percentage of an established. The insurance premium depends both the chosen yield coverage and price election.

55. Kulik, personal communication; USDA Flood Information Center, "USDA Emergency Assistance Paid to Flood States," Washington, DC: USDA, April 4, 1994.

56. Ibid.

57. PL 103-75, emergency supplemental appropriations for relief from the major, widespread flooding in the MidWest for the fiscal year ending September 30,. 1993, and for other purposes (Washington DC: U.S. Congress, August 11, 1993).

58. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Chemical Emergency Preparedness and Prevention Office, Draft Report, (Washington, DC: EPA, January 1, 1994).

59. "Big Disasters 1989-1994 -- Projected Infrastructure Funding."

60. Permitted pursuant to the Resource Conservation and Recovery Act of 1976 42 USC Sections 6901-6987.

61. EPA, Draft Report, January 1, 1994.

62. Goolsby, Donald A., william A. Battaglin, and E. Michael Thurman, *Occurrence and Transport of Agricultural Chemicals in the Mississippi River Basin, July through August 1993,* U.S. Geological Survey, Circular 1120-C, (Washington, DC: USGS, 1993).

63. Ibid.

64. Young, Admiral Frank, Director, Office of Emergency Preparedness National Disaster Medical System, Public Health Service, personal communication, January 10, 1994.

65. U.S. Environmental Protection Agency, *The 1993 Midwest Flood Water Quality Monitoring Update of EPA's Flood Monitoring Task Force/Water Workgroup,* (Issue 2, December 31, 1993).

66. Ibid.

67. *Occurrence and Transport of Agricultural Chemicals in the Mississippi River Basin, July through August 1993; Natural Disaster Survey Report, The Great Flood of 1993.*

68. *The 1993 Midwest Flood Water Quality Monitoring Update.*

69. Among proposed studies are the following: "Human Response to Repeated Floods", Carol North, Principal Investigator, Washington University, St. Louis, MO, and 'Marital Violence in the Wake of the Great Flood," Patricia Resick, Principal Investigator, University of Missouri, St. Louis, MO.

70. Young, personal communication.

71. Wilson, John, Tribal Liaison, Environmental Protection Agency, Region VII, personal communication, May 16, 1994.

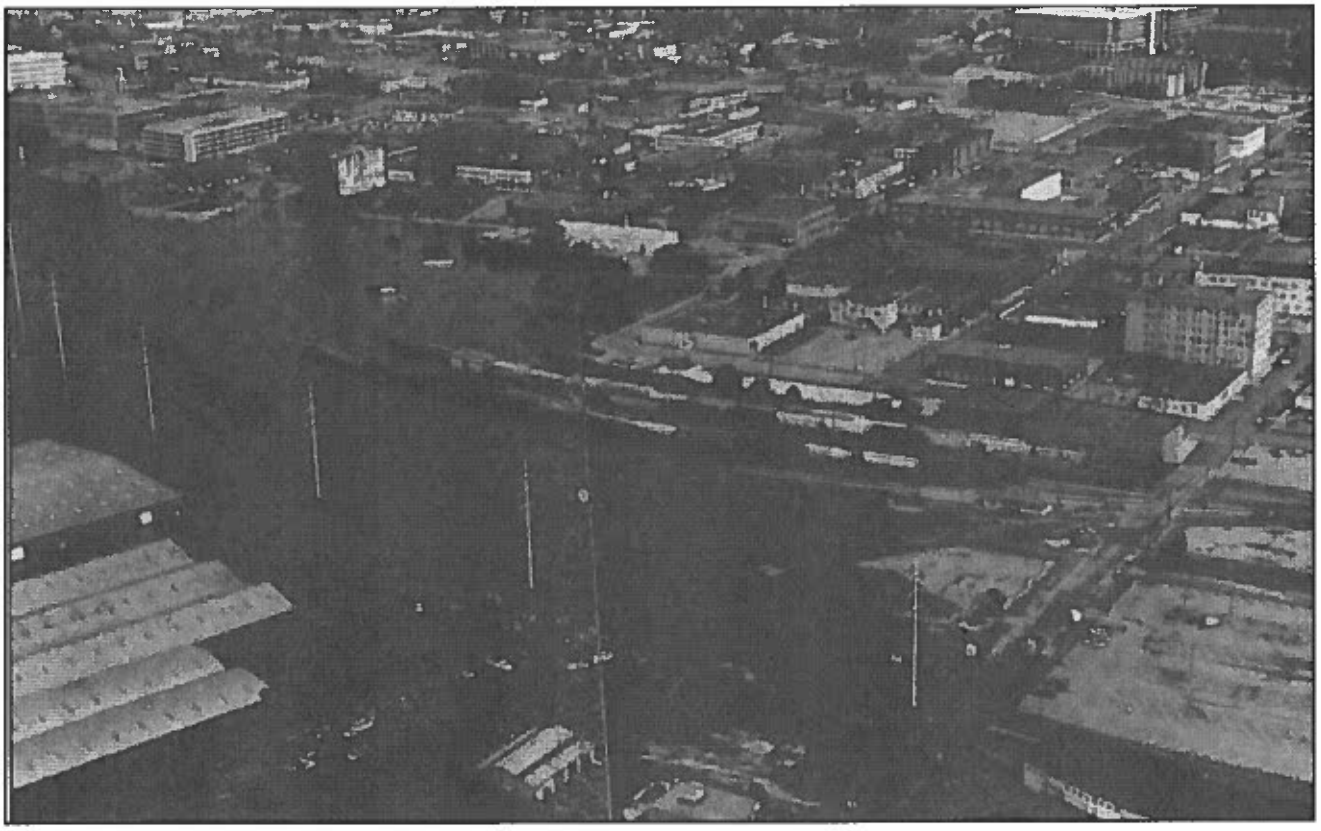
72. Ibid.

73. Oliver, Sheila, Department of Interior, Bureau of Indian Affairs, Sisseton Agency, South Dakota, personal communication, May 16, 1994.

74. U.S. Army Corps of Engineers, Memorandum CENCR-OD-RM, April 12, 1994.

75. Bayley, P.B., "The Flood Pulse Advantage and the Restoration of River-floodplain Systems," *Regulated Rivers: Research & Management,* 6:75-86, (1991); Junk, W.J., P.B. Bayley, and R.E. Sparks, "The Flood Pulse Concept I River-floodplain Systems,' In: D.P. Dodge (ed.) Proceedings of the International Large River Symposium, Can. Spec. Publ. Fish., Aquat. Sci. 106:110-127 (1989).

76. Hrabik, B., *October-December 1993 Open River Field Station Activities and Projects Report,* memorandum, (Cape Girardeau, MO: Missouri Department of conservation, 1994), pages 1-7.



Chapter 2

IMPACTS OF HUMAN INTERVENTION

In the matter of floodplain management, most people agree that some combination of structural and nonstructural methods are probably a better approach than the previous complete reliance on dams and levees.

Luna B. Leopold
Water Resources Update, Issue No. 95: Spring, 1994

HISTORY

The rivers and streams of the Midwest were focal points for early settlement because they provided sources of drinking water and avenues for transportation and trade. Once settlements were established along rivers, the problem of controlling floods to protect human life and investments became readily apparent. At first small mounds of dirt were thrown up to divert water away from towns, and over the course of time, these mounds became levees and floodwalls. Many people living in floodplains behind those levees and floodwalls remain at risk because of decisions made many years ago. The modern challenge is to reduce those risks.

As settlers spread west they altered prairie, forest, meandering streams, and free-flowing river landscapes to provide arable farmland, raw materials for homes and industry, and transportation. Federal policies encouraged extensive private land development which then required construction of reservoirs and levees for flood protection. Human use thus changed midwestern landscapes to the detriment of natural ecological systems. The Flood of 1993 raised questions as tow what extent these landscape changes have contributed to flood frequency and duration.

Agricultural Policy and Farm Production

Since the 1930s, when one quarter of the population lived on farms, U.S. farm policy has used a system of price supports (loans, purchases, payments, or a combination of methods) to improve farm income and promote conservation, while assuring a dependable Food supply for the United States. The Food, Agriculture, Conservation, and Trade Ace of 1990 (FACTA) continued the market orientation of its predecessor, the Food Security Act of 1985. Stated goals of the 1990 Farm Bill (FACTA) were to ease financial stress on farmers, reduce government costs, reduce crop surpluses, maintain export competitiveness, and enhance environmental quality. Among the best know features of the farm policy are the Production Adjustment/Price Support Programs administered by the Agricultural Stabilization and Conservation Service of the U.S. Department of Agriculture (USDA). Appendix C provides an example of how price supports operate.

Agriculture is the leading industry in most counties of the nine states affected by the Flood of 1993 (See Table 2.1).

PRODUCTION DIFFERENCES OF FLOODPLAINS VS. OTHER AREAS

Agricultural production in floodplains of the nine midwestern states affected by the flood is focused on commodity crops such as corn and soybeans. Corn yields in well-drained floodplains uniformly average 15 percent higher than the state average in Missouri. Production on portions of the floodplains, however, can be reduced by poor drainage. Upland production yields are variable, depending on soil type and location. The highest upland corn yields are 16 percent higher than the highest floodplain yields; however, high-yield upland areas are presently I full production. Any additional production in upland areas would be in areas with yields averaging 14-26 percent lower than the average well-drained floodplain yield.

The area's 208 million cropland acres represent 32 percent of the nation's farm acreage, 35 percent of total agricultural sales, and almost 60 percent of total national corn, wheat, and soybean acreage.[1] Combined production from Illinois and Iowa alone represent 33 percent of corn and 30 percent of soybean acreage in the United States, but dominant crops and yields vary by state throughout the region. Floodplains comprise approximately 11 percent of total acreage affected by the 1993 flood and 66 percent of this acreage is in agricultural production. [2]

Navigation

There are two types of navigation projects present in the Basin. One, on the upper Mississippi River, is slack water navigation created and controlled by a system of locks and dams. The other, open water navigation, is utilized on the Missouri River and middle Mississippi River.

Upper Mississippi River. The upper Mississippi River navigation system provides a variety of uses: commercial transportation, recreation, environmental resources, water supplies for domestic and industrial use, and energy production. The Water Resource Development Act of 1986 declared the upper Mississippi River system to be a nationally significant ecosystem and a nationally significant commercial navigation system.

Navigation on the Mississippi River was a primary factor in settlement of the valley. The federal government began to support commercial navigation actively in 1824; first with 4-foot channels. The navigation channel projects, authorized by Congress in the 1930s for the Mississippi and Illinois Rivers, extended 9-foot draft navigation upstream to Minneapolis/St. Paul and connected the St. Lawrence-Great Lakes with the Mississippi-Ohio-Missouri navigation systems (Figure 2.1)

The upper Mississippi River 9-foot navigation project has converted the Mississippi River (St. Louis to Minneapolis/St. Paul into a series of pools at low and normal flow (Figure 2.2). Navigation dams, each consisting of a row of gates mounted between piers over a low sill, are used to maintain sufficient water depth for navigation. During periods of high flow, the navigation gates are completely opened to allow passage of the flood flows.

Construction of the 29 lock and dam projects on the Mississippi River north of St. Louis was completed by 1950. These locks are nearing the end of their economic life span and may soon start to require

Table 2.1 Agricultural Characteristics of Flood Affected States

STATE	FARMLAND million acres	AVERAGE FARM SIZE acres	CASH CROPS $million/yr.	RECEIPTS: U.S. Bank	CASH LIVESTOCK $million/yr.	RECEIPTS: U.S. Bank
Illinois	28.5	321	3,913	3	2,262	10
Iowa	31.6	301	3,510	4	5,270	2
Kansas	46.6	680	1,807	11	3,914	6
Minnesota	26.6	312	2,165	6	3,645	7
Missouri	29.2	275	1,517	14	2,173	11
Nebraska	45.3	749	1,975	8	4,848	3
N. Dakota	40.3	1143	1,548	13	760	32
S. Dakota	44.2	1214	813	27	1,910	15
Wisconsin	16.6	221	795	28	4,222	5

Source: 1987 U.S. Department fo Commerce, *Census of Agriculture.*

expensive replacement. Locks and dam 26 near Alton, Illinois, was replaced during the early 1980s at a cost of nearly $1 billion. Below the southernmost lock, Lock 27 at Granite City, Illinois, navigation is maintained through placement of flow regulating structures such as wing dikes and by dredging that channelize, narrow, and deepen the river.

Maintenance of the upper Mississippi River navigation system requires periodic dredging at over 200 sites, removing an average of 9.5 million cubic yards of material annually. Additionally, about 2,400 submergent and 700 emergent wing dikes are maintained to reduce main-channel sedimentation and 420 miles of bank line stabilization are maintained to prevent shoreline erosion.[3]

Illinois River. Two construction projects have supported navigation activities on the Illinois River. The first, the Chicago sanitary and Ship Canal, completed in 1900, diverted water from Lake Michigan into the Illinois River. The second, a modern lock and dam system, similar to that in operation on the upper Mississippi River, consists of seven separate navigation locks. This system was completed in 1965.

Missouri River. In 1945 congress authorized a comprehensive navigation plan for the Missouri River system. The result was a 9-foot channel navigation project to channelize and deepen the river from St. Louis upstream to Sioux City, Iowa. Six multi-purpose mainstream reservoirs, affecting over 900 river miles, were developed above Gavins Point Dam. One purpose was to provide a regulated release of water for downstream navigation. Downstream of Gavins Point Dam, the river consists largely of a 735-mile navigation channel maintained with wing dikes, channel stabilization and other erosion and sedimentation control devices. Annual water release for navigation is based upon available water supplies. Navigation needs combined with winter releases for waste supply and hydropower demands obligate all available water during a normal year. The navigation season on the Missouri River is limited to the ice-free season between April 1 and December 1.

Figure 2.1 Upper Mississippi River System Nine-foot Commercial Navigation Project with Timetable of Development.

Timetable of Navigation Activities

Activity	Year
Mississippi River:	
Congress authorizes removal of snags and local obstructions	1824
Congress authorizes 4.5 ft. channel from St. Louis to St. Paul	1878
Congress authorizes 6 ft. channel	1907
Construction of Lock and Dam 19	1914
Construction of Lock and Dam 1	1917
Congress authorizes 9 ft. deep, 300 ft. wide channe St. Louis to Cairo	1927
Congress authorizes extension of 9 ft. channel to St. Paul through construction of locks and dams	1930
Construction of 29 locks and dams	1930-1950
Construction of Lock and Dam 27	1953
Construction of 1200 ft. chamber at Lock and Dam 19	1957
Illinois River:	
Congress authorizes construction of the Illinois and Michigan Canal	1822
Construction of Chicago Sanitary and Ship Canal and 5 low navigation locks and dams	1900
Construction of present day system of 7 locks and dams	1933-1939

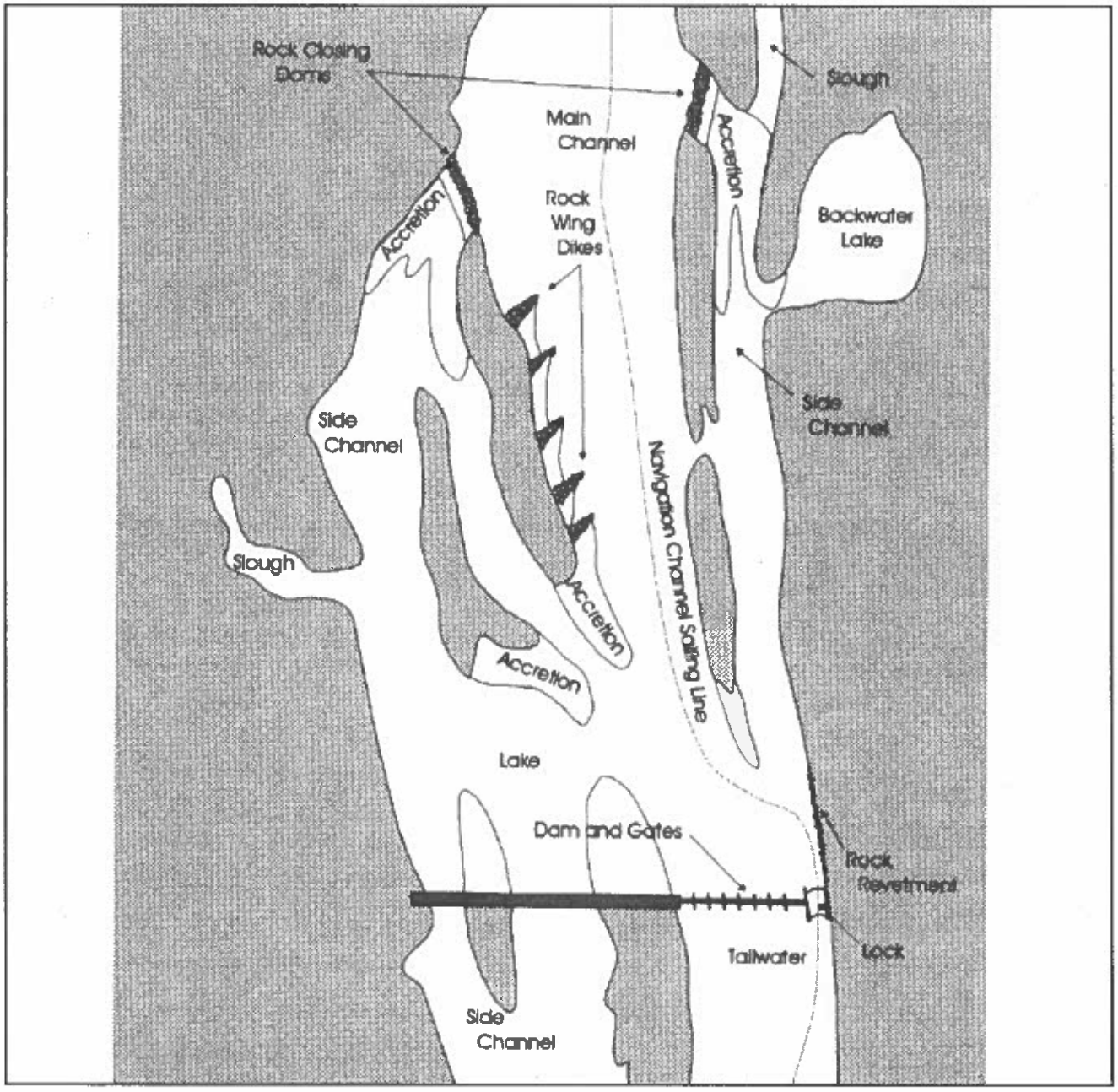


Source: Upper Mississippi River Basin Commissiom, *Comprehensive Master Plan for the Management of the Upper Mississippi River System.* January 1, 1982.

Flood Damage Reduction

A flood in 1927 affected millions of people throughout the Mississippi River Basin and demonstrated the inadequacy of the pattern of private flood damage reduction measures begun in 1879. It became a milestone event leading to major changes in national floodplain management policy. The 1928 Flood control Act, which established the lower Mississippi River flood damage reduction system, and the 1936 Flood Control Act were the first codification of the

Figure 2.2 Typical Upper Mississippi River Lock and Dam.



Source: Adapted from Upper Mississippi River Basin Commission, *Comprehensive Master Plan for the Management of the Upper Mississippi River System*. January 1, 1982.

federal interest in the coordinated development and installation of flood damage reduction measures. The primary method used to prevent damages in those early years was floodplain levees. Starting in 1936 the USAE responsibilities were focused on major rivers and development of congressionally approved plans for reservoirs, levees, channelization, and diversions. The method s used were those determined to be most cost effective for preventing flood damages.

The USACE has constructed 76 reservoirs in the upper Mississippi River Basin. These control a drainage area of almost 370,000 square miles and contain a total flood storage volume of 40 million acre-feet of water.[4] Forty-nine are located in the Missouri River Basin where the USACE also operates 22 Bureau of Reclamation reservoirs for flood storage. The majority of the reservoirs are operated to provide benefit s on the tributaries where they are located; some are operated to benefit the main stem rivers.

In addition to the reservoirs, the USACE has constructed or improved over 2,200 miles of levees for the protection of communities and agriculture in the upper Mississippi River Basin. Though records on the federal levees are kept by the USACE (Table 2.2), there is no known inventory about the estimated 5800 miles of non-federal levees that are in the upper basin.

Flood damage reduction-related activities of the SCS began nationally in 1944 with passage of PL 78-534 authorizing installation of upland treatment and flood damage reduction work selected watersheds. The Watershed Protection and Flood Prevention Act of 1954 (PL 83-566, referred to herein as PL-566) expanded the SCS flood damage reduction program to the entire nation. During the past 40 years, in the nine midwestern states affected by the Flood 1993, the SCS has planned and evaluated 316 watershed projects covering 40,000 sq.mi. (25.5 million acres). Locally sponsored PL-566 projects have resulted in the installation of 2,964 reservoirs that influence the drainage of over 5 million upland acres, and 818 miles of channel work, 75 percent of which is located in North Dakota, Minnesota, and Illinois. The SCS requires 75 percent of the land above a proposed reservoir site to be treated before construction. It is estimated that PL-566 has resulted in soil and water conservation treatments on more than 3 million upland acres.

Although flood damage reduction reservoirs and levees reduce the risk of flooding, they do not eliminate it. Given enough rainfall the flood damage reduction storage capacity of a reservoir can be exceeded and water will overtop the spillway. Local flooding may then occur downstream; its extent will depend upon the condition of the stream when

Table 2.2 Levee Constructed or Improved by the USACE in the Upper Mississippi River Basin.

River Reach	Corps District	Federal Maintenance (Miles)	Local Maintenance (Miles)
Upper Mississippi	Saint Paul		17
Upper Mississippi	Rock Island	27	650
Missouri	Omaha/Kansas City	15	1100
Middle Mississippi	Saint Louis		440
	Total Above Cairo, IL	42	2207

Source: USACE Headquarters.

the overtopping occurs. Throughout the basin, the Flood of 1993 exceeded the design capacity of many levees and the flood storage capacity of some reservoirs, flooding lands and property of persons who may have thought they were not at risk.

Wetland Losses

Wetlands occur in poorly drained soils and in areas where water is found at or near the ground surface. Between 1780 and 1980 an estimated 53 percent of the nation's original 221 million acres of wetlands were drained.[5] In the nine mid western states affected by flood 57 percent of the wetlands have been converted to other uses (Figure 2.3). The SwampLand Acts of 1849, 1850, and 1860 resulted in the transfer of nearly 65 million acres of wetlands in 15 states from federal state administration for the purpose of expediting their drainage.[6]

United States policy from the mid to the late 1800s has been to cede "overflow and swampy" lands to the states and to convert these lands to productive use.[7]

Substantial bottomland timber harvesting began with arrival of pioneers, and by the 1930s, most wetlands had been converted to from natural to agricultural used and over 84 million acres nationwide had been included in regional enterprises known as drainage districts.

By the 1950s, forested wetlands had been reduced to 66.7 million acres, and by the mid-1970s in additional 6.5 million acres had disappeared.[8]

Between the mid-1950s and 1970s an average of 458,000 wetland acres were lost each year in the coterminous United States. Agricultural development was responsible for 87 percent of the loss as wetlands were drained, filled, or otherwise converted to cropland.

IMPACT AND EFFECT

Development in the upper Mississippi River Basin for agriculture and other economic activity, flood damage reduction and navigation has greatly altered the original landscape. The characteristics of Food events and the modification of the basin's natural resources reflect these changes.

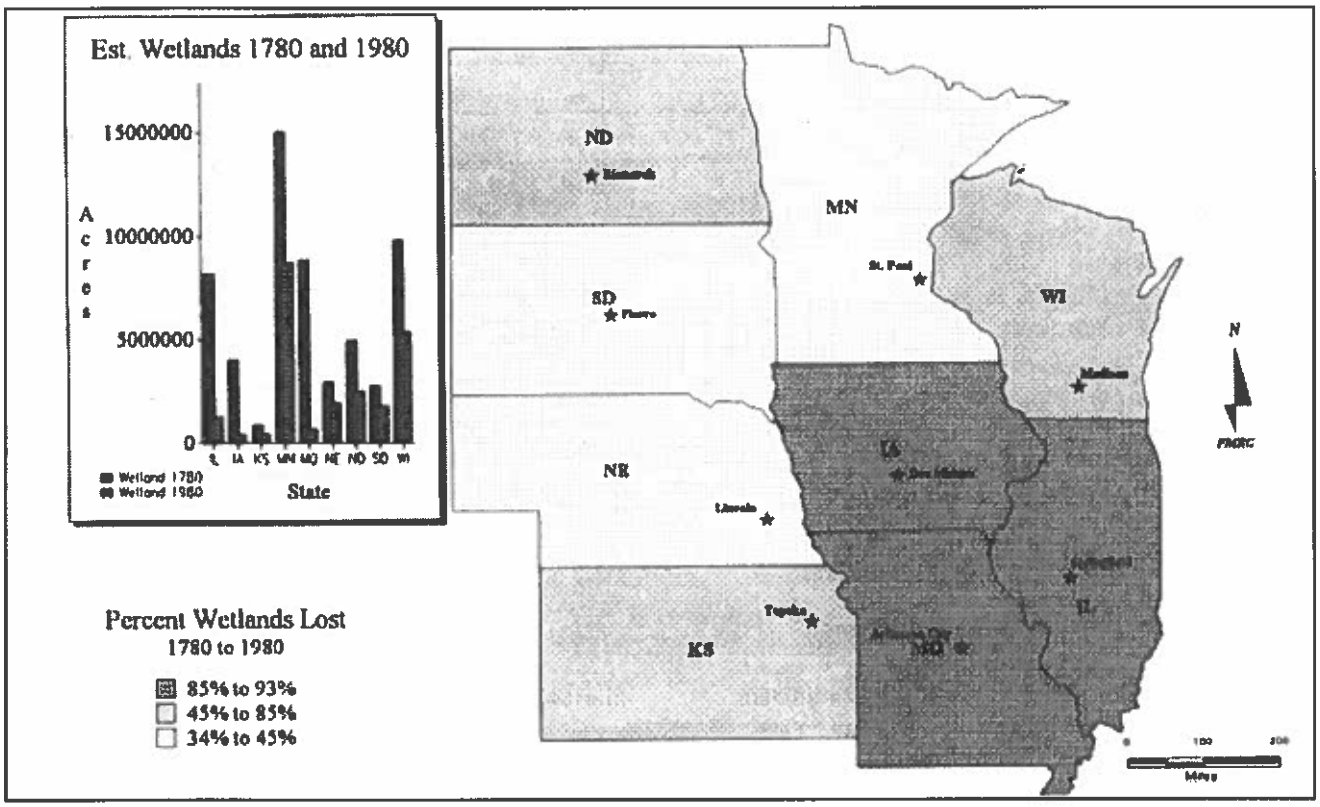
Upland Treatment and Runoff

Upstream land use and land treatment affect downstream flow regimes of rivers and floodplains. In considering floods and floodplain management, knowledge of where and how runoff occurs and which land practices can hold the rain where it falls for as long as possible become critical. Proper management can greatly affect the quantity and quality of water and sediment transported by floodwaters. Factors influencing the amount and velocity of run off include the amount and intensity of precipitation, soil type, land slope, available storage and land cover.

Proper management of agricultural lands requires use of protective cover or land conversation practices. In the Midwest cropland erosion can be reduced by using measures such as conservation tillage, terraces, crop rotation, field border, sediment and debris basins, strip cropping, and permanent vegetation. Such land use practices increase infiltration rates and help hold both water and soil in place. It is estimated that 37 percent of the nation's croplands have adequate land treatment installed.[9]



Figure 2.3 Estimated Wetland Losses, 1780 Through 1980

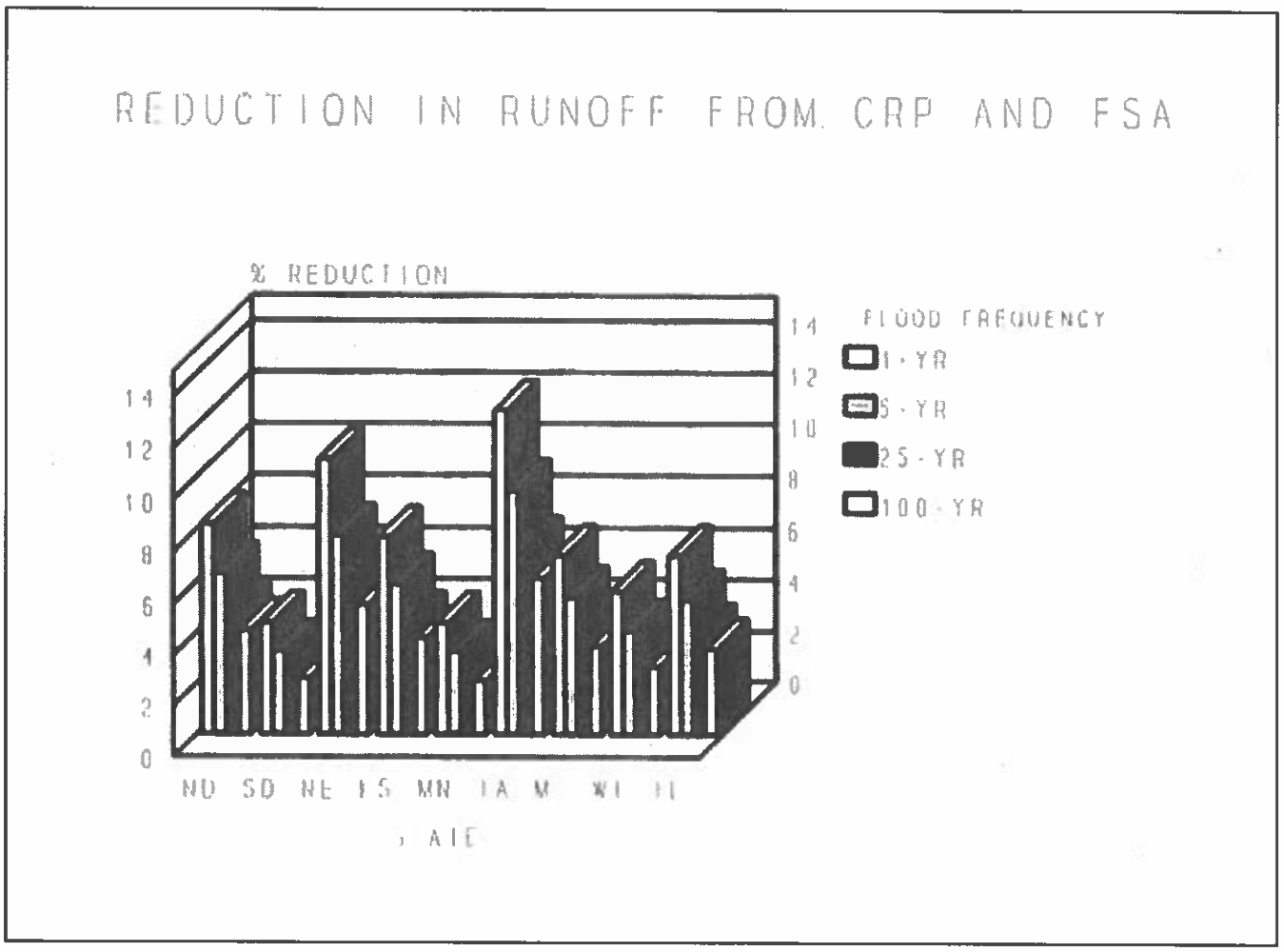


Source: Based on GAO/RCED-92-79FS, Report fo November 1991.



The 1985 Food Security Act (1985 Farm Bill) mandated treatment of all highly erodible land (HEL) with conservation measures needed to reduce erosion. The Conservation Reserve Program (CRP) established by the Act was intended to encourage landowners to retire highly erodible and other environmentally fragile land from crop production for ten years. In the upper Mississippi River Basin, over 200,000 CRP contracts were signed and 10.9 million acres were converted from cropland to grass or tree cover at a ten year cost of $11.3 billion. This has r educed the average erosion rate from 18.6 tons per acre per year. Assuming normal antecedent soil moisture conditions, CRT lands reduced runoff volumes by approximately 6-12 percent for the 1-year event, 3-8 percent for the 25-year event, and 2-4 percent for the 100-year event.[19] In the case of the 1993 flood, soils were saturated and the quantity and intensity of rainfall so great that runoff reduction attributable to land treatment was minimal (Figure 2.4)

Figure 2.4 Effects of the Food Security Act.



As CRP contracts begin to expire in September 1995, a large portion of enrolled acres is expected to revert to cereal, row-crop, and forage production. Current estimates are that 63 percent of land under contracts will revert to cropland and 23 percent to grazing and pastureland. The remainder is expected to remain in permanent grass and trees and other miscellaneous uses.[11] Conversion of these lands to cropland is expected to increase storm runoff even allowing for installation of proper conservation practices.

Conclusion: ***Upland watershed treatments such as conservation tillage practices and CRP land easements are effective in reducing upland runoff, especially for smaller storm events, for large events like the 1993 flood, upland treatments had little effect.***

Wetlands and Flood Storage

Pre-1850 historical records indicate that even prior to the clearing of wetland areas major floods occurred in the Mississippi River Basin. As part of economic development in the Midwest a substantial percentage of agricultural lands were created by drainage of wetlands and hydric soils. Hydic soils, good indicators of past and present wetland locations, total 10.4 percent of Mississippi and Missouri basin soils.[12] The review Committee heard numerous times that flooding would have been reduced had more wetlands been available for rainfall and runoff storage. An evaluation of the upper Mississippi River Basin's capacity to store rainfall runoff estimates that the soil profile has 10 times more storage capacity than above ground storage in depressional potholes.[13] Because much of the basin was depleted and unable to store water from the rains of June and July.[14]

Surface depressions or potholes occur throughout the glacial landscapes of north central Iowa, east South Dakota, and North Dakota. When these depressions fill, surface waters flow from pothole to pothole through an ill-defined network, eventually finding an outlet to a surface stream. This intricate network of depressions slows runoff. A different pattern of runoff occurs in the remainder of the basin. There surface runoff flows through and open network of streams, with only minor areas of surface water storage available. Historically, shallow wetlands and wet prairies, which occurred in these areas, served a similar, but less effective, function to that of potholes.

Topography has a direct impact on water movement and soil formation. The upper Mississippi River Basin is characterized by two distinct kinds of landscape: open systems, which drain externally and closed systems where drainage is trapped within a common depository. Due to the extended period of rain preceding the 1993 flood, the impacted area became completely saturated and surface depressions filled; therefore, storage available for additional runoff could only be found in the deep depressional areas located in the prairie pothole region of the Dakotas, Minnesota and Iowa.

Hydrologic mode studies of four watersheds that are representative of distinctly different upper Mississippi River Basin areas or terrain units were completed in 1994.[15] The modeled watersheds represent only 5 of the 70 terrain types in the basin and therefore information derived from these modes has limited applicability to assessing flood flow reductions basin-wide. The following watersheds were selected for hydrologic studies:

- Boone River near Webster City, Iowa –a Central Towa and MinnesotaTill Prairie with a relatively steep 380 sq.mi. watershed with well incised drainage.

- White Creek near Dallas, Iowa—an Illinois and Iowa Deep Loess and Drift and Iowa and Missouri Heavy Till Plain with a relative steep 380-sq. mi. watershed with well incised drainage.

- West Fork Cedar River near Finchford, Iowa—a Eastern Iowa and Missouri with Prairie with a flat 850 sq.mi.watershed but having well defined drainage system.

- Redwood River Watershed above Redwood Falls, Minnesota -- a Central Iowa and Minnesota Till Prairie and Loess Uplands and Till Plain with both high relief and low relief pothole areas of a 700 sq.mi.watershed.

For the analysis all model runs used antecedent moisture condition II for the start of modeling conditions Condition II is defined as the average soil condition prior to the annual flood event. For the 1993 flood antecedent conditions were condition III in most areas. Condition III indicates near saturated soils prior to the storm and gives significantly higher runoff that antecedent II. Because the model analysis used a lower antecedent moisture condition than was actually experienced in the 1993 flood, the peak discharge reductions resulting from the model analysis are greater than would have occurred.

In areas where opportunity exists, wetlands and small detention structures can aid in lowering peaks. However, flood peak discharge reduction is dependent on the topography of the watershed, the percentage of the basin containing deep depressional storage, and the intensity and volume of the rainfall.

In the watersheds modeled the maximum reduction for floodplain wetlands was 6 percent of 25- and 100-year storm event. Wetlands are more effective in upland areas with more deeply incised potholes, such as the Redwood River watershed. Where reductions were 23 percent of the 1-year event, 11 percent of the 25-year event, and 10 percent of the 100-year event. In areas of shallow depressions, such as the Boone River watershed, restored wetlands reduced peak discharge by 9 percent of 1-year event, 7 percent of the 25-year event, and 5 percent of the 100-year event.

With the installation of a combination of land treatment measures and restored wetlands in the watershed, the models indicate runoff reductions of 12 to 18 percent are possible for the 25-year or less event. This indicates these practices could be effective for the smaller storm events.

Wetland restorations in the uplands could function much the same as small upland reservoirs. It was shown more than three decades ago that small flood damage reductions dams are effective in the reach of stream immediately downstream but their effect diminishes rapidly with distance. As far as a series of small headwater dams is concerned, they are essentially ineffective under conditions in which major floods occur on large rivers.[16]

A State of Illinois report concluded that for certain watersheds, peak flow decreases as wetland areas increase. In very small watersheds (less than 100 sq.mi.), peak flowrates decreased by an average of 3.7 percent for each increase in wetland area equivalent to one percent of the area of the watershed. Applicability of this report may be limited only to the study areas. While wetlands may have some impact on peak flow in the smaller watersheds during smaller storms, their effects in larger watersheds during smaller storms, their effects in larger during larger events has not been sufficiently documented and needs further study.

Previous watershed evaluations, such as the study of Devils Lake in North Dakota (a closed basin), indicate reductions of peak flowrates up to 41 percent for 1 100-year storm. These widely ranging results from the aforementioned studies demonstrate that alternative watershed practices produce varying degrees of success in reducing flood runoff rates depending (in addition to the magnitude and intensity of the rainfall and antecedent moisture conditions) on the percentage of the basin treated and basin topography. Generally, as drainage areas increase, upland treatment measures, wetlands, and small detention structures have less effect in decreasing peak flowrates. In short, land treatment and detention storage (upland wetlands) can play a role in reducing peak runoff in some watersheds but are not a panacea for solving flood problems. Only a combination of upland and floodplain management practices can reduce floodplain damages in the future.

Conclusion: ***Upland wetlands restoration can be effective for smaller floods but diminishes in value as storage capacity is exceeded in larger floods such as the Flood of 1993. Present evaluations of the effect that wetland restoration would have on peak flows for large floods on main rivers and tributaries are inconclusive.***

Flood-storage Reservoirs

The 1993 flood demonstrated that dams and reservoirs, engineered and built to store and regulate floodwater discharge, could reduce flood damages. All federally funded flood storage reservoirs operated as planned during the 1993 flood. At some facilities, such as Tuttle Creek Reservoir (Kansas) and Coralville reservoir (Iowa), emergency spillway flows occurred when inflow volume exceeded reservoir storage capacity, the storage space allocated in a typical reservoir and effect of flood storage is depicted in Figure 2.5. During the period of peak flooding (April 1 to August 1, 1993), the USACE reservoirs stored 22.2 million acre-feet of flood water.[17] Approximately 18.7 million acre-feet were stored in the Missouri Basin, half of which was stored in the 6 main stem.

RESERVOIR OPERATIONS

Flood control reservoirs temporarily store a part of the flood flow for later release so that peak downstream flows will be reduced. Food-storage capacity is always located above sediment and multi-purpose pool elevations. Food damage reduction reservoirs have emergency spillways that allow safe passage of flows that exceed storage capacity. All managed flood damage reduction reservoirs are operated pursuant to a water control management plan. In no case will the peak discharge from the dam exceed that which would have occurred without the dam.

Missouri River reservoirs. Most of the remainder was stored in tributary reservoirs of Kansas and Osage rivers. About 3.5 million acre-feet of water was stored in the Mississippi River Basin and an additional 1.1 million acre-feet were stored in 2,964 small PL-566 upland flood damage reduction reservoirs. Flood damages reduction reservoirs effectively controlled excess runoff and reduced damages to downstream floodplains during the 1993 flood event. The combined effect of the storage of flood waters in the federal flood damage-reduction reservoirs in the Missouri River basin reduced the average discharge of the Missouri River near it mouth, during the month of July, by 211,000 cfs. This had the effect of lowering the peak stage of the Mississippi River at St. Louis by 5 feet.

Levees

Federally constructed levees, in concert with upstream flood-storage reservoirs, protect many large urban areas from potentially significant damage. For example, without levees or floodwalls, portions of low-lying areas in Rock Island and Moline, Illinois, and Kansas City would have been devastated. At St. Louis the Mississippi River crested at 49.6 feet on the USGS gage, almost 20 feet above stage, yet that portion of the city protected by the large flood wall escaped inundation.

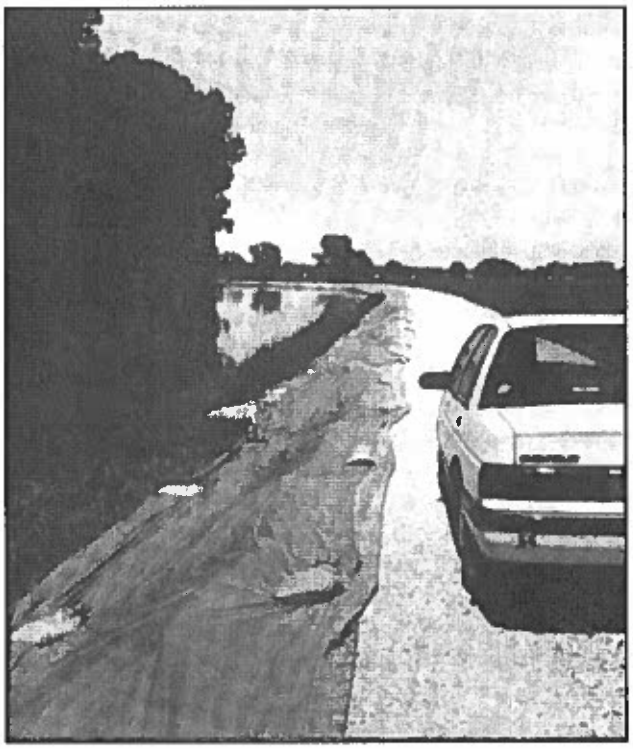
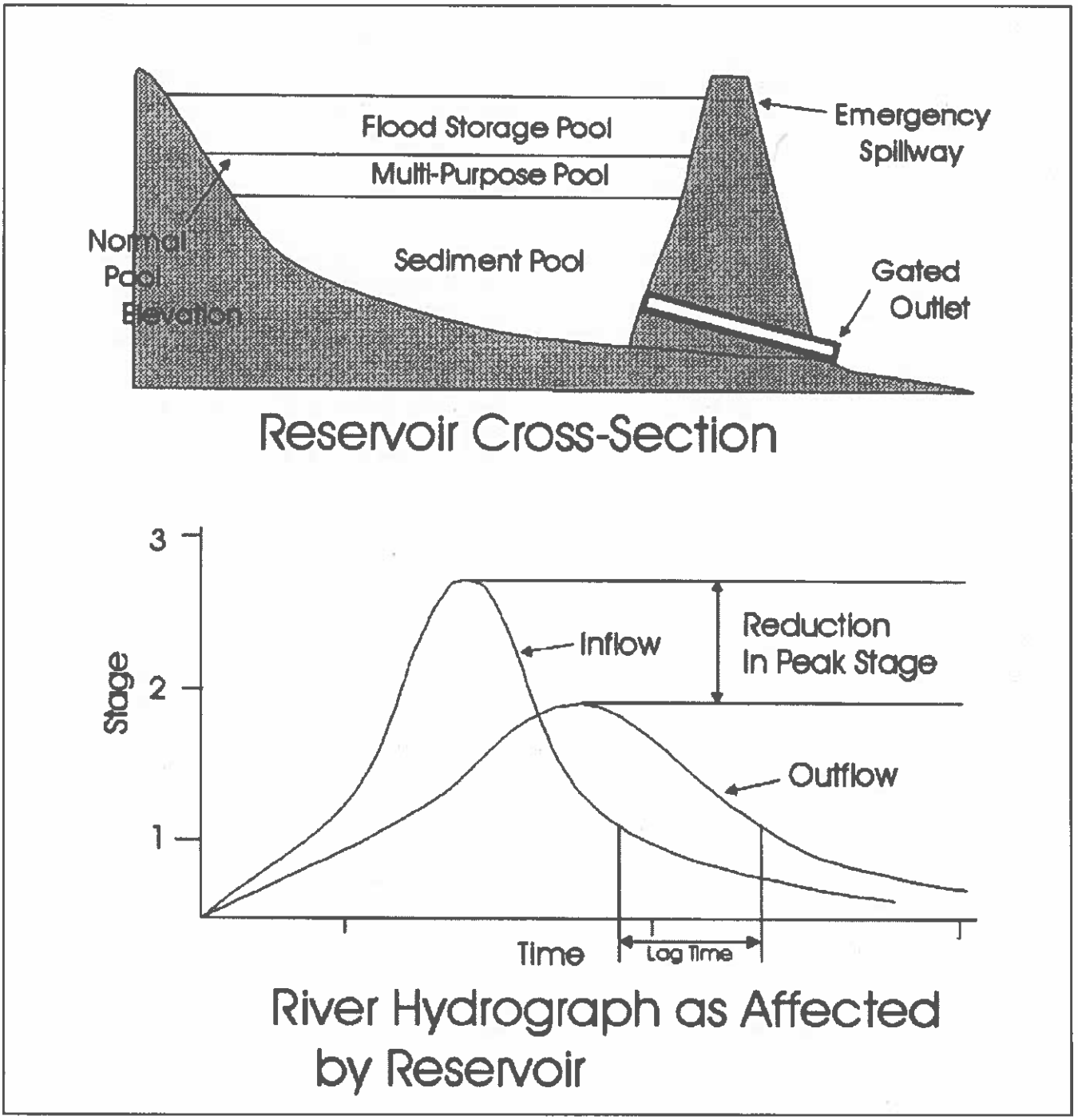


Figure 2.5 Typical Reservoir Cross Section and Hydrograph.



Source: Floodplain Management Review Committee. Adaption

Much of the speculation about the effect of levees on flood levels during the 1993 flood was based upon inferences drawn from comparisons between recent event data, obtained from systematically-measure d river flow (discharge) and river level (stage) records, and similar data for historical floods. Such discussions fail to recognize that significant differences in data quality exist between the modern (after 1930) and the historic record.[18] In addition, many other changes have occurred in the upper Mississippi River Basin which have created differences in flow regimes over time.

To ascertain the actual effect existing levees had on peak 1993 Mississippi and Missouri river flood stages, the UNET model, which analyzes unsteady state river flow condition,[19] was applied to the river reaches where cross-sectional data were available:

(1) the Mississippi River between Hannibal, Missouri, and Cairo, Illinois,

(2) the Missouri River between Hermann, Missouri, and the mouth at St. Louis, and

(3) the Illinois River Between Meredosia , Illinois, and the mouth above St.Louis.

The analysis used flow data from 1993, 1986, and 1973 floods and developed water surface profiles resulting from the same flood flows without levees. The model was calibrated and a range of possible floodplain ground covers was used.[20] The analysis suggested that if all the levees (other than urban levees) were absent, the peak stage at St. Louis in 1993 would have been reduced by 2.5 feet, but still more than 17 feet above flood stage and almost 4 feet higher than the previous known maximum level recorded during the 1973 event. This model scenario assumes the improbable condition of a totally open floodplain covered only with bare soil or short grass cover. If one assumes existing levees would have constructed to contain all flows, peak stages at St. Louis would have been increased by 2.3 feet.

An independent model commissioned by the *St. Louis Post-Dispatch* showed that the overtopping and breaching of two levees downstream from St. Louis at Columbia and Harrisonville, Illinois, reduced peak stage at St. Louis by 1.6 feet.[21] This analysis used steady-state model applied to a short stretch of the river and lends support to the UNET findings.

A physical model study conducted at the Waterway Experiment Station (WES) in 1979 by Foster and Allen[22] showed that the removal of the trees between the river bank and levee along the middle Mississippi River between St. Louis and Cape Girardeau would lower the stage at St. Louis about 2.5 feet for the 1973 flood, which corresponds with the mathematical (UNET) model results for the fully open, treeless floodplain assumption.

Farther downstream along the middle Mississippi River, the UNET mode predicted that there would have been a sizeable local drop in river levels in the absence of levee under the most conducive flow scenario. At Chester, Illinois, the stage of the Mississippi River during the 1993 flood would have been approximately 11 feet lower if the levees containing the river were removed. But the floodplain would have been under water. The mode predicted that there would be no stage reduction if the entire floodplain were covered dense forest or brush -- a scenario representing a least conducive flow condition. It is expected that a typical floodplain without levees would contain a mix of uses and associated land covers such as sloughs, side channels, forested and non-forested wetlands and agriculture.

Conclusion: ***Levees did not cause the 1993 flood. During large events such as occurred in 1993, levees have minor overall effects on floodstage, but may have significant localized effects.***

Erosion and Sedimentation

Upland erosion and the sedimentation in downstream areas are major causes of reduced water quality and habitat destruction in most midwestern rivers and streams. Sedimentation in the backwaters of the upper Mississippi River is the most significant problem in that river. In recent years, Missouri, Minnesota and Wisconsin have developed watershed management programs to reduce runoff and erosion. Land use planning and land stewardship are key nonstructural factors in reducing runoff and downstream flooding.

Significant floodplain erosion and deposition occurred during the 1993 flood, principally on floodplain agricultural lands along the Missouri River. Preliminary analyses of aerial photography, satellite imagery, and historic Missouri River floodplain maps reveal that more than 90 percent of the areas affected by significant erosion and deposition are associated with breached levees situated in active, high-energy floodplain zones.[23] Review of the history of levee failures in this area shows levees have been breached repeatedly at sites of natural river cutoffs or chutes in the past three decades. Construction of levees across these high energy channels is a risky investment which has required repetitive repair.

In most cases where levees breached, scour holes, locally known as blow holes or blue holes, occurred. These holes, typically 25 to 50 feet deep, are caused by scouring of alluvial soils underlying the levees and farm fields and are caused when the head of water exceeds the height of a levee or its ability to withstand water pressure, overtopping or breaching the levee and releasing river water through the constricted levee breach with velocities similar to that of a dam break flood wave. This sudden release of energy scours tremendous volumes of materials creating both new aquatic and terrestrial habitat. Erosional zones of scour and stripping can extend as far as one mile downstream from the larger breaches (Figure 2.6). Locally constricted floodflows in breaches through railway embankments and in the vicinity of railroad and highway bridges act in a similar manner.

Comparison of the effects of the 1993 floods on the upper Mississippi and Missouri rivers shows that river reaches in broadly similar physiographic regions may respond very differently to floods. The annual discharges of the upper Mississippi River are generally comparable to those of the Missouri River, but sediment yields of the Missouri average more than five times those of the Upper Mississippi. Average slope of the lower Missouri River floodplain (upstream of St. Louis) is about twice that of the middle Mississippi River floodplain (downstream from St. Louis). Levee breaches along the lower Missouri commonly resulted in high-velocity flows across its relatively narrow and relatively steep (high gradient) floodplain, contributing to extensive deep scour and thick sand deposition across agricultural lands located there. In contrast, levee breaches along the middle Mississippi produced less intense erosion and sedimentation; impacts were largely limited to passive inundation of large bottomland tracts.

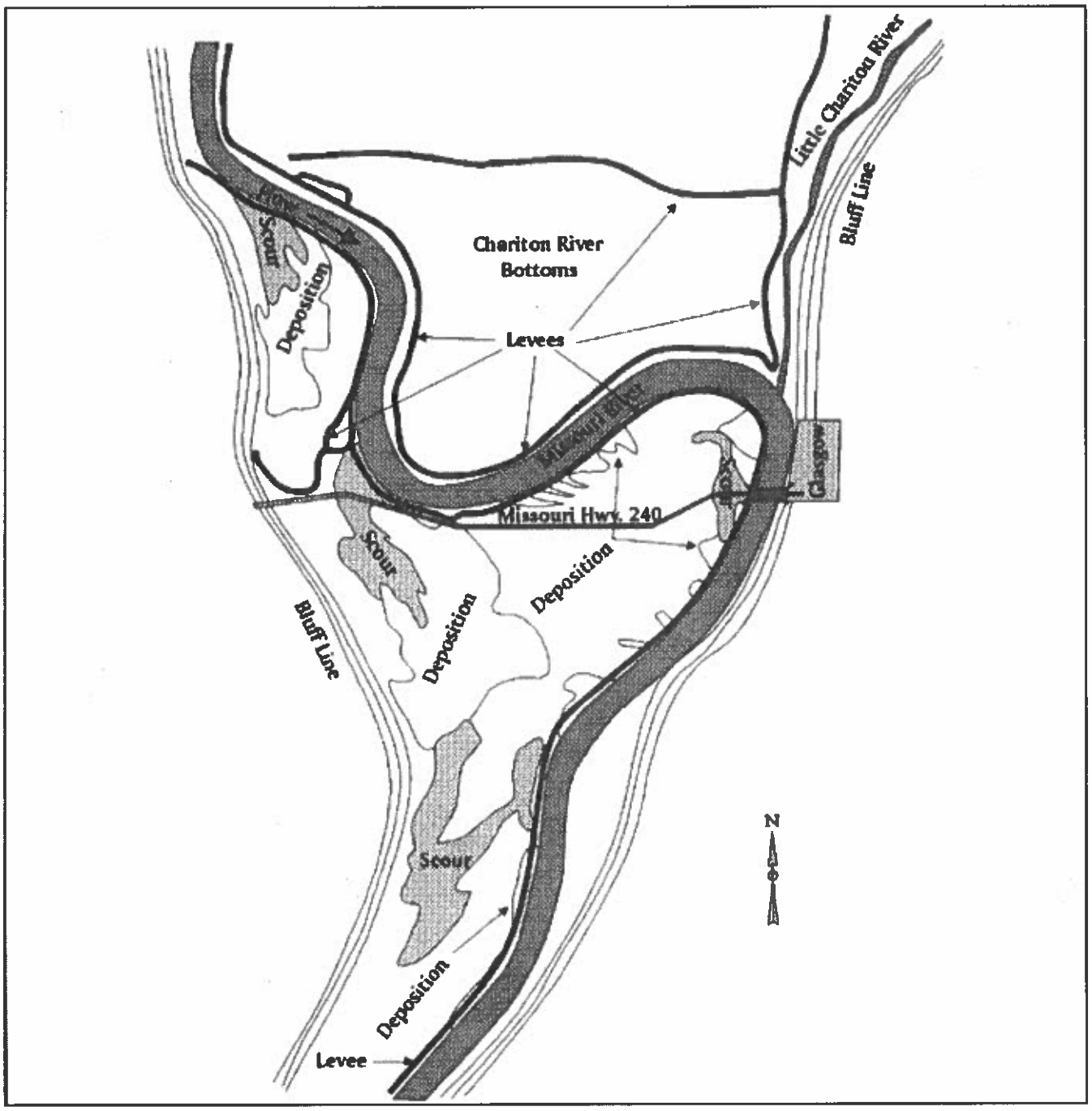
The Pick-Sloan plan authorized by Congress in 1944 called for the creation of a floodway from 3,000 to 5,000 feet wide between levees along the Missouri River from Sioux City, Iowa, to the mouth near St. Louis, Missouri. The purpose of this floodway was to provide sufficient space for flood waters to pass and reduce potential damage to adjacent farmlands. For a number of reasons, this plan was never implemented. The Flood of 1993 demonstrated the need for some form of floodway to provide greater capacity to convey flood flows. Implementation of any future flood damage reduction plan should recognize that in lieu of a standard setback distance, the floodway should coincide with the natural high-energy zone of the river, which commonly is wide in areas of large meanders and narrow in straighter portion of the river.

Conclusion: ***Levee location and height are factors in determining erosion and deposition in the floodplain. There are certain locations where levees should not be constructed. In these cases set-back levees might allow normal river functions. Each situation needs to be evaluated on its own merits.***

Navigation

The Review Committee received numerous suggestions that the flood crest could be lowered significantly by opening navigation dam gates before the arrival of flood waters. Hydraulic investigations by the University of Iowa,[24] and evaluations of the 1993 flood show that navigation dams cause slight, localized increases in

Figure 2.6 Reach of the Missouri River Bottoms Showing "High Energy" Erosion and Deposition Zones.



Source: Floodplain Management Review Committee. Adapted from SAST data, 1994

Flood height just upstream of a dam. They do not cause increases in flood elevations for the entire Mississippi River System. In the middle Mississippi (from St. Louis to the confluence with the Ohio River) and on the Missouri River, navigation channels have no locks and dams, and the dikes and revetments which are in place cause little or no restriction to flow.

Conclusion: ***Navigation dams and locks did not cause an increase in the stage heights of the 1993 flood.***

Habitat Loss

Fish and wildlife resources in the upper Mississippi River Basin have been significantly affected by the loss of wetlands and other terrestrial and aquatic habitats due to construction for navigation and flood damage reduction structures.

Upper Mississippi River. The upper Mississippi River was originally a free-flowing, alluvial riverine environment with associated riparian habitats. Construction of navigation control structures (rock dikes) and installation of the slackwater navigation dams have created habitat types substantially different from those found in a free-flowing alluvial river.

Habitat types within the upper Mississippi River slackwater navigation pools are created by coincident physical, water quality, and botanical characteristics. River position, depth, water-surface area, stage and discharge, vegetation, river-bottom types, water quality, and the superimposed structural elements within the river define the various habitats. Three distinct habitat zones occur in the slackwater navigation pools. The upper end of each pool is like the original river although subject to exaggerated water level fluctuations from the upstream dam releases. March development is limited. In the middle portion of the pools, downstream impoundment backs water up and over the islands and old hay meadows, creating large areas of shallow water. This section has the best marsh development, and some deep sloughs and wooded islands can be found. In the lower end, immediately above each dam, wide open water lake-like areas occur (Figure 2.2).

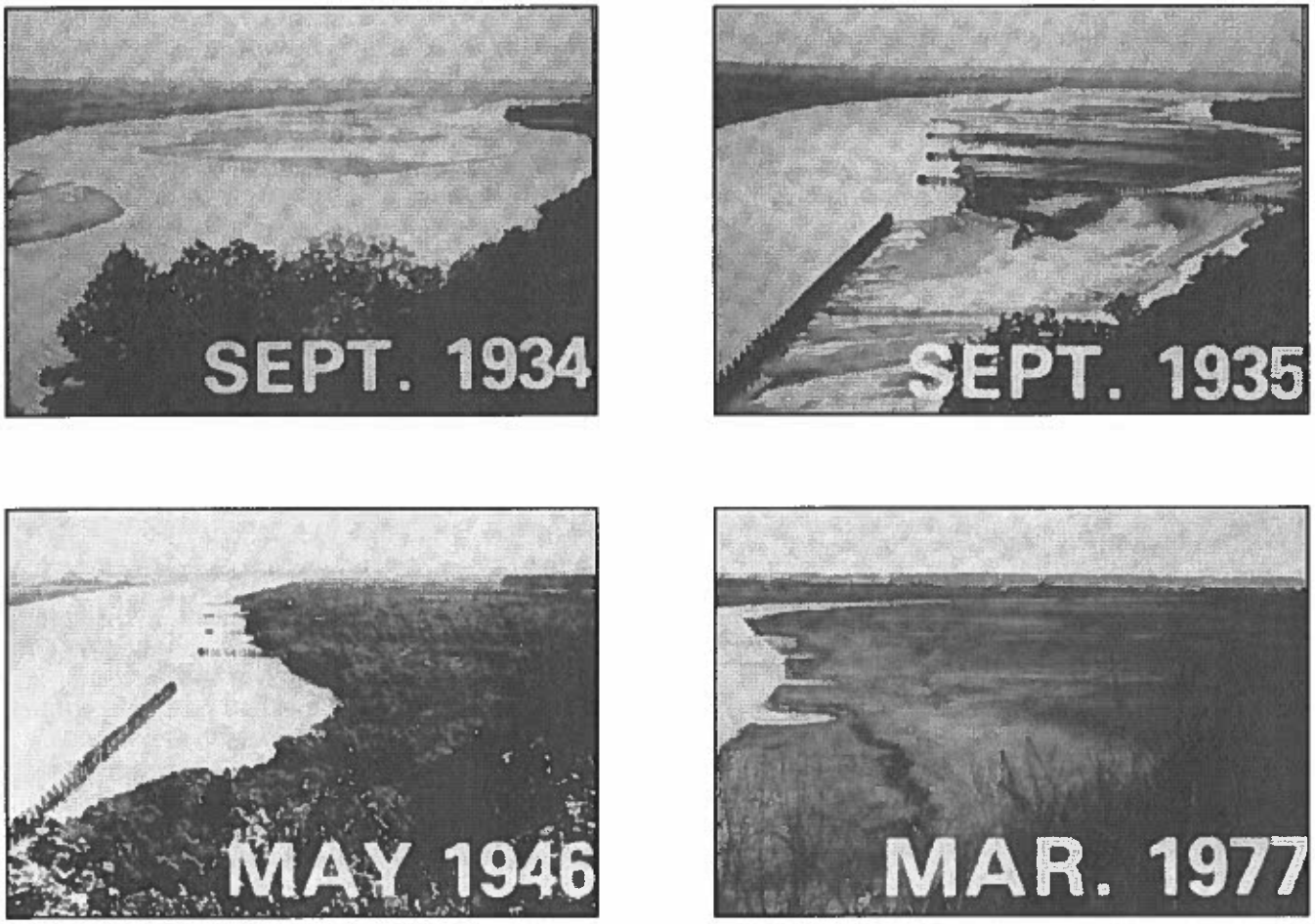
While impoundment of the upper Mississippi River for slackwater navigation created a variety of backwater and side-channel habitats, these dams also slowed river currents, starting the irreversible process of sedimentation. Many backwater habitats are filling with sediments from the erosion of upland agricultural and developed lands. Rock dikes and channel maintenance dredging also contribute to the problem. Mississippi River backwaters shill provide critical fish production and nursery habitats, but may be lost to sedimentation and eutrophication within 60 yrs.[25]

Downstream from its confluence with the Missouri River, the upper Mississippi River takes on a very different character, similar to that of the Missouri (see Missouri River habitat description). Forth-six species of Mississippi River fish, virtually all of which have been affected by flood damage reduction measures and navigation, are listed by basin states as rare, threatened, endangered, or a species of special concern.[26]

Missouri River. Parts of the Missouri River were well known as a braided river with swift, muddy flows. The historic floodplain was a ribbon of islands, chutes, oxbow lakes, backwaters, marshes, grasslands, and forests. Sandbars and wooded islands dotted the channel. Between 1879 and 1954, human actions and natural changes shortened the river by 45.6 miles, reduced river surface area by over 50,000 acres, reduced the number of islands from 161 (24,419 acres) to 18 (419 acres), and converted nearly 67,000 acres of river habitat from public to private ownership, most to agriculture.[27]

Nearly one-third of the Missouri River has been impounded, another one-third channelized, and the hydrologic cycle, including temporal flow volume and sediment transport, has been altered on the remainder. The Missouri River formerly had peak run-off during two periods, March-April and June. Prior to 1954 flushing flows, known as dominant discharge, occurred every 1.5 years. The river was in a state of equilibrium; net sediment entering a reach replaced an equal amount leaving allowing for ample habitat

Figure 2.7 Changes in Channel Morphology Following the Addition of Navigation Dikes, Indian Cave Bend, Missouri River, North of Rulo, Nebraska.

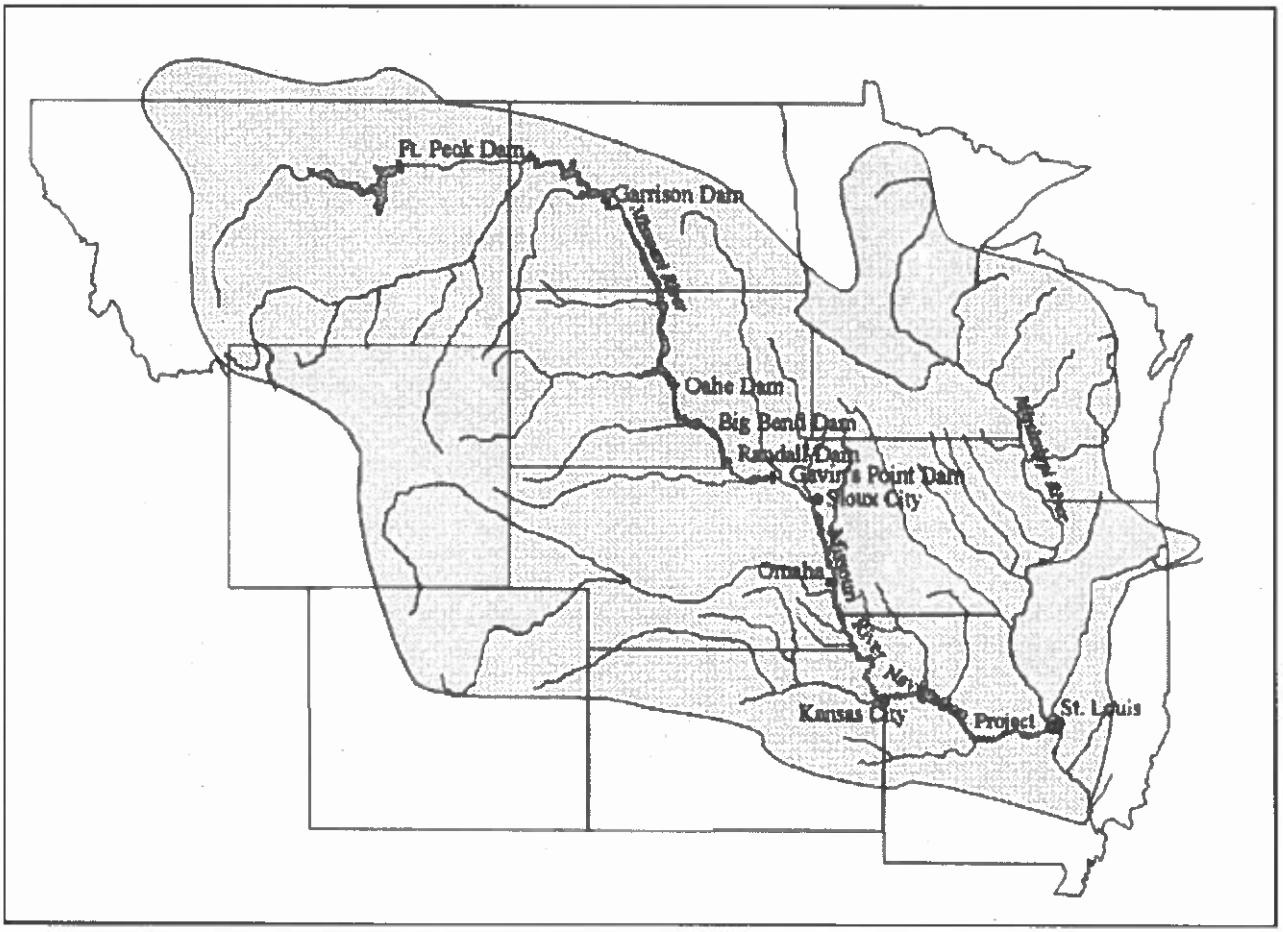


Source: USACE

development, and aquatic nutrition. Loss of sediment load let to channel degradation which contributed to the loss of off-channel habitat and further severed the river from its floodplain. Since the early 1950s the Missouri River has thus been deprived of a floodplain in most reaches. Water temperature, photoperiod, and run-off cues have been altered by reservoir releases for navigation and other purposes.[29]

Changes in basin and floodplain physiography and channel morphology have reduced commercial fish harvest by more than 80 percent and are implicated in the demise of native species. The Missouri River's natural riparian ecosystem has been nearly eliminated and presently consists of a discontinuous, single row of trees. Missouri River floodplain forest coverage decreased from 76 percent in 1826 to 13 percent in 1972, while cultivated lands increased from 18 percent to 83 percent.

Figure 2.8 Missouri River Reservoirs and Navigation System.



Thirty-four species of Missouri River Basin stream fish are listed by basin states as rare, threatened, endangered, or as species of special concern.[29] The pallid sturgeon, piping plover, least tern, and bald eagle are all native Missouri River species listed as endangered by the U. S. Fish & Wildlife Service (FWS).[30] Population densities of five species of chubs[31] and two species of minnows[32] have been reduced by as much as 95 percent since 1971.[33] Burbot have been nearly extirpated, sauger have been greatly reduced, and blue catfish are rare.

The Master Water Control Manual for the six Missouri River main stem reservoirs is currently under review by the USACE. Decisions made with regard to this manual are important to the future of the Missouri River ecosystem. For example reservoir water releases could be adjusted to simulate natural hydrographs and, in combination with riparian land acquisition, be used to restore many of the river's natural functions including low-level flooding of riparian lands.

Illinois River. Aquatic and terrestrial habitats of the Illinois River Valley have suffered a series of cataclysmic events since 1900: (1) permanent rise in water level from water diverted from Lake Michigan, (2) the draining of more than half of the 400,000 acre floodplain through the construction of levees and pumping stations, (3) an upsurge in untreated urban and industrial pollution during the 1920s, (4) the creation of a 9 ft. channel and its attendant navigation dams in the 1930s, and (5) an acceleration in sedimentation rates following World War II, apparently resulting from an increase in the amount of open row crops grown within the basin.[34] As an example, in 1908, a 200-mile reach of the Illinois River produced 10% of the total U. S. catch of freshwater fish (employing 2,000 commercial fishermen and yielding 24 million lbs. of fish annually). Commercial fish yield totaled about 178 lbs/ac of permenent water, but by the 1950s yield had dropped to 38 lbs/ac and by the 1970s to 4 lbs/ac, totaling 0.32% of the total U.S. freshwater harvest.[35]

Conclusion: ***Alteration of Mississippi, Illinois and Missouri Rivers and floodplains has resulted in significant changes or losses of habitat. The disruption of natural ecosystems has caused the destruction of many native species populations and has caused an increasing number to be listed as threatened or endangered.***

ENDNOTES

1. The statistics in this section are from U.S. Department of Commerce. *1987 Census of Agriculture,* (Washington DC: DOC, 1988). The 1992 census figures are being compiled as this report goes to press. A preliminary look at data from three states in the region indicates that the relative values are consistent with the 1987 figures.

2. U.S. Department of Agriculture, Soil Conservation Service. *Regional Analysis of 11 Major Land Resource Areas, Agriculture Handbook 296,* (Washington DC: SCS, December 1981).

3. Upper Mississippi River Basin Commission, *Comprehensive Master Plan for the Management of the Upper Mississippi River System,* (Minneapolis, MN: UMRBC, January 1, 1982).

4. The USACE and Bureau of Reclamation reservoirs in the Missouri River contain 28 million and 5 million acre feet of flood storage capacity respectively, those in the upper Mississippi River 4,5 million and those in the middle Mississippi River 1.2 million acre feet.

5. U.S. Government Accounting Office, Wetlands Overview, (Washington DC: GAO, November 1991).

6. Reuss, Martin, *Wetlands, Farmlands, and Shifting Federal Policy: A Brief History,* (Washington, DC: U>S> Army Corps of Engineers, February 1994), pages 3-5.

7. Ibid, page 3.

8. Sharitz, R., "Bottomland hardwood wetland restoration in the Mississippi drainage," pages 496-505 in National Research Council, *Restoration of Aquatic Ecosystems.* (Washington, DC: National Academy Press, 1992).

9. U.S. Department of Agriculture, Soil Conservation Service, *Summary Report 1987 National Resources Inventory,* Statistical Bulletin, No. 790, (Washington DC: SCS, 1988).

10. U.S. Department of Agriculture, Soil Conservation Service, *Impacts of Food Security Act (CRP and HEL),* SAST Studies, (Des Moines, IA:: SCS, February 1994)..

11. U.S. Department of Agriculture, Economic Research Service, *Analysis of the Conservation Reserve Program: Farmers' Plans and Environmental Targeting Issues,* (Washington, DC: ERS, April 1994), page 9.

12. Scientific Assessment and Strategy Team, "Scientific Assessment and Strategy Team Report", Draft, (Sioux Falls, SD: SAST, 1994).

13. Ibid.

14. Ibid.

15. Ibid.

16. Leopold, Luna B., "Flood hydrology and the floodplain", *Water Resources Update, 95:* page 11.

17. U.S. Department of the Interior, U.S. Geological Survey, *Effects of Reservoirs on Flood Discharges.,* Circular 1120-E, (Washington DC: USGS, January 1994).

18. Dyhouse, G.R., *Comparing Flood Stage-Discharge Data- Be Careful!* (Orlando, FL: American Society of Civil Engineers (ASCE) Hydraulics Specialty Conference, August 1985). Belt, C.B., Jr., Science Vol. 189, footnote 9, August 29, 1975

19. The UNET Model is a computer program that solves unsteady state flow equations to describe floodflow conditions. Unsteady state means that the depth of flow changes with both distance along the channel and with time. The model uses a network approach to solving the unsteady state flow relationships. UNET is a 1-dimensional model and assumes that the calculated velocity at a cross-section exists across the entire river. The area behind levees are modeled as storage cells. After calibration using flow data observed in the 1993, 1986, and 1973 flows with pre-flood conditions of levee development in the floodplain, the model analyzed the water surface profiles that would result from those same flood flows assuming levees were absent. Under such a scenario, land use in most areas would be different than presently exists as would ground cover types. Because the hydraulic roughness (resistance to flow) of the floodplain cross-section must be represented in the model, a range of possible ground cover types was used, from bare soil or short grass to dense forest or dense brush. A floodplain absent of levees would likely have a mix of ground cover types ranging between and including these extremes.

20. Ibid.

21. Koenig, Robert L., and Virgil Tipton, "The Flood That Wasn't", *St. Louis Post-Dispatch,* (December 26, 1993), B-1.

22. U.S. Army Corps of Engineers, Waterways Experiment Station, *Effects of Overbank Vegetation on the Mississippi River States in the Saint Louis -- To Thebes Reach, Vicksburg, MS,* (Mississippi Basin Model Report 81-6 (Vicksburg, MS: USACE, June 1979).

23. Scientific Assessment and Strategy Team Report.

24. The University of Iowa, Iowa Institute of Hydraulic Research, *Effects of Navigation-Dan Operating procedures on the Mississippi River Flood Levels,* (Ames, IA: The University of Iowa, August 1969).

25. Fremling, C.R., et al., ""Mississippi River fisheries: a case history", pages 309-351 In Dodge, D.P., (ed.) *Proceedings of the International Large River Symposium.* (Ontario, Canada: Can. Spec. Publ. Fish. Aquat. Sci. 106, 1989)

26. Ibid.

27. Funk, J.L., and J.W. Robinson. *Changes in the Channel of the Lower Missouri River and Effects on Fish and Wildlife.* Aquatic Series No. 11, (Jefferson City, MO: Missouri Department of Conservation. November 1974).

28. Ibid.

29. Hesse, L.W., J.C. Schmulback, J.M. Carr, K.K. Keenlyne, D.G. Unkenholz, J.W. Robinson, and G.E. Mestl. *Missouri River fishery resources in relation to past, present, and future stresses,* pp. 352-371. In: D.P. Dodge (ed.) Proceedings of the International Large River Symposium. Can. Spec. Publ. Fish. Aquat. Sci. 106. (1989)

30. Hesse, L.W. , et al., "Missouri River fishery resources in relation to past, present, and future stresses", pp. 352-371. In: D.P. Dodge (ed.) *Proceedings of the International Large River Symposium.* (Ontario, Canada: Can. Spec. Publ. Fish. Aquat. Sci. 106. (1989)

31. U. S. Department of the Interior, Fish and Wildlife Service, *Endangered and Threatened Wildlife and Plants,* 50 CFR 17.11 & 17.12, (Washington, Dc: FWS, 1993).

32. The sturgeon chub, sicklefin chub, flathead chub, silver chub, and speckled chub..

33. The plains minnow and the silvery minnow.

34. Hesse, L.W., "Flora and Fauna of the Missouri River Downstream from Fort Randall Dam to the Mouth as They Relate to the Alteration of the Hydrosystem," Prepared for the Scientific Assessment and Strategy Team (SAST) of the Interagency Floodplain Management Review Committee, (Sioux Falls, SD: SAST 1994), pages 1-68.

35. Sparks, R.E., "The Illinois River-floodplain ecosystem." Pages 412-432 in National Research Council, *Restoration of Aquatic Ecosystems.* (Washington, DC: National Academy Press, 1992).

Chapter 3

FUTURE FLOOD POTENTIAL

After the 1965 flood, they told us this wouldn't happen again for another 100 years.

Midwestern mayor
July 1993

This quote illustrates the lack of understanding by many individuals concerning flood potential. Many people think of flooding only in relation to a flood of a 100-year magnitude. They overlook the fact that although government regulators have selected the 100-year flood as a reasonable regulatory standard, it is not the only magnitude of flood that can occur. Floods are random, variable events. Through frequency analysis, hydrologists can characterize them as a 50-year flood, 100-year flood, or 500-year flood. The Midwest flood of 1993 varied from less than a 50-year flood at St. Paul, Minnesota, to less than a 100-year flood at Lincoln, Nebraska,[1] to over a 100-year flood at St. Louis, Missouri.[2] No one -- especially those living at risk in floodplains -- should be misled into believing that a 100-year flood occurs only once in a century. What happened in the Midwest in 1993 could happen again at any time!

WHAT IS A 100-YEAR FLOOD EVENT?

The American people have heard quite a bit recently about a 100-year flood. What exactly is it? A 100-year flood has a 1-percent chance of being equaled or exceeded in any given year. It has a 26-percent chance of occurring over the life of a 30-year mortgage, and a 63-percent chance of occurring over the next 100 years. The terminology used to describe the 100-year frequency flood, 1-percent flood, 1-percent annual chance flood, and base flood, which all refer to the same event, are often used interchangeable. Confusion can result because the 100-year flood is usually the only type people hear about, even though larger and smaller floods are likely to occur.

As commonly applied, the concepts of a 100-year flood and 100-year floodplain can be misleading. Technically only the outer edge of a 100-year floodplain has a risk of one percent. The risk rises for sites closer to a river, ocean or other water feature, and also at lower elevations, yet most people think of the entire area between the water body and the outer edge of the 100-year floodplain as subject to the same risk.[3] Variation of risk is not usually shown on floodplain maps. There are areas within the mapped 100-year floodplain that may flood more frequently and to greater depths than others.

Uncertainties surround 100-year discharges and elevations, and mapping 100-year floodplain boundaries is at best an imperfect science. Estimates of the 100-year flood discharge (or flowrate) can be based on a range of techniques, and current techniques provide estimates that could be off as much as 5 to 45 percent.[4] Factors such as the size of the watershed, the availability and length of streamgaging records, and the level of detail of mapping for use in determining model parameters contribute to the uncertainty in a 100-year flood discharge estimate. Flood discharges associated with

infrequent events, such as the 500-year flood discharge, are more difficult to predict and have more uncertainty associated with them. Even if a fairly accurate 100-year discharge is determined, it may subsequently change due to land-use changes in the watershed and natural and human changes to the channel and floodplain.

After determining a discharge rate, this figure is entered into a hydraulic model to determine the elevation of the 100-year flood. Hydraulic models, depending upon the level of accuracy of information on topography, friction losses, and hydrology, can produce estimates of 100-year flood elevations within 0.5 to 2 feet.[5]

Once the elevation of the 100-year flood has been determined, the extent of the floodplain can be mapped. Topographic maps vary in precision and level of detail.

The accuracy of the floodplain boundary line is influenced most strongly by the quality of the 100-year flood discharge estimate. The next most significant factor is the quality of the topographic mapping. Research suggests that the probable nationwide standard error for base (100-year) flood elevation mapping is 23 percent of the base (100-year) flood depth. This value, translated into an average depth, amounts to about 3 feet.[6] Thus, the floodplain boundary line shown on a map is not absolute and structures located within several feet (vertically) of the 100-year floodplain are still at risk. In flat areas, structures located within several hundred feet (horizontally) of the 100-year floodplain also may be at risk.

MARBLES AND FLOODS

At one of the public meetings attended by the Review Committee, a young Missouri farmer provided a correct explanation of the possibility of experiencing a 100-year flood. He described a bag full of 100 marbles with 99 clear marbles and one black marble. Every time you pull one of those marbles out, and it's black, you've got a 100-year flood. After each draw, you put all 100 marbles back in the bag and shake it up. It's possible that you could pull the black one out two or even three times in a row. To represent the uncertainty of estimating a 100-year flood, it's also possible that the bag could hold two or three black marbles.

STANDARD PROJECT FLOOD

Another magnitude of flood that can occur is one that results from the standard project flood (SPF) discharge. This event is not assigned a frequency or recurrence interval, although it is often used by hydrologic engineers to approximate the 0.2 percent annual chance (500-year) flood. The SPF discharge in a river represents the flow that can be expected from the most severe combination of meteorologic and hydrologic conditions reasonable characteristic of the geographic region involved. SPF discharges exclude extremely rare combinations. The SPF procedure is used in lieu of the discharge-frequency approach because of the unreliability inherent in estimating large magnitude infrequent events from short record, or even regional, discharge-frequency analyses.

The SPF discharge is currently used for design of engineered structures which, if compromised, could result in catastrophic flooding. The SPF discharge is generally used to determine the level of protection for urban population centers where there is great threat of loss of life and of damage to critical infrastructure.

RESIDUAL RISK BEHIND LEVEES

Risk exists in all areas within a floodplain -- both areas protected by channel modifications, dams, or levees and areas outside the 100-year floodplain. Levees built to provide a 100-year level of protection modify the natural overflow boundary of the 100-year floodplain and the boundaries for lesser floods. Individuals and businesses remaining in what was once the 100-year floodplain, are not required to carry flood insurance even though the chance of a flood greater than the 100-year flood occurring in the next 30 years is about 1 in 4. Uncertainties also surround a levee's level of protection. Engineers may account for discharge and elevation uncertainties in the design of levee by the use of freeboard -- the difference between the top of the levee and the design flood height. Even though areas protected by levees are considered safe, the potential for catastrophic loss still exists. If floodwaters overtop a levee, flooding in the protected area could reach depths equaling or exceeding the levee's height. Higher levees reduce risk but could increase potential damage.

CLIMATE CHANGE

Climate change could increase flood risk. Although considerable uncertainty exists, climate change could bring about more-frequent and/or more intense floods. Given that development in and near floodplains is expected to last considerable period of time and that the nation's ability to predict the magnitude and frequency of future events is still limited, it may be prudent to consider the potential effects of climate change when decisions are made (or revised) about the type and amount of development allowed in vulnerable areas. In the absence of sufficient data, flexible and cautious policies are preferred.

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FUTURE FLOODS

Not every state and local government regulates storm water runoff, and the volume of runoff and flood peaks may increase in the future because of urbanization. The streets, parking lots, gutter, drains, and storm sewers accompanying urbanization convey rainfall rapidly to stream channels. Natural channels are often straightened, deepened of lined, transmitting flood waves downstream more quickly. Storm waters can therefore accumulate downstream more quickly than in natural river systems and produce higher, shaper flood peaks. Unless steps are taken to mitigate the impacts of urbanization, flood volumes and peaks will continue to increase.

FUTURE FLOOD POTENTIAL

Current flood records are limited by their length. As flood records for more years become available, current estimates of flood discharge, volume, stage, and duration will change.

In the 1993 flood, out of more than 500 USGS gaging stations in the area of flooding streams,[7] 45 exceeded the 100-year discharge,[8] but at least 450 did not. Many people think that the entire upper Mississippi River Basin experienced a 500-year flood, when setimates indicated that only the research of the Mississippi River from Keithsburg, Illinois, to above St. Louis and the reach of the Missouri River from Rulo, Nebraska, to above Hermann, Missouri, endured such a flood.[9] Since 1900, St. Louis has experienced large floods in 1903, 1909, 1927,1973, and 1993. The communities in the Midwest that experienced a 10- to 50-year flood in 1993, may experience a 100- to 500-year flood in the near future. There is no question that flooding is inevitable. The open questions are when? Where? And how much?

Conclusion: ***Floods equal to and greater than the flood of 1993 will continue to occur across the nation. It is difficult to predict precisely when and on what rivers these large events will happen.***

ENDNOTES

1. Parrett, Chales, Nick B.Melcher, and Robert W.James, Jr., *Flood Discharges in the Upper Mississippi River Basin, 1993,* U.S. Geological Survey Circular 1120-A. (Washington, DC: U.S. Government Printing Office, Second Printing, with revisions, September 24, 1993).

2. Bhowmik, Nani G., et al., *The 1993 Flood on the Mississippi River in Illinois,* Miscellaneous Publication 151, (Champaign, IL: Illinois State Water Survey, 1994).

3. Interagency Floodplain Management Task Force, *Floodplain Management in the United States: An Assessment Report,* FIA-18, (Washington, DC: Federal Insurance Administration, June 1992).

4. Burkham, D.E., "Accuracy of flood mapping," *Journal of Research, U.S. Geological Survey,* 6(4): 515-527 (July-August 1978).

5. U.S. Army Corps of Engineers, Hydrologic Engineering Center, *Accuracy of Computed Water Surface Profiles,* (Davis, CA: USACE, December 1986).

6. "Accuracy of flood mapping," page 526.

7. Kirby, William H., Hydologist, Office of Surface Water, USGS, Reston, VA, personal communication, June 13, 1994.

8. *Flood Discharges in the Upper Mississippi River Basin,* page 1.

9. U.S. Army Corps of Engineers, Missouri River Division, *1993-94 Annual Operating Plan, Missouri River Main Stem Reservoirs,* (Omaha , NE: Zdecember 1993).

Part II

A BLUEPRINT FOR THE FUTURE

Chapter 4

A VISION FOR THE FLOODPLAIN

The Congress...declares that it is the continuing policy of the Federal Government, in cooperation with State and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and full till the social, economic, and other requirements of present and future generations of American.

Section 101, National Environmental Policy Act of 1969

...it is the sense of Congress that flood control on navigable waters or their tributaries is a proper activity of the Federal Government in cooperation with the States, their political sub-divisions, and localities thereof, for flood control purposes are in the interest of the general welfare; that the Federal Government should improve or participate in the improvement of navigable waters of their tributaries, including watersheds thereof, for flood control purposes if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of people are otherwise adversely affected.

Section 1, Flood Control Act of 1936

The United States, as it moves into 21st century, is at a crossroads in the use of its floodplains. The nation may choose to use these flood-prone lands for the primary purpose of economic development, or it may take action to better balance their economic and environmental outputs. Floodplain resources can be shared by human occupants and natural systems. Over the last century, in the upper Mississippi River Basin, while human activities have produced significant economic and social benefits, some of these activities have placed both human and nature at risk.

Flood control works have allowed cities to grow in the face of periodic high waters. Until the middle of this century, the nation did little to control the clearing of lands of the floodplains. Subsequent increases in runoff generated the need for additional flood damage reduction activities. Levees, built by both the federal government and private lawn owners, helped agriculture flourish in the fertile bottomland environment; however, the overtopping of these levees by floodwater created major economic losses. Reservoirs, like levees, reduce the flood threat to many downstream communities, but the reduction in flood flows simultaneously creates incentives for many people to settle riverbanks and become subject to the impacts of the next major flood. The promise of post-flood support from government and private agencies may encourage people to continue occupying land at frequent risk of flooding.

In recognition of this continuing vulnerability to flooding, watershed-focused programs are now emerging, and the United States has begun to move in a new direction. Concern for the environment and sustainable development as well as recognition of the severe limits on federal spending and of funding opportunities lost in flood recovery speak clearly to the need for reexamining the nation's flood damage reduction strategy.

This reexamination must acknowledge that the current state of floodplains reflects in part a succession of political decisions made at the national level. Much of the flood-control effort of the last half-century in combination with other infrastructure development had major land-development implications. Many people moved to or remained in the floodplain with the understanding that the federal government was providing them flood protection. Others saw upstream activity, over which they had no control, increasing their hazard. As the nations seeks a new approach for floodplain management, it must not lose sight of the realities of the past.

Recognition in the early 1960's of the natural functions and resources of the floodplain -- habitat, scenic beauty, water filtration, storm buffer, groundwater recharge, and floodwater storage -- caused the nation to reconsider its policy of supporting wholesale conversation of natural areas to other uses. Persistent flood losses during a half century of flood-control programs raise serious questions concerning the long-term efficiency of such programs. A movement to reduce flood damages through nonstructural means, limiting unwise development of the floodplain and evacuating those at most risk, gradually has become a viable alternative to the construction of dams, levees, and floodwalls.

DEFINING THE VISION

The National Commission on the Environment, a non-profit group, proposes a concept of sustainable development to accomplish economic progress by protecting and restoring the quality of the natural environment, improving the quality of life for individuals, and broadening the prospects for future generations.[1] Effective floodplain management embodies these very concepts by seeking to balance competing uses in a way that maximizes the net benefits to society.

What then should be the national vision for use of the floodplains? To assist in developing this vision, the Floodplain Management Review Committee reviewed the literature on early and recent goals of the nation's floodplain management. Committee members consulted with interest groups at national, regional, and local levels and discussed possible goals with citizens affected by the flood of 1993. The governors of the 9 flood-affected states in the Midwest provided their vision of future floodplain activity. The Review Committee looked to the *National Assessment* and the accompanying *Action Agenda* prepared by the Federal Interagency Floodplain Management Task Force definition.[2] Based on this input, the Review Committee proposes strategic and operational goals for the nation's future use of its floodplains and management of that use:

Strategic Goals

Reduce the vulnerability of the nation to the dangers and damages that result from floods.

Reduce the vulnerability to urban areas, industry and agriculture, when such reduction is justified and reasonable; avoid new development when reduction is not appropriate. As appropriate, move those currently at risk from the floodplain. Strive to eliminate threats to life, property, and the environment, and to the mental health

and well being of floodplain occupants. Ensure the viability of critical infrastructure and the regional economy.

Preserve and enhance the natural resources and functions of floodplains.

Treat the floodplain as part of a physical and biological system that includes the floodplain within the larger contact of its watershed. Seek to identify and enhance the cultural, historic, and aesthetic values of floodplains. Where appropriate, restore and enhance bottomland and related upland habitat and flood storage. Use existing government and private programs to acquire, over time, environmental interest in these lands from willing sellers. Ensure the consideration of social and environmental factors in all actions relating to the floodplain.

Operational Goals

Streamline the floodplain management process.

Implement consistent, equitable, flexible, cost-shared, and efficient floodplain management by improving the National Flood Insurance Program, federal-state-tribal-local-individual relationships, and the conduct of mitigation and disaster planning and execution. Ensure federal-state-tribal-local-individual collaboration and accountability in a bottom-up, shared planning and decisionmaking process. Reduce the cost to the nation of flood damages. Share the risk among all levels of government and among flood-affected individuals.

Capitalize on technology to provide information required to manage the floodplain.

Provide timely and accurate information to assists in identifying hazards, determining impacts of proposed actions, and developing a temporal and spatial basis for long-term action strategies. Leverage the strength of geographic information systems .

FLOODPLAIN OF THE FUTURE

If this vision was implemented, how would the floodplain of the future appear and how would it be managed? Human activity in the floor plain would continue (Figure 4.1) but with a clear recognition that any such activity would be subject to the residual risk of flooding and assumption of the costs of this risk by those sponsoring the activity, Determining future activities would depend on historical settlement, on a balancing of the economic, social, and environmental impacts of an activity together with a recognition of its place in the hydrologic and hydraulic regime of the river basin and what physical impacts its existence has on other segments of that basin.

Urban centers whose existence depends on a river for commerce or whose locational advantage is tied historically to a floor plain would be protected from the ravages of devastating floods by means of levees, floodwalls, upstream reservoirs, or floor water storage in managed upland and floodplain natural areas. Sections of communities with frequently flooded businesses or homes would become river-focused parks and recreation areas as former occupants relocated to safer areas on higher ground.

In areas outside of these highly protected communities, where land elevation provided natural protection from floods, state and local officials would control new construction by requiring it to be at elevations well out of harm's way. Those who were at risk in low-lying areas would be relocated, over time, to other areas. Higher land in these alluvial areas would continue to produce rich harvests. Outside of the urban areas, industry would protect its own facilities against major floods.. Critical infrastructure, such as water and wastewater treatment plants, power plants, and major highways and bridges would either elevated out of the flood's reach or protected against its ravages. Much of the infrastructure, as well as the homes, businesses, and agricultural activities located behind lower levees, would be insured against flooding through full participation in commercial or federally supported insurance programs.

At the upstream end of many levees, federally built water-control structures would permit river waters to keep sloughs wet though out the year maintaining and restoring aquatic habitat with resultant benefits for fisheries, waterfowl, and other wildlife. Levees would be modified to provide for controlled overtopping in the event of major high waters, eliminating the catastrophic failures that have occurred in the past.

Some bottomland owners behind modified levees would choose to convert from crops to alternative crops or silviculture or to return their lands to a natural state under federal or state easements. Owners would base their decisions on private and government analyses that found their land too wet for farming or in a location where levee protection was impossible to maintain.

Upland of the floodplain, federal-state-tribal-local programs to improve the treatment of lands, control new runoff, and restore wetlands, would reduce the flows during frequent floods and shave the peaks off larger events.

Both commercial and recreational vessels would continue to ply the river's waters, operating in a navigation system that would enhance river line ecosystems through water-level adjustments and control. Modifications in river-control structures would continue to increase fisheries and wildlife habitat.

Floodplain activity would guided by broad-based plans of federal-state-tribal-local governments working together as partners in a streamlined floodplain management effort. Operation of the waterway and the levee systems, with their attendant environmental components, would be focused in a single agency that would collaborate with other interested agencies. Levees along main stem rivers and principal tributaries would be maintained on a cost-shared basis by federal and state governments and local levee boards. Decisions concerning activities in and near the water would be assessed using computer models to indicate the effects of such actions on other regions of the river basin. Forecasts of river conditions would reflect the availability of basin-wide data and the rapid processing of these data. Use of high technology remote sensing platforms and data-filled geographic information systems would provide highly accurate information on which to base key decisions for both planning and crisis management.

A New Approach

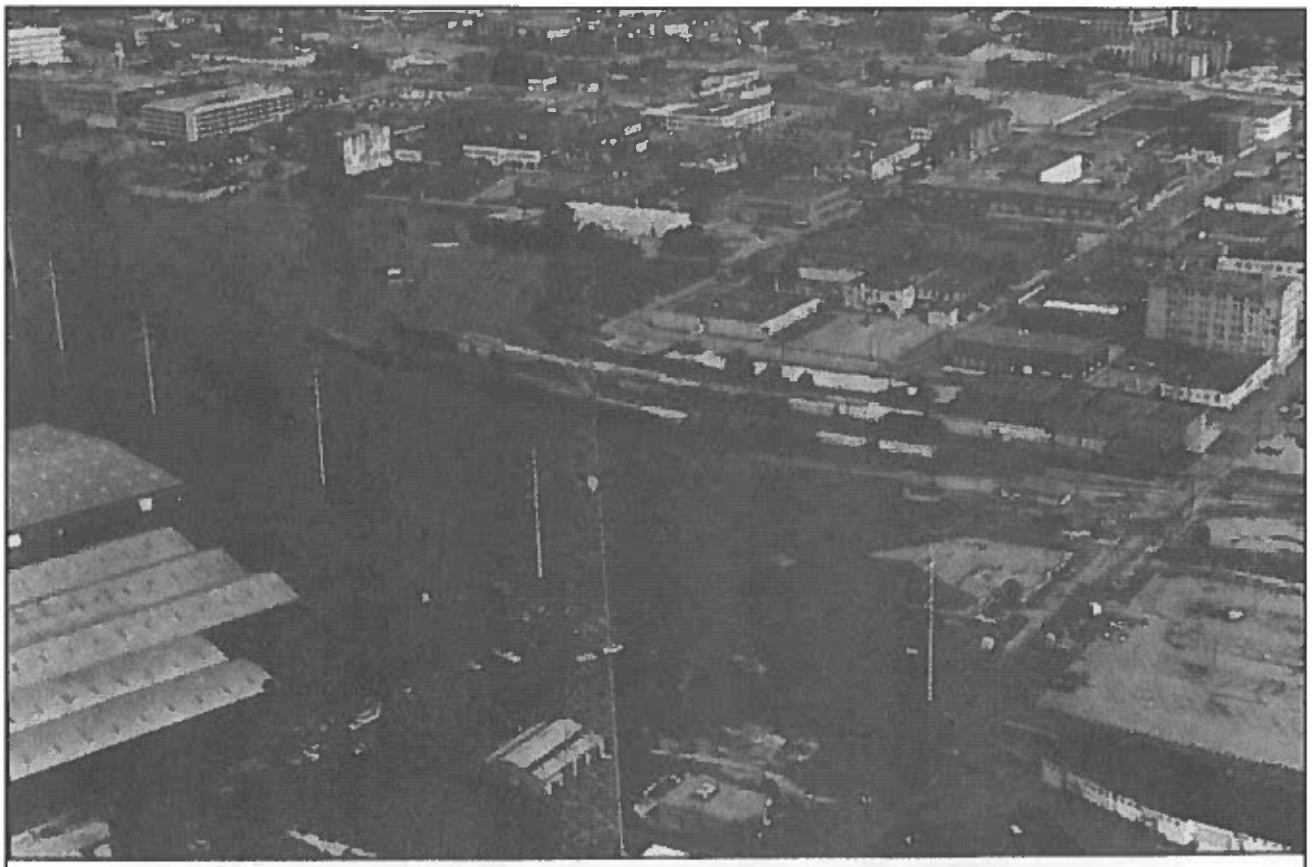
Through most of the past two centuries, the nation's approach to floodplain management has focused on reducing flood impacts through structural means. Floodplain management has been flood control. In the 19th century and the first half of this century, the debate was whether or not a levees-only policy should be pursued. Only in the last 30 years has the nation moved to increase the use of nonstructural approaches.

To achieve the goals of floodplain management, the nation must adopt a new approach -- one that takes full advantage of all methods available to reduce vulnerabilities to damages and, in parallel, to protect and enhance the natural resources and functions of the floodplain. Translated into actions this approach, espoused in the draft 1994 Unified National Program, would achieve floodplain management through:

- Avoiding the risks of the floodplain;
- Minimizing the impact of those risks when they cannot be avoided;
- Mitigating the impacts of damages when they occur; and
- Accomplishing the above in a manner that concurrently protects and enhances the natural environment.

The citizens of the nation bear a responsibility to exercise good judgement in their use of the floodplain and to share in the costs of their judgements. Under this approach, state and local governments serve as the principal managers of the land. The federal government provides support for state and local floodplain management, establishes broad national goals, and, by its own actions, sets an example. Federal actions will continue given the interstate nature of water and the related impact of all riverine activity on these waters, the ever-present potential for catastrophic floods, and the federal government's long-standing commitment to flood-control activities as being in the interest of the general welfare.

Figure 4.1 A Typical Reach of a 21st Century Floodplain.



Reducing the Vulnerability of the Nation to Flood Damages

Individuals and their investments in the floodplain will always be at risk. Though it is impossible to remove the risk completely and remain in the floodplain, it is possible to reduce the degree of risk.

One solution is to evacuate floodplains and move people and their public and private investments out of harm's way. This is not always a viable or desirable solution. Techniques that either modify the susceptibility to flood damage and disruption or modify the extent of the flooding may be more reasonable for cases in which evacuation is not feasible. The new vision seeks to reduce the vulnerability whose floodplain residents and activities whose continuing presence in the floodplain makes economic, social, and environmental sense.

The lessons of the flood of 1993 are clear. The United States should not continue to tolerate the loss of life and the damage to cites, rural communities, and farms caused by major flooding, nor should the nation carry the burden of massive federal flood disaster relief costs that current policies generate each time a major flood occurs. Even with a large infusion of federal funds, private donations, and volunteer assistance, the 9-state area still has not returned to normal. Individuals, communities, and agricultural sector will experience the long-term effects of the flood for years. Many of these damages could be avoided through vulnerability reduction measures.

This chapter addresses the vulnerability reduction goals that the Review Committee seeks to achieve with the new vision. Subsequent chapters will address, given the experiences of 1993, the strategies for achieving these goals.

Defining the Risk

Against what magnitude of flooding should damage reduction programs be focused? The answer depends on the social, environmental, and economic assets of the flood-prone area. This will be reflected by the use being made of land, as well as the amount of human activity and critical infrastructure located in the area.

Risk of damage or loss from flooding is greatest where human life and property are concentrated in highly populated areas on the floodplain. For any years following the passage of the Flood Control Act of 1936, the federal government focused its efforts on protecting communities at risk from the largest flood they could expect to encounter. Over time, with limited federal monies available for flood damage reduction purposes, selection of this high level of protection came to be driven more by benefit-cost analyses. Communities with little at economic risk received less protection that those with more. Today many cities and towns are able to see major floods move by with minimal effect. Others could not survive a lesser event without experiencing major trauma. Had the 1993 flood been centered slightly to the north, several urban centers would have been inundated. Given the social and economic consequences of such flooding in affected communities floodplain management activities need to focus on reducing the vulnerability of population concentrations to the most significant flood event expected to occur. Reducing the vulnerability of communities, where appropriate, to the discharge associated with standard project flood (SPF) provides a greater reduction in residual risk than is provided by using the 1 percent annual chance (100-year) flood discharge. The SPF serves as a practicable expression of the discharge to be considered in evaluating alternatives to reduce the vulnerability of activities associated with communities where large population and high-value property are involved. In most cases the SPF approximates the 0.2 percent chance (500-year) discharge.[3]

Recommendation 4.1: *Reduce the vulnerability of population centers to damages from the standard project flood discharge.*

The identification of a target flood does not represent a call for new levees or floodwalls. In fact, given this target discharge, floodplain managers would develop a strategy for evaluating vulnerability reduction considering all of the nonstructural and structural approaches available. Planning for the future may move a community to first seek funding for mitigation activities such as relocation or elevation. Availability of land in the watershed or in the floodplain may result in upstream storage or riverine floodways being considered better approaches. When other approaches have been reviewed, higher or upgraded levees or floodwalls might also be considered. The costs and benefits of each approach would determine whether the vulnerability would be eliminated, reduced, or the status quo maintained.

Critical Infrastructure

The risk of imposing severe hardship on the public or endangering public health and safety arises when infrastructure critical to maintaining the wellbeing of a community, region or nation is damaged. This is especially true in floods of long duration, such as the one that occurred in the Midwest in 1993. For example, when the city of Quincy, Illinois, lost both of its crossings over the Mississippi River, it faced the situation of having no open bridge across the river between Iowa and St. Louis, Missouri, for over two months. People were put out of work, local businesses were isolated from their market areas, and the local economy was disrupted.

Recommendation 4.2: *Reduce the vulnerability of critical infrastructure to damage from the standard project flood discharge.*

Critical infrastructure can be defined as structures, facilities, and installations of the following type and function:

- Those that, if rendered unserviceable, would impose significant hardship on the public, or
- Those that, if flooded, would pose a threat to public health, public safety, and/or the environment.

Critical infrastructure could include, on a situation-dependent basis, municipal drinking water facilities, stations, major highways bridges, major passenger and freight railroads, critical access roads running through or over floodplains, major airports, hospitals and related medical care facilities, electricity generating plants, and facilities that generate, store, or dispose of hazardous, toxic, or radioactive materials. For many of these facilities, such as roads, the element of flood duration must be considered in determining the applicability of the definition. A road out for five hours may not be critical, but one out for three months might be. The only road to a county hospital might be critical under any circumstances.

Where feasible, critical infrastructure should be located outside the floodplain. Critical infrastructure, which must be situated in the floodplain, should be evaluated for protection against the SPF discharge. This issue is not new. Floodplain Management Guidelines for implementing Executive Order (EO) 11988, issued by the Water Resources Council in February 1978, require that critical high-risk activities be protected at a minimum against the 0.2 percent annual chance (500-year) flood. They also provide planners assistance in determining whether infrastructure should be considered critical.[4] In 1982, a National Academy of Science panel concurred and recommended that critical infrastructure be protected against, at a minimum, the 0.2 percent annual chance flood.[5]

Vulnerability of Other Areas

If the goal of floodplain management is to reduce the vulnerability of population centers and critical infrastructure to damages from an SPF discharge, what should it be for areas that do not fall into these categories? While extending an SPF goal to all areas might seem equitable to many, such an action is neither physically, economically, environmentally, nor socially feasible. The strategy for damage reduction

and the target flood against which the strategy is based must be determined on a case-by-case basis using modern planning techniques and methods of analysis. In the long term, much human habitation and related businesses might move to higher ground leaving only agriculture, silviculture, and natural use behind existing levees. Where such an approach is not feasible or desirable and structural solutions appear appropriate, the hard facts of benefit-cost analysis normally will preclude using the SPF discharge as a basis for federally supported increases in protection.

The level of protection provided these areas would be determined considering social and environmental values as well as the economic benefits and costs. Depending on the mix of population, infrastructure industry, and agriculture, the level of protection will vary.

Sharing the Challenge -- Government, Business, Citizen

Since passage of the flood control act of 1936, the federal government has for the most part, dominated the nation's flood control efforts and as a result the nation's floodplain management activity. Structural programs needed for flood damage reduction were also the principal sources of funds for any efforts to stem the rising tide of flood losses. Many states and local governments have developed and carried out floodplain management efforts that both reduced flood damages and enhanced the natural functions of the floodplain; but in carrying out these programs they were hampered by the diversity that hindered efficient floodplain management. The dominant federal role in funding flood damage reduction and recovery activities limited the incentive for many state and local governments, businesses, and private citizens to share responsibility for making wise decisions concerning floodplain activity. Now is the time to:

- Share responsibility and accountability for accomplishing floodplain management among all levels of government and with the citizens of the nation.

- Organize the federal government and its programs to provide the support and tool necessary to carry out effective floodplain management.

Succeeding chapters detail how the nation should organize for successful floodplain management and then, by improving the efficiency and effectiveness of programs already in existence, reduce the vulnerability of the nation to flood damages in the years ahead.

ENDNOTES

1. National commission on the environment, Choosing a sustainable Future, (Washington, DC: World Wildlife Fund, 1992)

2. Federal Interagency Floodplain management Task Force. *Floodplain Management in the United States: an Assessment Report,* (Washington, DC: FIFMTF, 1992); and, white, Gilbert, et al., *Action Agenda for Managing the Nation's floodplains,* Special Publication 25, National Hazards Research and Application Information Center, (Boulder, CO: NHRAIC, March 1992).

3. The Economics Advisory Group strongly disagrees with the establishment of the standard project flood discharge as any form of a reference point, believing that the level of protection provided should be determined only by appropriate project evaluation. The Review Committee believes that there are sound engineering reasons to establish a target for vulnerability reduction and an understanding of the problems associated with passing the target flood discharge. Determination of the level of protection should result from appropriate benefit-cost analysis.

4. U.S. water Resources council, "Floodplain Management Guidelines for Implementing E.O. 11988," Federal Register, February 10, 1978 (44 FR 6030).

5. National Research council, committee on a levee Policy for the National Flood Insurance program, *A Levee Policy for the National Flood Insurance Program,* (Washington, DC: National Academy Press, 1982)

Chapter 5

ORGANIZING FLOODPLAIN MANAGEMENT FOR SUCCESS

...it is hereby declared to be the policy of the congress to encourage the conservation, development, and utilization of water and related land resources of the United States on a comprehensive and coordinated basis by the Federal Government, States, localities...

Section 2, Water Resources planning Act of July 21, 1965

The current system for managing floodplains and protecting the nation from impacts of unwise use is piecemeal. It is dispersed among a variety of agencies at federal, state, and local levels. The Unified National Program was intended to correct this...that program has not succeeded...the Unified national Program is neither unified nor national. In several respects if falls short of achieving the goals set out for it by the Congress and previous administrations.

Gilbert whit, et al.
Actin Agenda for Managing the Nation's' Foodplain
March 1992

The test of how well floodplain management activities are being carried out is in what happens at the level of individual farms, households, and local communities.[1] The 1993 Midwest flooding illustrates where local, state and nationa; efforts succeeded and failed. Progress has been short of what is desirable or possible or of what was anticipated when current policies and activities were initiated.[2]

The collective floodplain management efforts of federal, state, tribal and local governments, individuals, and the private sector must be improved. Together they can use the regionally and nationally significant assets of watersheds and associated floodplains to reduce risk, achieve economic efficiency, and enhance natural resources and functions. The current floodplain management infrastructure has the capability and the responsibility to influence floodplain development and recovery from floods. At issue is the appropriate distribution of responsibilities across and creation of accountability for governments and individuals.

DEFINE FEDERAL-STATE-TRIBAL-LOCAL RELATIONSHIPS AND RESPONSIBILITIES

The strengths fo the federal government -- nationwide experience; ability to examine issues from a national, inter-state and systems perspective; and multi-disciplinary technical expertise -- should guide strategic decisions regarding its obligations and duties. Since the Water Resources Council ceased operations in 1981, however, activities of the federal government have offered little leadership or guidance in resolving interstate waste-resource issues.

Management of the nation's water resources is provided by several agencies. Yet water resource issues are inextricably linked and accomplishedment of agency mandates requires coordination and collaboration among agencies. The National Flood Insurance Act of 1968 required reports to Congress analyzing the implementation of current programs and recommending actions needed to achieve a unified program of planning and action at all levels of government to reduce flood losses and losses of floodplain natural values.[3] Despite these *Unified National Program for Floodplain Management* reports, the United States, in practice, has no unified national program for floodplain management.[4] This stems in part from ambiguity in national goals.[5] If limited resources of money and people are to be utilized effectively, the vision articulated in this Report needs to be accepted and adopted by the populace and assimulated into all levels of government.

A major component of floodplain management is land-use control, which is the sole responsibility of state, tribal, and local entities. The local process for land use and construction decisions (i.e., what, where and how to build) is supplemented in some states by state floodplain permit programs. The federal responsibility rests with providing leadership, technical information, data, and advice to assist the states in their pursuit of sound floodplain management. The federal government is also a partner with states, tribes, and communities in funding floodplain management activities. Where the federal government is contributing finds to protect local communities, however, there is a compelling interest that the finds do not spur increased development in vulnerable locations and that local jurisdictions assume greater responsibility in their land use planning to not increase potential losses. The federal government should not undertake actions that lower the incentive for those in the floodplain to avoid risk because they know the federal government will provide compensation for damages resulting from the risk (see Chapter 14). The floes while promoting and assuring interstate commerce, national econimic development including a viable agriculture industry, and national environmental quality including the enhancement of the quality of the human environment. Congress established the federal interest in flood damage reduction.[6] This interest complements the fundamental state, tribal, and local interest in flood damage reduction.

Action 5.1: *Enact a national Floodplain Management Act to define governmental responsibilities, strengthen federal-state coordination and assure accountability.*

The Administration should propose enactment of a Floodplain Management Act to declare a national policy and goals for floodplain management. These should reflect the vision articulated in Chapter 4 and move the nation toward implementation of a new floodplain management vision that:

- Reduces vulnerability to flooding by avoiding of flood risk through watershed planning, buyout of structures in the floodplain, and mitigation;

- Reduces vulnerability to flooding by modifying flood risk or protecting against floods by minimizing risk to existing population centers (such as cities), protecting existingcritical infrastructure, and protecting the nation from flood-related releases of hazardous materials; and

- Recognizes that floods will continue to occur but that the residual risk in floodplains can be reduced by insuring against flood loss and rebuilding properly when flood losses occur.

The purpose of the Act should be to provide incentives including funding for state and local entities to develop and implement floodplain management plans and increase their accountability for actions in the floodplain. This should be achieved by assigning primary responsibility for floodplain management to states and providing federal guidance and technical and financial assistance to them for development and implementation of floodplain management programs meeting minimum federal standards. The act should authorize funds to supplement state efforts to build and institute effective floodplain management programs. Participation in on-going, non-disaster flood damage reduction and mitigation activities could be withheld from those states that do not conduct floodplain management planning. To support local planning and emphasize state leadership, the Act should require that federal activities affecting floodplains be consistent to the maximum extent practicable with federally approved state programs. The fundamental components of the proposed Floodplain Management Act are found in Appendix D.

...there needs to be a fundamental change in the federal flood protection role. This new role must be to facilitate and to assist state and local government in the implementation of these multi-objective programs.

Doug Plasencia, P.E.
Chair, Association of State Floodplain Managers
Testimony before Congress, October 27, 1993

IMPROVE FEDERAL COORDINATION, EFFICIENCY AND FEDERAL-STATE-TRIBAL PLANNING

The 1965 federal Water Resource Planning Act established the U.S. Water Resources Council (WRC).[7] However, the WRC ceased operations in the early 1980s when funding was discontinued. Lost with the WRC funding was its ability to provide interagency coordination, technology transfer, and data and information services. Deficiencies inheret in the original WRC which established a command-and-control, top-down approach to achieve consistency in federal water resources activities should not be repeated.[8] Nevertheless, the WRC provided an avenue to bring together federal agencies to address water resources issues, in general, and floodplain management, in particular. The Midwest Flood of 1993 illustrates the need to move toward the unified nation program of floodplain management that the nation has sought since, at least, 1968.

Some federal agancies and states, numerous organizations and individuals noted to the Review Committee the continued need to revive the WRC or some WRC-type of organization to provide a coordination function. Many examples demonstrate why a WRC, composed of department and agency heads, is needed to provide policy-level coordination of cross-cutting issues of floodplain management and other water resource issues:

- Federal agencies continue to fail to comply with the spirit and letter of Executive Order 11988, Floodplain Management, by locating or funding nonfloodplain dependent activities in floodplains putting federal investments at considerable risk (this issue is further discissed below);

- The shortcomings of and opportunities for increasing the effectiveness of floodplain management identified by the Federal Interagency Floodplain Management task Force in 1992 in its *Floodplain Management in the United States: An Assessment Report* have not been acted upon. No entity exhists to act upon those recommendations.

- The Unified National Program is neither unified nor national -- it does not adequately integrate either the numerous program aimms that have been set forth or the efforts of those charged with implementing them. There is no central direction for the Unified National Program.[9]

A minimal staff would facilitate operations of the Council and would prepare, based on input form federal agencies and states, items for discussion or action by the Council.

Action 5.2: *Revitalize the Water Resources Council.*

Immediate revitalization of the WRC would launch and promote cooperation among federal agencies and the states-tribes. The WRC would, among other things, serve to align federal floodplain management goals with other broad national goals; provide a single point of focus to assist coordination and resolution of interstate water resource management issues; serve as an innovative planning and technology center, including intergovernmental data gatehering and dissemination activities; and facilitate resoulution of federal agency issues. The Secretary of the Interior, as designated chairwoman of the WRC, should request that the Administrator of the EPA and the Director tof the FEMA become full-time participants on the Council. Other full-time members, as established by the 1965 federal Water Resources Planning Act, are the secretaries of Army; Agriculture; Commerce; Housing and Urban Development (HUD); and, Helath and Human Services and the Chair of the Federal Energy Regulatory Commission. The Secretary of the Interior, as the Chair of the WRC, should restaff the Council. A small staff and budget to support pursuit of the Council's mandate is suggested. Appendix I provides additional details about this proposal.

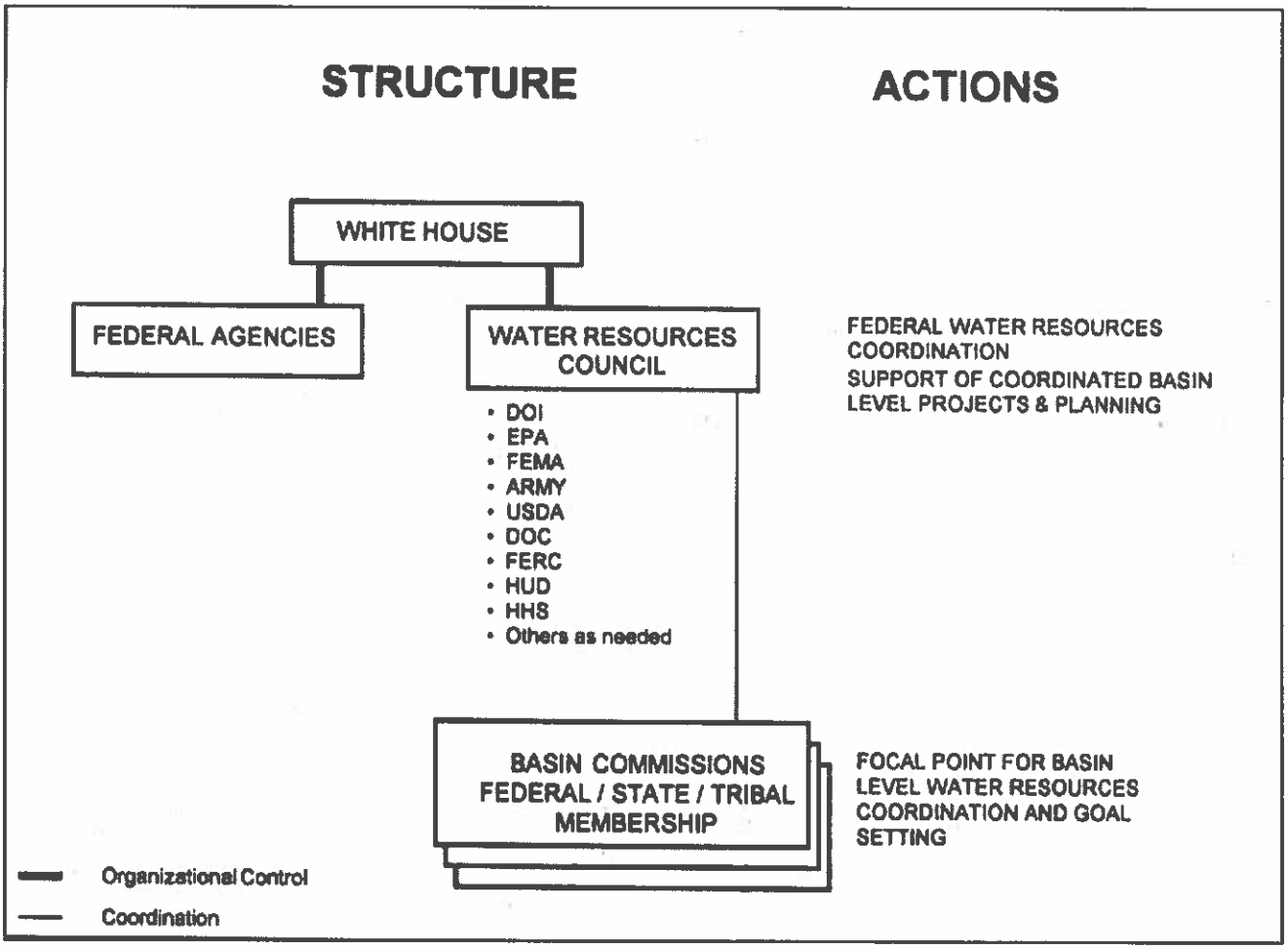
The 1965 federal Water Resource Planning Act also authorized creation of federal-state-tribe basin commissions and authorized financila assistance to states-tribes for water planning.[10] The individual basin commissions produced comprehesive, coordinated plans for water and related land resources that were advisory to federal, state, tribal and local authorities. The basin commissions established pusuant to the Act were abolished, along with federal funding, in 1981.[11] While several interstate organizations evolved to fill, in part, the gap left by the demise of the basin commissions, federal participation is limited to non-voting membership. A mechanism is needed to facilitate enhanced federal presence among continuing participation with these groups.[12] Basin commissions provide a means of preserving and enhancing the state and local attention to floodplain management as well as broader water and natural resource issues, while providing a mechanism to involve or enroll appropriate federal agencies in state and local floodplain management activities. Because watersheds and associated ecosystems do not coincide with, nor do water resources and environmental protection problems respect, political boundaries, a vechicle is needed to integrate federal-multi-jurisdictional examination of issues and solutions. This basis for formation of basin commissions remains valid.

Action 5.3: *Reestablish basin commissions in a revised form reflecting current needs.*

The president should reestablish basin commissions to provide a forum for coordinaated federal and state planning. Basin commissions are not needed everywhere. Basin commissions would be formed in consultation with the governors of states for those areas where the governors determine that interstate or federal-state coordination of several activities was needed or appropriate. The states, in consultation with the WRC, would define the geographical

extent of each proposed basin commission. Each basin commission would serve as the principal agency for the coordination of federal, state-tribe, interstate, local and non-governmental plans for their designated areas and would indertake other activities pursuant to Title II of the Water Resources Planning Act of 1965. Their focus should be results oriented and their process collaborative. Their charters should look beyond traditional water and flood management challenges to allow the commsiisions to address regional issues of biodiversity conservation, water quality, sustainable development, and other environmental goals. Each basin commission would be co-chaired by a state and federal representative and would operate with a limited staff of four to five professionals. While many federal agencies would participate on the commissions, that voice could be limited to increase state significance and responsibility in addressing land-use planning issues. The basin commissions would use federal and state agencies, working within exhisting programs and structures to realize commission responsibilities. Actual staffing requirements, therefore, would be small. Public participation and comment should be vital aspects of their functions. The above changes are proposed to address criticisms of the original basin commissions. Funding of

Figure 5.1 Proposed Institutional Framework for Water Resource Council, River Basin Commissions, and Federal Agencies.



the commissions would be shared by federal and state governments. It is anticipated that no increase in costs to state will occur for those states currently participating in river basin associations; however, the federal government would have to contribute some funding.[13] Appendix I describes in greater detail the Review Committee's concept of revived basin commissions.

FEDERAL ACTIONS IN THE FLOODPLAIN -- SETTING AN EXAMPLE

In 1977 with issuance of Executive Order (EO)11988, Floodplain Management, Presudent Carter raised federal agency attention to issues of floodplain use.[14] With time, however, it has become apparent that some federal agencies either are unaware of or misunderstand the requirements fo the EO and either build or support building in floodplains. Under the EO, federal agencies must

- Demonstrate that no practible alternative site exhists outside of the floodplain, and

- If no alternative exhists, take steps to minimize direct and indirect impacts of the proposed action and no restore and preserve the floodplain.

Review Committee visits to the Midwest and discusses with the FEMA, USACE, and state floodplain manager revealed several examples of apparent non-compliance by federal agencies with the EO. While responsible agencies no doubt believe they have complied with the EO, these developments point our some of the deficiencies with the EO. Among the most notable examples were a low-income housing project finded by HUD and a federally funded state prision within floodplains, and a proposed construction of a federal weather station behind an uncertified levee. The Association of State Floodplain Mangers report that such federal activities occur nationwide. This type of activity lessens the capacity of the federal government to demonstrate leadership in floodplain management.

The EO also requires that federal agencies with responsibility for federal real property and facilities in the floodplain comply with the National Environmental Policy Act (NEOA) requirements and the construction standards of the NFIP. This task if evaluating cumulative, direct, and indirect impacts and risks associated with individual projects within a floodplain requires scientific and technical expertise beyond the capacity of a single reviewer, and often requires consultation with FEMA or USACE.

The EO applies to all feseral agency activities including the acquisition, management, and disposition of lands and facilities. It covers federally undertaken, financed, or assisted construction and improvements and federal activities and programs affecting land use. Thise include but are not limited to water and related land resources planning, regulation, and licensing activities. One objective of the EO is to ensure that all federal agencies aviod, to the extent possible, the long- and short-term adverse impacts associated with the occupancy of floodplains.

Federal activities that induce development weaken the effectiveness of exhisting local or state floodplain management regulations and place pressure on local governments to relax their regulations. Conversely an active federal program to undertake activities outside the floodplain sets an example and encourages the establishment and implementation of state and local programs. A number of states and communitiies have enacted floodplain management regulations, some of which are more stringent than those issued by FEMA.[15] The EO does not explicitly recognize the exhistence of local or state floodplain regulations or the effect federal actions may have on them. Neither are federal agencies required to consult with state floodplain managers concerning floodplain activities. Fedreal leadership in floodplain management requires an adjustment in the way that federal activities are undertaken in the floodplain.

The EO does not explicitly recognize that certain federal actions or activities in the floodplain are critical to the health and welfare of floodplain inhabitants. The extended closure of transportation systems, pipelines, dispersal of hazardous materials, and power outages caused by the

1993 flood demonstrated the vulnerability of floodplain infrastructure. The destruction or disruption of critical infrastructure can have a widespread impact on a community or region. The current definition of critical actions contained in the EO Guidelines, "those for which even a slight chance of flooding would be too great," suggests that critical actions not be undertaken in any area subject to flooding of greater than a 500-year frequency. The guidelines, which fail to recognize that flood events differ in frequency, duration, and type, must be made more flexible.[16]

Federal and federally sponsored facilities, including critical infrastructure, remain at risk. To reduce the possibility of major losses, the vulnerability of these existing buildings and infrastructure should be assesed. Federal agencies that provide funds for improvements to previous investments in the floodplain fall under the EO requirements and accordingly should take measures to reduce the risk of flood loss and minimize the impact of floods on human safety, health, and welfare. There is an opportunity to mitigate the impacts of federal activities completed prior to the creation of the NFIP and the EO that may have resulted in flow constrictions that increased flood risk.[17] Continuing improvements to federal facilities in the floodplain, such as the Defense Mapping Agency's facility in St. Louis that was severly flooded and damaged in the 1993 flood, also require consideration of the EO. Federal programs that are delegated to or assume by states may fall outside the EO. Examples of the latter are stating revolving authorized by the EPA and Rural Development Administration or situations where the use of federal funds is at the discretion of state or local governments. These federal funds may directly or indirectly affect development in floodplains in ways that are inconsistent with the intent of the EO.

The federal government also leases some of its property in floodplains for seasonal recreational cottage use. Some leasees are using the cottages on a full-time basis. In St. Charels County, Missouri, 13 percent of the repetitive NFIP claims are from properties on land leased from the federal government.[18] These leases appear to contradict the EO mandate that the government "take action to reduce the risk of flood loss to minimize the impact of floods on human safety, health, and welfare"; however, Section 1134 of the Water Resourced Development Act of 1986 directed the Secretary of the Army to extend the leases until such time as they are terminated by the leaseholder or their assigns.

Action 5.4: *Issue a new Executive Order to reaffirm the federal government's commitment to floodplain management with an expanded scope.*

A new EO, built upon EO 11988, will reaffirm the federal commitment to floodplain management by addressing the full scope of federal activities, particularly critical infrastructure, acknowledging uncertainties of scientific information, stating the economic policy implications of floodplain development, and requiring an interagency consultative process. The EO would provide a means to clearly articulate and thereby institutionalize the new vision of floodplain management. It would emphasize avoidance of federal activities in the floodplain. Requiring federal agencies to evaluate all structures during maintenance and repair activities to determine the feasibility of mitigating flow constrictions or undertaking other mitigating measures will reduce the risk of flooding and minimize the impacts of floods. Requiring federal activities to comply with state and local regulations when more stringent than national standards will affirm the states role as floodplain manager. The revision will aslo require each agency to prepare new implementing guidelines for activities potentially occuring in or affecting floodplains, increasing agency awareness of the issue, and allowing agencies to address issues unique to their programs. It would also require that federal spending does not increase development in sites vulnerable to flood damages. The FEMA will provide oversite of EO compliance as described in Appendix G.

Action 5.5: *OMB should direct all federal agencies to conduct an assesment of the vulnerability of flooding using a scientific sample of federal facilities and those state and local facilities constructed wholly or in part with federal aid.*

This vulnerability assessment should identify and quantify the total federal investment subject to flood damage. The target flood for protecting critical infrastructure (i.e., SPF or 500-year) should be considered in the assesment. The assesment also should contain recommendations on mitigation measures to protect federal facilities currently at risk. The results of this study would be used to make decisions regarding the need, if any, to take mitigative measures.

Action 5.6: *Seek revision of Section 1134 of the Water Resources Development Act of 1986 to provide for phase-out of federal leases in the floodplain.*

The Administration should seek reivsion of Section 1134 which requires continuation of leases of federal lands. Then the Administration should phase out leases along the Mississippi River to reduce the risk of flood loss and minimize the impact of floodx on human safety. The USACE should enforce provisions of the leases prohibiting year-round occupancy. In the interim community floodplain management ordinances should apply.[19]

The EPA's regualtions for the Resource Conservation and Recovery Act (RCRA) on permitting hazardous materials treatment, storage, or disposal facilities have locational standards; but these standards appear inconsistent with the EO guidelines for critical actions.[20] The EPA, in draft regulations (1978), proposed design standards for facilities located in the 500-year floodplain. Public comment on the draft reflected dificulties with identifying the 500-year floodplain and a concernthat the EPA was holding these facilities to a higher standard than that required by EO 11988. The final regulations addressing flood design require that no wash out of hazardous materials occurs. Therefore they apply only to those facilities located in the areas with a 1 percent annual chance of flooding.[21] The EPA requires that permitted facilities have contingency plans addressing notification and response for any unplanned sudden or non-sudden release. The regulations do not specifically require that the plans address flooding events, even for facilities in areas with 1 percent annual chance of flooding where an obvious cause of releases could be flooding.[22] Furthermore, there exists no feedback mechanism regarding plan effectiveness in the event of a hazardous material release.

Recommendation 5.1: *Revise the RCRA locational standards and contingency planning regulations for consideration of flood hazards in areas impacted by the Standard Project Flood.*

Revision of the site regulations to recognize that releases of hazardous materials are critical actions for which "even a slight chance of flooding is too great" would provide a greater level of environmental protection and public health and safety and would be consistent with implementing guidelines for EO 11988.[23] Revision of the EO would automatically trigger this action. Specifically requiring contingency plans to reflect the special activities and coordination required in the event of flooding would also decrease the risk of hazardous material releases and enhance governmental response. An additional requirement for review of contingency plans after hazardous material releases would provide the means to enhance pre-disaster planning.

STATES LEAD THE WAY

The state should be the entity best able to coordinate the overall watershed and floodplain management activities occurring within its borders. Communities deal with local problems and solutions. Active involvement by the states is necessary to develop flood-reduction projects consisent with multiple floodplain and watershed amanagement goals as well as other state natural resource and economic goals. States need to be more involved in setting floodplain management priorities, adjudicating intrastate issues regarding priorities and determining impacts of floodplain management projects, and in brokering federal assistance. Currently, the extent of state involvement in locally sponsored flood-reduction projects is highly variable, ranging from requiring approval of the governor

at the end of project planning to multiple agency collaborative commitment throughout project planning. In many areas state-level leadership and coordination is vital: flood-fighting, repair activities, buyouts, hazard mitigation, permitting of levees and other structures that impact beyond the local area. State involvement in levee programs should be increased. The Association of State Floodplain Managers notes that only 16 of the contiguous states regulate levees -- five of which are Midwest states.

States floodplain management programs vary within the region and the nation. Several of the states in the upper Midwest are pioneers in floodplain management and have programs that pre-date the NFIP. These states have adopted floodplain management laws and minimum floodplain management regulations implemented with state funds. They provide technical assistance to communities and undertake other activities that are critical to achieving the vision articulated in this report. Other states in the region have minimal state floodplain management programs. In these states floodplain management is often incidental to other resource and emergency management. Appendix F summarizes state floodplain management activities.

Prior to the 1993 flood, states took little cognizance of the fact that many levees repair program. States need to be more involved in coordinating floodlight to ensure that these efforts do not harm other parties, that they are focused to ensure greatest public benefit, and that they have no long-term adverse effect on floodplain management. Several midwesten communities noted that because they did not belong to a levee district offering some level of protection, they were not involved in levee maintenance or floodfight decisions. State involvement could raise community issues to the attention of federal officials. State involvement in coordinating levee repairs needs to be enhanced. Some states did not assume an active role, so the USACE and USDA levee repair programs had to work directly with local entities. An example of more appropriate state involvement is the PL-566 watershed program wherein each governor makes recommendation and sets priorities for proposed local watershed projects.

Increasing state involvement will require greater state technical capabilities in floodplain management. Few incentives exist, however, for the state to build this expertise. The federal government currently provides technical assistance directly to local entities and/or states through the USACE Floodplain Management Services and Planning Assistance to States Programs, the SCS PI-566 Program, and the Tennessee Valley Authority (TVA) programs. Provision of technical assistance directly to individuals and local communities does not build and, in fact, detracts from state capabilities. The FEMA Community Assistance Program provides technical assistance to local entities through the states. The TVA, in a self-review to increase customer service, determined that provision of assistance directly to individuals was not the most efficient use of federal resources and decided to focus its assistance on states.24

Recommendations 5.2: *Increase the state role in all floodplain management activities including, but not limited to, floodfighting, recovery, hazard mitigation, buyout, floodplain regulation, levee permitting zoning, enforcement, and planning.*

A shift towards a state role from what is now primarily a federal-local relationship is necessary to set priorities, adjudicate intrastate issues regarding priorities and impacts of floodplain management projects, and broker federal assistance. This could be accomplished for all federally assisted or funded floodfight, repair and recovery, flood damage reduction, and other floodplain activities by requiring:

- State sponsorship or co-sponsorship in conjunction with local sponsorship or
- Prior state approval.

The non-federal cost share could be provided by either or both the state and local entity or both.

Recommendation 5.3: ***Restructure and refine the scope of federal technical services programs and increase funding for the USACE in the areas of Floodplain Management Services and Planning Assistance to the States programs and increase funding for states through the FEMA Community Assistance Program.***

By altering the focus of technical and planning assistance for floodplain management from individual and local assistance to state assistance for coordinated dispersal to local areas, federal programs can create an incentive for states to build these types of expertise. Federal information transfer and training for the states for subsequent transmittal to local governments are far more efficient uses of federal expertise and limited federal funds because the same information reaches more people and provides a public service. In its most recent testimony to Congress, the Association of State Floodplain Managers indicated that floodplain management funding and planning assistance for states are not sufficient to provide dissemination of critical data necessary to support sound decisions at the local and state level. This viewpoint was echoed by state officials in the in the Midwest. The federal government receives far more requests for assistance from local governments and individuals than can be accommodated given current funding constraints. The inability t to provide assistance in some situations can lead to inappropriate floodplain development decisions and, therefore, increased long-term costs. Additional funding would allow federal agencies to provide and analyze pertinent data necessary for state and local governments to make sound floodplain management decisions.

INCREASE THE STATE-LOCAL STAKE IN FLOODPLAIN MANAGEMENT

Ultimate responsibility for floodplain management rests with individuals and local government through local land use planning decisions. The federal government must ensure that it provides incentives for, and no disincentives to, community-based floodplain management. Cost sharing is essential to maintain the state and local stake in all floodplain management activities and should be retained.

In the series of recent disasters impacting large populations (I.E., Hurricane Andrew, the Midwest flooding, and Northridge earthquake), non- –federal cost-share requirements were decreased to respond to state and local financial constraints. Disaster-specific changes in federal/non-federal cost-share percentages for FEMA disaster assistance may have an adverse effect on floodplain management. The federal-state cost-share originally 75/25 was adjusted for all three disasters to a 90/10 basis. These cost-share changes have two potentially significant consequences. First they set up an expectation of similar treatment in subsequent disasters and increase political pressure to provide a lower non-federal share. This perpetuates the dominant federal role in recovery and increases federal costs. Second they may defeat the fundamental purpose behind cost sharing which is to increase the amount of local involvement, responsibility, and accountability. By lessening the non-federal investment, state and local governments have less at stake and, therefore, may have a lower incentive to develop and adopt sound floodplain management policies and practices.25Community consequences for choosing not to participate in the NFIP are limited because FEMA disaster assistance pays for damages to all public (i.e., community) facilities and infrastructure other than buildings regardless of whether a community is participating in the NFIP. In non-participating communities individual citizens suffer the consequences. Few, if any, incentives exist for communities to seek private insurance for damages to community facilities; rather, most communities rely solely on FEMA to provide reparation. This is inconsistent with the philosophy that federal disaster assistance should be provided in situation where communities and states, due to the magnitude of damages, will exhaust their resources and not have the capability to recover on their own.

PRIVATE INSURANCE HELPS CITY COVER ITS LOSSES

In July 1993 the Des Moines Water Works was inundated and put out of commission for two weeks. The damage totaled $12 million, $9.9 million of which will be covered by private insurance previously obtained by the water works. This resulted in minimizing federal public assistance costs to $2.1 million. Although the insurance carrier would not renew their insurance, the water works was able to acquire new insurance for the water treatment plant. The new private insurance premium of $1,720 per year purchased $10 million of flood insurance. Subsequent to the flood of 1993, the levees surrounding the plant have been raised six feet and concrete floodgates have been constructed to close the gap made by the roadway into the plant.

Recommendation 5.4: *Hold FEMA's existing disaster assistance cost-sharing requirements to no more than 75/25; seek to make other agencies disaster programs' cost-share requirements consistent at 75/25.*

By retaining 75/25 as the basic FEMA disaster assistance cost-share for mitigation and disaster, non-federal investments will serve as an incentive for non non-federal interests to pursue means to protect those investments through more effective floodplain management. Cost-sharing requirements by other federal programs for flood-fighting and repair should be consistent. Circumstances may occur where changes in the cost-share ratio are justified; further evaluation of how to define those circumstances is warranted.

Action 5.7: *For communities not participating in the NFP, limit public assistance grants.*

Create additional incentives for communities to participate in the NFIP by limiting public assistance given to on-NFIP communities to rescue and emergency operations only. Participation in the NFIP will help assure that new infrastructure complies with basic floodplain management requirements and does not adversely impact other development.

Action 5.8: *Encourage communities to obtain private affordable insurance for infrastructure as a prerequisite to receiving public assistance.*

Require a community desiring public assistance to demonstrate that it had done all it could to secure affordable private insurance for public facilities. This would help to increase community responsibility and accountability and would reduce the federal taxpayer burden associated with risky behavior in floodplains.

FUNDING FOR PUBLIC FACILITIES

Concerns have been expressed that the current FEMA public assistance program may provide disincentives for communities to take actions to protect public infrastructure from flood damages or to relocate those facilities out of the floodplain. Public Assistance funds the repair of damaged public facilities under a 75/25 cost share formula (although a 90/10 cost share was used for the Midwest flood). A local cost share of less than the cost of relocating the facility out of the floodplain or protecting the facility from flood damages, creates a disincentive for the community to mitigate. A further concern is that communities may not budget adequate funds for the maintenance and upgrading of infrastructure and other public facilities are damaged, a portion of the damage may be due to deferred maintenance or to the community's failure to upgrade or properly size the infrastructure. Although FEMA can reduce the amount of the grant to account for deferred maintenance, it is often difficult to make this distinction and the community receives a windfall in the form of a new or repaired facility.

A further problem is that storm and sanitary sewer systems were inadequate to handle the high groundwater and rainfall that occurred in many areas of the Midwest in 1993. This resulted in flooding and sewer back up into the basements of thousands of homes and businesses. The public assistance program currently will provide funds to repair sewer systems to their pre-flood conditions but not to up grade those systems so that they are adequately sized to handle similar storm events with minimal damages.

The Review Committee considered a recommendation that all public assistance to communities for the repair or upgrading of infrastructure or other public facilities be in the form of loan rather than grants to remove these disincentives, but loans may not be practicable for a community devastated by a major disaster.

FEMA can provide limited funds through the public assistance program for cost effective mitigation measures that will reduce future damages to a facility. In addition a community can decide not to repair, restore, reconstruct, or replace a facility at its existing location and obtain up to 90 percent of the federal share of repair cost to expand alternate facilities, build a new facility, or fund hazard mitigation measures. However, the community must pay any additional cost to relocate or upgrade the facility. If it can not afford to do so, the facility is then repaired to its pre-flood condition at its current location and remains vulnerable to further flood damage. Some funds may also be available through FEMA Section 404 Hazard Mitigation Grant Program to upgrade these systems. However, these funds are often fully allocated for other purposes and are not available for public facilities.

States and communities should undertake efforts to identify vulnerable facilities in the floodplain. This inventory would help target priorities for pre-disaster mitigation and would be necessary to determine insurance needs.

Action 5.9: *Provide loans for the upgrade of infrastructure and other public facilities.*

A loan program would encourage and enable communities to undertake action during recovery to reduce future damages to public facilities by relocating or protecting those facilities rather tan repairing the facility at its current location. In addition such a program would assist communities to upgrade undersized storm sewer systems or other flood control facilities. Because upgrades are capital improvements that have long term benefits for the community, loans are more appropriate than grants. The loan program can be established to allow flexible terms based on the communities' ability to pay (e.g., zero or low interest rates and long repayment period). The Administration should seek Congressional action to establish such a program.

PROVIDE A BALANCED FOCUS IN THE PLANNING PROCESS

Federal actions taken to develop water resources reflect the objectives set over several decades by the Congress. Various Administration s have defined federal water resources objectives.[26] The two most significant publications on federal water resources development are *Principles and Standards for Planning Water and Related Land Resources* commonly referred to as *Principles and Standards* or *P&S,* published in 1973, and *Econimic and Environmental Principles and Guidelines for Water and related Land Resources Implementation Studies* commonly referred to as *Principles and Guidelines* or *P&G* published in 1983. The *P&S* was a rule applied to water and land programs, projects, and activities carried out by the federal government and non-federal entities with federal financial or technical assistance the rule guided formulation and evaluation of projects to enhance national economic development (NED) and the quality of the environment. When the *P&S* was superseded by *P&G* in 1983, rules became guidelines. The *P&G* contain a single objective for planning of water resource s projects: "contribute to national economic development consistent with protecting the Nation's environment, pursuant to national output of goods and services, expressed in monetary units. Under *P&G,* alternative plans can reduce net NED benefits to further address other federal, state, local, and international concerns not fully addressed by the NED plan. A plan recommending federal action is to be that with "the greatest net economic benefit consistent with protecting g the nation's environment" (the NED plan), unless the Secretary of a department or head of an independent agency grants an exception to this rule. Exceptions require overriding reasons for recommending another plan, based on other federal, state, local, and international concerns. Since 1983, exceptions to the NED plan have been limited.

Calculations of NED are meant to include all environmental and social benefits and costs which monetary values can be obtained. The monetary focus on NED, however, does not give adequate consideration to unquantifiable environment and social values.

Because of their non-market nature,environmental quality, ecosystem health, the existence of endangered species, and other social effects are not as easily quantified in monetary values.[27] This limits formulation and acceptance of projects capable of striking a better balance between flood damage reduction or other water resources development and the environment.

Action 5.10: *Establish as the new, co-equal objectives for planning water resources projects under Principles and Guidelines:*

- ***To enhance national economic development by increasing the value of the Nation's output of goods and services and improving national economic efficiency, and***

- ***To enhance the quality of the environment by the management, conservation, preservation, creation, restoration, or improvement of the quality of natural and cultural resources and ecological systems.***

The current nationaleconomic develpoment objective of the *P&G* should be revised immediately through the issuance of an executive order. This will provide a balanced focus for guiding decision making.

Update *Principles and Guidelines*

The *P&G* are now more than ten years old, and several areas are in need of thorough review. Critics of the *P&G* see a bias toward structural solution to flooding problems and a failure to evaluate nonstructural alternatives in the same way as structural alternatives, such as levees. One of the differences in the evaluation is that for structural alternatives the reduction in flood damages is included as a measure of the benefits of a project, while for some nonstructural alternatives, such as evacuation of structures from the floodplain, reduced damages must be separated

into internalized and externalized damages. Then, only the externalized damages prevented (those borne by other than the floodplain residents) are claimed as benefits for the nonstructural evacuation alternative. There is an economic rationale for doing this, but the concern still exists that it results in a bias against nonstructural projects. In addition, many social benefits of removing people at risk from the floodplain and environmental benefits of a natural floodplain are not included adequately within the evaluation. Although the *P&G* do not exclude these considerations, application deficiencies exist because of the non-market nature of the impacts. Because of these application deficiencies, research is recommended in Chapter 11 to allow greater consideration of difficult to quantify inputs for which no market system exists and to improve techniques for measuring social or environmental outputs that result from alternative actions.

A system-of-accounts analysis can provide critical information on market and non-quantifiable, non-market impacts necessary to provide the basis for trade-off. Such analysis can support a sound formulation-of –alternatives process that includes quantified impacts where available as well as qualitative impacts and displays beneficial and adverse effects of each alternative considered on the following accounts: national economic development; regional economic development; other social effects; and environmental quality of various project alternatives. The *P&G* do not require the system-of accounts; however, some agencies strongly encourage this comparison of impacts to these four areas within agency rules. The system of accounts or something similar is needed to help ensure balanced planning.

SHIFTING THE PROJECT ANALYSIS PARADIGAM

Utilizing benefit-cost analysis under the existing system, net monetary benefits must exceed zero. Under the proposed approach, the sum of net monetary benefits and society's value of net nonmonetary benefits must be greater than zero

The *P&G* require the responsible federal agency to contact the governor or designated agency for each affected state before initiating a study. It requires the federal planning agency to provide the state agency or agencies responsible for or concerned with water planning with opportunities to participate in defining the problems with opportunities in scoping the study and in review and consultation. A truly collaborative approach, however, is not required or encouraged. The *P&G* also states that interested and affected agencies groups, and individuals should be provided opportunities to participate throughout the planning process and that a coordinated public participation program should be established with willing agencies and groups. This falls short of establishing partnerships and collaborating within an ecosystem context on major watershed efforts. Benefits of collaborative approaches include improved efficiency and cooperation (both within and across agencies) and improved service to the public. The approach also serves to crystallize public opinion regarding problems and builds consensus for solutions. Criteria should be established to indicate where collaborative approaches are appropriate and recommend a mechanism for implementation to include single or separate agency funding of participation in the collaborative efforts. For cost-shared feasibility studies, a determination should be made as to whether it is reasonable to require participation in collaborative funding by the non-federal cost-sharing sponsor.

The *P&G* provides and overriding philosophy and process for formulating alternative plans an weighing the impacts of each alternative to select a recommended plan for meeting the study needs. The requirements of the NEPA are included as part of the *P&G* process. This process can be applied to all federal agency evaluations of alternatives to most efficiently allocate scarce resources to meet the needs of the nation.

Currently the only federal agencies required to use *P&G* are the USACE, the SCS, the TVA, and the Bureau of Reclamation. To increase efficient resource allocation,

P&G should be extended. It should apply to the planning and evaluation of the effects of water and land programs, projects, and activities carried out by the federal government and by the states or other entities with federal financial or technical assistance.

Action 5.11: ***Establish an interdisciplinary, interagency review of the P&G by affected agency representatives to address:***

- ***Structural versus nonstructural project bias;***
- ***Inclusion of system of accounts or a similar mechanism for displaying impacts;***
- ***Inclusion of collaborative planning in an ecosystems context for major studies; and***
- ***Expansion of the application of the revised P&G to water and land program, projects, and activities to include:***
  - ***All federally constructed watershed and water and land programs;***
  - ***National parks and recreation areas;***
  - ***Wild, scenic, recreational rivers and wilderness areas;***
  - ***Wetland and estuary projects and coastal zones; and National refuges***

An interdisciplinary, interagency committee of individuals from potentially affected federal agencies should be established to focus on the new broadened objectives, and to make specific recommendations for revisions to the current *P&G,* based on the four areas identified above an any others as appropriate. Revision must be consistent with the intent of EDO 12893, Principles for Federal infrastructure Investments, and EO 12898, Environmental Justice, both issued in 1994. This committee should be convened as soon as possible with a goal of making all necessary revisions by December 1994. To ensure that coordination of planning principles occurs at the state, tribal, and local level and that a balanced approach is taken, any revisions to *P&G* should be published and provided for public review and comment prior to finalizing.

COLLABORATIVE EFFORTS

Ecosystem, watershed, and large-scale river studies lend themselves to collaborative approaches by virtue of their scope. Only by working in partnerships with other federal agencies, state agencies, tribes, local governments, and private organizations can individual agencies look beyond their defined missions. A collaborative approach in an ecosystem context is needed for major watershed and floodplain management planning to move agencies away from single-agency problem solving. A more comprehensive evaluation of problems and solutions is likely is if a collaborative approach includes governmental parties at all levels as well as public and private stakeholders. Such collaborative partnerships also constitute a means of leveraging limited funds to implement projects with multiple benefits. Collaborative efforts require more than consultation, coordination, seeking public input; they require a commitment to working collectively to solve complex, interrelated concerns.

The ongoing USACE 18-month Floodplain Management Assessment study provides an opportunity to include other agencies as partners in a collaborative atmosphere. The study is being coordinated federal agencies, many of which would prefer to participate as a partner in the Assessment. By redirecting the current planning process, the Assessment can become a partnership of federal

agencies in a collaborative effort to assess the floodplain management objectives of the basin. Funding for this collaborative planning effort may necessitate a supplemental appropriation. If necessary, funds would be dispersed at the discretion of USACE, the lead agency, after consultation with collaborating agencies. If the supplemental request is not approved, USAC E should provide the opportunity for other agency collaboration of the expense of each individual agency. Active involvement by multi-agency participants in all aspects of the USACE Floodplain Management Assessment would ensure a holistic review of the area's floodplain management issues. A collaborative approach would identify a broader set of alternative solutions that address problems or multiple state and local objectives. It would build greater trust in a support for findings and recommendations o of the Assessment.

In keeping with the trend toward ecosystem-or watershed based planning federal agencies are expected to work as partners or to collaborate. Currently funding constraints limits the ability or most federal agencies to participate without reprogramming their funds. The USACE districts are particularly limited by the project-specific nature of their funding. Feasibility studies are cost-shared with the non-federal sponsor on a 50-50 basis, and partner interests are more likely to be limited to the study area than to the entire watershed. Additional funding is needed for all federal agencies for the purpose of collaborative planning. While it will cost more initially, collaborative planning is an investment in the future that will reduce future project-specific planning expenditures.

Recommendation 5.5: *The Administration should seek increased funding for federal agencies to support collaborative planning participation with other federal agencies.*

For major ecosystem or watershed planning studies, the lead federal agency should budget for adequate funding to reimburse other key federal agencies for their collaborative participation. Studies that are not watershed in scope or that have not been adequately funded to support a multi-agency collaborative effort may require that individual agencies budget their own participation monies.

Programmatic NEPA Documents

The Review Committee heard comments that requiring independent NEPA documents on similar but individual projects can be an inefficient and time-consuming approach to decision making. Efficiencies can be realized by analyzing all the anticipated actions as a group and applying NEPA on a programmatic basis before proceeding on individual projects requiring site-specific NEPA compliance. Application of multi-agency programmatic environmental impact analyses performed at the watershed scale allows agencies to focus on issues that are geographically related or have timing, impact, or other subject matter similarities. In addition the programmatic NEPA process provides a formal public involvement mechanism to address strategic decisions. Subsequent impact analyses would only focus on project-specific purposes and needs and those issues n need of decisions.[28] Where subsequent plans are consistent with the programmatic analysis, further analysis would be focused, costs reduced, and planning made more efficient.

The Council on Environmental Quality (CEQ) needs to actively pursue use of programmatic NEPA documents and issue a directive to agencies to also increase their emphasis on this approach.

Recommendation 5.6: *Promote the use of programmatic NEPA documents in the planning process.*

A workshop should be sponsored on strategic and programmatic application of NEPA by CEQ so that success stories in this area can be shared. This will build knowledge about the applicability of these approaches. Their utility, and the means of undertaking broad programs-level analyses. The CEQ should explore other means to pursue strategic programmatic analysis of problems.

Federal Agency NEPA Participation

Currently lead agencies designate those agencies that should cooperate in the NEPA process. Where agencies have not been designated by the lead agency but specially request participation due to a vested interest, these agencies should be allowed to cooperate in the process. No mechanism exists to require the lead agency to include these other requesting agencies in the process. The CEO should revise the regulations implementing NEPA to require the lead agency to designate those federal agencies formally requesting cooperating agency status, where appropriate. This would further the goal of establishing collaborative planning among pertinent federal agencies.

REEVALUATING WATER RESOURCES PROJECTS

Many of the nation's water resources projects were constructed a number of years ago. The Review Committee heard concerns that: (1) these projects will eventually need major maintenance expenditures, (2) conditions have changed that make them less effective (such as headwater development that increases runoff and flood stages causing protection downstream to be lessened, and (3) consideration is not adequately given to changing societal goals with regard to potential modifications to the projects themselves or modifications in the operation of them.

Recommendation 5.7: ***OMB should issue a directive that requires periodic reevaluation of federal water resources project to include potential operation and maintenance modifications.***

Projects for which construction was completed 40 or more years ago should be reevaluated to consider potential project modification and insure project integrity. Other projects less than 40 years old should be reevaluated when know major problems exist, where conditions have changed that impact the effectiveness of the project, or where changing societal goals demand that modification be considered. Specific procedures tied to the new *P&G* should be established and a directive issued by OMB. Legislation should be provided in a Water Resources Development Act or other act to give water resources construction agencies the blanket authority to address these issues, where appropriate, without the need for project-specific study authorizations Congress.

FUNDING CONSIDERATIONS FOR PROJECTSTHAT INCLUDE FUTURE DEVELOPMENT

Some flood damage reduction projects, in their effort to reduce damages for existing floodplain structures, also provide protection for undeveloped land areas that have a high potential for future development. In these cases, future development savings resulting from the project are estimated and included in the benefit-cost ratio. A separate accounting of existing and future benefits is required by P&G to provide decisions makers with the information necessary to make informed decision. The total benefit-cost ratio, however, is reported in the feasibility report and usually used for budgetary considerations in establishing funding priorities.

Recommendation 5.8: ***OMB should use only the benefit-cost ratio for damage reductions to existing development in establishing Administration funding priorities unless a standard project flood level of protection is provided.***

The Office of Management and Budget should give more detailed consideration to the type of project benefits being claimed for each individual project recommendation. Future development benefits should not be used as the basis for increasing the funding priority of flood damage reduction projects unless a standard project flood level of protection is provided.

ENDNOTES

1. White, Gilbert, et al., *Action Agenda for Managing the Nation's Floodplains.* Special Publications 25. (Boulder, CO: National Hazard Research and Application Information Center, March 1992

2. Ibid, page 4-5

3. National Flood Insurance Act, PL 90-488 (Section 1302 © 1968. The "Unified National Program for Floodplain Management " report has been submitted to Congress in 1979 and 1986 and is planned for submittal in 1994.

4. *Action Agenda for Managing the Nation's Floodplains,* page 8.

5. Ibid, page 4

6. Concern was expressed to the Committee regarding the magnitude of the federal interest.

7. Water Resources Planning Act of 1965, 79 Stat. 244, 42 USC 1962, 1965

8. Ibid.

9. *Action Agenda for Managing the Nation's Floodplains,* page 9.

10. Water Resources Planning Act of 1965

11. Executive Order 12319 -- River Basin Commissions, September 9, 1981.

12. National Fish and Wildlife Foundation, Mississippi River Initiative Part II: After the Flood, (Washington, DC: National Fish and Wildlife Foundation March 1994).

13. Historically revenue of the Upper Mississippi River Basin Commission was shared between the federal government and the participating states. Generally the federal share ranged from 50 to 75 percent of each years revenues; an even larger federal proportion occurred when the WRC funded preparation of a Master Plan in 1980; Stoerker, Holly, Executive Director, Upper Mississippi River Basin Association, personal communication May 5, 1994.

14. For example, see Federal Interagency Floodplain Management Task Force, *Floodplain Management in the United States: An Assessment Report,* FIA-18 (Washington, DC: Federal Insurance Administration, June 1992

15. Association of State Floodplain Managers, Inc., *Floodplain Management 1992: State and Local Programs.* (Madison, WI: ASFPM, 1992).

16. U.S. Water Resource Council, "Floodplain management guidelines for implementing EO 11988", 43 *Federal Register* 5030 (Part II, Step 1, Section 1(c). February 10, 1978.

17. Several examples were provided by Kucera, Ron, Director, and Intergovernmental Cooperation Department of Natural Resources, MO, and personal communication March 3, 1994. Bachant, Joe, Department of Conservation, MO, personal communication April 28, 1994.

18. Zensinger, Larry, Coordinator, Midwest Acquisition Relocation Program, Federal Emergency Management Agency (based on analysis performed by Miriam Anderson, St. Charles County Planning Department), personal communication April 26, 1994.

19. The U.S.Department of Justice indicated to the Review Committee that state and local floodplain management requirements can apply to structures on lands leased from the federal government.

20. "Floodplain management guidelines for implementing EO 11988."

21. 40 CFR 264.18. Wright, Felicia, EPA office of Solid Waste, personal communication April 26, 1994.

22. Ibid.

23. Floodplain management guidelines for implementing EO 11988.

24. Miller, Barbara A. Manager, Flood Risk Reduction, Tennessee Valley Authority, personal communication February 22, 1994.

25. The Economics Advisory Group pointed out to the Review Committee that optimal cost-share payments should reflect the relative net benefits gained by federal, state, local, and individual interest. If such a cost-share program could be implemented, project costs would e allocated in proportion to the benefits that were accrued by each party.

26. Some objectives are defined in laws such as PL 89-80, the Water Resources Planning Act of 1965; the Flood Control Act of 1936; and the Water Resource Developments acts. Some are defined in Congressional Reports, such as the 1958 the report to the Inter-Agency Committee on Water Resource "Proposed Practices for Economic Analysis of River Basin Projects;" and the 1962 "Policies, Standards, and Procedures s in the Formulation, Evaluation, and Review of Plans for use and Development of Water and Related Land Resources," commonly referred to as "Senate Document Number 97".

27. The Economics Advisory group pointed out that there methods exist for quantifying and monetizing environmental benefits and cost, but these methods frequently cannot be used because of the lack of an accurate characterization of the biological effects of environmental changes.

28. Council on Environmental Quality, *Regulations for implementing the procedural provisions of the national environmental policy act*, 40 CFR Part 1502.20, (Washington, DC.: CEQ, 1986).


BOATMEN'S
BANK

Chapter 6

AVOIDING VULNERABILITY THROUGH PLANNING

Throughout human history it has been the way of nature to visit us on occasions with disaster, without apparent cause, without explanation, often without mercy, always reminding us that we need to live our lives with a little more humility and always understanding that we are not in full control...We know we cannot contain the fury of a river.

President Clinton
Remarks on signing flood relief legislation at a tribute to flood heros in St. Louis, Missouri, August 12, 1993

The goals of floodplain management are to reduce the nation's vulnerability to floods while concurrently integrating preservation and enhancement of the natural resources and functions of the floodplain. The basic tenet of reducing vulnerability is to avoid risks as much as possible in the planning stage. Moving people out of harm's way or limiting development in the floodplains lessens risks from flood damages. Planning on the watershed level can balance competing and compatible uses of the floodplain to meet social, environmental, economic, and other community goals.

For planning to be effective, it needs to be coupled with an educational program for local people involved with planning activities as well as landowners. Once communities and individuals understand the residual risk inherent in floodplain use, and once they understand how natural and hydraulic systems operate, they can make more informed decisions that balance multiple objectives.

With planning and education as the cornerstones of floodplain management, the nation can further reduce risks through watershed management, programs such as the NFIP, and acquisition of flood prone lands. By pursuing planning efforts in a collaborative and coordinated fashion, the nation can reduce its vulnerability to flooding substantially.

MANAGING FLOODPLAINS AS WATERSHED COMPONENTS

What happens in the larger watershed affects what happens in the floodplain. The upper Mississippi River Basin consists of watersheds of varying size. Each watershed is a physically discrete hydrologic unit in which water is channeled from upland areas to lower areas and eventually into main stem rivers. The flood stage, frequency, and duration normally are influenced by the degree to which rainfall is captured and released in the uplands. As discussed in Chapter 2, wetland restoration and maintenance and upland treatment can be effective for smaller floods with lesser impacts on larger floods. The correlation between upland rainfall capture and release and

downstream flood stage, though complex and incompletely understood, indicates that well-managed watersheds reduce downstream flood stages with concomitant reductions in flood damages and increases n water quality and ecosystem benefits.

A number of Midwest communities flooded in 1993 reported to the Review Committee that they perceived an increase in flood stages and frequencies over the past few decides. Some attribute this to structural flood control (levees), and others to changed land use practices in upland areas of the watershed. Among the changes they mentioned were agricultural development and paving of residential and industrial areas -- both of which reduce storage capacity and increase runoff. People rarely consider the downstream cumulative effects of individual activities, in large part because water sheds typically encompass a number of political jurisdictions with differing economic interests.

Watersheds have long been recognized as the optimal management unit for water resources planning. As early as the 1970s, the USACE was performing analyses of water quality and supply using watersheds as the basic planning unit.[1] The USDA for decades has recognized benefits of watershed planning under its PL 566 program and through the Forest Service.[2] More recently within the Department of the Interior, the National Park Service and the Fish and Wildlife Service have instituted watershed management programs, and the Environmental Protection Agency has begun using watersheds as the most practical unit to resolve problems that traditional programs have been unable to address adequately.[3]

Federal watershed programs and policies suffer from a lack of coordination and a failure to develop achievable multiple objectives. Many of these programs focus exclusively on water quality or habitat improvements derived from watershed management but disregard flood damage reduction benefits. Federal watershed programs primarily operate in rural areas, neglecting non-agricultural urban and suburban land uses. Program eligibility requirements and incentives also differ among agencies. The regional of most federal agencies, tied to state boundaries, complicates the ability to focus on watersheds.

Any pending legislation dealing with watershed planning and management should consider achieving multiple objectives, including flood damage reduction as an element of watershed management and incentives based upon demonstrated flood reduction. Legislation should also consider opportunities to trade for flood control, such as payments from floodplain farmers to induce upland farmers to install land-management practices that reduce flood peak and frequency. Currently, pending legislation (S. 2093, formally S. 1114; President Clinton's Clean Water Initiative; and H.R. 3938)[4] considers the achievement of multiple objectives for watershed, although flood control management activities and incentives are not explicitly stated.

The best parts of federal programs must be merged to encompass a holistic and synergistic approach to watershed management. Opportunities for change include current congressional action n the Clean Water Act and reauthorization of the Farm Bill due in 1995. To capitalize on potentially forthcoming legislative authority, the federal government must build on going watershed programs, focusing on the most effective means of achieving multiple objectives, and targeting conservation programs to complement watershed management goals.

Action 6.1: *The Administration should establish an interagency task fore, jointly chaired by the USDA and EPA, to formulate a coordinated, comprehensive approach to multiple objective watershed management.*

Many federal agencies undertake watershed programs to achieve goals consistent with their primary mission. Such goals may be inconsistent with local, regional, or basin-level ecosystem needs. Currently, success is measured by achieving agency goals irrespective of other attainable benefits. For example, the Forest Service watershed program seeks to improve stream habitat through reduced siltation and temperature reduction. Success is measured by increases in fish population. Flood damage reduction and water quality -- goals that could be accomplished with small incremental expenditures of expertise and money -- are not factors in determining program success.

The recommended task force would provide an overview of federal watershed management programs to ascertain their effectiveness and identify areas for improvements. The task force will necessarily include the USACE and the DOI due to their missions and jurisdiction in water resources activities. Task force members could identify areas in which interagency missions coincide and are achievable through watershed management on a collaborative level. The task force should also follow up on the demonstration project discussed in Chapter 11 under the section on hydrologic and hydraulic benefits of natural floodplain functions.

Enhancing Stream and Riparian Areas

Stream and riparian restoration vital to watershed management holds, for a relatively small investment, promise of improved water quality, wildlife habitat, and reduced runoff. Federal efforts designed to restore non-urban stream and riparian areas include those of the Bureau of Land Management, the National Park Service, the Soil Conservation Service, and the Forest Service. Nonprofit groups and private and local interests have also focused on similar activities. Unfortunately many stream and riparian sites located within urban and suburban areas are degraded, undervalued, and ignored by federal programs. Properly restored urban streams provide the same benefits as restored rural streams, often becoming centerpieces for urban revitalization. Recognizing the need for stream and riparian restoration, Congress recently introduced legislation to establish a national urban watershed restoration program.[5] On the national level, current stream and riparian restoration is largely uncoordinated; federal expertise is decentralized and underutilized; and valuable information on costs, techniques, and effects is unavailable.

Action 6.2: *The DOI, USDA, and EPA should coordinate and support federal riverine and riparian area restoration.*

Because of the importance of stream and riparian restoration to water resource management, the Administration should establish a stream and riparian restoration program with DOI, USDA, and EPA cooperating to provide technical assistance for state, tribal, local, and private restoration.

Enhancing Agricultural Conservation Programs

The Food Security Act of 1985, and the Food, Agriculture, Conservation, and Trade Act of 1990, the last comprehensive congressional actions on agricultural policy, contained strong conservation measures to reduce soil loss and improve water quality by creating incentives and disincentives, primarily through cross-compliance with other agricultural programs. Two programs were of particular importance: the Conservation Reserve Program (CRP), introduced in 1985, provided payments to farm operators who agreed to protect temporarily highly erodible lands, and the Wetland Reserve Program (WRP), established in 1990, acquires conservation easements on agricultural lands from voluntary sellers and restores wetland conditions. About 36.4 million acres currently enrolled in the CRP will begin to come out of the program in 1995. Even with application of conservation practices, conversion of these acres to cropland will increase runoff.

The emergency supplemental appropriation for the Midwest floods established an Emergency Wetlands Reserve Program (EWRP) applicable to farmland damaged by flooding in the nine affected Midwest states. The Review Committee suggests that the authority for the WERP be continued in some form to provide an alternative means of recovery for farmers. Other programs within the Agricultural Resource Conservation Program of the USDA also are used to protect wetlands from development and degradation.

The USDA found many acres that met program criteria, but funding constraints precluded enrolling all of the eligible land. Conservation programs need to target limited funds to acquire critical lands that offer the greatest benefits per federal dollar. Present selection criteria, which consider natural characteristics on a site-by-site basis, do not recognize flood control benefits as an objective. Other benefits of the programs are well documented.[6] A systems approach to watershed management would consider a wider range of environmental objectives within enrollment criteria.

Action 6.3: ***The Administration's legislative proposals for the 1995 Farm Bill should support continuation and expansion of conservation and voluntary acquisition programs focused on critical lands within watersheds. The proposal should support technical and financial assistance for implementation of watershed management, riparian enhancement, wetland restoration, and upland treatment measures.***



STREAMLINING DISASTER PLANNING

A floodplain management plan that attains the national goals described in Chapter 4 is dependent on the ability to tie together pre-disaster, response, recovery, and mitigation programs with long-term floodplain planning efforts. Many federal agencies have programs designed to help disaster-stricken areas. Such programs can be improved by streamlining the system so that pre-disaster and post-disaster efforts are natural extensions of each other. Comprehensive pre-disaster planning and mitigation efforts will reduce risks and damages during the emergency, and recovery efforts will be consistent with long-term floodplain management goals. Improvements in federal coordination made before the 193 flood led communities to report that things worked "better than expected."

Pre-Disaster Planning

Pre-disaster planning needs to coordinate individual, business, community, state, tribal, and federal personnel and activities to minimize health and safety impacts and environmental risks. Such planning will help ensure adequate response. Awareness of flood threat, the first step in pre-disaster planning, relies on individuals who understand their risk and plan for disasters. Individual responsibility in knowing what to do, such as closing household gas lines, and when and where to evacuate in the event of a flood or other emergency is essential. The Review Committee heard from communities where owners did not remove mobile home trailers on wheels and farm equipment from low-lying areas. Some individuals refused to evacuate voluntarily when access was open and later required evacuation by air or boat, endangering both themselves and their rescuers. For better participation by individuals in pre-disaster planning, federal agencies must undertake education and outreach.

Pre-disaster planning is also a corporate responsibility. Operators of facilities generating, storing, or disposing of hazardous materials -- including farmers who use herbicides, pesticides, and fertilizers -- need plans for removing such materials should the facility lack the capability of assuring that no materials will be released. Local emergency managers need to be aware of locations of hazardous materials within their jurisdiction; local hospitals, fire companies, and others potentially involved with response need to be knowledgeable about threats posed by hazardous materials, their treatment, containment, and removal n the event of an unplanned release. Several emergency managers working in the Midwest flood reported the need for more pre-disaster information about facilities where hazardous wastes are generated, stored, and disposed. Siting issues should go hand in hand with pre-disaster planning.

Planners also need to consider how to safeguard valuable assets, such as cultural and historical properties. Communities should identify these properties prior to a disaster and coordinate with emergency managers, local government officials, federal agencies, and other following and event.

Pre-disaster planning requires action, involvement, and cooperation among not only floodplain residents, tribes, businesses, and industries but also across local, state, and federal government agencies. Application of advanced geographic information systems technology will increase efficiency and facilitate coordination.

Recommendation 6.1: *Enhance pre-disaster planning and training.*

The FEMA, in coordination with the EPA, UACE, USDA, DOT, and other federal agencies involved with aspects of emergency response, should increase state, tribal, local, public, and corporate awareness of risk. Those involved should practice implementation of pre-disaster plans. The EPA should work with the FEMA and states to emphasize local pre-disaster planning, including notification and coordination procedures for responding to releases of hazardous materials. Pre-disaster plans for spilled hazardous materials must identify suitable containment areas and develop a coordinated response of the emergency network. All agencies should encourage the use of geographic information systems to link data sources.

FLOODPLAIN PLANNING AND THE NATIONAL FLOOD INSURANCE PROGRAM

The National Flood Insurance Program (NFIP) is a primary component of the nation's floodplain management strategy. The congress created the NFIP in 1968 in response to mounting flood losses and escalating costs to the general taxpayer for disaster relief. Federal flood insurance is available only in communities that adopt and enforce floodplain management regulations that meet minimum NFIP requirements.

Building on NFIP Floodplain Management Requirements

The NFIP provides a framework for protecting new construction from flood damages through its floodplain management requirements that communities adopt and enforce as a condition of program participation. New and substantially improved residential buildings must be elevated to or above the elevation of the 100-year flood and non-residential buildings must be elevated or flood proofed at least to that elevation. Flood insurance premiums support floodplain mapping. In riverine floodplains, encroachments in the floodway are prohibited if they will result in any increase in flood stages. This limits development in areas of the floodplain adjacent to the river channel.

Flood insurance rates reinforce NFIP floodplain management requirements. Rates on new buildings are actuarial (based on the risk of flooding). When a structure is built in compliance with a community ordinance, the flood insurance premium is generally affordable. When a building violates a community ordinance, the flood insurance premium can increase to thousands of dollars a year or the building can be denied insurance at the request of the community

In the Midwest, the NFIP tends to discourage floodplain development through the increased costs in meeting floodplain management requirements and the cost of an annual flood insurance premium, although this may not be the case elsewhere in the nation. Individuals and developers appear to choose locations out of the floodplain to avoid these costs. Developers have the added incentive of wanting to avoid marketing flood prone property. Many communities visited by the Review Committee actively discourage floodplain development.

The NFIP, however, has its limitations. NFIP requirements are minimum standards applied throughout the nation in areas subject to very different flooding conditions. Requirements that are reasonable and prudent in some parts of the nation are not reasonable in others. As a result minimum standards tend to be just that. An example of a requirement that might be reasonable to apply in some areas of the country but not in others, is access to subdivisions and other new development at or near the elevation of the 100-year flood. While access to buildings may not be a critical issue in areas of the country subject to shallow or short-duration flooding, it is critical in the bottomlands of the Mississippi and Missouri rivers. A home elevated to above the flood elevation is of little use to a family if the house cannot be occupied for weeks at a time because it is cut off by floodwaters. Provisions of emergency services to these areas also can be a burden on a community. These issues are best addressed at the state or community level, not through a minimum federal regulation. Several states in the Midwest have more restrictive state floodplain management regulations that address a number of these issues.

NFIP requirements dictate how the structures are to be built to minimize property damage but not whether the location is appropriate given the flood risk and the overall objectives of the community. Because land use planning is traditionally a responsibility of state and local governments, the NFIP does not require that communities undertake these decisionmaking processes that are a necessary part of an effective floodplain management program. Decisions such as subdivision approval and providing capital improvements for roads and sewer, water, and other utilities are critical to the location of development. Such decisions largely determine the uses of the floodplain. Land-use controls, including techniques such as density controls, cluster development, performance zoning, dedication of floodplain lands, and maintenance of greenways and buffers, can result in development that avoids or minimizes impacts on the floodplain but ensures property owners and developers an adequate return on their investment.

The NFIP Community Rating System (CRS) provides discounts on flood insurance premiums in those communities that have floodplain management programs above and beyond NFIP minimum requirements. The CRS recognizes those communities that have developed floodplain management plans and in some instances encourages communities to undertake new floodplain management initiatives. These premium discounts, however, are not sufficient to encourage widespread participation in the Midwest. New initiatives are needed to encourage local floodplain management planning.

Addressing Issues Raised by States and Communities

One state expressed a concern to the Review Committee that NFIP requirements were not being enforced by some communities. Although most communities visited by the Review Committee had little new floodplain development since joining the NFIP, without a review of permit files, it is difficult to determine how well these communities were implementing floodplain management requirements that applied to buildings substantially damaged by the Midwest flood. FEMA regional staff have conducted systematic visits to NFIP communities impacted by the flood to monitor enforcement of local floodplain management ordinances. Preliminary results from these visits indicate that many communities are not enforcing their ordinances adequately, often because they do not understand the program requirements or the long-term benefits of reducing flood damages. This finding indicates the continuing need for federal or state agencies to provide technical assistance to communities and to monitor their compliance. The enactment and funding of the Floodplain Management Act called for in Action 5.1 of this report will enable states to provide significantly increased levels of technical assistance to communities. This assistance will improve implementation by communities of floodplain management programs and compliance with NFIP requirements.

States and communities have suggested that the FEMA amend its minimum floodplain management criteria to provide freeboard and a more restrictive floodway requirement. They also advocate discontinuing the practice of issuing Letters of Map Revision that remove from the floodplain those properties elevated on fill. Other issues of concern include access above the 100-year flood elevation to all subdivisions and other development in areas subject to deep flooding and appropriate require-

ments for agricultural buildings. The FEMA should review these issues in the context of its minimum criteria for floodplain management with consideration given to hydraulics and environmental effects.

Action 6.4: *Promote the NFIP Community Rating System as a means of encouraging communities to develop floodplain management and hazard mitigation plans and incorporate floodplain management concerns into their ongoing community planning and decision making.*

The NFIP Community Rating System (CRS) credits many of the more restrictive floodplain management requirements suggested by states and communities currently. The CRS provides discounts on flood insurance premiums in those communities that implement floodplain management programs exceeding the NFIP minimum.

The CRS should provide additional credits to encourage comprehensive planning at the community level to incorporate floodplain management into day-to-day decisions on capital improvements and land development.

Action 6.5: *Provide funding for the development of state and community floodplain management and hazard mitigation plans.*

The development and implementation of state and community floodplain management and hazard mitigation plans can reduce significantly federal expenditures of future disasters. Funding should be provided to encourage these planning initiatives. One source of this funding could be a mitigation fund established using NFIP premiums (such as that provided for in S. 1405 and H.R. 3191 both entitled the National Flood Insurance Reform Act of 1994). An additional source of funding could be a portion of the monies appropriated for the FEMA Disaster Fund or other appropriated funds.

Recommendation 6.2: *The FEMA should review its policy of issuing revisions to flood insurance maps which remove property from the floodplain based on fill.*

Under current NFIP policy, if floodplain areas are filled to above the 100-year flood elevation, the property be removed from the floodplain by revising the flood insurance map for the community. Within these areas, floodplain management measures and the mandatory flood insurance purchase requirement do not apply. This policy may encourage the filling of floodplains by developers to avoid community floodplain management requirements and to assist in marketing flood prone properties. It also may result in individuals making decisions to purchase a property without full knowledge of the residual risk of flooding, the advisability of obtaining flood insurance coverage, or access problems during floods. FEMA's review of this policy should include consideration of all program and engineering issues.

Identifying Those at Risk

State and local officials are concerned that some sparsely populated rural counties with occupied floodplains have not been mapped by FEMA. The agency did not map these areas because their low populations and minimal development did not warrant the expenditure or because base mapping was not available when the initial identification of flood prone communities was made in the mid-1970s. Funding constraints have limited the agency's subsequent ability to map these communities given the priority for communities with more concentrated development. Without floodplain maps federal sanctions do not encourage community participation. In the nine Midwest states, 209 counties have not been mapped, including 108 that were declared as disaster areas due to the 1993 floods.

Action 6.6: *Map all communities with flood hazard areas that are developed or could be developed.*

The FEMA should review flood prone communities that have never been mapped, and map those communities with flood hazard areas that are developed or have potential for development. NFIP communities then would have the information necessary to enforce floodplain management regulations and to ensure that individuals at risk purchase flood insurance. Mapping the floodplain will provide an incentive for non-participating communities to join the program because federal assistance for acquisition and construction of buildings is not available in designated flood hazard areas unless a community is participating in the NFIP.

Improving Accuracy and Timeliness in NFIP Mapping

The nation must have an adequate floodplain mapping program to achieve its floodplain management goals. At the core of any floodplain management program is knowledge of the risk-floodplain boundary and flood elevations.

The flood risk information on the NFI Flood Insurance Rate Map (FIRM) forms the technical basis for administering federal flood insurance and is utilized nationwide. Since creation of the NFIP 25 years ago, it has identified approximately 22,000 communities as flood prone. Nearly 21,000 of these have been mapped, and over 18,300 are participating in the NFIP.[7]

States and communities indicated to the Review Committee that for some areas, NFIP maps are out of date, inaccurate, take too long to get revised, or may not exist. Others encountered difficulty in obtaining copies of the maps. The program for maintaining and distributing maps if funded entirely by flood insurance policyholders through a $25 surcharge on each policy. The annual mapping budget is $35 million.[8] This surcharge covers administrative costs as well. This funding allows the FEMA to initiate about 250 studies per year and to respond to requests to update maps based on local or state date.[9] A small portion of the budget goes to the digital conversion of the maps. About $4 million annually covers the printing and distribution of the maps.[10]

The FEMA is striving to automate the mapping process as much as possible under current funding constraints. Beginning in FY 1995, all engineering studies contracted by the FEMA will be submitted in digital format. A tool for automated review of engineering models has been developed. The mapping program recognizes the benefits derived from using digital technology but has not implemented it through to the final phase of the map production process. Because a large inventory of old, traditionally mapped FIRMs do not meet national map accuracy standards, the addition of horizontal control to the FIRM has become part of the digital conversion process. The current level of production is slightly over 2,000 digital map panels per year.[11] With current funding and procedures, it would take 40 years to complete the digital conversion of 80,000 map panels nationwide. The FEMA is drafting a plan for flood studies maintenance that would inventory and prioritize nationwide floodplain mapping needs every five years.

Action 6.7: *To improve and accelerate delivery of NFIP map products, the Administration should propose supplementing those funds obtained for floodplain mapping from NFIP policyholders with appropriated funds.*

Current NFIP funding derived from the $25 federal policy charge is not adequate for maintaining and updating floodplain management maps. Raising this surcharge may undermine efforts to market flood insurance and would not be equitable since policyholders are only one user of these maps. Since the maps are critical for floodplain and emergency management, Congress should supplement policyholder dollars with appropriated funds. Flood insurance claims payments for the 1993 Midwest flood totaled $297 million,[12] a small percentage of the federal payments for this disaster. The federal government has an interest in maintaining and updating the NFIP'S $1 billion investment in floodplain mapping to ensure that all levels of government and individuals have the information necessary to manage their floodplains and reduce future damages.[13]

USERS AND USES OF NFIP MAPS

WHO	WHY
Communities participating in the NFIP	Enforce floodplain management ordinances
State and local floodplain managers	Enforce regulations and land use decisionmaking
State and local emergency managers	Response and recovery planning
Federal Agencies	Compliance with EO 11988
Federal Insurance Administration	Establish insurance rates
Insurance companies and agents	Rate flood insurance policies
Lenders	Comply with mandatory purchase requirements
Designers of floodplain development	Determine design requirements
Disaster response agencies	Coordinate disaster response and recovery
Real estate brokers and agents	Disclosure of the flood risk

Action 6.8: *Utilize technology to improve floodplain mapping.*

The FEMA should investigate alternative methods of expediting the conversion of FIRMs to digital format. Digital conversion will result in a long-term cost savings because of reduced ongoing map maintenance requirements. The digital format will enable the efficient accommodation of large as well as small changes and will result in more accurate maps. Digital floodplain boundary information combined with land parcel records from a community or street address range data, such as are available from the U.S. Bureau of the Census TIGER files, will facilitate applications under floodplain and emergency management. The simplest and most common use is to look up the flood risk data for a specific address. Some areas in which the FEMA would realize savings and increase efficiency are in processing certain revisions, verifying insurance ratings, analyzing repetitive loss data, assuring local compliance, and marketing. Digital FIRMs will also facilitate the completion of a national inventory of floodprone structures, which is recommended in Action 11.2 of this report.

INCREASING EDUCATION AND OUTREACH EFFORTS

If individuals and communities are going to participate in pre-disaster, response, recovery, and mitigation efforts, then awareness of natural hazards should be the first step in pre-disaster planning. This is especially true for flood hazards since individuals have to make decisions that affect their vulnerability. To increase awareness, the

federal government should pursue education and outreach activities.

Because the general populace may not have a complete understanding of natural physical processes, such as the hydrologic cycle and river hydraulics, and of geomorphology, they poorly grasp their vulnerability to flooding and the economic, environmental, and social benefits of alternative strategies to avoid or reduce risk. Unawareness of flood vulnerability results in the inappropriate development of floodprone areas. Another result is that only a portion of the public responds appropriately to flood warnings, and this lack of response can have grave results.[14]

Floodplain information is not distributed widely beyond floodplain regulators, federal and state agencies, and the insurance and lending industries. Many individuals may not even be aware that flood and other hazard information exists for their community. Success stories of local efforts in the area of zoning, pre-disaster planning, biotechnical engineering, and collaborative programs should be distributed and shared with all levels of government in an effort to achieve widespread application of successful floodplain management strategies and tools.

Recommendation 6.3: *Federal agencies involved in floodplain management should include information regarding floodplain management and pat and probable future flood heights and extents in their education and public affairs initiatives.*

Floodplain information should be available to the general public in formats that the average person can understand and use. All agencies involved in floodplain management should continue efforts to inform and educate the public about the nature of flood hazards, the natural resources and functions of floodplains, and the various strategies and tools available for comprehensive floodplain management.[15] Agencies should adhere to guidance given in EO11988 (or in a revised EO on floodplain management) regarding the conspicuous delineation of past and probable flood heights on property used by the general public.

Recommendation 6.4: *State floodplain management officials should encourage local school districts to include natural hazard education in their curricula.*

Education regarding the existence of natural hazards, such as floods, should be introduced into the elementary and secondary education curricula to provide an early awareness and understanding of how and why floods occur. Information should include what to do in the event of a natural hazard emergency. If educated from an early age, adults will be better able to participate in pre-disaster, response, recovery, and mitigation efforts.

ENDNOTES

1. Water Resources Development Act of 1974, PL 93-251, Section 22.

2. Harper, Warren, Water Resources Program Manager, Watershed and Air Management Division, U.S. Forest Service, Department of Agriculture, Washington, DC, personal communication, May 1994.

3. U.S. Environmental Protection Agency, *Draft Watershed Protection Framework document,* (Washington, DC: EPA, August 29, 1991).

4. Introduced during the 103rd Congress (1993).

5. H.R. 3873, introduced on February 22, 1994.

6. Young, C. Edwin, and C. Tim Osborne, *The Conservation Reserve Program: an Economic Assessment,* Agricultural, Agricultural Economic Report No. 626, (Washington, DC: USDA Economic Research Service, February 1990).

7. Federal Emergency Management Agency, reports form the National Flood Insurance Program Community Information System, (Washington, DC: FEMA, December 1993).

8. Federal Emergency Management Agency, Mitigation Directorate, *The Flood Studies and Mapping Activities in Support of the National Flood Insurance Program, A Report to the U.S. Congress,* (Washington, DC: FEMA, February 1994).

9. Croxdale, Cynthia, Federal Emergency Management Agency, Mitigation Directorate, Washington, DC, personal communication, April 15, 1994.

10. Federal Emergency Management Agency, "Flood Risk Directories: Applications for the NFIP," (Washington, DC: FEMA, June 30, 1991).

11. Cotter, Daniel M., Federal Emergency Management Agency, Mitigation Directorate, Washington, DC, personal communication, April 28, 1994.

12. Federal Emergency Management Agency, Federal Insurance Administration, Washington, DC, computer print-out, March 16, 1994.

13. Federal Emergency Management Agency, Federal Insurance Administration, *A Cost Effective Plan for Flood Studies Maintenance*, (Washington, DC: FEMA, February 1989).

14. Federal Interagency Floodplain Management Task Force, *Floodplain Management in the United States: an Assessment Report*, (Washington, DC: FIFMTF, 1992).

15. Natural Hazards Research and Applications Center, *Action Agenda for Managing the Nations' Floodplain*, Special Publication 25, (Boulder, CO: NHRAC, 1992).



Chapter 7

FOCUSING ON ENVIRONMENTAL ENHANCEMENT

Even before the Great Flood of '93, we had started to realize that some of the areas within our levees should have never been cleared for farming. The events of the last year have driven this point home. Many farmers with marginal and sub marginal land are tired of fighting the river and want to find a way to get out from under their financial burdens.

Letter from Union County Board of Commissioners
to U.S. Senator Paul Simon (D-IL), April 1994.

During the 1993 flood, environmental easement and land acquisition programs became tools in assisting recovery and in removing people from long-term flood vulnerability. In addition to meeting the needs of disaster relief victims, these programs can be effective in achieving the nation's environmental goals. Environmental enhancement and mitigation programs essential to ecosystem management are often part of federal development projects. In the past, though, such programs have been delayed, under funded, or not funded at all. Had they been implemented before the 1993 flood, these programs would have restored natural lands and provided a measure of flood protection through reduced runoff and increased floodwater storage. Environmental mitigation programs also have tended to be site-specific rather than focusing on broader ecosystem goals. This chapter recommends ways to use federal environmental programs in ecosystem management to meet the needs of human development and the environment.

ESTABLISHING A LEAD AGENCY FOR LAND ACQUISTIONS

Following a disaster like the 1993 flood, landowners can benefit from a number of federal assistance programs, such as fee title or land easement acquisitions. During the early post-flood response period, land acquisition did not emerge as a viable risk-reduction option for a number of reasons: limited funds, lack of a participatory mechanism for mixing funds from different agencies, and lack of a focal point within the government for such action. Part of the problem is that no single federal agency has authority to coordinate existing land buyout or easement programs for environmentally related acquisitions, such as the USDA Wetland Reserve Program, Emergency Wetland Reserve Program, and FS forest acquisition program; the USACE Missouri River Mitigation Project; and the FWS National Wildlife Refuge acquisition program.

Federal acquisitions and easement programs share capabilities to restore habitats for native fish and

FEDERAL AGENCIES COMPETING FOR THE SAME LAND

Stan Hinnah's farm on e Missouri River near Glasgow, Missouri, was devastated by the 1993 flood. His farm lies in one of the river's high energy zones on the site of an old channel bed. When Mr. Hinnah's levee broke, a surge of water scoured out unconsolidated sands from the old channel and deposited them across the remainder of his fields. Mr. Hinnah owns other lands in the nearby uplands and would like to sell his Missouri River bottomlland and get on with his farm operations at another location "out of harm's way," as he put it. When Review Committee members spoke with him, he was frustrated because even though several federal and state acquisition programs were available, none were clearly defined, and none were able to get funding approved and released to complete the sale. Mr. Hinnah was confused by the number of governmental units involved in buyouts, and he was hesitant to make a deal with any one of them and miss a better deal.

wildlife species of special federal interest. Such programs can address the needs of landowners who may wish to discontinue row cropping or who may simply wish to sell fee title interest altogether. One way to overcome problems associated with these programs is to involve non-governmental organizations (NGOs) that can contribute financially to the federal buyout process and act as a catalyst between landowners and government agencies.

During visits with government agencies and landowners, the Review Committee found an interest in establishing on federal agency as the lead for environmental land acquisitions.

Action 7.1: *The Administration should establish a lead agency for coordinating acquisition of title and easements to lands acquired for environmental purposes.*

Several federal agencies have land acquisition authority, but lack of coordination between them creates confusion and provides opportunities for landowners to shop around, promoting potential bidding wars between interested agencies. Taken together, government land acquisition-easement programs provide an opportunity to address both landowner and ecosystem needs. Several programs already exist to address these needs, but coordination among the primary agencies -- DOI, USDE, and USACE -- would improve efficiency. Because the mission of the FWS within the DOI "...is to conserve, protect and enhance the Nation's fish, wildlife and habitat for the continuing benefit of the American people...", the Review Committee suggests that the DOI coordinate federal acquisitions of environmental lands. this role does not imply ultimate exclusive ownership or management by the DOI but provides for leadership in identifying the capabilities and interests of other federal agencies, states, tribes, and local resource managers, as well as individual landowners.

The recommended cooperative land acquisition-easement program would develop Memoranda of Agreement (MOA) between the DOI, USDA, USACE and other agencies. Federal land acquisition agencies would establish rules for acquisitions and easements based on program authority. Transfer of acquisition funds to the DOI would be made, as appropriate, under Cooperative Agreements (CAs). When such CAs have been completed, agencies would provide

PRIVATE INVOLVEMENT IN PUBLIC BUYOUTS

NGOs, such as the Iowa Natural Heritage Foundation and the Conservation Fund, played significant roles in acquisition of the Louisa No. 8 Levee District on the Iowa River near its confluence with the Mississippi River. Louisa No. 8 had a history of repair from past floods, and, although it was eligible for repair under the USACE PL 84-99 program, affected landowners expressed an interest in alternatives to continued farming. Administrative and authority limits in the land acquisition programs of federal Disaster Field Office participants prevented federal agencies from pooling funds to initiate land acquisition. By utilizing their funds, the Iowa Natural Heritage Foundation and the Conservation Fund were able to step in and purchase the land, holding it until federal funds were released to finish the buyout. This allowed landowners to get on with their lives.

oversight and would assist the DOI with landowner contacts to assure that all federal mandates are met. The DOI would not be involved in non-environmental land acquisitions, such as the purchase of construction sites or FEMA sturture-buyouts that offer no special potential for environmental enhancement.

The nation needs a coordinated program to maximize federal use of funding for programs such as the FWS refuge acquisition program, the USACE Missouri River Mitigation Project and the USDA Wetland Reserve Program. Coordinated leadership would help ensure that federal environmental land acquisition programs focus on ecosystem management to meet the needs of interjurisdictional, native, and threatened and endangered species. it would help guard against acquisitions or easement involving disconnected or disaggregated lands that are checkerboard in appearance and difficult to manage.

Federal land acquisitions would be coordinated with existing state and local programs to avoid conflicts, as well as complement and further their environmental activities. In addition, the DOI would not necessarily maintain fee title and operation and maintenance responsibility for acquired lands. When appropriate, a cooperating agency or state would assume ownership and operation-maintenance responsibility, although the DOI would maintain those lands critical to federally listed threatened and endangered species.

PROTECTING THE TAX BASE OF LOCAL GOVERNMENTS

During discussions with individuals and local governments regarding federal land acquisitions, the Review Committee learned that lost tax revenues from acquired lands are an issue. For acquisitions involving the DOI, Congress designed the Refuge Revenue Sharing Act (RRSA)_ to reduce the financial hardship lost tax revenues by providing government payments in lieu of taxes. Inadequate funding of the RRSA program, however, has limited the attractiveness of federal land acquisition in various areas of the country.

Recommendation 7.1: ***The Administration should support increased funding for the Refuge Revenue Sharing Act.***

Increased funding of the RRSA, in conjunction with review and revision of implementing regulations, would assist in equitable distribution of funds among different regions of the country and would address of concerns of local governments regarding tax base impacts that negatively affect schools and infrastructure.

ALLOWING AGENCIES PROCEDURAL FLEXIBILITY IN DISASTERS

In examining the federal flood response, the Review Committee learned of difficulties encountered by agencies in their efforts to enhance natural resources while considering landowner needs. Uncertainty among landowners about the ability of federal agencies to execute timely real estate actions limited their interest in full or partial land sale or easement acquisition. Statutory feature of easement-acquisition authorities for federal agencies prevent spending without first completing full procedural cycles. In a disaster response situation, procedural flexibility would be advantageous for federal agencies and economically distressed landowners.

Action 7.2: ***The Administration should develop emergency implementation procedures to organize federal agencies for environmental land acquisitions.***

The waiver of certain procedural components of land acquisition programs that require extended intra- and interagency review and comment would improve response to economic hardships during immediate post-disaster periods. The Administration should direct the DOI, in cooperation with other federal land acquisition agencies, to develop an interagency, programmatic environmental land acquisition plan that could be implemented during emergency situations.

All agencies with jurisdiction or special expertise in land acquisition should participate in the DOI interagency plan. Agencies will have program-specific interests in a planning area, but, within the context of a programmatic document, they can integrate their interests to articulate the range of federal, tribal, state, and local options. Following disasters, the federal government could use available funds to immediately acquire lands with pre-identified environmental values and hazard plans. This approach, similar to one used by the FWS for acquiring available parcels within pre-identified Waterfowl Production Areas, would involve a larger group of agencies.

Recovery Operations

The 1993 flood caused major infrastructure damage throughout the upper Mississippi River basin. An August 1993 interagency letter of cooperation' signaled the Administration's awareness that disaster response must provide innovative actions using various federal programs, such as the USDA Emergency Wetland Reserve Program, Section 1135 of the Water Resources Development Act (WRDA) of 1986, and public-private partnerships. The acquisition of the Louisa No. 8 Drainage District exemplifies this partnership. Although the lack of experience and institutionalization of buyouts limited actions similar to the Louisa No. 8 buyout, this situation could be improved if the ad hoc relationship established by the aforementioned letter were formalized.

Action 7.3: ***The DOI should formalize environmental considerations in multi-agency disaster recovery land restoration activity through a coordinated Memorandum of Agreement.***

The Administration should direct the DOI to use the Louisa No. 8 project as an example to develop a MOA

between agencies for post-disaster recovery. Formalization of working relationships would expedite recovery efforts by providing coordination points and a central clearinghouse for information on buyout options, sources of funds, and a list of potential cooperators.

Emergency Funding

PL 84-99 provides the USACE with flexibility to quickly reprogram funds from agency accounts to fund Presidentially declared flood disaster response efforts. This enables the USACE to use appropriated funds to address emergencies and disaster response in a timely manner.

Action 7.4: *Seek legislative authority for flexibility in use of programmed funds in emergency situations.*

The Congress should provide legislative authority and flexibility, similar to that provided the USACE by PL 84-99, to other agencies and programs. Such flexibility would expedite landowner relief and enhance the federal ability to capitalize on environmental enhancement opportunities. Funds used could be reimbursed, if necessary, from supplemental appropriations, when they became available and, as appropriate, by reprogramming funds from other sources within agency. As an example, following the 1993 flood, the FWS was unable to access several million dollars of appropriated Land & Water Conservation (LAWCON) funds. If the FWS had been able to access those funds, which were earmarked for other uses, the agency could have offered landowners an immediate alternative to realigning and repairing levees. The opportunity to restore wildlife habitats was missed. The LAWCON account could have been reimbursed subsequently either by special appropriation or transfer from other accounts.

ACQUIRING AND RESTORING LAND ON PROBLEM RIVER REACHES

Federal agencies are focusing on ecosystem management in recognition of the functional relationships between living resources and physical features of the landscape. This is evidenced by the March 1994 concept document *Ecosystem Approach to Fish and Wildlife Conservation* circulated by the FWS; the April 1993 *Ecosystem Management Principles and Applications* document prepared by the FS for the Eastside Forest Ecosystem Health Assessment, and the *Reinventing Environmental Management* document prepared by the National Performance Review (NPR) in September 1993. These documents call for interagency coordination and a resultant collaborative approach to managing the health of whole ecosystems, such as the upper Mississippi River Basin.

Ecosystem management is in its infancy, and federal agencies have just begun ecosystem planning and related programs. Explicit funding for ecosystem management remains minimal and plan development incomplete. In the absence of plans and funding, the DOI, as the recommended lead agency for environmental land acquisitions and easements, should focus federal acquisitions and easements on problem river reaches with known habitat values and threatened and endangered species.

Action 7.5: *The DOI should focus land acquisition efforts on river reaches and areas with significant habitat values or resource impacts.*

The Administration should provide funding for and the DOI should develop and implement cooperative ecosystem management plans with the states and other agencies. The NBS currently operates a major GIS system for the upper Mississippi River main stem and is in the process of developing GIS capability for the Missouri River main stem. The Congress should appropriate funds to expand these facilities to survey the natural resources of the entire upper Mississippi River Basin. The NBS should work in collaboration with the states, NGOs, and other agencies to identify critical habitats, significantly impacted ecosystems, and opportunities for ecosystem management. Participating states and agencies should evaluate site-specific, collaborative management plans developed as part of their own operations for use in ecosystem management.

The Accompanying Report on the DOI by the NPR[2] identified several factors that prevent the agency from making long-term decisions that provide for wise ecosystem planning and management. In response, the NPR indicated that the DOI should be able to acquire lands using a comprehensive approach and that it should have a set amount of discretionary funds so that the Secretaries of the Interior and Agriculture can take advantage of unforeseen opportunities or urgent acquisition developments. The NPR Action for this issue stated: "the Secretaries of the Interior and Agriculture and the Director of OMB should modify the process for determining land acquisition priorities and modify current procedures." The Review Committee endorses this action as a key component in providing better focus for such acquisitions.

USING O&M FUNDS TO MANAGE ECOSYSTEMS

Construction of various federal navigation and flood control projects have impacted federal trust resources in many rivers of the upper Mississippi River Basin.[3] Operation and maintenance of some of these projects continue to impact fish and wildlife resources and, in some cases, may accelerate those losses. In the 1970s and 1980s, concerns related to these impacts on the upper Mississippi River resulted in formation of cooperative interagency management efforts, such as the Great River Study,[4] Upper Mississippi River Master Plan,[5] and Upper Mississippi River Environmental Management Program.[6] These programs, which address both development and natural resource needs, have resolved many interagency conflicts and problems.

Across the upper Mississippi River Basin, though, federal agencies need to develop and implement ecosystem management plans. Especially on the Missouri River, such plans would help ensure protection of fragile ecosystems and address the needs of plant and animal species that are of interjurisdictional federal interest. Presently a funding mechanism to develop and implement ecosystem management plans does not exist.

As a matter of practice, agencies responsible for operating and maintaining major development projects should procure funding for representation and participation of other federal agencies in their major study and implementation efforts. The USACE-FWS Memorandum of Agreement for fund transfers related to Fish and Wildlife Coordination Act compliance makes such participation possible during the planning process, but no authority exists to transfer funds for support of post-construction ecosystem planning. Similarly no funding mechanisms exist for state or local participation in either the planning or post-construction phases of federal water resources development.

Action 7.6: *Require agencies to co-fund ecosystem management using Operation and Maintenance funds.*

Ecosystem management planning would document natural resource needs and identify actions that federal agencies can take to offset development impacts and enhance ecosystem sustainability. Funding for development and implementation of ecosystem management plans should be an annual standard component of each federal agency's operation/maintenance/construction budgets along with annual funding for development projects, which often impact the ecosystem. Funds should provide for participation of outside agencies and the states. Once costs of minimizing environmental impacts become a standard part of project costs, they can be reflected more closely in federal benefit-cost ratios.

EXPANDING FEDERAL, STATE, AND NGO COST-SHARING

Many levee and drainage districts contain remnant natural features, such as oxbow lakes and sloughs, that were hydraulically disconnected from the main stem river either by natural processes or by levee construction. Structural modifications to these levees would allow periodic, controlled flows between the river and former oxbows or channels. By providing these connections, off-channel habitat could be available during spawning periods. Such area could contribute to the river fishery and increase seasonal wetland values.

During the PL 84-99 review process, resource agencies and landowners sought to use levee modifications to reconnect some oxbows and sloughs to the river, but they were unable to do so because Congress authorized PL 84-99 only for emergency structural repair and not for modification to serviceable projects. New construction for other purposes was simply not possible. On the other hand, the USACE environmental enhancement authority provided by Section 1135 of the 1986 WRDA includes new construction as an option. Additionally, Section 906 of the 1986 WRDA provides general authority to undertake mitigation measures for projects, whether completed, underway or unstarted, including acquisition of any needed related lands. Section 906 provides for mitigation cost-sharing consistent with other project purposes. The review Committee found that potential activities authorized by Section 906 have not been pursued.

It was brought to the Review Committee's attention that current reporting and approval processes require multi-level review of Section 1135 projects within USACE. This may discourage pursuit of small scope projects. it is anticipated that many small projects could be pursued at lower administrative costs with abbreviated report requirements and decentralized approval authority. In discussions of the Section 1135 option with several landowners and drainage district representatives, the USACE found that many did not accept it because of the cost-share burden added under PL 84-99. The USACE could not overcome the cost-sharing problem because other federal agencies, such as the FWS, are not able to participate as cost-share sponsors.

Action 7.7: *Enact legislation allowing cost-share participation and eligibility requirements under Sections 906 and 1135 of the 1986 WRDA to include federal, state, and non-governmental contributions as well as work in-kind.*

By expanding the array of possible cost-share sponsors and by providing for cost-sharing consistency in Section 906, more enhancement opportunities can be leveraged by cooperating federal, state, and non-governmental organizations. Permitting work in-kind to qualify as local sponsor cost-share contributions would expand the availability of Section 1135 for environmental restoration activities.

MOVING MITIGATION AT THE SAME RATE AS DEVELOPMENT

Development projects often require agreement to purchase mitigation lands before project construction plans receive approval. Although authority exists for mitigation measures and acquisition of mitigation lands and although agency policy encourages concurrent mitigation, funding of mitigation land acquisition has not proceeded on the same schedule as construction funding. In some cases this lack of funding has led to unmet mitigation over periods of years.

Action 7.8: *Allocate funds for mitigation lands in concert with and at the same pace as project construction.*

The Administration through OMB must assure anequitable funding stream where mitigation is required as part of authorized projects.

ENDNOTES

1. Joint White House/OMB guidance on procedures for evaluation and review of repair and restoration projects for levees, August 23, 1993.

2. National performance Review, *Department of the Interior Accompanying Report of the National Performance Review,* U.S. Government Printing Office, Superintendent of Documents, (Washington, DC; September 1993).

3. Bellrose, F. C., F. L. Paveglia, Jr., and D. W. Steffeck. "Waterfowl populations and the changing environment of the Illinois River Valley", *Illinois Natural History Survey Bulletin,* 32: 1-54. (1979); Fremling, C.R., et al., "Mississippi River fisheries: a case history" pages 309-351, and Hesse, L.W., et al., "Missouri River fishery resources in relation to past, present, and future stresses" pages 352-371 in Dodge, D.P.(ed.) *Proceedings of the International Large River Symposium.* Ontario, Canada. Can. Spec. Publ. Fish. Aquat. Sci. 106. (1989(; Shaw, S. P., and C. D. Fredine. *Wetlands of the United States,* Circular 39, Washington , D.C.: FWS (1971); Sparks, R.E., "The Illinois River-floodplain ecosystem," pages 412-432 in National Research Council, *Restoration of aquatic ecosystems,* (Washington , DC: National Academy Press 1992).

4. Great River Environmental Action Team I (GREAT I). *A Study of the Upper Mississippi River.* 9 vols, (St. Paul, MN: USACE, St. Paul Dist., 1980); GREAT II, *Great II Main Report and Appendices,* Rock Island, IL: USACE, Rock Island Dist., 1980); GREAT III. *Great River Resource Management Study,* St. Louis, MO USACE, St. Louis Dist., 1982).

5. Upper Mississippi River Basin Commission, *Comprehensive Master Plan for the Management of the Upper Mississippi River System,* (Bloomington, MN: UMRBC, 1982).

6. U.S. Army Corps of Engineers, *Fifth Annual Addendum -- Upper Mississippi River System, Environmental Management Program,* (Chicago, IL: USACE North Central Division, 1990).

Chapter 8

MINIMIZING THE VULNERABILITY OF EXISTING DEVELOPMENT

Floods are an act of God; flood damages result from acts of men.

House Document 465, 89th Congress, 2d Session
A Unified National Program for Managing Flood Losses, August 1966

Development will continue to occur in the nation's floodplains. Two fundamental strategies -- protection or removal -- can minimize the vulnerability to floods in these lowlands. Each strategy is appropriate in different circumstances. The nation should discourage new development in floodplains. For areas with existing concentrated development, such as cities where removal is impracticable, combine structural and nonstructural measures to protect existing development.

In the past structural measures were the primary approach to flood damage reduction. Throughout history, well-designed and well-sited structural measures have demonstrated their effectiveness in protecting property and saving lives. The traditional structural strategies to modify flooding have relied on the following tools: dams and reservoirs; urban stormwater management systems; dikes, levees, and floodwalls; channel alternations; and diversions, spillways, and floodways.

Each of these measures carry environmental and social impacts that may limit their future applicability. While they work well, they also create problems. Structural approaches, particularly those taken prior to implementation of federal environmental protection statutes, have caused or contributed to environmental degradation. The 1993 flood demonstrated not only the strengths of structural approaches but also their weaknesses, particularly those of levees.

Another approach to minimizing vulnerability, not widely used in the past, is the removal of vulnerable populations from the floodplain. Because of the severity and duration of the 1993 flood, the general public has taken a new interest in this strategy. Building on its experience with the NFIP, the FEMA capitalized on this interest in removals. The Administration responded by targeting federal recovery programs that support buyouts and relocation of floodplain populations. The fundamental value of buyouts over structural approaches is that they completely eliminate flood risk for affected individuals and, at the same time, may have environmental and hydrologic benefits. Relocation associated with buyouts can, however, involve social, environmental, or hydrological impacts. For federal relocations, compliance with the NEPA would identify and help to avoid such impacts. Careful planning by state and local agencies should also identify these issues.

ADOPTING A SYSTEMS APPROACH

The first step in minimizing flood vulnerability is to approach the problem from a systems perspective. Determining the array of potential solutions requires an understanding of the source of the vulnerability and the current risk that flooding poses. Is the risk one of debris-laden flows from highly erodible canyons? Is it increased runoff? Is it changed river hydrology? Is it flash floods or slowly rising waters? The best solution to a localized flooding problem may be watershed management rather than channelization. The flooding river cannot be analyzed separately from its watershed and ecosystems. The initial focus ought not be exclusively on structural

flood damage-reduction projects. The situation calls for a system-wide approach that accounts for basin hydrology, hydraulics, and ecosystem concerns. Such an approach will identify the nature of the flooding problem and help in the selection of the most appropriate combination of flood damage reduction measures. A systems approach allows planners to address flood vulnerability and identify the best means for minimizing flood impacts, when they do occur. The systems approach brings to the forefront the ecosystem effects of flood damage-reduction projects, and it allows for avoiding, minimizing, and compensating for adverse effects and capitalizing on environmental opportunities.

The next step in changing the historic approach to flood damage reduction is to equally consider structural and non-structural approaches. Objective consideration of the various flood damage reduction options looks at their short- and long-term engineering and their environmental, social, and economic feasibility. Such a consideration is vital to achieving a new pattern of flood vulnerability reduction. The revisions proposed by the Review Committee for the *Principles and Guidelines* would facilitate this type of consideration. If structural alternatives provide the only means to address a local flooding problem, they need to be considered within the context of the larger systems of the river and its watershed. The direct and incremental impact of each structure on river hydrology, hydraulics, and ecology needs evaluation and balancing. By understanding the system and designing and constructing in response to that system, more efficient opportunities to reduce the vulnerability of flood impacts can be found.

Existing and future damage reduction strategies must consider the impact on upland and riparian areas of the ecosystem. The design, operation, and repair of flood damage reduction systems can lessen these impacts and may, in some circumstances, enhance the environment. Chapter 7 focused on flood damage reduction measures that also protect and improve wildlife habitat.

Recommendation 8.1: ***Federal agencies should capitalize on opportunities, within existing authorities and resources, to enhance the environment when reviewing operations or undertaking repairs or improvements to existing flood damage reduction programs.***

IMPROVING STRUCTURAL MEASURES

Levees will continue to serve as a means of minimizing flood vulnerability. Of the approximately 8,000 miles of levees in the upper Mississippi River Basin, roughly half were constructed by the federal government or meet federal standards and thus receive support from the federal government in post-disaster situations. Some new levees may be built to protect critical infrastructure, but the remainder of these structural flood damage reduction facilities with their numerous strengths may also have room for improvements.

Constructing and Repairing Levees

Five different federal agencies are engaged in the repair of federal and non-federal levees damaged by the 1993 flood. These agencies are involved in funding, design, construction, or a combination of the three. The water resources design and construction agencies, the USACE and SCS, have been joined in the levee repair and construction business by the FEMA, EDA and HUD, through their public assistance and grant programs. Normally only the USACE and SCS construct levees as part of projects authorized by Congress, although in recent years, SCS levee construction has significantly declined.

These agencies have not used the same engineering standards or methods of economic analysis in carrying out their programs. Some of the differences rest with the purpose of the programs and the varying nature of the levees. Nevertheless these differences cause confusion among those dealing with the multiple programs. The nation cannot afford to have this duplication of effort in

the federal system. The costs to the nation of this multi-agency approach, measured in dollars or social and environmental impacts, remain large.

Action 8.1: *Establish the USACE as the principal federal levee construction agency.*

This action is not a call for new levee construction, but a recognition that when repairs or construction are authorized, the USACE would be the principal agency for the work on major rivers and tributaries. The USACE, with its long history of levee building and repair, has the in-house expertise to serve as the federal government's principal representative pertaining to major levee construction and repair. The SCS has the history and expertise for assistance pertaining to small agricultural levees in small watersheds and assistance to individual landowners. To coordinate their different responsibilities and engineering and evaluation guidelines, the USACE and the SCS should review and modify, as appropriate, the existing 1986 Memorandum of Agreement (MOA). When complete this MOA should be provided to all states and appropriate levee districts. Other government agencies wishing to pursue levee construction must arrange planning, design, and construction through the USACE which will follow the revised *P&G* procedures. For small agricultural projects, the USACE would coordinate the action with the SCS.

While multiple federal agencies currently participate in levee construction and repair, this report recommends in Action 8.1 that USACE be established as the principal federal levee construction agency. If this recommendation is implemented, cost-sharing inconsistencies between different federal agencies currently involved in levee construction would be resolved. If the recommendation is not implemented, cost-sharing inconsistencies exist that should be rectified to eliminate shopping by non-federal sponsors for the best federal deal. Regardless of the decision made on levees, inconsistencies between federal agencies for similar types of activities also exist for other federal water resources projects. One example is under the SCS PL 83-566 program, in which non-federal sponsors provide the lands necessary for project construction, but 100 percent of the cost for flood damage reduction is provided by the federal government. Non-federal sponsors of flood damage reduction projects constructed by the USACE are required to pay a minimum of 25 percent of the total project cost and a maximum of 50 percent. A minimum cash contribution of 5 percent of the total project cost is required as a part of this cost-share. In addition, the USACE requires a 50 percent cost-sharing for feasibility studies while the SCS feasibility studies are at 100 percent federal cost. The SCS multi-purpose projects involve non-federal cost-sharing but SCS allows credit for in-kind services in meeting that requirement. The USACE allows credit for in-kind services only for meeting a portion of study cost-sharing requirements. The SCS multi-purpose projects involve non-federal cost-sharing but SCS allows credit for in-kind services in meeting that requirement. The USACE allows credit for in-kind services only for meeting study cost-sharing requirements.

Another example is in relation to the levee rehabilitation program. The SCS Emergency Watershed Protection Program requires a non-federal cost-share of 25 percent of the cost of the project which excludes inspections and design. Under the USACE PL 84-99 program, there is no cost-sharing for federally built levees. However, the non-federal cost-share for qualified non-federally constructed levees is 20 percent of the cost of the project to include inspections and design. The FEMA and the EDA also are players in levee repair with non-federal shares of 25 percent for the FEMA repairs (although this was modified to 10 percent for the 1993 flood) and 20 to 25 percent for the EDA repairs. Other examples of inconsistencies also exist but are not elaborated on in this document.

Recommendation 8.2: *The Administration should propose legislation that establishes consistent cost-sharing across agencies for non-federal participation in like activities.*

Affected federal agencies should coordinate with each other to identify all differences in cost-sharing and in-kind services and provide documentation of inconsistencies to the Administration. For those flood damage reduction activities where multiple federal agencies will still be participating, consistent cost-sharing is recommended. In addition, consistent approaches should be taken regarding

non-federal credit for in-kind services in meeting the cost-sharing requirement.

Performing Emergency Repairs

The federal review of levees impacted by the Midwest Flood of 1993 provided valuable lessons in applying the USACE emergency flood-control repair program under PL 84-99. Approximately 1,600 levees (1,400 of them non-federal) were damaged to the point of requiring some form of rehabilitation or repair.[1] Less than 500 of these levees are under the USACE program, and of these, only 229 were federally constructed. Many levees which had been under the USACE program in the past were not under it at the time of the flood for various reasons, such as responsible parties failure to operate and maintain the levee properly, individual decisions not to participate, lack of a public sponsor, or inability to meet required engineering criteria. In the past, benefit-cost analyses have not included consideration of previous levee failures and the potential for future failures.

Given the seriousness of this situation and the fact that less than 15 percent of the non-federal levees that were damaged qualified for repair consideration under the USACE program, the Administration and Congress provided supplemental funding for levee repair. Even with the waiver of the USACE requirements, the Administration and Congress stipulated that levee districts or sponsors would have to meet the following requirements to receive federal funding: agree to join the USACE program and, within two years, provide public sponsorship, ensure levee maintenance, and meet engineering, environmental and other eligibility requirements of the program.

The USACE program should continue in the future. The Review Committee reviewed the eligibility requirements of the program and found them to be reasonable. Even though the 1993 flood was not a typical flood, this is no reason to deviate from the established and sound principles of the levee program. Waivers of these requirements may send the wrong message to levee sponsors. It is in the interest of the nation to provide incentives to ensure the integrity of public levees. This can best be accomplished by the participation of levee sponsors in the USACE program. It must be clear that the federal government will provide repair assistance in the future only to levees enrolled in the program and that the risks associated with non-participation are simply too great to take.

Action 8.2: *The Administration should reaffirm its support for the USACE criteria under the PL 84-99 levee repair program and send a clear message that future exceptions will not be made.*

In addition to the specific requirements of the USACE program, the USACE should ensure that levees are properly located and aligned to reduce the probability of repetitive losses and do not adversely impact river hydraulics and other properties. Benefit-cost analyses should be expanded to include consideration of environmental and social benefits and costs, in addition to the traditionally quantifiable benefits and costs. Where levees have a history of failures and realignment is not feasible, the benefit-cost analysis should consider the greater risk of failure, adjusting operation and maintenance cost estimates appropriately. Where the site is unsuitable, no federal support should be provided.

Design Considerations to Lessen Levee Overtopping Impacts

During the 1993 flood, many levees were overtopped and catastrophic damages occurred from scour and sand deposition. There are various methods for lessening these types of impacts such as use of spillways, control structures, and levee superiority (choosing where a levee should overtop first).

Recommendation 8.3: *The USACE should investigate procedures to minimize impacts associated with levee overtoppings.*

Differing methods to lessen levee overtopping impacts should be investigated. A report should be prepared by USACE that details preferred engineering techniques to improve current levee structures, where appropriate.

Coordinating Economic Evaluation Criteria

Both the SCS and USACE have requirements for economic feasibility with regard to potential levee repairs. Differences exist in the detail of analysis, period of analysis, and interest rate used for each of these programs.

Recommendation 8.4: *The USACE should coordinate with the SCS to decide on appropriate criteria for evaluating the economics of levee repairs.*

The Review Committee recommends that one agency, the USACE, be the principal federal levee repair and construction agency. Past differences in the evaluations by the two agencies suggest that coordination of methods could lead to an improved procedure.

Floodfighting on Levees

Threatened communities and owners of agricultural levees conducted heroic levee floodfighting during the Flood of 1993. They took action, however, without knowledge or consideration of the effects that keeping the water off their portion of the floodplain would have on the river level in proximity to that location. The act of raising a levee during rising flood conditions has the effect of increasing the river level in the immediate area and possibly upstream and downstream as well. The magnitude of the increase could be minor or significant, depending on hydraulic factors pertinent to the affected levee and river reach. If the water level raise is significant, it could cause greater damage than otherwise would have occurred to nearby lands, especially if levee raising results in the failure of a neighboring levee.

Action 8.3: *Federal and state officials should restrict support of floodfighting to those levees that have been approved for floodfighting by the USACE.*

The USACE would determine by advance planning, with the benefit of river hydraulic modeling analysis, those levees that can and those that cannot be floodfought without significant adverse impacts on other properties in the floodplain. This action would not prevent floodfights which are consistent with state and local floodplain management regulations under the National Flood Insurance Program (NFIP).

Floodfight Controls

In 1978, during federal construction of an agricultural levee on the Missouri River downstream of Brunswick, Missouri, the USACE, FEMA, the City of Brunswick, and the levee sponsor agreed to limit the height of the levee being constructed to a 25-year protection level and that the levee district would not increase the levee height during a flood event. This agreement was to prevent the levee from raising upstream flood elevations more than one foot, especially at Brunswick. During the 1993 flood, the USACE provided technical assistance to the Brunswick Dalton Drainage District in its efforts to fill in low spots in the levee -- locations where the levee elevations were below the authorized project levels. Therefore, in accordance with the agreement, the levee sponsor did not raise any sections of the levee above the design grade. In late July, the levee overtopped.

Urban Stormwater Management

The use of detention basins as a type of structural flood damage reduction measure has greatly increased over the last 20 years. Many local ordinances now require "zero-increment" runoff for new development, which means that on-site detention must be provided. State and federal government involvement in runoff management is typically limited to managing stormwater runoff from roads and highways. The *Floodplain Management in the United States* report indicates that federal and state governments have increased attention to this problem due to an awareness that a large percentage of flood insurance claims come from areas not identified as floodplains.

Flooding can be increased significantly by the runoff from land that has been stripped of vegetation or covered with buildings, pavement, and other impervious materials. Historically the approach to such runoff has been to confine and transport that water as quickly as possible. As urbanization spread, this approach contributed significantly to increased magnitude and frequency of downstream flooding and the construction of flood damage reduction structures. Reduced groundwater supplies and degraded water quality are frequent byproducts of this approach. New efforts to handle runoff from frequent storms (e.g., 2- to 10-year events) include on-site detention or retention though a variety of measures and management of total runoff within a watershed to ensure that discharges from watershed sub-units reach the main channel at different times and, therefore, reduce peak flows in downstream areas. Most on-site detention measures typically provide little protection from large, infrequent events such as those that caused the Midwest flood because their capacity is exceeded.

While the main objective of on-site detention is to prevent excessive runoff from developed areas, a secondary benefit is that on-site detention measures can be designed to trap pollutants and, therefore, improve water quality. Throughout the country there is considerable interest in using natural wetlands or creating wetlands to help manage stormwater runoff.

EXPANDING NONSTRUCTURAL MEAUSRES

Hazard mitigation includes those action taken by individuals and communities to reduce damages from such hazards as earthquakes, tornados, and floods. Examples of actions commonly taken after a flood are buyouts, elevation or floodproofing of damaged buildings, structural flood protection, flood-warning systems, and flood hazard awareness programs. There are ways to reduce the vulnerability of floodplain structures through design for all flood loads, selection of flood-resistant materials, and use of flood-resistant construction practices.

The Administration established buyouts of flood-damaged properties as the first priority for mitigation funds available for the Midwest flood. As of April 25, 1994, the federal government had approved applications from 61 communities for acquisition or relocation of 4,181 buildings. Other applications are pending, and as many as 6,000 buildings will be acquired or relocated.[2] This initiative represents a turning point in flood recovery policy, since it is the first time that buyouts have been attempted on such a large scale.

Buyouts are an appropriate federal response for the Midwest flood and for floods like it. Many of the buyout neighborhoods have been damaged repetitively by flooding. Subject to deep and long-duration flooding, they were isolated by floodwaters for extended periods of time. In addition, a significant percentage contain older, lower value housing, much of it of poor quality and in need of rehabilitation. Under the right circumstances, the buyouts will not only reduce flood damages and protect people and property, but also achieve other objectives such as improving the quality of affordable housing, increasing recreational opportunities and wildlife values, and general betterment of the community.

A TEAM EFFORT

The Home Life Restoration Committee, a local citizen's group in Hannibal, Missouri, and the Missouri Housing Development Office joined forces to assist four families whose homes had been severely damaged in the flood of 1993 to move into new housing outside the floodplain. Bridge loans of up to $5,000, bearing interest of 1%, were provided to each family through a program of the Housing Development Office. The Committee members, in conjunction with another charitable group, the Natural Resources Community Action Coalition, solicited a total of $50,000 in donations from local business and industry. This joint state/local effort enabled four homes outside the floodplain to be acquired and rehabilitated. The state loans will be forgiven if these families remain in their new homes for five years.

Buyouts and Other Hazard Mitigation Actions Following a Flood

Prior to the current buyout initiative, the primary federal response to mitigating damages to flooded structures was the substantial damage requirement implemented by communities participating in the NFIP. Buildings damaged so that the cost of repair is equal to or greater than 50 percent of the market value prior to the flood must meet program requirements for new construction, such as elevating above the 100-year flood elevation. Substantially damaged structures also become subject to actuarial rates under the NFIP.

While enforcing a substantial damage requirement is critical to achieving long-term objectives of reducing flood damages, financial assistance will be required to assist property owners who cannot afford to elevate or relocate their buildings or obtain replacement housing. The buyout initiative, in part, meets this need.

Individuals and communities impacted by the Midwest flood appear to be far more receptive to buyouts than after past floods. Often in the past, people regarded a flood as a one-time event. Any interest in acquisition or relocation waned with time as memories of the flood faded. But with the Midwest flood, the duration of the flooding and the multiple flood crests and floodfights created stress for floodplain occupants and communities. By the end of the summer, floodplain occupants just wanted out.

Implementation of buyouts has not been without problems. Federal agencies had to overcome significant obstacles to make the initiative work. This resulted in confusion and uncertainty among states, communities, and individuals. Since no federal or state agency had ever attempted buyouts on this scale, agencies had to invent policies and procedures and establish relationships between programs. They had to create mechanisms to coordinate programs and provide technical assistance to small communities with limited resources and expertise. They also had to develop expedited procedures for compliance with the NEPA, historic preservation, and other federal mandates.

A common theme throughout the Review Committee's meetings with states, communities, organizations, and interest groups has been the need for common policies and procedures among federal agencies participating in buyouts and other mitigation activities,. The current initiative with multiple programs, applications, and eligibility requirements is overwhelming to communities, even with the improvements made to date. A corollary need is for sufficient flexibility in these programs to respond to a variety of flooding conditions or other circumstances, including responding to other types of disasters.

Expedited decisions on buyouts would reduce the uncertainty of property owners and avoid needless

PRINCIPAL SOURCES OF FUNDING FOR BUYOUTS

The following federal programs provide funding for buyouts following a disaster such as the Midwest Flood of 1993:

Department of Housing and Urban Development Community Development Block Grants (CDBG). The 1993 Supplemental Appropriation included $200 million for the CDBG program to assist in acquisition and relocation and in meeting other housing needs. The 1994 Earthquake Supplemental included an additional $250 million for a total of $450 million.

Federal Emergency Agency Section 404 Hazard Mitigation Grants. The Hazard Mitigation and Relocation Assistance Act of 1993, signed into law on December 7, 1993, revised the formula for determining the amount of the Section 404 Hazard Mitigation Grant in the Stafford Act and changed the cost share to 75/25. Under the revised formula the FEMA estimates that $134.9 million will be available through the Hazard Mitigation Grant Program funds for the Midwest flood.

Economic Development Administration (EDA) Grants. The 1993 Supplemental Appropriation included $200 million for EDA for grants to states and communities to preserve or create jobs or upgrade infrastructure. The funds can be used to assist in the relocation of businesses or for the infrastructure needed to support those businesses.

National Flood Insurance Program Section 1362 Flood Damaged Property Purchase Program. Several million dollars are available from the appropriation for the NFIP Section 1362 program for acquisition of insured properties. These funds are paid from the National Flood Insurance Fund, using premium dollars.

Other Programs. Funds were available from other programs such as the FEMA Public Assistance Program to assist in various aspects of buyouts and relocation. SBA loans are available to help individual property owners not eligible for CDBG monies.

expenditures for repairs to houses that are subsequently purchased. This duplication cannot be entirely avoided. It takes time to properly conduct a buyout, particularly for relocation of buildings or neighborhoods. Situations will continue to occur where making minimal repairs to a structure will be more cost-effective than providing rental assistance through the FEMA Disaster Housing Program.

While the Review Committee applauds the work of federal and state agencies in adapting existing programs to make buyouts work, these gains need to be consolidated to position the government for future buyouts and other hazard mitigation initiatives. A critical issue is how to transfer the buyout experience and other mitigation actions of the 1993 flood to other floods. The Midwest flood, a unique event covering a 9-state area and impacting over a thousand communities, required large supplemental appropriations. For more typical floods without supplemental appropriations, funding for mitigation must come from the FEMA Section 404 Hazard Mitigation Grant Program, the NFIP Section 1362 program, and other existing programs.

Recommendation 8.5: *Maintain flexibility in hazard mitigation programs to promote cost-effective and appropriate mitigation techniques.*

Buyouts are the optimal solution for many neighborhoods impacted by the Midwest flood. Circumstances arise, however, where other mitigation techniques may be the most cost-effective method for reducing flood damages with the least impacts on the community and the environment. In areas of shallow, short-duration flooding, elevation of structures on site may be the preferred alternative. Where high groundwater or sewer backups flood basements in or out of identified flood hazard areas, the optimal mitigation action could be making drainage improvements, upgrading sewer systems, or installing backwater valves. Future mitigation initiatives must be flexible enough to respond appropriately to these differences.

Action 8.4: *Establish a task force to develop common procedures for federal buyouts and mitigation programs.*

A federal interagency task force should coordinate pre- and post-disaster buyouts and other hazard mitigation actions. This task force should include representatives of agencies that could be involved in a buyout program as well as agencies with responsibilities for consultation and oversight on compliance with laws and executive orders. The task force should build on the Midwest flood experience to accomplish the following objectives:

- Develop common policies and procedures among agencies for buyouts and provide for increased flexibility in programs to respond to the unique circumstances of a disaster;

- Address compliance with the NEPA, applicable executive orders, historic preservation requirements, and other federal mandates during multi-agency buyouts;

- Design delivery systems to expedite buyout decisions to be responsive to disaster victims and minimize duplication of assistance in instances where properties are to be bought out;

- Identify statutory barriers buyouts and other mitigation actions and propose changes where appropriate; and

- Make recommendations on how supplemental appropriations would be channeled through a single program such as the FEMA Section 404 Hazard Mitigation Grant Program rather than being provided through multiple agencies and programs.

Coordination issues that arise during future disasters should be resolved through the Interagency Hazard Mitigation Task Force.

Recommendation 8.6: *Encourage establishment of state-chaired task forces to coordinate buyout and implementation of other hazard mitigation activities.*

One of the success stories of the Midwest flood is the creation and operation of state task forces to coordinate buyouts and other mitigation actions. These task forces include participation by representatives of state agencies and of field offices of various federal agencies. In some cases communities have had to make only one application to the task force, which then determined the funding sources and amounts available to the community. These task force have proved to be important forums for resolving differences between agencies and for coordinating buyout programs. They have provided the additional benefit of involving agencies that previously had not conducted floodplain management. Operating at the state level, they could effectively coordinate future buyout programs and package FEMA Section 404 funds with other available state and federal funds.

Action 8.5: *Provide states the option of receiving FEMA Section 404 Hazard Mitigation Grants as a block grant.*

A number of states have indicated an interest in coordinating buyouts and other mitigation actions after disasters. They feel that they could be more responsive to communities and could expedite decisions if they received

FEMA Section 404 Hazard Mitigation Grants in the form of a block grant. Under the current program, states already are given considerable latitude in establishing priorities and allocating Section 404 Hazard Mitigation Grant Program monies. A block grant also may provide greater flexibility to use these funds in conjunction with other federal, state, and local funds. The Review Committee suggests that block grants be offered as an option for those states that have adopted approved floodplain management or hazard mitigation plans. Block grants are consistent with the Review Committee's call for an expanded state role in floodplain management and hazard mitigation.

The block grants should be subject to the current cost share and to general federal requirements, including the establishment of overall priorities for hazard mitigation actions. Issues such as compliance with the NEPA, the Endangered Species Act, Historical Preservation, EO 11988 and other Federal mandates require resolution. For the CDBG program, the HUD is authorized to delegate these responsibilities to states and communities, but the FEMA is not.

Action 8.6: *Provide funds in major disasters where supplemental appropriations are made for buyouts and hazard mitigation, through FEMA's Section 404 Hazard Mitigation Grant Program.*

The federal government is providing funds for buyouts and other hazard mitigation activities for the Midwest flood through several agencies and programs. For major disasters that require supplemental appropriations, a better approach would be to make supplemental appropriations to the Section 404 Hazard Mitigation Grant Program. The FEMA should issue mission assignments to other agencies with expertise in community development and in providing technical support to states and communities in developing buyout programs. Providing funds to a single agency would invoke a single set of policies and procedures.

Action 8.7: *Establish a programmatic buyout and hazard mitigation program with funding authorities independent of disaster declarations.*

The current buyout program is funded primarily through supplemental appropriations made only after extraordinary floods and other disasters. Most flood events impact on much smaller geographic areas and may or may not result in a Presidential disaster declaration. Programs need to be in place to accomplish buyouts and other appropriate mitigation for such floods on an on-going basis.

Money currently available for mitigation activities includes funds from existing programs -- such as the FEMA Section 404 Hazard Mitigation Grant Program, the NFIP Section 1362 program, SBA loans to individuals, and any monies remaining available from funds allocated to states and communities through CDBG and EDA. Recent changes to the Section 404 Hazard Mitigation Grant Program to increase available funding will help.

Mitigation insurance coverage through the NFIP and cost-shared mitigation grants for states communities for on-going hazard mitigation planning and actions also should be components of such a program. Such funding measures are included in pending legislation.

In addition to this NFIP mitigation fund, the FEMA should have authority to allocate a percentage of its annual Disaster Assistance Fund appropriation to states for community hazard mitigation plans and action.

Recommendation 8.7: *Encourage use of CDBG, EDA, and other funding to acquire and relocate or take other mitigation actions where consistent with program objectives.*

The Midwest Flood of 1993 demonstrates a commonality of objectives between mitigation actions to protect neighborhoods and businesses from flooding and

ON-GOING ACQUISITION AND RELOCATION PROGRAMS

A number of communities in the nine states affected by the Midwest flood have undertaken systematic programs to acquire or relocate buildings in their floodplains. Two examples are Beatrice, Nebraska and Austin, Minnesota.

Beatrice, Nebraska. Over a multi-year period, the City of Beatrice, Nebraska, obtained annual Community Development Block Grants (CDBG) totaling about $3 million to purchase owner occupied floodplain properties from willing sellers. The city usually purchased these properties when they became vacant which minimized acquisition costs. Between 85 and 90 properties were acquired. More recently the city has acquired an additional 20 to 25 properties using their own funds. The lands acquired have been converted to parks.

Austin, Minnesota. After a 1978 flood, the city of Austin, Minnesota, consulted with the USACE over construction of a flood damage reduction project but decided that the best alternative was to clear out the floodplain. At that time the city obtained $1.4 million in CDBG money and acquired 44 homes, 16 of which were relocated. In 1983 the city initiated an NFIP Section 1362 project to acquire flood-damaged buildings covered by flood insurance. The city made offers on 11 home and eventually acquired 6 of them. Others dropped out because they had spent their insurance/disaster assistance and could not afford to move. The city is currently putting together an application for another relocation project for another 40-50 homes that were damaged by the 1993 flood.

the missions of federal housing and development programs intended to provide safe and sanitary affordable housing and to create and preserve jobs. For example, many of the neighborhoods most severely impacted by the Midwest flood are low-income neighborhoods with substandard housing. Often these neighborhoods further deteriorate as a result of floods or the threat of floods. Similarly, efforts to create or preserve jobs are made more difficult in communities where business expansion is prevented or results in the relocation of these businesses to other communities or regions. Agencies administering these programs should continue to be active participants in floodplain management and to seek out opportunities for reducing flood losses.

Reducing Risks to Insured Buildings Substantially or Repetitively Damaged

NFIP minimum criteria require that substantially improved buildings, including those substantially damaged, meet most requirements for new construction, including the requirement that residential structures be elevated to or above the elevation of the 100-year flood. The substantial damage requirement is an integral part of the NFIP strategy to reduce future damages to existing floodprone development. The substantial damage requirement has been difficult to enforce because property owners often do not have the funds necessary to meet it or to obtain replacement housing.

PENDING LEGISLATION ON FLOOD INSURANCE

Legislative initiatives are pending in the Congress that would provide for increased financial assistance for mitigating flood damages. The National Flood Insurance Reform Act (S. 1405) has passed the Senate as Title VI of S 3474, the Community Development, Credit Enhancement, and Regulatory Improvement Act of 1994. The bill provides for mitigation insurance that would pay for the additional costs of elevation, floodproofing, demolishing or relocating substantially damaged or repetitively damaged building (two damages in 5 years averaging 25 percent of the value of the property) as a standard benefit to the policy holder. A mitigation program funded by $20 million from the National Flood Insurance Fund would be established at a 75/25 match for state and community mitigation projects to reduce damages to other insured buildings. A portion of these funds would be available for state and community mitigation planning.

The House of Representatives has passed H.R. 3191, also called the National Flood Insurance Reform Act of 1994, which provides for a study of mitigation insurance and establishes a mitigation fund of more than $30 million per year for state and community mitigation projects and planning. H.R. 3191 would provide grants from the Mitigation Fund, through an application process, to be available to individuals for floodproofing, demolishing or relocating substantially damaged or repetitively damaged buildings. These projects and activities would be funded through a surcharge on flood insurance policies. Neither bill addresses mitigation for uninsured buildings.

For the Midwest flood and for several other recent catastrophic disasters, the FEMA has allowed communities to use replacement cost instead of market value for calculating substantial damage except where state regulations are more restrictive. The use of replacement cost usually means that far fewer structures will be deemed as substantially damaged. This change has been a source of controversy in the Midwest. Because the agency did not communicate the change to communities early enough, some communities, after making determinations based on market value, had to recalculate based on replacement cost to placate affected property owners. Because fewer buildings are considered substantially damaged using replacement cost, some states and communities believed that the change was inconsistent with sound floodplain management as it resulted in fewer buildings being elevated, demolished, or relocated.

Persuasive arguments can be made for using either market value or replacement cost to define substantial damage. The FEMA needs to decide on a definition and be consistent.

A related issue is that of repetitively damaged structures, i.e., those damaged on two or more occasions since 1978. These buildings currently account for 35.9 percent of all NFIP losses and 44.2 percent of all payments.[3] Unless these buildings are substantially damaged by one flood, no regulatory requirements apply and flood insurance continues to be available at highly subsidized rates. Significant numbers of these repetitive loss buildings, including buildings that have had as many as eight losses, can be found in areas in Missouri and Illinois.

St. Charles County, Missouri, alone has 1,055 of these repetitively damaged buildings which have sustained a total of 3,625 losses.[4] Other communities in the surrounding counties of Missouri and Illinois also have large numbers of these buildings in areas with chronic flooding problems. Because repetitive-loss buildings were substantially damaged by the Midwest flood, rigorous implementation of the requirement should reduce the numbers of these buildings.

Action 8.8: *The FEMA should continue to enforce substantial damage requirements, but decide on a definition of substantial damage and stick to that definition.*

The NFIP substantial damage requirement is crucial to reducing flood damages to structures built prior to the adoption of floodplain management regulations in participating communities. The FEMA should decide on a definition of substantial damage/substantial improvement and consistently apply that definition in disaster and non-disaster situations. This will eliminate confusion and improve the overall level of compliance with NFIP regulations.

Action 8.9: *The Administration should support insurance coverage for mitigation actions necessary to comply with local floodplain management regulations.*

Critical to continued enforcement of the substantial damage requirement is providing NFIP flood insurance coverage for the costs of elevating, floodproofing, or relocating substantially damaged buildings. Currently flood insurance pays only for the repair of physical damage to the building. Mitigation insurance would provide coverage that pays the costs of bringing insured buildings that are substantially damaged by floods into compliance with community floodplain management regulations either by elevating, floodproofing, demolishing, or relocating the building. The coverage would be funded by flood insurance premiums and be part of the claims adjustment process. Mitigation insurance has a number of advantages:

- It supports consistent enforcement of the substantial damage regulatory requirements;
- It more fully indemnifies policyholders from flood-related losses;
- It is funded by flood insurance premiums and not by appropriated funds;
- It would reduce over time the subsidy for these pre-FIRM buildings; and
- The flood insurance claims adjustment procedure is an efficient way to deliver assistance.

The National Flood Insurance Reform Act of 1993 (S. 1405 which has passed the Senate) authorizes the NFIP to provide mitigation insurance. Similar legislation that has passed the House of Representatives (H.R. 3191) provides for a study of mitigation insurance.

Action 8.10: *Develop a program to reduce losses to repetitively damaged insured properties through insurance surcharges, increased deductibles, mitigation insurance, and/or mitigation actions.*

Repetitive loss buildings account for a disproportionate percentage of NFIP losses and represent a significant liability for the program. The FEMA should develop a comprehensive strategy to address these losses, including flood insurance premium surcharges and increased deductibles. Such a strategy should reflect more accurately the increased risk to these buildings and provide an incentive for protecting the buildings from flooding. Mitigation insurance should cover the cost of mitigation for the most vulnerable structures. Buyouts and other mitigation initiatives should place a high priority on these buildings. When such structures are substantially damaged, the FEMA should enforce this requirement rigorously.

The flood insurance program should include cost-shared funding for on-going pro-active planning and mitigation independent of disasters. This element should include provision for a mitigation fund financed out of NFIP premiums (such as that provided for in S. 1405 and H.R. 3191 both entitled the National Flood Insurance

Table 8.1 NFIP-insured Buildings with Repetitive Losses, Midwest States, 1978-1993.

State	Buildings with Repetitive Losses	Number of Losses for Such Buildings
Missouri	3,268	10,038
Illinois	1,351	3,774
Iowa	287	565
Nebraska	247	608
Minnesota	201	627
Kansas	175	441
North Dakota	142	713
Wisconsin	66	177
South Dakota	16	35
TOTAL	5,723	16,978

Source: Federal Emergency Management Agency, Federal Insurance Administration, computer Printout, Washington, DC, February 7, 1994.

Reform Act of 1994) for state and community mitigation projects and planning. Since the source of these funds is NFIP premiums, projects financed by the mitigation fund should mitigate damages to insured buildings. Any assistance to uninsured buildings should be incidental and necessary to the success of the project.

ENDNOTES

1. Some estimate the total at approximately 2,200 levees which would mean approximately 2,000 non-federal levees.

2. Federal Emergency Management Agency, "Acquisition/Relocation Program. Project Approval Summary," (Washington, DC; FEMA, April 25, 1994).

3. Federal Emergency Management Agency, Federal Insurance Administration, Washington, D.C., computer print-outs, July 21, 1993, and unknown date.

4. Federal Emergency Management Agency, Federal Insurance Administration, Washington, D.C., computer print-out, February 7, 1994.

Chapter 9

MITIGATING FLOOD IMPACTS THROUGH RECOVERY AND INSURANCE

Keep in mind, we can't hold harmless everybody from every loss...there are programs to help businesses, farms, communities, and individuals who are out of work and who have no means of support.

President Clinton
Interview with Larry King, July 20, 1993

Despite efforts on the part of the government and affected individuals to reduce vulnerability, flood disasters will continue to occur. The eventuality of flooding carries with it the necessity to have a coherent and coordinated disaster response and recovery strategy and effective insurance programs. The National Flood Insurance Program indemnifies individual property owners for their losses without requiring costly disaster assistance expenditures. The Federal Crop Insurance Corporation provides partial coverage for crop losses caused by natural perils. The challenge to the federal government is to develop a cooperative framework under which federal, state, and local entities can marshal their forces to address emergency response and recovery issues. At the federal level, the Review Committee is calling for a streamlining of disaster-related activities to avoid duplication of effort or working at cross purposes. In addition, the Review Committee seeks to encourage those who voluntarily chose to live in a floodplain to purchase NFIP coverage so that they can bear, to the degree possible, the costs associated with the risks. Ultimately, flood insurance will reduce disaster payments by internalizing the costs of living in the floodplain and by creating an incentive to move out of harm's way.

REORGANIZING DISASTER RECOVERY

The key to mitigating damages during recovery, especially after a disaster such as the Flood of 1993, is in organizing the recovery effort to establish leadership at the federal level and to involve fully all appropriate federal, state, and local government agencies.

Integrating Flood Response and Recovery under a Single Federal Agency

Congress established the FEMA in 1979 to consolidate emergency management programs that previous were scattered among multiple agencies. Over the last several years, the federal government has assigned other agencies the leadership responsibility for the recovery portion of disaster response following larger disasters in an attempt to provide a more responsive system.[1] These agencies, however, do not have the collective experience in disaster recovery offered by the FEMA, nor do they have an expansive knowledge of federal floodplain management goals or existing recovery and hazard mitigation programs, including multiple hazards. The nation needs a single agency to coordinate federal flood response and recovery because the two are integrally linked. A single agency also can develop and maintain a core knowledge of the full suite of federal programs available to help recovery.

By decoupling flood response from flood recovery, the nation is losing opportunities for hazard mitigation and floodplain management. Response activities that occur without regard to potential recovery alternatives may foreclose opportunities to lessen future damages. This may leave people and property at risk and potentially increase future disaster support. The federal government must strike a balance between being responsive and adding to the inherent confusion resulting from any disaster.

Recommendation 9.1: *Integrate federal flood response and recovery under the FEMA.*

The Review Committee suggests that the FEMA be the federal agency coordinating response and recovery to help achieve floodplain management goals. Development of a federal response and recovery plan would incorporate national floodplain management goals and reflect state floodplain management responsibilities by identifying federal and state agency roles and responsibilities and establishing consistent rules and priorities, thus streamlining both response and recovery by the federal government.

Linking Response and Recovery with Floodplain Management

In 1980 the Office of Management and Budget established a FEMA-led Interagency Hazard Mitigation Task Force through a Memorandum of Agreement (MOA) to coordinate federal post-disaster recovery and to identify means to mitigate hazards.[2] Thirteen federal agencies agreed to participate in the task force and on interagency hazard mitigation teams activated for each flood disaster.[3] The USACE, SCS, and NWS have participated regularly on these teams as have state agencies. The FEMA encouraged states to lead these teams and, in the process, to build expertise transferable to disasters not needing federal disaster assistance. Participation by other federal agencies has been limited (see Table 9.1) by lack of staff and travel funds, a perception that the teams are tangential to an agency's mission, and the lack of high level support.

Most federal agencies participated on hazard mitigation teams for the Midwest flooding. Although activation of a 13-agency team is not necessary for each Presidentially declared disaster, regional coordination is desirable to review and determine each agency's involvement in such disasters.

While the Federal Interagency Floodplain Management Task Force and the Interagency Hazard Mitigation Task Force provide for interagency exchange of information, neither has successfully created the interagency dynamic and commonality of purpose needed for floodplain management activities.[4] Separation of the two task forces perpetuates a distinction between hazard mitigation and floodplain management when, in fact, the former is a key component of the latter. Neither has provided a link between emergency response and recovery, hazard mitigation including multiple hazards, and floodplain management at large. While both provide some information transfer, they do not coordinate federal funding to focus on priority problems, nor do they provide research oversight, planning advice, or issue resolution.

Between emergencies, federal agencies need to improve their coordination. In the aftermath of an emergency, the priority issues of that emergency soon fade into an agency's daily activities with little resolution. In 1986, the USACE and the SCS signed a Memorandum of Agreement to establish engineering standards for levees and levee repair responsibilities. But when the 1993 flood occurred, the two agencies had not yet set levee standards and did not fully delineate their separate responsibilities until months into the flood recovery, creating additional confusion.[5]

Recommendation 9.2: *Enhance the linkage among response, recovery, and floodplain management.*

Coordinating the Interagency Hazard Mitigation Task Force, the Interagency Floodplain Management Task Force, and other groups involved with emergency response will help link disaster response into a seamless set of functions. In the intervals between disasters, the increased support and interest by all federal agencies

Table 9.1 Interagency Hazard Mitigation Teams, 1992-1993.

Teams and Member Agencies	National Disasters	1993 Midwest Flood June 1992-July 1993
Interagency Teams	14	6
Member Agencies by Service on Teams		
Federal Emergency Management Agency	14	6
U.S. Army Corps of Engineers (DOD)	12	6
Soil Conservation Service (USDA)	11	6
National Weather Service (DOC)	10	6
U.S. Geological Survey (DOI)	5	2
Housing and Urban Development	4	2
Small Business Administration	4	2
Environmental Protection Agency	3	3
Department of Energy	2	0
Forest Service (USDA)	2	1
Economic Development Commission (DOC)	1	2
Department of Transportation	1	3
Public Health Service (HHS)	1	1
Bureau of Reclamation (DOI)	1	NA
U.S. Fish and Wildlife Service (DOI)	1	3
Bureau of Indian Affairs (DOI)	1	1
National Ocean Service (DOC)	1	NA
National Park Service (DOI)	0	1

NA = Not Applicable

Source: FEMA, Interagency Hazard Mitigation Team reports for disasters between June 1992 and the 1993 Midwest flood (Washington, DC: FEMA, 1992-1994).

would facilitate all facets of floodplain management, including disaster planning, recovery, and hazard mitigation.

Action 9.1: *Hold an interagency strategic planning meeting for those Presidentially declared disasters that require a multi-agency recovery effort.*

Coincident with deliberations regarding each proposal for a Presidential disaster declaration, the FEMA should hold an interagency strategic planning meeting to review and determine the necessary or desired involvement of each agency. At such a meeting, the FEMA could brief each agency on the situation and figure out its involvement. More efficient interagency coordination, early enlistment of agencies, and clear direction regarding agency involvement should result.

Recommendation 9.3: *Continue to seek federal-state co-leadership of an interagency hazard mitigation team.*

State co-leadership of hazard mitigation teams formed in response to a Presidentially declared disaster recognizes the responsibility of the states for floodplain management. In addition the experience gained by state participants increases opportunities for hazard mitigation in state or locally declared disasters and should decrease federal expenditures for hazard mitigation in the future.

REBUILDING MORE EFFICIENTLY

As part of flood response and recovery, the federal government should offer individuals and communities that choose to relocate or rebuild opportunities to integrate energy efficient technologies, such as solar devices and more efficient lighting, into the design and construction of new structures. For example, the town of Valmeyer, Illinois, received assistance from the Department of Energy to integrate more energy-efficient standards into building designs. Relocations, in particular, offer a unique opportunity to start from scratch in planning and constructing to assure that sustainable development becomes an integral part of the entire community. Each community would choose the characteristics it values such as an agricultural base, the historic or rural nature of the town, affordable housing, energy and/or water efficiency, diversity of species, or natural resources. Communities would incorporate these into planning and construction. Individuals also would use energy-efficient technologies to conserve limited natural resources with resultant cost savings. Rebuilding also offers an opportunity for reducing potential damages from hazards other than floods and for increasing awareness of these hazards. As part of response and recovery, a team of federal experts would work through state agencies to provide communities and individuals technical assistance and information on the use of more innovative technologies.

MITIGATING LOSSES THROUGH FLOOD INSURANCE

The National Flood Insurance Program was created by Congress in 1968 in response to mounting flood losses and escalating costs to the general taxpayer for disaster relief in the belief that flood insurance is preferable to disaster assistance. To encourage participation in the NFIP by communities and purchase of flood insurance by individuals, the federal government subsidizes the premiums for buildings constructed prior to the issuance of a FEMA Flood Insurance Rate Map (FIRM). This subsidy also recognizes that many floodplain buildings were built or purchased without knowledge of the flood risk. New construction (post-FIRM) is charged an actuarial premium that reflects the property's risk of flooding. Currently 59 percent of NFIP policyholders pay a full actuarial rate and 41 percent are subsidized.*

If the NFIP is to be successful in indemnifying property owners from flood losses and reducing federal expenditures for disaster assistance, a high percentage of property owners must purchase and maintain flood insurance coverage. The program depends on the mandatory flood insurance purchase requirement contained in the Flood Disaster Protection Act of 1973 and voluntary purchase by other property owners at risk. The 1973 Act requires the purchase of flood insurance by property owners who receive federal grants or loans, or loans from a federally supervised, regulated, or insured lender for the acquisition, construction, or improvement of structures located in identified special flood hazard areas (the 100-year floodplain). In the 9-state region affected by the 1993 flood, only about 20 percent of structures in the floodplain carried flood insurance, a rate well below optimal levels.

FLOOD INSURANCE VS. DISASTER PAYMENTS

The federal government should encourage the purchase of flood insurance because it internalizes the risk of locating investments in the floodplain, and it more adequately indemnifies property owners from flood losses. The Midwest flood confirms the Congressional findings in the Flood Disaster Protection Act of 1973, which states:

...the Nation cannot afford the tragic losses of life caused annually by flood occurrences, nor the increasing losses of property suffered by flood victims, most of whom are still inadequately compensated despite the provisions of costly disaster relief benefits; and it is in the public interest for persons already living in floodprone areas to have both an opportunity to purchase flood insurance and access to more adequate limits of coverage, so that they will be indemnified for their losses in the event of future flood disasters.

NFIP Market Penetration

The NFIP has not achieved the public participation needed to reach its objectives. This situation is evidenced by the assistance provided to individuals and businesses during the Midwest flood. Although policyholders filed 16,167 flood insurance claims,[7] the FEMA approved 89,734 applications for the Disaster Housing Program and 38,423 applications for Individual and Family Grants. The SBA approved 20,285 loans for individuals and businesses.[8] Many of these applications or loan approvals were for persons outside of identified flood hazard areas or from renters who do not normally purchase flood insurance. Others, including many of those who obtained SBA loans, should have had flood insurance either because it was required or because they were at risk. Some of those who obtained SBA loans may have had flood insurance, but their coverage may not have been sufficient to cover their losses.

Estimates of those covered by flood insurance nationwide range from 20 to 30 percent of the insurable buildings in identified flood hazard areas. Initial estimates in the Midwest flood area ranged from below 10 percent up to 20 percent. None of the estimates are authoritative, since no nationwide inventory of floodprone structures exists. The Review Committee obtained reliable structure counts for a number of Midwest communities. Sources of these data included inventories conducted by state and federal agencies, data from community geographic information systems, data submitted by communities participating in the NFIP Community Rating System, and counts obtained by Review committee members on visits to Midwest communities. Market penetration in these communities ranges from less than 5 percent to more than 50 percent. Based on this information, the Review Committee believes that market penetration in small rural communities is probably less than 10 percent. For most medium to large communities, market penetration appears to be in the 20 to 30 percent rage. For a few large communities with middle-income floodplain populations and a high degree of flood hazard awareness among community officials, lenders, and property owners, market penetration can exceed 30 percent and, in one instance, 50 percent.

FLOOD INSURANCE COVERAGE IN THE MIDWEST

Although the nation lacks the structure inventories necessary for a reliable estimate of NFIP market penetration, the Review Committee obtained inventories for individual communities and groups of communities in the Midwest. These data indicate that market penetration is highly variable, depending on the size of the community, the history of flooding, the economic status of floodplain occupants, and the awareness of flood hazards among community officials, lenders, and individual property owners.

State or Community	Buildings Zone A	Policies Zone A	Market Penetration Zone A
Austin, Minnesota	316	174	55.1%
Lincoln, Nebraska (1-4 family)	2,076	475	22.8%
17 Midwest NFIP CRS Communities	14,876	4,467	30.0%
North Dakota (1-4 family)	13,907	3,933	28.3%
23 Minnesota Communities	1,095	157	14.3%

Source: Building counts provided by states, communities, the USACE, and the FEMA; NFIP policy data are from the NFIP Community Information System.

Increasing Flood Insurance Purchase

Lender compliance to the requirement for mandatory flood insurance has been receiving a considerable amount of attention during hearings on pending legislation. The concern is that lenders do not require purchase of flood insurance at closing, nor do they ensure that property owners maintain flood insurance coverage for the life of a loan. Despite differences of opinion over how well lenders comply with the mandatory purchase requirement, most people agree on the need for improvement and for increased compliance to increase NFIP market penetration. However, the current dependence on the mandatory purchase requirement to drive high levels of market penetration may be unrealistic. According to the 1989 American Housing Survey, 42.4 percent of owner-occupied housing in the nation is owned free and clear of mortgages.[9] An additional percentage of those that are mortgaged were financed by

sellers, other individuals, lenders not covered by the mandatory purchase requirement, or they were financed prior to implementation of the requirement. For the nation as a whole, it appears that over half of owner-occupied properties are not subject to the mandatory purchase requirement.

Reasons other than lender noncompliance contribute to low levels of NFIP market penetration in the Midwest flood area. The most striking characteristic about the floodplain sections of communities visited by the Review Committee is that they appear to be predominantly low-income areas, whose populations have higher than usual percentages of renters, elderly, public assistance recipients, and property owners without mortgages. Housing ownership and sales in small rural communities differ from those in urban or suburban communities. Sales in small rural communities occur less frequently, often as cash sales or as sales financed through land contracts, loans from lenders who are not federally insured or regulated, or loans from family members. These small communities are precisely the areas where the mandatory purchase requirement would be applied least often and where voluntary purchase of flood insurance is least likely.

In the view of the Review Committee, other explanations for low market penetration in the upper Midwest include the false sense of security due to levees, particularly agricultural levees along the main stems of the Mississippi and Missouri rivers, the reluctance of insurance agents to market flood insurance in communities with few potential buyers, and a low level of awareness of the risk to those on the fringes of the floodplain.

Recommendations 9.4: *States should actively encourage flood insurance purchase by their citizens.*

States must play an active role in improving market penetration for flood insurance by working with communities and lenders and by assisting in education efforts. Fiscal assistance to states for floodplain management under a Floodplain Management Act should take into account a state's willingness to undertake this effort.

Action 9.2: *Increase NFIP market penetration through improved lender compliance with the mandatory purchase requirement.*

The Review Committee supports current attempts in pending legislation (S. 1405 and H.R. 3191, both entitled the National Flood Insurance Reform Act of 1994) to improve the level of lender compliance. This should include establishment of penalties for lenders who do not require the purchase or maintenance of flood insurance coverage.

Action 9.3: *Provide for the escrow of flood insurance premiums or payment plans to help make flood insurance affordable.*

The escrow of flood insurance premiums in those instances where the lender escrows property taxes and hazard insurance would ensure that coverage is maintained over the life of a mortgage. Additionally, those who may not be able to afford a one-time annual payment of a flood insurance premium would be more likely to purchase and maintain flood insurance coverage, if it were possible to spread the cost of the premium through the escrow of flood insurance premiums. The NFIP should provide payment plans for those who do not have mortgages and voluntarily purchase flood insurance.

Action 9.4: *Develop improved marketing techniques.*

Although improved lender compliance is critical to achieving increased market penetration, it will not by itself drive insurance purchase to the levels necessary to achieve program objectives. The program requires additional measures to increase voluntary purchase of flood insurance by those property owners not subject to the mandatory purchase requirement.

Counteracting Negative Incentives for Insurance Purchase

A perception persists that disaster assistance compensates homeowners as fully as flood insurance coverage. This may or may not be true depending on the value of the property affected and the income of the owner. A particular concern expressed by communities and others after the Midwest flood is that disaster victims, particularly those with lower incomes, who obtain disaster assistance from the Individual and Family Grant Program, the Disaster Housing Program, the Red Cross, and other programs may end up as well off as those who purchase flood insurance and receive payment for claims. Generous disaster assistance creates negative incentives for the purchase of flood insurance. The government and the insurance industry must ensure that the public is fully aware of the advantages of flood insurance and the limitations of disaster assistance. They must work to ensure that disaster benefit payments do not approach or exceed flood insurance benefits. Floodplain occupants must be aware that disaster assistance is only available during a Presidentially declared disaster, while flood insurance claims are paid any time a general condition of flooding occurs.

Action 9.5: *Reduce the amount of post-disaster support to those who could have bought flood insurance but did not, to that level needed to provide for immediate health, safety, and welfare; provide a safety net for low-income victims.*

The FEMA should seek authority to limit the amount of disaster assistance to individuals in the 100-year floodplain who have not purchased flood insurance and investigate approaches that could be used to provide a safety net for those not able to afford flood insurance premiums.

Insuring Those Behind Levees

The Midwest flood brought to the forefront issues regarding the residual risk behind levees, the catastrophic damages that can occur, and the false sense of security that develops among floodplain occupants. Most of the levees that were overtopped or failed were agricultural levees not credited as providing 100-year flood protection, but some credited 100-year levees were overtopped or failed, such as a local levee at Chesterfield, Missouri, and a federal levee at Elwood, Kansas. The mandatory NFIP purchase requirement and floodplain management regulations do not apply behind credited 100-year levees. New structures were not protected from flood damage, and many buildings were not insured. Flooding threatened other credited levees that protect urban areas, and they too could have overtopped or failed had floodwaters been higher.

Currently if a levee meets minimum criteria established by the FEMA, that levee is credited as providing flood protection, and the application of floodplain management requirements and the purchase of flood insurance are not mandatory. The FEMA criteria require that the levee be at or above the elevation of the 100-year flood plus three feet of freeboard and meet certain structural requirements. Levees built by the USACE or other federal agencies are certified by the sponsoring agency.

The Review Committee is concerned that the minimum level of protection recognized by NFIP levee criteria and the level of protection that could result form current USACE procedures for selecting the design level for a federally constructed levee are not sufficient, given the residual risk to new and existing buildings behind levees. The residual risk to a building constructed behind a levee designed to provide protection from a 100-year flood is substantially greater than the risk to a building elevated to or above the 100-year flood elevation. This difference in residual risk, produced by the catastrophic damage that would occur if the levee is overtopped or fails, warrants a reevaluation of current federal policies toward levees and levee construction. Residual risk further warrants designating areas behind levees as flood hazard areas subject to the mandatory flood insurance purchase requirement.

PAYING CLAIMS BEHIND THE MONARCH-CHESTERFIELD LEVEE

The Monarch-Chesterfield Levee at Chesterfield, Missouri, is an example of a levee that induced floodplain development and of the residual risks that result from depending on a levee for flood protection. The Monarch Levee was an agricultural levee with an extensive emergency repair history that was upgraded during the 1980s to meet early NFIP standards. Subsequent to the completion of the levee and its being credited by the NFIP as providing 100-year protection, an industrial area developed behind the levee. In 1993 when it became apparent that the levee might overtop or fail, many property owners were able to purchase flood insurance and later to receive claims payments. Other property owners did not have flood insurance or did not meet the 5-day waiting period for coverage. The Review Committee identified at least 67 flood insurance claims payments behind the Monarch Levee that totaled $13.2 million. This represents nearly 5 percent of the total flood insurance payments for the 9-state region. The flooding of this industrial area had severe impacts to the area not only from insured and uninsured damages but also from the temporary or permanent loss of jobs.

SOURCE: FEMA Federal Insurance Administration, claims data for 1993, geocoding by the Floodplain Management Review Committee.

Action 9.6: *Require actuarial-based flood insurance behind all levees that provide protection less than the standard project.*

The FEMA should designate as AL zones those areas behind levees designed to meet current minimum NFIP criteria but which do not provide protection from the Standard Project Flood (SPF) discharge. The AL zone would include those areas landward of the levee that are below the 100-year flood elevation. The mandatory flood insurance purchase requirement would apply within this AL zone, and new buildings would pay flood insurance premiums based on actuarial rates. The FEMA could establish floodplain management requirements for these areas, although elevation or floodproofing to or above the 100-year flood elevation should not be mandatory. This recommendation is similar to one in the 1982 National Academy of Science's National Research Council report, *A Levee Policy for the National Flood Insurance Program.*

A mandatory flood insurance purchase requirement behind such levees would provide a number of benefits to the public and to property owners:

- Property owners would be insured against the real possibility that a levee will be overtopped or will fail,
- Federal expenditures for disaster assistance would decline,
- Property owners would be more fully aware of the residual risk in building or locating behind a levee, and
- Communities would have an incentive to seek higher levels of protection

Existing Flood Insurance Rate Maps should be revised where appropriate to reflect AL zones. The FEMA should obtain a legal opinion on whether this designation could be made based on residual risk of catastrophic loss, or if it would require legislation.

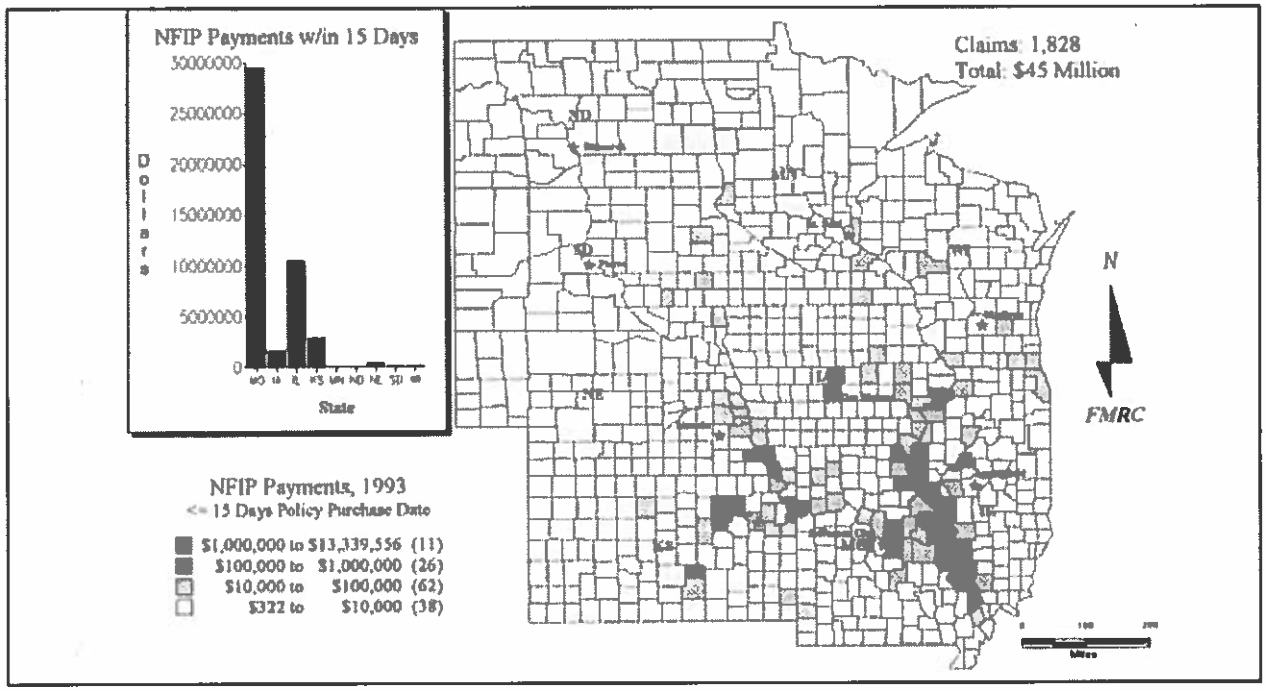
Increasing the Waiting Period for Flood Insurance

The NFIP requires a 5-day waiting period between the time of purchase of a flood insurance policy and when coverage becomes effective. At the closing on the sale of a property, flood insurance can be purchased with coverage effective immediately. The intent of the waiting period is to ensure that property owners cannot wait and purchase flood insurance only when floodwaters threaten their building.

The Midwest flood demonstrates that a 5-day waiting period before flood insurance becomes effective is insufficient for main stem flooding. In the Midwest flood, 13,310 losses resulted in claims payments totaling $297 million. Over a third of these claims were for losses that occurred within 60 days of the purchase of the initial flood insurance policy for the property. If a 15-day waiting period had been in effect for the Midwest flood, 1,828 fewer claims would have qualified, and claims payments would have been $45 million less (Figure 9.1). If the waiting period had been 30 days, 3,390 fewer claims would have qualified, and claims payments would have been $82 million less. If the waiting period had been 60 days, 4,588 fewer claims would have qualified, and claims payments would have been $105 million less.[10]

Most of these losses were for properties in downstream areas behind levees in Illinois and Missouri. Owners of these properties purchased flood insurance after watching upstream levees overtop and fail. In at least one instance, a community undertook a gallant floodfight not in expectation of protecting a school but rather to keep it from flooding until the 5-day waiting period had expired. The 5-day waiting period creates an incentive to purchase flood insurance coverage on watching upstream levees overtop and fail, and only when flooding is imminent. It is also inequitable for those policyholders who have

Figure 9.1 NFIP Payments for 1993 Losses that Occurred Within 15 Days of the Purchase of the Policy.



bought and maintained coverage for a period of years. If the practice became widespread, it could threaten the fiscal soundness of the National Flood Insurance Fund. One consequence of this flood is that some policyholders in the lower basin may drop their coverage in expectation of having time to purchase coverage based on flood forecast.

Action 9.7: ***Increase the 5-day waiting period for flood insurance coverage to at least 15 days.***

The 5-day waiting period for flood insurance coverage is too short for main stem riverine flooding and should be increased to at least 15 days. At the closing on the sale of a property, coverage should continue to become effective immediately. A 15-day waiting period would introduce sufficient uncertainty to ensure that property owners did not purchase flood insurance only when flooding was imminent. Data from the Midwest flood alone would warrant a 30-day waiting period. FEMA should balance the benefits of a 30-day waiting period against possible impacts on the marketing for flood insurance.

IMPROVING THE FEDERAL CROP INSURANCE PROGRAM

Multiple Peril Crop Insurance has been available to farmers for more than 50 years. There have been substantial changes in the program, however, during the intervening years. The Federal Crop Insurance Act of 1980 (PL 96-365) was the last major overhaul of the way insurance is offered to farmers. The purpose of the legislation was to create an insurance program that was almost actuarially sound and had limited government financing and to completely replace ad hoc disaster payments.[11] In the 1970s the existing policy for agricultural crop disaster assistance was expensive and encouraged production in high-risk areas.[12] However, the results of the 1980 reform were disappointing. The program suffered from poor actuarial performance and limited participation, and failed to eliminate federal crop disaster assistance. In fact, disaster payments exceeded $6.9 billion from 1980 to 1989.[13] The current insurance program subsidizes the transfer of risk from farmers to the government rather than being an efficient risk-sharing mechanism.[14]

The Administration has proposed to reform the Federal Crop Insurance Program as a result of these longstanding problems and as a direct response to problems experienced by farmers in 1993 who had crop insurance and were flooded. The Administration's Federal Crop Insurance Reform Act was submitted to Congress in March 1994 by the Secretary of Agriculture. The Act contains several features that promise to improve the crop insurance program as a risk-sharing mechanism. It also proposes to repeal standing disaster assistance authority and require that crop insurance coverage be linked to obtaining farm program benefits and FmHA loans.

Data on participation in the current program by floodplain farmers are not available. Discussions with floodplain residents indicate that few farmers choose to participate in the crop insurance program because they consider the 75 percent maximum coverage too low, flooding is relatively rare, and disaster assistance is available that almost equals the insurance indemnity. Drought is the primary natural peril for which farmers make claims, and floodplain farmers are less at risk for the effects of drought than upland farmers. On average, floods represent only 2 percent of the FCIC insurance payments.[15]

Action 9.8: ***The Administration should continue to support reform of Federal Crop Insurance that limits crop disaster assistance payments, increases participation, and makes the program more actuarially sound.***

The Review Committee supports the current initiatives by the Administration to pass the Federal Crop Insurance Reform Act of 1994. It is proposed that FCIC modify its process to make crop insurance actuarially sound. Insurance participation will be increased if coverage is a prerequisite for participation in other USDA programs and will bring more floodplain farmers into the program. The Act also attempts to reduce the demand for ad hoc disaster assistance.

ENDNOTES

1. In 1992 after Hurricane Andrew, President Bush tasked the Secretary of Transportation with recovery and in response to the 1993 flooding disasters, the secretary of Agriculture was tasked.

2. Director of the Office of Management and Budget; memorandum to heads of agencies on non-structural floodplain measures and flood disaster recovery, July 10, 1980.

3. Memorandum of Agreement on Interagency Hazard Mitigation. Signed by 13 federal agencies, December 16, 1980.

4. The Federal Interagency Floodplain Management Task Force was established in 1975 within the U.S. Water Resources Council. In 1982, OMB assigned its responsibilities to FEMA, which assumed the role of chair. See Federal Interagency Floodplain Management Task Force, *A Unified National Agenda for Floodplain Management* (draft), FEMA Document 248, (Washington, DC: FEMA, April 1994).

5. Memorandum of Agreement between the USDA Soil Conservation Service, and the U.S. Department of the Army, May 20, 1986.

6. Krimm, Richard W., Associate Director, Federal Emergency Management Agency, memorandum, May 9, 1994.

7. Federal Emergency Management Agency, Federal Insurance Administration, computer print-out SRR1387C, March 16, 1994.

8. "Status of Individual Assistance Activities for Major Disasters in the Midwest," Federal Emergency Management Agency, (Washington, DC: FEMA, April 14, 1994).

9. U.S. Department of Commerce and U.S. Department of Housing and Urban Development, *"American Housing Survey Data Chart,"* (Washington, DC: DOC and HUD, 1989).

10. Developed by the committee from computer data provided by the FEMA Federal Insurance Administration, May 1994.

11. Miranda, Mario J., "Area-yield Crop Insurance Reconsidered," *American Journal of Agricultural Economics,* 72:233-242 (May 1991).

12. Miranda, Mario J., and Joseph W. Glauber, "Providing Crop Disaster Assistance Through a Modified Deficiency Payment Program," *American Journal of Agricultural Economics,* 72:1233-1243 (November 1991).

13. U.S. General Accounting Office, *Disaster Assistance: Crop Insurance Can Provide Assistance More Effectively Than Other Programs,* Report to the Chairman, Committee on Agriculture, U.S. House of Representatives, GAO/RCED-89-211, (Washington, DC: GAO, September 1989).

14. Nelson, Carl H., and Edna T. Loehman, "Further Toward a Theory of Agricultural Insurance," *American Journal of Agricultural Economics,* 69: 523-531 (August 1987).

15. U.S. Department of Agriculture, Federal Crop Insurance Corporation, "1994 Guide to Crop Insurance Protection: Risk Management for the 90's," Management Support Branch Report (Washington, DC: USDA, 1994).

Part III

A FRAMEWORK PLAN FOR THE UPPER MISSISSIPPI RIVER BASIN

Chapter 10

A NEW APPROACH FOR THE UPPER MISSISSIPPI RIVER BASIN

...we need a comprehensive strategy to substitute for what has been the piece-by-piece building of our levee system in the Upper Mississippi. The River is a single system. Actions in one place to keep water out mean that pressure elsewhere along the system increases, often with adverse effects on other communities...

Richard Gephardt
House Majority Leader
October 1993

Earlier chapters of this report have suggested a new approach for floodplain management, including collaborative planning by all stakeholders, i.e. local, tribal state, and federal governments, businesses, and the people who occupy floodplains either through choice or happenstance. The Review Committee has addressed floodplain management issues from both a national perspective and as they apply to the flood-affected nine-state area. This chapter, in response to the Committee's charge, considers the current state of the upper Mississippi River Basin, considers improvements to the present situation, and suggests ways to apply new approach to those improvements.

DEALING WITH THE RIVER SYSTEM AS A WHOLE

The upper Mississippi River Basin is affected by a complex of independently managed federal programs for navigation and flood damage reduction, water quality improvement, natural resources protection and enhancement, and agricultural production. To coordinate and sustain water resources development consistent with national floodplain management goals, these programs need to be integrated using existing or modified institutional arrangements among federal, state, tribal, and local agencies. The federal sector, however, must first set an example by coordinating programs across its agencies.

Currently no single entity has federal or federal-state oversight responsibility for the range of activities within the upper Mississippi River basin, or for ensuring that funding and performance among programs are commensurate with national goals. The Review Committee found no single hydraulic or hydrologic model and no system-wide flood reduction strategy or ecosystem management strategy within the basin. Linkage exists among system components, but separate federal agencies deal with component problems independently. With the demise of the river basin planning institution embodied in the Water

Resources Planning Act of 1965 (PL 89-80), the coordinated basin-scale approach lost prominence in American water resources planning in favor of more generic and site-specific solutions.[1] This state of affairs exists despite the tenets of the *P&G* and the NEPA that call for direct, indirect, and cumulative impact analyses and integration of regional federal actions. The situation is exemplified by the number of separate activities currently underway in the basin, such as the Missouri River Master Manual Review and Update Study, the Upper Mississippi River-Illinois Waterway Navigation Study, the Upper Mississippi River Basin Floodplain Management Assessment, the Missouri River Mitigation Project, the Upper Mississippi River Environmental Management Program, and many USACE studies directed at improving or building individual levee projects in the basin.

REDUCING THE VULNERABILITY OF THOSE IN THE FLOODPLAIN

Three situations made evident by the 1993 flood point to the need for reducing the vulnerability of those in the floodplain of the upper Mississippi River Basin. First is the hazard of being in the floodplain. The 1993 flood was a major natural event but floods of even greater magnitude or over a larger area could occur any time. USGS staff reported to the Review Committee that only 30 percent of the streamgaging stations in the flood-affected area recorded discharges having greater than a 10-year recurrence interval and less than one in ten recorded flowrates greater than that of the 100-year flood. Another factor to consider is the presence of the New Madrid Fault, which has potential to create seismic damage to structures over an area encompassing many of the 1993 flood-affected states. This points to the need for multi-hazard planning in known hazard zones. Second, the federal government is being asked to restore much of the pre-flood structural system on an individual project basis without knowledge of system-wide benefits or costs. Structures, lives, and livelihoods will remain vulnerable to damage even with complete restoration of levees and despite buyouts and relocations. Third, the flood-related, landscape-shaping processes witnessed in the 1993 flood will recur, and these processes will help define compatible uses of the floodplain. Some areas will remain more inherently risky to occupy or develop than other areas.

Current Approaches To Flood Damage Reduction

Development of flood damage reduction strategies in the upper Mississippi River Basin contrasts sharply with that in the lower basin. From the mouth of the Ohio River downstream almost to the Gulf of Mexico, the nation has an integrated system of federally planned, designed, constructed, and maintained facilities. The system includes main stem and tributary levees, floodway bypasses, interior drainage pumping stations and flood storage dams. In the upper Mississippi River Basin, most flood damage reduction facilities were not constructed in accordance with any system plan but were developed on a project basis by a host of individuals, drainage and levee districts, and the federal government.

Major tributary and main stem flood storage reservoirs in the Missouri River Basin were developed by the USACE and the Bureau of Reclamation as part of the Pick-Sloan Plan (Chapter 2). However, the systematic approach for building main stem levees offered by the Pick-Sloan was never fully implemented. Many levees were constructed by local owners without consideration of the Plan's provision to set levees sufficiently back from the riverbank to retain the floodplain's capacity to convey floods. The result is a collection of federal and non-federal facilities of greatly varying structural integrity, providing widely varying levels of protection for similar land uses, and placed, in some cases, upon the floodplain without full regard to their impacts on the river upstream, across or downstream. Some levees were sited without adequate consideration of physiographic features, the forces the river itself imposes upon them during flood, or their riparian environment. For most of the past 60 years, construction of structural measures was the primary method chosen for flood damage reduction. Under the new approach, nonstructural measures, consideration of

basin-wide hydrologic and river hydraulic processes and ecosystem functions would weigh heavily in project planning and design. Structural flood damage reduction projects have been built throughout the upper Mississippi River Basin. These projects should be reviewed and in-depth consideration given to modifications that will achieve floodplain management goals.

Levees

By some counts, over 8,000 miles of levees of various descriptions exist in the upper Mississippi River Basin (Chapter 2). They represent a mix of age, ownership, size, purpose, and quality. Most levees, other than those connected with the navigation system, have their origins in effort by communities, individuals, and groups to protect their land from flooding. They date back, in many cases, to early settlement. Since passage of the 1936 Flood Control Act, many levees have been upgraded or replaced by federal construction and are maintained by local owners or sponsors. Others, built and maintained by local owners, are eligible for post-flood emergency repair under the USACE PL 84-99 program. Eligibility for inclusion in the USACE program requires that a levee be a primary one that provides an adequate level of protection, that it be sponsored by a public entity, that the sponsor maintain the levee to a standard established by USACE, and that the cost of any levee repair be shared: 20 percent by the local sponsor and 80 percent by the federal government. Local sponsors also provide all lands, easements, and rights-of-way needed for repairs. Levees not in the USACE program tend to be smaller, single-owner structures of those publicly sponsored levees whose sponsors did not desire to maintain them to USACE standards.

These levees constructed by different agencies and individuals at various times and under various times and under various programs, have very few common characteristics. Their physical composition varies by reach of the river. Some are on the riverbank while others are set back appropriately to permit flood flow conveyance. Many of those built in areas subject to swift currents during floods or over formerly active channels are destined to fail again and again. Most non-federal levees were built without any substantive understanding about impacts on river hydraulics and the riparian environment. Many of the federal levees were built prior to the availability of river hydraulic models and geologic maps that could provide such needed information. In some cases flows have increased for the same meteorological conditions because of upstream development. Determination of the level of protection provided by a levee is an important piece of information frequently difficult to obtain.

Natural Resources

From the ecosystem perspective, current flood-reduction strategies have direct effects on the floodplain resources and functions at locations where they were implemented, and indirect effects elsewhere in the system (Chapter 2). The lower Mississippi River currently is receiving hydrologic restoration through installation of water control structures in selected interior areas. The upper Mississippi River is receiving ecosystem restoration attention through the Environmental Management Program. The Missouri River, however, remains one of the most highly impacted and least attended floodplain ecosystems. The watersheds of those floodplains receive varied attention through federal programs.

The assemblage of levees described in the preceding section may be considered a metaphor for natural resource management on these rivers. System-wide, coordinated, and integrated management of the Mississippi River ecosystem is not currently a defined objective of any agency, nor is such an approach a part of agency operational plans at the regional or local levels.[2] The Review Committee has found this to be a case with the Missouri River as well. Although several federal agencies have complementary goals and the NEPA establishes a common environmental goal for all federal agencies, no single agency serves as the necessary focal point for ecosystem protection needs in ongoing water management decisions.[3] Separate government programs address land use, nonpoint source pollution, major point sources of pollution, wetlands, and a host of other environmental concerns. Failure to integrate such programs makes it difficult for land and water managers to achieve their goals.[4]

System Integration

It is now recognized that the combination of existing levees requires a systematic hydrologic and hydraulic analysis to determine flood-damage reduction efficiency. Federal agencies must become partners in conducting a system analysis of basin hydrology, hydraulics, and overall ecosystem condition. Future decisions regarding federal, state, and local investments will require assessment of the following:

- Impacts that levees may create as physical factors having hydraulic and ecological consequence,

- Effects of river regulation as a hydraulic and hydrologic factor having ecological and flood consequences,

- Effects of watershed condition as a hydrologic factor having ecologic and flood consequences, and

- Impacts of physical and hydrologic characteristics on economic productivity and of government policies as incentives or disincentives on decisions to develop the floodplain.

Detailed analysis of system hydrology and hydraulics will result in the means to evaluate levees for a variety of factors, such as current protection level, flood insurance, rate mapping, habitat restoration, flood storage and/or conveyance, and design modification to achieve any combination of objectives. At the same time, an ecological inventory and analysis of species-habitat relationships will provide a sound basis for cooperative decisions regarding river regulation, land acquisition, watershed planning, flood damage reduction, and mitigation activities. The assessment of economic productivity and effects of government policies will determine tradeoffs inherent in watershed planning choices. Many operational and administrative efficiencies should be realized subsequent to completion of system-wide analyses.

Administrative integration

To organize ongoing activities, the Review Committee sees the need for two levels of activity:

- A strategic level that will result in development of comprehensive plans for water and related land resource development. This strategy is embodied in the authorities of the basin commissions established under Title II of PL 89-80;

- An operational level such as that of the Mississippi River Commission, but with an expanded focus to include stewardship of the ecosystem that supports current and desired levels of development.

At the strategic level, utilization of a regional institutional framework for comprehensive planning was exemplified by the Upper Mississippi River Basin Commission (UMRBC). The UMRBC prepared a Comprehensive Master Plan for Management of the upper Mississippi River system in response to Section 101 of the Inland Waterways Authorization Act of 1978 (PL 95-502). Termination of the UMRBC and five other basin commissions by EO 12319 in 1981 complicated implementation of the master plan, which represented a successfully integrated federal-state-local planning effort with substantial public input. PL 99-88 and PL 99-662 ultimately authorized implementation of portions of the master plan, one element of which is the Environmental Management Program. This requires federal and state agency input to the USACE through the Upper Mississippi River Basin Association (UMRBA) is basically a policy research and coordination forum for the upper Mississippi River basin states. Because the UMRBA is a state initiative, the federal government has no voice in planning activities.

Action 10.1: *Establish upper Mississippi and Missouri basin commissions with a charge to coordinate development and maintenance of comprehensive water resources management plans to include, among other purposes, ecosystem management, flood damage reduction, and navigation.*

Reestablishment of the basin commissions will help decisionmakers reach fully coordinated floodplain management decisions within the larger context of

basin-level water resources planning and goals. Through minimal staffing with qualified leadership, the basin commission format, authority, and funding mechanisms provided by PL 89-80 will stimulate non-federal attention to timely completion, update, and implementation of multiple-use plans (Figure 10.1). The Review Committee considers basin commissions to be a necessary link between federal and state agencies and a coordination forum for implementing national policy. The basin commission structure is described in detail in Appendix I.

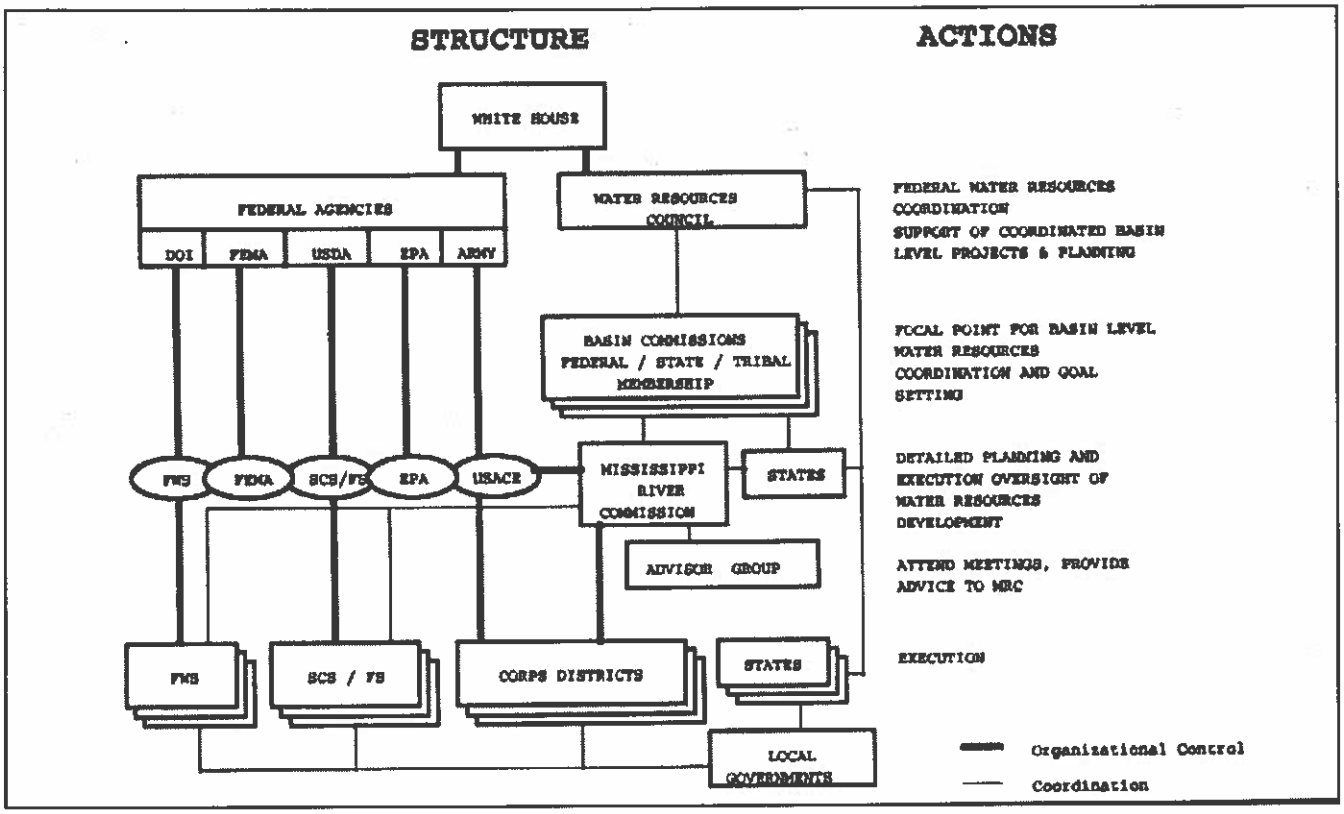
At the operational level, an institutional framework is currently in place to effect operational modifications of flood damage reduction and navigation facilities throughout the basin. The foundation of this framework is the technical capability on water resources found within the USACE. Beyond this technical capability, Congress provided for detailed project planning and implementation oversight on the Mississippi River by establishing the Mississippi River Commission (MRC) in 1879. The MRC Act authorized the Commission to extend its activities "between the Head of Passes near its mouth to it (Mississippi River) headwaters." Until the late 1920s the MRC was based in Saint Louis, Missouri, and was active in mapping the entire river. In 1928 the current Mississippi River and Tributaries (MR&T) project was authorized for the lower Mississippi River basin as a result of the devastating 1927 flood. Since then the MRC, which relocated to Vicksburg, Mississippi, has focused on the MR&T project, though it did continue to build levees in the upper Mississippi River Basin as far north as Rock Island, Illinois, until the early 1950s. For more than 60 years the MRC has focused attention on the MR&T project, but its authority still extends to the Mississippi River headwaters. The MRC reports program performance directly to the USACE Chief of Engineers and the White House. No similar framework or technical foundation is in place within one agency or between agencies responsible for natural resource protection or management within the upper Mississippi River basin. Of major importance, no direct connection exists between natural resource management and management of the river and floodplain for other uses.

Action 10.2: ***The Administration should expand the mission of the Mississippi River Commission to include the upper Mississippi and Missouri rivers. Further, to recognize ecosystem management as a co-equal federal interest with flood damage reduction and navigation, the Administration should request legislative change to expand commission membership to include the DOI.***

The Review Committee heard from a number of groups who expressed a desire for establishment of a coordinating body. Conversely many groups have expressed concern over this recommendation. Both pro and con positions are based on perceptions of the MRC and past action under MRC oversight, primarily the MR&T project. To many the MRC has been synonymous with big levees, uniform main stem river protection, and loss of habitat. The MR&T project began its 70-year development with a structural focus on navigation and a uniform level of flood protection on the main stem Mississippi River. In furtherance of national goals, the MR&T project supported development of agriculture. Environmental resources and natural floodplain functions were foregone. Over the last 20 years, in response to a shift in national goals toward environmental quality, the MRC has been adjusting the MR&T project to provide habitat restoration and environmental enhancement.

The expanded commission will provide for detailed planning and execution oversight of water resources development project, and it will assure appropriate fiscal attention to programs necessary for achievement of national floodplain management goals. The USACE Chief of Engineers and the Secretary of the Interior will receive annual commission reports on the performance of navigation, flood damage reduction, and ecosystem management projects. Because of the direct relationship between basin hydrology, river hydraulics, and floodplain ecosystem function, expanded membership of the commission will ensure coordination between multiple-use interests. The principal utility of the MRC

Figure 10.1 Proposed Institutional Framework



model is accountability. It is anticipated that multiple program integration and performance will be assured by assigning responsibility to a single entity, which answers directly to the public and the Administration. DOI membership is provided to ensure that its programs for ecosystem stewardship are fully integrated with other activities under MRC oversight. Because of the interrelationship of missions and responsibilities involving water resources, transportation, and emergency preparedness, the MRC advisor group membership must also include the DOT, FEMA, USDA, and EPA. Current and expanded river commission function and structure are suggested in Appendix I.

COORDINATION OF LEVEE ACTIVITY

At the same time that the Administration is considering long-term floodplain management objectives, the federal government has appropriated funds for the repair of many levees damaged by the 1993 flood. The actions proposed subsequently in this chapter and elsewhere in the report are not directed at stopping ongoing authorized activities but are presented to provide necessary integration among federal programs. Federal and state oversight over non-federally constructed levees is diffuse. Several states regulate construction in floodplains, but many do not. The situation is further exacerbated by the potential for future flow increases that could occur if development continues upstream and the uncertainty about changes that may occur in long term weather patterns. Without a systematic approach, a variety of levee problems will continue.

Action 10.3: *Assign responsibility for development of an Upper Mississippi River and Tributaries (UMR&T) system plan and for a major maintenance and rehabilitation program for federally related levees to an expanded Mississippi River Commission, operating under the USACE.*

The objective of developing the UMR&T system plan is to determine how best to integrate existing facilities in the upper Mississippi River Basin into an efficiently functioning flood damage reduction system that is compatible with floodplain ecosystem function. A component of the plan would incorporate all eligible levees in the upper Mississippi River basin into a program to ensure their long-term functional integrity for flood damage reduction and to improve ecosystem function. The functional integrity objective would be accomplished through a federal-state-local cost-shared program of systematic major maintenance and major rehabilitation. Routine maintenance and repair would continue to be a state-local responsibility. The ecosystem function restoration objective would be met by such measures as installation of water control structures in the levees to allow connection of the river with floodplain wetlands and former channels during non-floodplain wetlands and former channels during non-flood periods. These facilities would also be used to control flooding of areas behind levees when overtopping is imminent to avoid a levee breach and the consequence of catastrophic flooding. Involvement in the program by levee sponsors would be voluntary.

Development of such a plan will require a survey to evaluate and identify all levees on the main stems of the Mississippi, Missouri, and the Illinois rivers, for program eligibility and/or design criteria. The survey will include tie-back or flank levees on tributaries and those tributary levees currently in the USACE PL 84-89 program. During this survey, information can be gathered to form a foundation for systematic analysis of each levee under the objectives of system floodplain management and flood damage reduction.

The USACE is currently engaged in completing repairs to hundreds of levees under its PL 84-89 program. In addition the Congress has charge the USACE with completion of a Floodplain Management Assessment of the upper Mississippi River Basin by the spring of 1995.[5] This ongoing activity could, with congressional approval, be redirected in scope to take advantage of information gathered during the post-flood recovery and reconstruction process.

Action 10.4: *Seek approval from the Congress to redirect the USACE Floodplain Management Assessment of the upper Mississippi River Basin to development of an UMR&T systems plan. Place this assessment under the Mississippi River Commission operating under USACE.*

The refocused study would assess the condition of presently existing levees and would develop a general plan for basin flood damage reduction, including structural and nonstructural measures. Development of a flood damage reduction strategy should be collaborative and conducted using the revised *P&G* and the NEPA process to ensure full participation of affected and interested parties in floodplain management. The systemic approach will necessarily involve consideration of the upper Mississippi River Basin and the basin of its principal tributary, the Missouri River, as individual and aggregate watersheds with both unique and common human uses and ecosystem functions. Representatives of the USDA, FEMA, DOI, and EPA should participate on the study team because of their agency missions in watershed management, floodplain regulation, natural resources stewardship, and water quality protection.

Action 10.5: *Following completion of the survey, seek authorization from the Congress to establish the UMR&T project.*

Authorization of the UMR&T project is needed to assign responsibility to the USACE to develop and execute the federal program of major maintenance and major rehabilitation (MM&MR) of those levees found to be eligible for inclusion. The UMR&T project would be identified as a separate line item in the USACE budget and would be funded by annual appropriation.[6] Under the MM&MR program, the USACE would be responsible for major maintenance and major rehabilitation of levees that are

determined by the USACE to be eligible for the federal program. Major maintenance includes such activities as levee survey and setbacks; repair of levee slides, culverts and floodwalls; slope paving; and major erosion protection. The FY 94 MRC budget for repair of 1,600 miles of main stem levees in the MR&T projects is $4.9 million. Although by comparison the total length of levees in the UMR&T project would be greater, they are smaller in size and the river depths and velocities are lower. Thus the annual cost of major maintenance for the proposed UMR&T project is expected to be the same order of magnitude as for the MR&T project. The cost of major rehabilitation is one of either pay now or pay later; money not spent in a systematic way to rehabilitate aging levee drainage pumping facilities, culverts, gate structures and like facilities will be spent making emergency repairs during and after floods. The federal cost of repairing levees in the upper Mississippi River Basin that were damaged during the 1993 flood is expected to amount to $300 million.

To be eligible for inclusion in the MM&MR program, levees would have to be of such construction as to meet the USACE engineering standards for structural integrity and for proper siting, and they would have to be in good standing in the current USACE PL 84-99 program (or be working toward that end under the 1993 flood-recovery effort). Local levee sponsors would include the states as co-sponsors, and would have to be a part of a community enrolled in the NFIP, agree to obtain structure and crop insurance (in the amended program), limit floodfighting, and participate in environmental enhancement activities. For details of the MM&MR program, see Appendix H.

Role of the States

Levees not currently eligible for emergency repair under the PL 84-99 program, and thus not eligible for the UMR&T project, should be regulated by the states when changes are made for either repair, rehabilitation, realignment, or improvement. Future inclusion of a levee in the PL 84-89 program would require, in addition to meeting current USACE eligibility criteria, acknowledgement by the state that the levee is publicly sponsored, does not cause adverse river hydraulic conditions elsewhere, and provides an appropriate level of protection. A levee that subsequently becomes eligible for the PL 84-89 program would require congressional authorization to become eligible for inclusion in the UMR&T project. Levee sponsors and owners who choose not to participate in the PL 84-89 program and those ineligible for participation will not receive federal assistance for repair of damaged levees. This may not preclude assistance under the USDA Emergency Watershed Program.

As discussed elsewhere in this report, not all states in the upper Mississippi River Basin have a permit program whereby either proposed or existing levees are reviewed for compliance with state-established standards for design, construction, maintenance, and repair. Few if any control either the decision about where levees are placed relative to the river channel or whether a particular levee should be protected from overtopping (floodfought) during a flood, although such actions can have hydraulic and environmental consequence elsewhere. The Review Committee found that some states have little or no involvement in the processes associated with federal levee programs since federal agencies generally deal directly with levee districts. Given these circumstances and the number of levees damaged in the flood of 1993, it is clear that there is need for greater involvement of the states in the design, construction, maintenance, and repair of levees.

Recommendation 10.1: *Where they do not already do so, states should assume responsibility for regulating levee-related activities such as levee location, alignment, design, construction, upgrade, maintenance, repair, and floodfighting.*

This is not a call for levee construction but for state oversight of levees to assure their structural integrity and that actions in one location along the river do not create adverse impacts elsewhere.

Using current technology, the states have the capability to assure that existing levees are properly located and aligned to avoid or minimize hydraulic impacts and to avoid high energy, damage-prone locations on rivers. Using a levee permit program, states could also assure that the

embankment and foundation conditions meet engineering and environmental standards, that the level of protection afforded is commensurate with land use, that maintenance and repair are performed to assure structural integrity, and that floodfighting is limited to areas deemed critical by the state.

ECOSYSTEMS NEEDS

Although federal and state agencies recently have articulated general policies regarding pursuit of ecosystem management, they need a coordinated, multi-agency, ecosystem-based plan upon which to base water resource and floodplain management decisions. Pursuit of watershed planning requires a single hydrologic/hydraulic model. It also requires development of a natural resource baseline against which agencies can develop and implement appropriate maintenance or restoration plans within their areas of jurisdiction or expertise.

Ecosystem planning strives to protect or restore the function, structure, and species composition of an ecosystem, recognizing that all components are interrelated. The Review Committee recognizes that agriculture is the dominant land use in the upper Mississippi River Basin. Ecosystem planning, therefore, will necessarily include agriculture and forestry as vital contributing elements to ecosystem function and values. The FWS recognizes that the initial step to ecosystem planning is the identification of natural resource needs.[7] Information on the distribution, abundance, and ecological relationships of species and a comprehensive inventory and classification of ecosystems are fundamental nationwide needs.[8] Such information is largely incomplete for the upper Mississippi River Basin[9], and the Review Committee found that funding and support for the effort have been lacking. Ecosystem information is critical for setting resource objectives, examining alternatives within multiple-use planning, and implementing solutions. Additional uses of this information include scientifically sound input to ongoing flood damage reduction, navigation, private lands, water quality, and watershed programs of other agencies.

Action 10.6: *DOI should complete an ecological needs investigation of the upper Mississippi River Basin and provide a report to the Administration within 30 months.*

The ecological needs investigation would be collaborative between government agencies and private groups. It would incorporate information from the NBS, under the Long Term Resource Monitoring Program, the USACE, the USDA National Resource Inventory, and the Review Committee's Scientific Assessment and Strategy Team. An interim report will be necessary to assist activities described subsequently for Action 10.9. This interim report should be completed prior to August 1995. The final report would provide the necessary focal point from which government agencies could develop coordinated management strategies that reflect true resource needs, measure response to those strategies, and refine further research needs.

Ecosystems components have value for national trust resources such as migratory birds, wetlands, and interjurisdictional fisheries. It is anticipated that the investigation will identify missing components and contribute to understanding the mechanisms that move organisms toward endangered species candidacy. It also will assist avoidance of development conflicts resulting from endangered species listing.

Action 10.7: *Provide an early report in the USACE Upper Mississippi River - Illinois Waterway Navigation Study of environmental enhancement opportunities in the upper Mississippi River.*

COMMERCIAL NAVIGATION AND RECREATIONAL USE OF THE UPPER MISSISSIPPI RIVER

The upper Mississippi River 9-foot depth navigation project provides a wide range of recreational uses (from hunting, fishing, boating, and swimming, to sightseeing). Such recreational use supported over $1.2 billion in national economic benefits in 1990 (1990 price levels) and over 18,000 jobs. Boating (33.2%), fishing (28.8%), and sightseeing (15.8%) were the most popular activities. Visits included 62.7% to developed areas, 26.3% to marina slips, 7.0% to sightseeing areas, and 4.0% to permitted docks. Management of the project for commercial navigation produces some impacts on their natural and recreational resources, including conflicts between recreational and commercial use of the locks.

Using information generated during the DOI ecological need investigation, the USACE should develop a report detailing the relationship of its ongoing operation and maintenance activities as well as those of new navigation construction alternatives to ecological needs identified by the DOI. Because the Review Committee recognizes the value of identifying and acting on environmental enhancement opportunities as soon as possible, it is imperative that the USACE establish this report as a milestone in the overall schedule for the Navigation Study. The milestone will be based on the DOI investigation. The Review Committee recognises that the DOI investigation will be collaborative with the USACE and that establishment of the milestone will not affect the overall schedule for the Navigation Study.

A potential opportunity to enhance upper Mississippi River resources exists through alteration of dam-regulation operations (at-dam vs. mid-pool hinge control points) on some headwater pools at the USACE navigation dams.[10] With little or no impact to navigation, habitat benefits may be gained by alternately drying and inundating areas adjacent to the main channel between a navigation pool midpoint and the dam.

Action 10.8: *Provide a report on the ecological effects of relocating navigation pool control points under the USACE Navigation Study.*

A complete evaluation of navigation dam operations should be conducted under the ongoing USACE Navigation Study to determine if moving navigation pool control points from mid-pool to the dam is feasible and would produce significant benefits. Currently a similar interagency investigation is underway for Lock and Dam 25 on the upper Mississippi River. The Review Committee endorses this effort and would support expansion of the investigation, as necessary, to other facilities. If feasible from the standpoints of navigation and the acquisition of needed lands, and if benefits are significant, modification of water control plans should be implemented.

The Environmental Management Program (EMP) on the upper Mississippi River includes a major habitat rehabilitation component. Land acquisition, however, has not been utilized in alternative development, as a point of Administration policy. This has hampered habitat

rehabilitation efforts along the Illinois and middle Mississippi rivers, where few federal lands occur, even though these are the reaches in most need of rehabilitation.

Recommendation 10.2: *The USACE should consider land acquisition as an alternative during planning and design of habitat rehabilitation and enhancement projects under the Upper Mississippi River Environmental Management Program.*

This change would improve the effectiveness of the program, and could help to meet both environmental and flood flow attenuation needs. The Review Committee supports the efforts of state and federal EMP partner agencies in their pursuit of additional appropriations to support EMP land acquisition.

The upper Mississipps River Basin should be used as a demonstration ecosystem study area under the current National Performance Review's (NPR) "Reinventing Environmental Management" action item (Env 02 Develop Cross-Agency Ecosystem Planning and Management).[11] The study should be undertaken by the FWS to take advantage of other ongoing initatives in the Missouri and Mississippi river basins, as well as the information obtained through Action 10.6.

Action 10.9: *The Administration Interagency Ecosystem Management Task Force should select an Ecosystem Management Demonstration Project within the upper Mississippi River Basin, and establish a cross-agency ecosystem management team under DOI to develop plans and budgets for the project.*

Cross-agency partnerships have already been forged on the upper Mississippi and Missouri rivers through a variety of coordination mechanisms. Given the existence of these coordination groups, attainment of the NPR goal of August 1995 for completion of initial ecosystem management plans is possible. Expanding existing partnerships to develop measurable objectives for protection of existing resources and restoration of missing system components will require selection of one federal agency to serve in a lead capacity. While agency priority and budget adjustments will be necessary, this action is seen largely as a focused coordination effort and is not intended to represent a significant impact to the federal budget. Over time this coordination should result in elimination of duplicative efforts and their costs. DOI representation on the MRC will assure integration of the Demonstration Project with other MRC activities.

ENDNOTES

1. Executive Order 12319 -- River Basin Commissions, September 9, 1981, 46 FR 45591, 3 CFR, 1981, p. 175; PL 89-80, 22 July 1965, (1965 Water Resource Planning Act-79 Stat. 244,42 USC 1962); Platt, Rutherford H., "Geographers and Water Resource Policy" in *Water Resources Administration in the United States: Policy, Practice and Emerging Issues.* (East Lansing, MI: American Water Resources Association/Michigan State University Press, 1993).

2. Upper Mississippi River Conversation Committee, *Facing The Threat: An Ecosystem Management Strategy for the Upper Mississippi River,* (Rock Island, IL; UMRCC, 1993

3. Section 101 (a) of the NEPA of 1969, as amended. (PL 91-190, 42 USC 4321-4347, January 1, 1970, as amended by PL 94-52, July 3, 1975, and PL 94-83, August 9, 1975); Long's Peak Working Group on National Water Policy, *America's Waters: A New Era of Sustainability,* (Boulder, CO: Natural Resources Law Center, December 1992).

4. Council on Environmental Quality, "Linking Ecosystems and Biodiversity," in *Environmental Quality: Twenty-first Annual Report of the Council on Environmental Quality,* (Washington, DC: CEQ, 1990).

5. 1994 Energy and Water Development Appropriation Act, U.S. Congress, HR 2445 and House Resolution (Docket 2423, November 3, 1993).

6. Some federal government reviewers of the draft report expressed concern for increasing USACE responsibility without providing commensurate budget increases.

7. U.S. Department of the Interior, Fish and Wildlife Service, "An Ecosystem Approach to Fish and Wildlife Conservation," (Washington DC: FWS, 1994).

8. Ibid.

9. *Facing the Threat.*

10 Sparks, R.E., "Can We Change the Future by Predicting It?" *Aquatic Ecology Technical Report 93/19,* (Havana, IL: Illinois Natural History Survey, 1993)

11. National Performance Review. *Creating a Government That Works Better and Costs Less, Reinventing Environmental Management, Accompanying Report of the National Performance Review,* (Washington, DC: Government Printing Office, September 1993)

Part IV

INTO THE 21ST CENTURY



Chapter 11

USING SCIENCE AND TECHNOLOGY TO GATHER AND DISSEMINATE CRITICAL WATER RESOURCE INFORMATION

Policy decisions are being made in a data vacuum. Yet we are now in an era when the ability to collect and use field data has been greatly augmented by satellite and computer based technologies. There is an immediate need to provide a comprehensive inventory of damaged buildings, damaged infrastructure, impacted lands, and natural areas for conservation and restoration.

Association of State Floodplain Managers
Testimony before Congress, October 27, 1993

Science and technology can be utilized to improve the gathering and dissemination of information critical to water resources management. Floodplain managers need easy access to information about natural and manmade physical features, cultural resources, living resources, climatology, and hydrology of the basins in which they operate. In some flood-related areas, however, the social and physical sciences have knowledge gaps that require research.

Recommendations to improve basic knowledge and provide technical services required for floodplain management were made in 1966 in House Document 465, *A Unified National Program for Managing Flood Losses.*[1] At that time, some of the recommendations were unrealistic. In 1994, however, advances in science and technology now make many of them possible.

A COMMON DATABASE

Vice President Gore's National Performance Review (NPR) contains recommendations regarding the use of information technology to create a government that works better and costs less. The NPR advocates creation of a national spatial data infrastructure that would establish standards for data collection and cataloging and create a clearinghouse for finding, accessing, and sharing spatial data, in addition to addressing related issues.

As indicated in the NPR report, "Data collection is duplicated at the federal, state; local, and private levels for different purposes. Moreover, different entities are often unaware that much-needed data have already been acquired by another party. Even when specific spatial data are knownto exist, non-standardized collection procedures and lack of easy access often restrict their use."[2]

The most difficult task for the Review Committee was compiling useful data regarding the upper Mississippi River Basin. Basic information such as the amount of damages from the 1993 floods and the amount of expenditures related to disaster response and recovery

were not readily available, nor easily obtainable. Data assembled from a variety of sources were difficult to use because they were neither spatially referenced nor were they in compatible formats or structures. Precise answers to many questions were difficult, if not impossible, to obtain. For example: How many structures are in 100-year floodplains along the Mississippi and Missouri rivers? How many structures were affected by the flood? Where were levees located and what level of protection did they provide? How many people applied for assistance in a given county or community? Where is critical infrastructure located with respect to the floodplains? What is the expected flood crest, given a certain flow in the river? During a floodfight, the availability of such information is key to decisionmaking. Other data, such as the boundaries of the 100-year floodplain, were not in digital format and had to be digitized. Neither the public nor the nonprofit sectors uniformly apply Federal Information Processing Standards (FIPS) in collecting pre-disaster, response, or recovery data.

The SAST gathered information and geographically referenced data regarding the physical and environmental characteristics of the basin. The team collected several hundred gigabytes of information with the help of states, local communities, and federal agencies. The nation needs to continue maintaining and sharing the results of this effort with all entities having an interest in the upper Mississippi River Basin and to develop this database as a prototype for other future regional efforts. The USGS would be an appropriate lead agency to achieve this.

Action 11.1: *The USGS should establish a federal clearinghouse for data gathered during preparation of the Review Committee report.*

To manage floodplains, mitigate flood damages, and respond to and recover from a disaster, analysts and decisionmakers require easy access to basic data to audit disaster expenditures, identify loss concentrations, and formulate new preparedness and mitigation strategies. The USGS, in coordination with the Federal Geographic Data Committee, should take the lead in establishing a federal clearinghouse consistent with that outlined in the NPR for accessing and updating data acquired and developed for the flood-affected 9-state region in the Midwest. The SAST effort demonstrates the benefits of leveraging science and technology. The nation should share its findings with states, communities, and all interests in the upper Mississippi River Basin. Consideration should be given to the establishment of a multiagency committee to assist present and future users of the data.

BUILDING ON THE DATABASE

Advances in science and technology enable improvements to be made in data acquisition, hydrologic and hydraulic analysis, flood forecasting, and mapping.

National Inventory of Structures

The Review Committee was unable to obtain definitive numbers on how many structures were impacted in the Midwest Flood of 1993. Estimates ranged from 55,000 to 100,000 structures. It was also difficult to estimate the level of NFIP market penetration without time- and labor-intensive studies. These are two tasks that could easily be accomplished if a national inventory of structures existed. Nationwide, there is no authoritative estimate of the number of structures exposed to floods and other natural hazards. As a result, floodplain and emergency management decisions are often made based on inadequate information. This results in inappropriate allocation of resources.

Action 11.2: *FEMA should investigate the costs and feasibility of completing a national inventory of floodprone structures.*

A national inventory of floodprone structures should be performed by FEMA through the states and tribes to determine the number, location, building type, and functional uses of structures in floodplains. Technology

certainly makes such an inventory feasible. These data and the risk analysis that would become possible for the first time could allow the nation to focus mitigation and pre-disaster planning at specific areas of high risk. At the same time, funding for these activities could be targeted and adjusted in relation to the degree of exposure to the relative risk. In the event of a disaster, an immediate assessment of response needs would be available in summary format. This information would also enable targeting specific addresses to inform residents of the flood risk and the availability of insurance. Other potential users of such a database are communities, lenders, planners, citizen groups, and underwriters. This database would serve as a cornerstone in the national spatial data infrastructure recommended in the NPR.

Hydrologic, Hydraulic, and Hydrometeorologic Analysis

The Review Committee originally wanted to answer some questions about flow characteristics for the entire reach of the Mississippi River from Cairo to St. Paul and for the Missouri River from its mouth to Gavins Point. A model to accomplish this task, however, does not exist. Five USACE districts are involved in managing these river reaches, and the models used by each differ. Additionally, the availability of topographic data is limited to only certain river reaches.

Current one-dimensional models are unable to satisfactorily model the complex condition of flow in large rivers where water moves into large storage areas in the overbank floodplain and where land cover varies both in the cross section and along the length of the river. The most widely used model for flood elevation determination is HEC-2, a steady-state, one-dimensional, rigid-boundary model that cannot simulate levee breaches or take storage effects into account. UNET, a one-dimensional unsteady-flow model used by the Review Committee to model a portion of the basin, has the capability to assess impacts of levee breaches and associated storage effects. A system-wide, unsteady-flow model of the main stem rivers in the upper Mississippi River Basin would help evaluate the impacts of proposed structures and floodfighting, and could be used for coordinated ecosystem modeling, and for floodplain management decisions. Further, advanced hydrologic and hydraulic models can be combined with meteorologic observations and forecasts to provide information to enable better floodplain and water resources management.

Action 11.3: *The USACE, NWS, and USGS, with other collaborators, should continue development of basin-wide hydrologic, hydraulic, and hydrometeorologic models for the upper Mississippi River system.*

Federal, state, tribal, and local agencies should develop coordinated estimates of floodflow frequency curves, flood elevation profiles, and floodplain maps. Overall improvement in the modeling of complex river systems will lead to advances in hydrologic prediction capabilities for both real-time forecasts of flood events and for water-resources planning. Floodplain managers should consider one- and two-dimensional models for modeling complex areas.

Flood Risk Assessment

Models used for determining flood heights require current estimates of flood discharges. Maintaining up-to-date estimates of discharge-frequency curves requires that they be reviewed as the period of hydrologic record increases and whenever new peak flowrates are recorded. By doing so, the representative sample of the parent population of hydrologic event data is enlarged and the estimate of the frequency of occurrence associated with a given discharge is improved. The 1993 flood established new peak discharges on many tributaries and on major reaches of the main stem rivers. Discharge-frequency curves should be reevaluated to reflect the new data.

In addition, the adequacy of the existing streamgaging network for defining regional flood risk should be evaluated and the network enhanced if necessary. Enhancements coud include reactivation of discontinued streamflow gages or establishment of new gages at critical locations where flood risk is not reliably defined.

Recommendation 11.1: ***Federal water agencies, in collaboration with state, tribal, and local entities, should review and update, as necessary, discharge-frequency relationships for streamflow gages in the upper Mississippi River Basin to reflect the 1993 flood data. The adequacy of the existing streamgaging network should also be reviewed.***

In 1979 the USACE estimated flood discharges for the upper Mississippi River corresponding to the 5-, 10-, 50-, 100-, and 500-year frequency floods. Water surface profiles for the Mississippi River developed from these discharge frequency curves form the basis for FEMA's flood insurance rate maps for the areas along the Mississippi River. This is an example of the use of discharge-frequency curves and indicates the importance of keeping them representative of present conditions.

Federal Standards for Determining Flood Risk

Currently, the method of computing the relationship between annual flood peak discharge and frequency of occurrence is standardized among federal agencies.[3] Though this method was reviewed less than ten years ago, the magnitude of the 1993 flood and its possible effects on discharge-frequency curves for stations in the upper Mississippi River Basin provide the opportunity to ascertain the adequacy of the recommended method to reflect the probability distribution of annual peak discharges.

Action 11.4: ***The Hydrology Subcommittee of the Federal Interagency Advisory Committee on Water Data should review the current standards for computing discharge-frequency relationships in light of observations from the 1993 flood and other recent large floods in the upper Mississippi River Basin.***

Frequency curves are generally developed using the current federal standard distribution function (log-Pearson Type III) for annual peak discharges. This methodology should be reviewed. The bases for concluding which method produces the most representative relationships should include, in addition to probability theory itself, the end uses of the curves such as selecting the heights of flood protection facilities, evaluating the degree of risk of a site or a structure, determining regulatory floodplain limits, and establishing flood insurance rates.

Flood Forecasting

State and local authorities need river stage and discharge information for emergency situations, for local flood relief efforts, and for floodplain management. During the Midwest flood, conflicting estimates of flood crests created difficulties for local emergency response efforts. Especially important for floodwarning and forecasting are the presence of streamflow gages at location critical for providing flood alert for downstream populations center, and capabilities for remote sensing of gages, data transmission, and communications with other agencies. The NWS, USGS, and USACE should collaborate on a study of the effectiveness of the existing flood monitoring and information distribution system.

Recommendation 11.2: ***Federal agencies, coordinated by NWS and USGS, should collaborate on an assessment of the effectiveness of the streamgaging network and flood forecasting during the 1993 Midwest floods.***

This assessment should include an evaluation of the ability of the present streamgaging network to monitor the Mississippi River system and provide the public with timely and reliable flood warnings. The assessment should identify gaps, inconsistencies and areas of duplication in the present system and make recommendations on improvements. NOAA's *Natural Disaster Survey Report*[4] identifies the need for improvements to real-time hydrologic forecasting and provides 106 findings and recommendations resulting from an interagency evaluation of the 1993 Midwest flood.

Mapping

Critical to the development of any computer model used to estimate flood elevations is detailed topographic information. Engineers can use topographic information in a digital format more efficiently in computer models. Topographic information of the appropriate resolution or accuracy does not exist in a digital format for many locations in the flood-affected 9-state region of the Midwest, or in the nation, at a scale useful for floodplain management or for use in engineering models. Floodplain managers generally prefer contour intervals of two feet or less. Technologies are beginning to emerge that will produce accurate, high resolution digital elevation models at reasonable costs. Such models soon will be generally available.

Action 11.5: ***The Administration should support the USGS in development and acquisition of detailed digital topographic data and other land characteristics for use in floodplain management and other water resources management activities. Existing DOD technologies should be leveraged to assist in the acquisition of these data.***

Floodplain managers use detailed topographic data and other land characteristics in floodplain areas for many applications, such as floodplain boundary delineation, habitat and land cover/land-use mapping, and restoration projects.

MAPPING TECHNOLOGY TRANSFER INIATIVES

NASA has developed a scanning laser device (LIDAR) that operates from a commercial aircraft and collects fine- resolution, digital terrain data used in hydraulic models. The Houston Advanced Research Center, in coordination with NASA, developed an aircraft-mounted prototype suitable for a wide range of commercial applications. Concurrent with the LIDAR data, the prototype acquires high resolution color video imagery that can be digitally draped over the terrain data to visualize land use. NASA will conduct a system demonstration for an area downstream of Gavins Point Dam in June 1994.

The DOD Advanced Research Projects Agency (ARPA), working in conjunction with the USACE Topographic Engineering Center, is sponsoring the use of IFSARE (InterFerometric Synthetic Aperture Radar for Elevation), a radar technology employing a Lear Jet data-collection platform. Fine-resolution digital terrain elevations, as well as synthetic aperture radar (SAR) imaging will be generated by this system. The Environmental Research Institute of Michigan and the Jet Propulsion Laboratory are principal contributors to this program. Data have been acquired in the vicinity of Iowa City, Iowa, to provide sample data for applying this technology to the development of hydraulic models.

NASA, the USGS, and the USACE have agreed to participate in a test of these technologies along a reach of the Missouri River in the vicinity of Glasgow, Missouri.

ANALYSIS AND RESEARCH NEEDS

The Review Committee investigated some of the benefits and costs of floodplain occupancy, agriculture uses, and associated floodplain management measures. This investigation considered national productivity, the impacts on natural functions, and the equitable distribution of benefits, costs, incentives, and disincentives. Federal programs provide for transfer of funds that support several types of private floodplain activities; for example, navigation, agriculture, flood control, and transportation. The National Science Foundation should consider funding research to examine fully the flood-related impacts on these areas.

Although the Review Committee devoted a good deal of its time to floodplain hazards associated with levees, other flood hazards warrant study. These include alluvial stream channels and storm drainage overflow and backup. The National Science Foundation and interested federal agencies should establish a cooperative, jointly funded program to develop methods for mapping, regulating and identifying natural functions in these areas. SAST data would form the basis for further investigation.

Studies on the epidemiological factors and mental health impacts of floods are few in number. Research regarding the social impacts of floods needs federal support. Other items warranting further investigation are the funding of disaster relief and support of floodplain agriculture. With regard to the NFIP, the reasons for limited flood insurance market penetration should be studied.

Many questions posed by the Review Committee remain unanswered because of time or resource constraints or a lack of information. Even where available, information often led to new questions and new areas to be explored. Listed below are several topics that merit additional study.

Quantifying and Assessing Environmental Impacts

Environmental quality and species diversity remain as social services not sold in conventional markets. Evaluation methods that do not depend on market prices are needed to estimate the benefits of such services. The non-market value to be estimated is the amount of income an affected person would be willing to give up for an environmental service. Where environmental outputs can be identified and effects can be monetized, these monetized environmental effects should be included in benefit-cost analyses.

Significant research exists on non-market evaluation techniques. Most of this research estimates recreation benefits rather than benefits of passive services such as ecosystem health. Economists use two primary approaches to estimate the value of non-market goods: an indirect approach and a direct one.[5] Indirect approaches, such as the travel cost method or hedonic analyses, are based on the premise that the value people place on services is revealed by the choices they make in consuming them. These techniques depend on the observation of human behavior in a particular circumstance and cannot be used for hypothetical situations such as wetland restoration.

The direct approach uses survey techniques to directly elicit a person's value or willingness to pay. The most widely used approach is the contingent valuation method, where respondents are presented with information about the proposed environmental service (either an improvement or degradation) and asked what the change would be worth to them. The direct approach can also be used to evaluate existence values (the satisfaction an individual receives from simply knowing an environmental amenity exists or will continue to exist, even though the individual will never use it) and non-existing or hypothetical situations that indirect methods cannot handle. The reliability of estimates from surveys in these situations is often questionable. Experience with the contingent valuation method indicates it can be successful in estimating values associated with recreation outputs for which the potential user is familiar, for which the product can be clearly defined, and for which a plausible market can be defined. Applications become less successful when the respondent lacks familiarity with the product or when

the amount, quality, or other attributes of the product cannot be clearly defined. This especially true in trying to measure changes in the quality of environmental amenities or other management actions.

Action 11.6: *The Administration should direct that scientific research be conducted to identify state-of-the-art techniques or applications for estimating and assessing environmental and social impacts.*

Research should identify practical methods and improved techniques to allow greater consideration of impacts, both positive and negative, for which no market system exists. Such research would assist in evaluating the economic value of an environmental output or the willingness to pay to avoid an impact. Research is needed to improve techniques for measuring social or environmental outputs and for establishing criteria to assess the significance of such outputs from a regional and national perspective.[6] Many federal agencies, universities, and private consulting firms are focusing on research in these areas. An organization such as the National Research Council of the National Science Foundation could foster this type of research, with federal oversight provided by the Office of Environmental Policy. The Administration should require that research and case studies be completed and recommendations made concerning appropriate state-of-the-art techniques within three years of initiation.

Geomorphology

Satellite imagery and data analyses provide evidence that some levee failures along the Missouri River coincided with historic river channels (see Figure 2.6). Evidence indicates that levees that were largely responsible for raising flood water to levels that generated the high energies necessary to overpower and blow the levees, creating the scour holes and generating the sands that damaged the very farmlands the levees were designed to protect. In many areas riparian forests had minimal flood erosion or deposition damage. These areas commonly coincided with levees that did not fail, indicating some protection was given to levees by riverward forested areas. Evidence also indicated that levees placed in high energy zones would not hold, even if it were possible to excavate all the sand from the old channel and place the levees on a clay core. This suggests that levees should not be reconstructed in such high energy erosion zones, but should be set back to allow high energy zones to remain within a designated, functioning floodway. A mix of compatible land uses, such as dry-year farming, open space, recreation, fish and wildlife habitat, could occur within high energy floodways. Any such use, however, should not be eligible for future emergency federal disaster assistance. A study is needed immediately to better define, ducument, and map such high energy zones, at least along the Missouri River.

Recommendation 11.3: *The USACE and USGS should investigate and better define relationships between high energy erosion zones, other zones in floodprone areas, and levee failure.*

Hydologic and Hydraulic Benefits of Natural Floodplain Functions

The federal government establisheds the Minnesota Valley National Wildlife Refuge in the lower Minnesota River valley near the Minneapolis/St. Paul metropolitan area, in part, to maintain the floodplain as part of a naturally functioning ecosystem and floodwater storage/conveyance mechanism. Although the government did not establish the upper Mississippi River National Wildlife and Fish Refuge as a mechanism for flood damage reduction and control, it may have played a significant role in reducing local flood damages in the upper Mississippi River valley. Nonstructural flood damage reduction and control capabilities of floodplain land uses such as green spaces and wildlife refuges have not received adequate evaluation.[7]

Environmental groups have identified upland wetland water-storage capabilities lost to drainage over the past century as contributing factors in the heights of the 1993 floods in the upper Mississippi River Basin.[8] At the same time, agricultural interests have indicated that drainage tiles (underground drains) installed to dry out wetlands and wet soils provided a positive benefit in reducing flood heights by voiding the soils of water and creating a capacity in the soils for water storage. Once rains exceed a threshold level,

however, and soil surfaces are sealed, the ability of rainwater to infiltrate soil is lost and the water runs off.[9] Drainage tiles may have contributed to flood heights rather than lessening them.

Floodplain and upland areas functioning as temporary storage areas can have impacts on flood peaks. The quantification of these impacts has not been well documented. Use of natural storage areas (wetlands) for temporary storage of floodwater to decrease downstream flood heights has not been utilized in modern flood control policy. The mathematical models exist to analyze these impacts, although additional field data may be necessary. The Administration should request completion of these investigations as soon as possible. The functions of wetlands and their drainage for agricultural purposes need better evaluation.

The current USACE project in Marshall, Minnesota, offers the opportunity to further explore the effectiveness of upland treatment in flood damage reduction. Consideration should be given to the use of the watershed component of this project as a demonstration of the capabilities of upland treatment in reducing flood damages. A joint USACE-USDA evaluation of the results would add to the information available of this subject.

Action 11.7: ***The USACE and USDA, in collaboration with the DOI, should evaluate the effect of natural upland storage and floodplain storage in such areas as wetlands and forested wetlands on main stem flooding.***

Biotechnical Engineering

State, local, and private engineers and planners rely heavily on federal design manuals. Currently these manuals do not address biotechnical engineering -- channel or bank modification techniques that use vegetation in innovative ways in contrast to traditional bank sloping and riprap protection. Traditional approaches typically focus on maximizing flood conveyance only. Biotechnical engineering techniques can be employed in engineering designs and contribute to the natural functions of floodplains. These practices have not been incorporated into federal government standards. Federal agencies responsible for establishing guidelines should test and incorporate these methods into their design manuals.

Recommendation 11.4: ***Federal agencies should conduct research on biotechnical engineering techniques and incorporate them into design manuals.***

Disaster Relief Funding

Natural disasters in the United States are costly events in terms of both human lives lost and property damaged. Since FY 1989, over $27.6 billion has been spent on federal disaster assistance programs.[10] The Review Committee heard concerns expressed about the current system of funding disaster relief through emergency supplemental appropriations and the subsequent effects on the federal deficit.

Recommendation 11.5: ***OMB should review the current system of funding disaster relief; consideration should be given to encouraging the National Science Foundation to support a review.***

Floodplain Agriculture

The role of the federal farm programs in influencing sound floodplain management continues to receive great attention. Other federal policies, however, also affect land-use decisions. Data currently exist to support research on the effects of federal incentives and disincentives on agricultural production in the floodplain.

Recommendation 11.6: ***USDA should evaluate the impact of federal farm programs on agricultural land use decisions in and out of the floodplain.***

Flood Insurance Market Penetration

The Review Committee was not able to obtain definitive information on NFIP market penetration or on who buys flood insurance and who does not and why. Much of the information that is currently available is based on inadequate information, personal observation, or speculation. This knowledge is critical to developing strategies to increase compliance with the mandatory purchase requirements and to increase voluntary purchase of flood insurance.

Recommendation 11.7: ***FEMA should conduct research on the issue of NFIP market penetration to determine who buys flood insurance and who does not and why.***

Other Research and Analysis Needs

The Review Committee's investigation revealed several other areas in which research is needed, as described in the following recommendation.

Recommendation 11.8: ***The National Science Foundation should consider funding research on the following subjects:***

- ***Full accounting of all public and private benefits and costs of floodplain occupancy and associated floodplain management measures, including both monetary and non-monetary methods of accounting,***
- ***Mapping and regulating areas with movable stream channels and storm drainage overflow and backup,***
- ***Special impacts of floods, including epidemiological and mental health factors, and***
- ***The feasibility and effectiveness of the use of meteorologic data and geomorphic and botanical evidence in conjunction with hydrologic and hydraulic models to estimate flood frequency.***

ENDNOTES

1. 89th Congress, 2nd Session, House Document 465, *A Unified National Program for Managing Flood Losses*, (Washington, DC: U.S. Government Printing Office, August 10, 1966).

2. National Performance Review, *Department of the Interior: Accompanying Report of the National Performance Review*, (Washington, DC: U.S. Government Printing Office, September 1993).

3. Hydrology Subcommittee, Interagency Advisory Committee on Water Data, *Guidelines for Determining Flood Flow Frequency, Bulletin #17B*, (Reston, VA: USGS, March 1982).

4. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Natural Disaster Survey Report: The Great Flood of 1993 (Silver Spring, MD: DOC, NWS, February 1994).

5. Smith, V. Kerry, "Nonmarket Valuation of Environmental Resources: An Interpretive Appraisal," Land Economics, 69(1): 1-26 (February 1993); Ribando, Marc O., and Daniel Hellerstein, *Estimating Water Quality Benefits: Theoretical and Methodological Issues*, Technical Bulletin 1808, (Washington, DC: USDA Economic Research Service, September 1992).

6. The interagency Economics Advisory Group pointed out that although methods exist for qualifying and monetizing environmental benefits in terms of both direct and indirect uses, these methods have not been applied to all areas for which monetized values are desired. Any application, however, requires a clear definition of the ecological effects that result from alternative actions. This is usually obtainable for impacts of national significance. It becomes difficult for lesser effects and smaller projects where the biological increments of change are small. Without a clear definition, survey responses about the value of hypothetical environmental changes will be unreliable.

7. Leopold, L., "Flood Hydrology and the Floodplain," pages 11-14 in *Universities Council on Water Resources Update*, (Carbondale, IL: UCOWR, Spring 1995).

8. Hey, D., "Prairie Potholes," pages 505-509 in National Research Council, Commission on Geosciences, Environment, and Resources, Water, Science and Technology Board, Committee on Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy, Restoration of Aquatic Ecosystems, (Washington, DC: National Academy Press, 1992).

9. Satterlund, D.R., and P.W. Adams, Wildland Watershed Management, (New York, NY: John Wiley & Sons, Inc., 1992).

10. Leuthy, Cameron, Office of Management and Budget, Budget Review and Concepts Division, Washington, DC, personal communication, April 13, 1994.

Chapter 12

A FLOODPLAIN ACTION PLAN

Any great disaster or problem usually produces a by-product called "opportunity". This is no less true today as we review the Great Flood of 1993 and our policies for managing floodplains.

Jim Edgar
Governor of Illinois, June 1994

The Review Committee advocates a new approach to managing the floodplains and related watersheds of the nation. This approach involves a shared challenge. The situation that exists on floodplains today is the result of past federal policy decisions that were successful in achieving past national goals changed. In evaluating ongoing and future floodplain management, the nation must recognize not only that these shifts and changes have occurred but that no action taken today should reduce the opportunity for future adjustments in national goals and purposes. The Review Committee presents a vision for floodplain management that meets these goals.

Achieving this vision of floodplain management will require cooperative action by the Congress, the Executive branch, and the states. The vision and supporting action plan formulated by the Review Committee are interrelated and interactive. Partial success is possible with piecemeal application, but attaining the vision requires complete implementation by all parties in a timely fashion.

The theme developed by the Review Committee is that government at all levels and individuals must share the responsibility of appropriately managing land and water resources to reduce the nation's vulnerability to flood disasters. Coordination of environmental, social, and economic planning is essential to maximize efficiency, equitably share burdens, and distribute responsibility.

The Review Committee calls upon Congress to act on a legislative agenda designed to maximize the efficiency and effectiveness of existing programs, respond to identified gaps with new programs, and provide funding to enable existing programs to function as designed. Major legislative actions requested include:

- Enactment of a Floodplain Management Act to coordinate federal-state actions, and
- Amendments to the NFIP to reduce moral hazard problems and to decrease federal disaster expenditures.

The Review Committee recognizes that these requests require analysis and deliberation by the Congress. Although action is desirable sooner rather than later on these actions, which are indispensable components of the new direction in floodplain management, delay in enactment will not prevent commencement of the policy shift proposed by the Review Committee.

The Review Committee also asks the Executive branch of the government to make changes. The Executive Office of the President can have an immediate impact on floodplain management by promptly implementing the following changes:

- Revitalizing the Water Resources Council to Coordinate and direct federal plans for water management;
- Reestablishing basin commissions;
- Reissuing an expanded EO 11988; and
- Establishing new objectives for *Principles and Guidelines.*

Concurrent with these actions by the President, the Review Committee asks federal agencies involved with water resource and floodplain issues to convene interagency task forces to coordinate activities presently conducted independently. In addition, suggested changes in federal regulations will further the goals of floodplain management programs.

The need for reform in floodplain management is great and the number of proposed actions considerable. Timing, an essential element, is critical. The first step is to get moving and begin the needed changes.

ACTION OUTLINE

CONGRESSIONAL ACTIONS

Legislative Actions

Floodplain Vision/Resource Planning:

- Enact a national Floodplain Management Act (Action 5.1);
- Continue and expand conservation and voluntary land acquistion programs in the Farm Bill, focusing on critical lands (Action 6.3); and
- Support insurance coverage for mitigation actions necessary to comply with local floodplain management regulations (Action 8.9).

Operations:

- Revise Section 1134 of the Water Resource Development Act of 1986 to provide for phase-out of federal leases in the floodplain (Action 5.6);
- For communities not in the NFIP, limit public assistance grants (Action 5.7);
- Provide authority for loans for the upgrade of infrastructure and other public facilities (Action 5.9);
- Enact legislation allowing cost share participation and eligibility requirements under Sections 1135 and 906 of the WRDA of 1986 to include federal, state, and non-governmental contributions (Action 7.7);
- Provide states the option of receiving FEMA Section 404 Hazard Mitigation Grants as a block grant (Action 8.5);
- Provide funds in major disasters where supplemental appropriations are made for buyouts and hazard mitigation, through FEMA's Section 404 Hazard Mitigation Grant Program (Action 8.6);
- Provide authority to reduce the amount of post-disaster support to those who could have bought flood insurance but did not, to that level needed to provide for immediate health, safety, and welfare; provide a safety net for low-income flood victims (Action 9.5);
- Continue to support reform of Federal Crop Insurance that limits crop disaster assistance payments, increases participation, and makes the program more actuarially sound (Action 9.8); and
- Establish the UMR&T project (Action 10.5).

Floodplain Management Funding:

- Provide authority for flexibility in use of programmed funds in emergency situations (Action 7.4).

Planning, Coordination, and Hazard Mitigation:

- Establish a programmatic buyout and hazard mitigation program with funding authorities independent of disaster declarations (Action 8.7);
- Increase the NFIP market penetration through improved lender compliance with the mandatory purchase requirement (Action 9.2); and
- Provide for the escrow of flood insurance premiums or payment plans to help make flood insurance affordable (Action 9.3).

EXECUTIVE BRANCH ACTIONS

Administrative Actions

Leadership, Policy, Planning and Coordination:

- Revitalize the Water Resources Council (Action 5.2);
- Reestablish the basin commissions in a revised form reflecting current needs (Action 5.3);
- Issue a new Executive Order to reaffirm the federal government's commitment to floodplain management with an expanded scope (Action 5.4);
- Direct all federal agencies to conduct an assessment of the vulnerability of flooding using a scientific sample of federal facilities and those state and local facilities constructed wholly or in part with federal aid (Action 5.5);
- Establish new co-equal objectives for planning water resources projects under the Principles and Guidelines document to enhance national economic development and enhance the quality of the environment (Action 5.10);
- Establish a lead agency for coordinating acquisition of title and easements to lands acquired for environmental purposes (Action 7.1);
- Allocate funds for mitigation lands in concert with and at same pace as project construction (Action 7.8);
- Establish the USACE as the principal federal levee construction agency (Action 8.1);
- Establish upper Mississippi and Missouri basin commissions (Action 10.1);
- Expand the mission of the Mississippi River Commission to include the upper Mississippi and Missouri Rivers. Expand Commission membership to include the DOI (Action 10.2);
- Assign responsibility for development of an upper Mississippi River and tributary system plan for a major maintenance and major rehabilitation program for federally related levees to an expanded Mississippi River Commission, operating under the USACE (Action 10.3); and

- Seek approval from the Congress to redirect the USACE Floodplain Management Assessment of the upper Mississippi River Basin to development of the UMR&T system plan. Place this assessment under the expanded Mississippi River Commission (Action 10.4).

Operations

- Propose supplementing, with appropriated funds, funds obtained for floodplain mapping from NFIP policyholders (Action 6.7);
- Develop emergency implementation procedures to organize federal agencies for environmental land acquisitions (Action 7.2);
- Require agencies to co-fund ecosystem management using Operation and Maintenance funds (Action 7.6);
- Support the USGS in development and acquisition of detailed digital topographic data and other land characteristics for use in floodplain management and other water resources management activities (Action 11.5); and
- Direct that scientific research be conducted to identify state-of-the-art techniques or applications for estimating and assessing environmental and social impacts (Action 11.6).

Disaster Relief/Recovery:

- Provide funding for the development of state and community floodplain management and hazard mitigation plans (Action 6.5);
- Reaffirm support for the USACE criteria under the PL 84-99 levee repair program and send a clear message that future exceptions will not be made (Action 8.2); and
- Hold an interagency strategic planning meeting for those Presidentially declared disasters that require a multi-agency recovery effort (Action 9.1).

Interagency Activities

Policy, Planning, and Coordination:

- Establish interdisciplinary interagency review of the *P&G* document by affected agency representatives with regard to the potential structural vs. nonstructural project bias, inclusion of a system of accounts, inclusion of collaborative planning, and expansion of *P&G* application to water and related land programs, projects, and activities (Action 5.11);
- Establish an interagency task force, jointly chaired by the USDA and EPA, to formulate a coordinated, comprehensive approach to multiple objective watershed management (Action 6.1);
- Coordinate and support federal riverine and riparian restoration (Action 6.2);
- Formalize environmental considerations in multi-agency restoration activity through a coordinated Memorandum of Agreement (Action 7.3);
- Restrict support of floodfighting to those levees that have been approved for floodfighting by the USACE (Action 8.3);
- Establish a task force to develop common procedures for federal buyouts and mitigation programs (Action 8.4);
- Select an ecosystem management demonstration project within the upper Mississippi River Basin and establish a cross-agency ecosystem

management team under the DOI to develop plans and budgets for the project (Action 10.9);

- Continue development of basin-wide hydrologic, hydraulic, and hydrometerologic models for the upper Mississippi River system (Action 11.3);
- Review the current standards for computing discharge-frequency relationships in light of observations from the 1993 flood and other recent large floods in the upper Mississippi River Basin (Action 11.4); and
- Evaluate the effect of natural upstream storage and floodplain storage in such areas as wetlands and forested wetlands on main stem flooding (Action 11.7).

Individual Agencies

Federal Emergency Management Agency:

- Encourage communities to obtain affordable private insurance for infrastructure as a prerequisite to receiving public assistance (Action 5.8);
- Promote the NFIP Community Rating System as a means of encouraging communities to develop floodplain management and hazard-mitigation plans and incorporate floodplain management concerns into their ongoing community planning and decisionmaking (Action 6.4);
- Map all communities with flood hazard areas that are developed or could be developed (Action 6.6);
- Utilize technology to improve floodplain mapping (Action 6.8);
- Continue to enforce substantial damage requirements, but decide on a definition of substantial damage and stick to that definition (Action 8.8);
- Develop a program to reduce losses to repetitively damaged insured properties through insurance surcharges, increased deductibles, mitigation insurance, and/or mitigation actions (Action 8.10);
- Develop improved marketing techniques for NFIP (Action 9.4);
- Require actuarially based flood insurance behind all levees that provide protection less than the standard project flood (Action 9.6);
- Increase the 5-day waiting period for flood insurance coverage to at least 15 days (Action 9.7); and
- Investigate the costs and feasibility of completing a national inventory of floodprone structures (Action 11.2).

U.S. Army Corps of Engineers:

- Provide an early report in the Upper Mississippi-Illinois Waterway Navigation Study of environmental enhancement opportunities in the upper Mississippi River (Action 10.7); and
- Provide a report on the ecological effects of relocating navigation pool control points under the Navigation Rehabilitation Study (Action 10.8).

U.S. Department of the Interior:

- Focus land acquisition efforts on river reaches and areas with significant habitat values or resource impacts (Action 7.5); and
- Complete an ecological needs investigation of the upper Mississippi River Basin and provide a report to the Administration within 30 months (Action 10.6).

U.S. Geological Survey (DOI):

- Establish a federal clearinghouse for data gathered during preparation of the Review Committee report (Action 11.1).

Chapter 13

COST ANALYSIS

Some of the recommended actions may result in increased costs to the federal government as well as to states, non-federal sponsors, and individual floodplain occupants. Many of the costs will be incurred over the next few years but will ultimately result in savings to the same parties for many years in the future. Many also reflect the cost of normal business or operations. Costs have been estimated for certain significant actions such as the enactment of a national Floodplain Management Act (Action 5.1), revitalizing the Water Resources Council (Action 5.2), and reestablishing basin commissions (Action 5.3). The cost details for Action 5.1 are found in Appendix D and for Actions 5.2 and 5.3 in Appendix I. The Review Committee did not have the time or resources to develop specific costs for all of the proposed actions. The details of specific action implementation should be analyzed and the costs estimated by those who will administer these actions.

Table 13.1 attempts to identify where additional costs to the federal government are likely and where potential savings, to whomever they may accrue, may occur. This additional cost commitment may take the form of a shift in priorities for human resources or a cost of normal Washington level attention and coordination. These items are annotated with the abbreviations "SIP" for shift in priorities and "CNB" for cost of normal business. For some actions, however, increased federal government costs are required and are identified in the table by the abbreviation "IC" for increased cost.

Potential savings for each recommended action are handled similar to the cost column and abbreviations for the areas of savings are as follows: environmental enhancements (EE); improved customer assistance (ICA); increased efficiencies (IE); reduced claims payments (RCP); reduced disaster assistance (RDA); reduced environmental impact (REI); and reduced flood damages (RDA).

Table 13.1 Fiscal Impact of Actions Recommended by the Review Committee

ACTIONS	ADDITIONAL COSTS TO FEDERAL GOVERNMENT	POTENTIAL SAVINGS
Action 5.1: Enact a national Floodplain Management Act to define governmental responsibilities, strengthen federal-state coordination and assure accountability.	IC	ICA, IE, RDA, REI, RFD
Action 5.2: Revitalize the Water Resources Council.	IC	ICA, IE, REI
Action 5.3: Reestablish Basin Commissions in a revised form reflecting current needs.	CNB, IC, SIP	ICA, IE, REI
Action 5.4: Issue a new Executive Order to reaffirm the federal government's commitment to floodplain management with an expanded scope	CNB, SIP	RDA, REI, RFD
Action 5.5: OMB should direct all federal agencies to conduct an assessment of the vulnerability of flooding using a scientific sample of federal facilities and those state and local facilities constructed wholly or in part with federal aid.	CNB, SIP	RFD
Action 5.6: Seek revision of Section 1134 of the Water Resources Development Act of 1986 to provide for phase-out of federal leases in the floodplain.	CNB	RDA, REI, RFD
Action 5.7: For communities not participating in the NFIP, limit public assistance grants.	CNB	RDA
Action 5.8: Encourage communities to obtain affordable private insurance for infrastructure as a prerequisite to receiving public assistance.	CBE	RDA
Action 5.9: Provide loans for the upgrade of infrastructure and other public facilities.	CBE	RDA

Table 13.1 Fiscal Impact of Actions Recommended by the Review Committee (continued)

ACTIONS	ADDITIONAL COSTS TO FEDERAL GOVERNMENT	POTENTIAL SAVINGS
Action 5.10: Establish as the new, co-equal objectives for planning water resources projects under Principles and Guidelines: (1) To enhance national economic development by increasing the value of the Nation's output of goods and services and improving national economic efficiency, and (2) To enhance the quality of the environment by the management, conservation, preservation, creation, restoration, or improvement of the quality of natural and cultural resources and ecological systems.	CNB, SIP	EE, ICA, REI
Action 5.11: Establish interdisciplinary, interagency review of the *P&G* by affected agency representatives to address: (1) Structural versus non-structural project bias; (2) Inclusion of system of accounts or a similar mechanism for displaying impacts; (3) Inclusion of collaborative planning in an ecosystems context for major studies; and (4) Expansion of the application of the revised *P&G* to water and land programs, projects, and activities to include: (a) All federally constructed watershed and water and land programs; (b) National parks and recreation areas; (c) Wild, scenic, recreational rivers and wilderness areas; (d) Wetland and estuary projects and coastal zones; and (e) National refuges.	CNB, SIP	EE, ICA, IE, REI
Action 6.1: The Administration should establish an interagency task force, jointly chaired by the USDA and EPA, to formulate a coordinated, comprehensive approach to multiple objective watershed management.	CNB	ICA, IE

Table 13.1 Fiscal Impact of Actions Recommended by the Review Committee (continued)

ACTIONS	ADDITIONAL COSTS TO FEDERAL GOVERNMENT	POTENTIAL SAVINGS
Action 6.2: The DOI, USDA, and EPA should coordinate and support federal urban and suburban stream and riparian area restoration.	CNB	EE
Action 6.3: The Administration's legislative proposals for the 1995 Farm Bill should support continuation and expansion of conservation and voluntary acquisition programs focused on critical lands within watersheds.	IC	EE, REI, RFD
Action 6.5: Provide funding for the development of state and community floodplain management and hazard mitigation plans.	IC	ICA, IE, REI, RDA, RFD
Action 6.6: Map all communities with flood hazard areas that are developed or could be developed.	IC	ICA, IE, RDA, REI, RFD
Action 6.7: To improve and accelerate delivery of NFIP map products, the Administration should propose supplementing those funds obtained for floodplain mapping from NFIP policyholders with appropriated funds.	IC	ICA, IE, RDA, REI, RFD
Action 6.8: Utilize technology to improve floodplain mapping.	IC	ICA, IE, RDA, REI, RFD
Action 7.1: The Administration should establish a lead agency coordinating acquisition of title and easements to lands acquired for environmental purposes.	CNB	EE, ICA, IE, RCP, RDA, REI, RFD
Action 7.2: The Administration should develop emergency implementation procedures to organize federal agencies for environmental land acquisitions.	CNB	IE
Action 7.3: The DOI should formalize environmental considerations in multi-agency disaster recovery land restoration activity through a coordinated Memorandum of Agreement.	CNB	EE, IE, REI

Table 13.1 Fiscal Impact of Actions Recommended by the Review Committee (continued)

ACTIONS	ADDITIONAL COST TO FEDERAL GOVERNMENT	POTENTIAL SAVINGS
Action 7.4: Seek legislative authority for flexibility in use of programmed funds in emergency situations.	CNB	EE, ICA, REI
Action 7.5: The DOI should focus land acquisition efforts on river reaches and areas with significant habitat values or resource impacts.	CNB	EE, REI
Action 7.7: Enact legislation allowing cost-share participation and eligibility requirements under Sections 906 and 1135 of the 1986 WRDA to include federal, state, and non-governmental contributions as well as work in-kind.	CNB, SIP	EE, ICA, REI
Action 8.2: The Administration should reaffirm its support for the USACE criteria under the PL 84-99 levee repair program and send a clear message that future exceptions will not be made.	CNB	IE, RDA
Action 8.3: Federal and state officials should restrict support of floodfighting to those levees that have been approved for floodfighting by the USACE.	CNB	IE
Action 8.4: Establish a task force to develop common procedures for federal buyouts and mitigation programs.	CNB, SIP	ICA, IE
Action 8.5: Provide states the option of receiving Section 404 Hazard Mitigation Grants as a block grant.	CNB	ICA, IE
Action 8.6: Provide funds in major disasters where supplemental appropriations are made for buyouts and hazard mitigation, through FEMA's Section 404 Hazard Mitigation Grant Program.	CNB	ICA, IE
Action 8.7: Establish a programmatic buyout and hazard mitigation program with funding authorities independent of disaster declarations.	CNB, SIP	IE, RCP, RDA, REI
Action 8.8: The FEMA should continue to enforce substantial damage requirements, but decide on a definition of substantial damage and stick to that definition.	CNB	RCP, RDA

Table 13.1 Fiscal Impact of Actions Recommended by the Review Committee (continued)

ACTIONS	ADDITIONAL COSTS TO FEDERAL GOVERNMENT	POTENTIAL SAVINGS
Action 8.9: The Administration should support insurance coverage for mitigation actions necessary to comply with local floodplain management regulations.	CNB	IE, RCP, RDA, RFD
Action 8.10: Develop a program to reduce losses to repetitively damaged insured properties through insurance surcharges, increased deductibles, mitigation insurance, and/or mitigation actions.	CNB, SIP	RCP, RDA, REI
Action 9.3: Provide for the escrow of flood insurance premiums or payment plans to help make flood insurance affordable.	CNB	ICA, IE, RDA
Action 9.4: Develop improved marketing techniques.	CNB	ICA, RDA
Action 9.5: Reduce the amount of post-disaster support to those who could have bought flood insurance but did not to that level needed to provide for immediate health, safety, and welfare; provide a safety net for low-income flood victims.	CNB	IE, RDA
Action 9.6: Require actuarial-based flood insurance behind all levees that provide protection less than the standard project flood.	IC	ICA, RDA
Action 9.7: Increase the 5-day waiting period for flood insurance coverage to at least 15 days.	CNB	IE, RCP
Action 9.8: Administration should continue to support reform of Federal Crop Insurance that limits crop disaster assistance payments, increases participation, and makes the program more actuarially sound.	IC	ICA, IE
Action 10.1: Establish upper Mississippi and Missouri basin commissions with a charge to coordinate development and maintenance of comprehensive water resources management plans to include, among other purposes, ecosystem management, flood damage reduction, and navigation.	IC	ICA, IE, REI

Table 13.1 Fiscal Impact of Actions Recommended by the Review Committee (continued)

ACTIONS	ADDITIONAL COSTS TO FEDERAL GOVERNMENT	POTENTIAL SAVINGS
Action 10.2: The Administration should expand the mission of the Mississippi River Commission to include the upper Mississippi and Missouri rivers. Further, to recognize ecosystem management as a co-equal federal interest with flood damage reduction and navigation, the Administration should request legislative change to expand commission membership to include the DOI.	IC, SIP	ICA, IE, REI
Action 10.3: Assign responsibility for development of an Upper Mississippi River and Tributaries (UMR&T) system plan and for a major maintenance and major rehabilitation program for federally related levees to an expanded Mississippi River Commission, operating under the USACE.	IC, SIP	EE, ICA, IE, RDA, REI, RFD
Action 10.4: Seek approval from the Congress to redirect the USACE Floodplain Management Assessment of the upper Mississippi River Basin to development of an UMR&T systems plan. Place this assessment under the Mississippi River Commission, operating the USACE.	CNB, SIP	ICA, IE
Action 10.5: Following completion of the survey, seek authorization from the Congress to establish the UMR&T project.	CNB	ICA,IE, RDA, REI, RFD
Action 10.6: DOI should complete an ecological needs investigation of the upper Mississippi River Basin and provide a report to the Administration within 30 months.	CNB, SIP	ICA, REI
Action 10.7: Provide an early report in the USACE Upper Mississippi River - Illinois Waterway Navigation Study of environmental enhancement opportunities in the upper Mississippi River.	CNB	EE, REI
Action 10.8: Provide a report on the ecological effects of relocating navigation pool control points under the USACE Navigation Rehabilitation Study.	CNB	EE, REI

Table 13.1 Fiscal Impact of Actions Recommended by the Review Committee (continued)

ACTIONS	ADDITIONAL COSTS TO FEDERAL GOVERNMENT	POTENTIAL SAVINGS
Action 10.9: The Administration Interagency Ecosystem Management Task Force should select an Ecosystem Management Demonstration Project within the upper Mississippi River Basin and establish a cross-agency ecosystem management team under the DOI to develop plans and budgets for the project.	CNB, SIP	EE, ICA
Action 11.1: The USGS should establish a federal clearinghouse for data gathered during preparation of the Review Committee report.	IC	ICA, IE, REI
Action 11.2: FEMA should investigate the costs and feasibility of completing a national inventory of floodprone structures.	CNB	ICA, IE, RDA, RFD
Action 11.6: The Administration should direct that scientific research be conducted to identify state-of-the-art techniques or applications for estimating and assessing environmental and social impacts.	CNB, SIP	EE, ICA, IE, REI
Action 11.7: The USACE and USDA, in collaboration with the DOI, should evaluate the effect of natural upstream storage and floodplain storage in such areas as wetlands and forested wetland on mainstem flooding.	CNB, SIP	EE, ICA, RDA, REI, RFD

LEGEND:

COSTS

CBE: Cannot Be Estimated
CNB: Cost of Normal Business
IC: Increased Cost
SIP: Shift in Priorities

SAVINGS

EE: Environmental Enhancement
ICA: Improved Customer Assistance
IE: Increased Efficiency
RCP: Reduced Claims Payment
RDA: Reduced Disaster Assistance
REI: Reduced Environmental Impact
RFD: Reduced Flood Damages

Chapter 14

PERCEPTIONS, IDEAS, AND PROPOSALS

From the outset of this review, the Floodplain Management Review Committee has benefited from the support of hundreds of individuals and groups, many of which had strong opinions on what should be done to solve the problems of the floodplain. With less than five months to complete its review, the Review Committee was unable to address each and every issue raised. Some concerns clearly merited further study, and Chapter 11 describes needed analysis and research.

Other issues were deemed beyond the scope of the Review Committee's charge, but nonetheless deserve consideration in the on-going debate about the management of the nation's resources. Should steps be taken to reduce or eliminate federal subsidies of floodplain activities? Have government programs induced inappropriate floodplain usage by shifting the consequences of certain actions from individuals to the federal government? Should the contribution of local interests to construction and repair of flood control structures be increased? Should disaster funding policies and procedures within the federal budget process be changed?

FEDERAL FARM PROGRAMS

Throughout the review, some federal economists and many non-federal groups have proposed phasing out federal subsidies in general and federal farm program payments in particular to floodplain activities, because they represent intrusions into the free market by distorting incentives and thus may encourage floodplain activity. The Review Committee did examine the role of federal farm programs as they influence individual farmers' decisions to farm in bottomlands. The study looked at both program payments and the support provided to farmers by federal levee repairs.

Each agricultural producer in the floodplain makes farming decisions based on a collection of factors, many of which differ from location to location. Input prices tend to be the same at all locations, but production practices and potential yields depend on the characteristics of the land. Cash receipts will depend on whether the farmer participates in a crop price support program. In addition, the level of flood protection will determine whether a given year's yield will be realized and what the expected flood damages will be. From a farmer's perspective, the viability of farming a particular area depends on the net income that can be earned. Government programs for price and income support, levees, drainage, technical assistance, subsidized crop insurance premiums, and crop disaster assistance all serve to lower the cost of farming on the floodplain.

Many agricultural levees were constructed and maintained by local districts with no use of federal or state funds prior to 1993, so those flood control structures cannot be considered as part of a past subsidy to floodplain agriculture. If these levees are repaired with federal funds, the added benefit would reduce future production costs for the farmer. Farm programs offer a producer higher profits for growing certain crops, so the type of bottomland agriculture is also influenced by government policies. Farmers with lower levels of flood protection may switch to alternative crops such as growing biomass fuel. The economic viability of such choices is currently being studied. Site characteristics and government policies will determine a farmer's choices. Programs offering easements, levee set-backs, or "green" payments will have to take factors affecting farmer decisions into account.

Preliminary results from a study funded by EPA and being conducted by the Center for Agricultural and Rural Development at Iowa State University and the Center for National Food and Agricultural Policy at University of Missouri - Columbia indicate that in some areas participation in federal farm programs and the existence of levees will determine whether a crop is grown and which crop is chosen. In other areas of the floodplain, agriculture would be profitable even without participation in any farm or levee program.

Elimination of federal farm programs for floodplain farmers might make operations less viable and might influence some to leave the floodplain. It appeared to the Review Committee that it would be difficult to determine which floodplain farmers should not receive program payments. A substantial portion of American farming is in the floodplain. Much of the agricultural base of Missouri, Arkansas, Mississippi, and Louisiana exists in the floodplain. If the intent of removing payments or subsidies is to alter behavior that is believed to contribute to environmental problems, then it might be more productive to remove payments or offer "green payments" in areas where agriculture operates under less than optimal conditions, e.g., highly erodible land, drylands, etc.

While the issue of the merits of federal farm programs is important, it merits airing in a context lager than the floodplain and with a greater recognition of the difficulties of selective application of any such policy.[1]

MORAL HAZARD

In providing support for a range of floodplain activities, does government create a "moral hazard?" This phrase is used in the insurance industry describe the situation when an insured party has lower incentive to avoid risk because an enhanced level of protection is provided.

If an individual or government entity does not bear the financial consequences of an action there is little reason to mitigate the danger; therefore, the insured party is more likely to be at risk (or will expend too little effort to avoid risk) than one who has to bear all consequences. The insurance provider usually has few ways of observing whether proper care or precautions are taken. Private insurance companies deal with the moral-hazard problem by offering less than full coverage and requiring payments (deductibles) which increase the policyholder's incentive to take protective measures. Another way that insurance providers cope with moral hazard is to base each period's premiums on claims from previous periods. This method increases the policy holder's level or risk avoidance. Some federal provision of hazard insurance is subsidized through reduced premiums and administrative fees which lowers an individual's stake in avoiding harm. The availability of supplementary compensation diminishes the efficiency of insurance to encourage risk sharing. The Review Committee recognizes that through provision of disaster assistance and, in some cases, enhanced flood protection, the government may in fact be reducing incentives for local governments and individuals to be more prudent in their actions. The subject was discussed frequently in the field and with many of the Review Committee's advisors but without resolution. Some older studies have indicated that the presence of federal support does not create a disincentive to buy flood insurance. The Review Committee has sought to reduce the moral hazard through recommendations that limit disaster assistance and propose loans rather than grants for infrastructure upgrades. The Review Committee notes the potential for moral hazards to develop and cautions agencies involved in floodplain management to be aware of this potential.

FEDERAL FISCAL ROLE IN FLOOD CONTROL

Some people state that the federal government's role in funding flood control projects should be limited to paying costs related to federal benefits, with responsibility for costs associated with regional and local benefits falling to the local sponsor.[2] At present, under the provisions of the Water Resources Development Act of 1986, cost-sharing

for flood control projects is set at a local contribution of not less than 25 percent and not more than 50 percent, depending on the circumstances. Levee repairs, carried out under the provisions of PL 84-99 by the USACE, require a 20 percent local contribution, although the requirement for cost-sharing was determined by the Administration, not the Congress.

The federal interest in flood control was stated most clearly by the Flood Control Act of 1936, "...the Federal Government should improve or participate in the improvement of navigable waters or their tributaries...for flood control purposes if the benefits to whomsoever they may accrue are in excess of the estimated costs..." The rationale for this federal involvement was based in part on the magnitude of the physical threat and potential damages to the nation from flooding, and in part on recognition that navigable waters are interstate and activities in one area can have major effects on other areas.

The Congress, working with The Administration, has set cost-sharing rules based on congressional and Administration determinations as to the nature of the threat and the ability of state and local governments to bear the costs of projects rather than on the allocation of net benefits. The Review Committee recognizes that shifts in cost-sharing formulas would alter floodplain behavior but had neither the time to analyze nor the resources to develop any rationale for changing the existing cost-share arrangements.

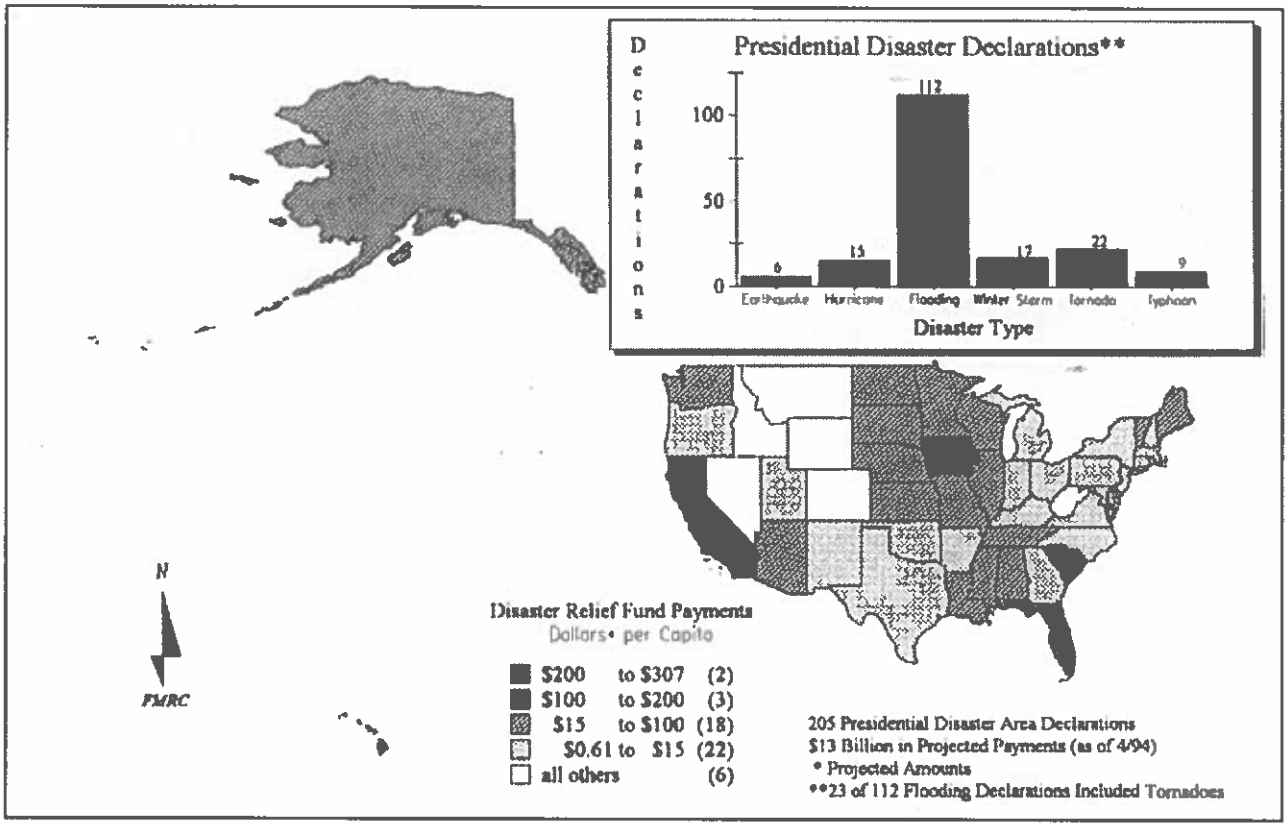
FUNDING DISASTERS

Natural disasters in the United States are costly events in terms of both human lives lost and property damaged. From FY 1989 through FY 1993, over $27.6 billion has been spent on federal disaster assistance programs. Figure 14.1 shows the number of Presidential declarations over the past five years by disaster type and the dollars per capita that went to disaster relief payments for each state under the FEMA program. Although flood declarations comprised the majority of Presidential disasters declarations, earthquakes (California) and hurricanes (South Carolina, Florida) have caused greater per capita damage. All but six states experienced disasters severe enough to warrant Presidential declarations. States in the northeast battled coastal flooding while the south recovered from hurricanes and the midwest from floods.

The rising frequency and costs of natural disasters have prompted a variety of concerns. Some have questioned the federal government's role in funding disaster recovery, citing the potential for rising expenditures in an era of budgetary restraint, the possible incentives that federal relief creates for people to locate in disaster-prone areas, and the potential for elements of federal, state, and local government to rely on disaster relief for infrastructure repair. Others, assuming that a federal obligation to fund recovery exists, point to hazard mitigation as a cost-effective alternative to providing disaster assistance. Funding preventive measures such as relocating structures out of the floodplain can decrease the demand for disaster relief.

Although congressional budgetary reform policies are outside the scope of this report, the Review Committee frequently heard concerns expressed about the current system of funding disaster relief through emergency supplemental appropriations, exempting disaster relief from the scrutiny received by other spending, while permitting it to add to the federal deficit. This situation also may create an incentive for federal agencies to accept backlogs in maintenance for activities in disaster prone areas, recognizing that an emergency spending opportunity for catching up may occur. The OMB should support study of and attention to the long-term implications of the 'above-cap' funding process.

Figure 14.1 Presidential Disaster Declarations, 1989-1993



Source: Federal Emergency Management Agency. April 1994.

PEOPLE, THE MEDIA, AND THE FEDERAL FLOOD RESPONSE

Compassion plays a major role in the way people respond to disasters and rush to provide disaster relief. The speed with which the entire nation learns of disasters is almost immediate. For example, because of the television coverage of the 1989 World Series, those watching had the experience of actually being present during a major earthquake. As for the 1993 floods, the nation can remember pictures carried by CNN of the house being swept away when a levee was breached. Viewers were left wondering how this could happen rather than why the house was there in the first place.

The best media flood-relief stories became those of suffering people and those complaining about the lack of quick government assistance. Politicians and decision-makers were bombarded with calls and they responded by declaring additional counties part of the disaster area and by promising quick relief. FEMA Disaster Field Offices, set up in many cities and towns, were themselves flooded with applications for disaster relief. The media attention helped agencies get needed information to citizens, but also may have increased expectations about the level of assistance that was available or the speed at which help could be provided.

Human compassion and the way news is reported influences how Congress and the nation respond to disasters. A great push arose to replace levees along the Missouri River, many of which should not be replaced without careful design and engineering considerations. If federal response to disaster relief is driven by the immediacy of an event, rather than by rational

decisionmaking, the effort to put everything back to the way it was may increase future risk rather than promote long-term solutions to risk reduction. In the haste of some disaster relief and under the pressure of the media effect, the nation may have subsidized some bad decisions and penalized some good ones, foregoing opportunities for change. A caring, supportive approach for disaster victims must never be lost; but there must be, in tandem, an effort to ensure decisionmaking that reflects long-term as well as short-term goals.

NON-URBAN LEVEES

Congressional and Administration support of the 1993 supplemental appropriations for PL 84-99 clearly indicates strong support for that program. Several groups in and outside the federal government, however, proposed eliminating all federal support of levee repairs under PL 84-99. Lack of federal post-disaster support probably would result in eventual economic failure for some previously protected land and a gradual conversion of formerly protected land from agriculture to natural areas, which in turn could provide additional flood storage and reduce future agricultural flood damages.

Before a levee can be repaired, on a cost-shared basis, under PL 84-99, the USACE or SCS must conduct an economic analysis indicating that the benefits of the repair outweigh the costs. This requirement mirrors the requirements for new construction, but looks only at the costs and benefits associated with the emergency repairs. Sponsors of levees that do not meet the benefit-cost test for repairs may not find it profitable to continue to farm, but the action that forced this decision was one based on accepted analysis practices rather than one based on a desire to reallocate the land. Provisions are available under current laws to obtain interest in such land from willing sellers (see Chapter 7).

MISSOURI RIVER BANK STABILIZATION AND NAVIGATION

Clearly, there is a relationship between the Missouri River Bank Stabilization and Navigation Project and the decline of habitat and ecosystems along that river. In recent years the USACE has made efforts to adjust operation of the system to better accommodate environmental concerns. Nevertheless, during the course of its review, the Review Committee encountered many individuals and several conservation agencies that believe the economic and social benefits derived from the project do not outweigh the environmental costs associated with it. The Review Committee reviewed benefit-cost calculations for the navigation component of the project prepared by the USACE Institute for Water Resources using the current *Principles and Guidelines* procedures for the reach of the river between Sioux City, Iowa, and Kansas City. This analysis indicated that, using the existing procedures, there is a favorable ratio, even when navigation tonnage involving river operations and bank stabilization benefits is excluded. The Review Committee recognizes that the USACE is in the process of completing its multi-year study of the water control operations of the Missouri River main stem reservoir system and is about to release a draft Environmental Impact Statement (EIS) covering the program of releases from the reservoirs and their relationship to the ecology of the river, navigation, hydropower, flood control, water supply, and recreation. Discussions with the USACE indicate that the draft EIS will address many environmental concerns. The 'Master Manual' review study is being conducted under a full public involvement process in accordance with the NEPA. The Review Committee believes it would be appropriate for the USACE, after completion of the action on the 'Master Manual,' to conduct an analysis of potential modifications to the structural components of the navigation system to determine what benefits can be obtained through these actions. The USACE should also, under the recommended procedures for project review (Chapter 5), conduct an analysis, by reach, of the total benefits and costs of navigation operations on the Missouri River.

PROPERTY RIGHTS

Two senior members of Congress expressed to the Review Committee a concern felt by many individuals who also corresponded with the Review Committee.

> The respect and adherence to the rights of property owners as drafted in our Constitution are of central importance to the federal government's role in floodplain management. Any acquisition of lands, expansion of wetlands, and the purchase of easements and rights-of-way should be done with adequate compensation to the landowner. Likewise, the federal government should refrain from the use of condemnation when attempting to move residents out of the floodplain. Any expansion of buyout and relocation initiatives must be carried out on a willing-seller basis.

There has been no suggestion in this report that either land or property be condemned by the federal government. Sound floodplain management will result from a strong partnership among federal, state/tribal and local governments and the private citizens of the nation. Decisions on land acquisitions should result from consultations within this partnership. The recommendations of this report tie all federal acquisitions of land or property for environmental or relocation purposes to a willing-seller scenario.

The report recognizes that the federal government should not support fiscally the rebuilding of some flood damaged structures, to include levees and homes, when it does not make economic or engineering sense. To some, this failure to support rebuilding is seen as an abridgement of the rights of the owners of the property. The Review Committee does not see this to be the case. Some individuals have stated that the federal government's failure to repair their flood-damaged levees, even though they were ineligible for participation in one of the emergency programs, constitutes an abridgement of their entitlement to these repairs and thus a violation of their property rights. The Administration has determined the eligibility criteria for each existing levee repair program. The Review Committee has endorsed the criteria being used by the USACE to determine eligibility for participation in levee repair programs (Action 8.2) and does not see the denial of repairs to be either an entitlement or a property rights issue.

Similarly, some individuals have complained that any restrictions on an individual's or a group's 'right' to floodfight constitutes another possible abridgement of property rights. The Review Committee recognizes the rights of individuals and groups to protect their own property from destruction provided that their actions do not increase flood damages to other groups or individuals. The law concerning protection against a common enemy is complex and the rights and responsibilities of individuals and groups involved in such actions vary widely by state and locality. The Review Committee has recommended that before federal and state governments provide fiscal or in-kind support to floodfights, they ensure that the actions being taken will not have adverse impacts on other groups or individuals. Individuals and groups retain the ability to 'go it on their own' subject to state and community floodplain management regulations (including floodway regulations adopted by communities to participate in the NFIP). These individuals and groups are subject to whatever liability they generate as a result of their actions. Land use controls developed by a community as a result of participation in the NFIP represent community decisions.

Several individuals discussed with the Review Committee their concern that national environmental programs have resulted in a shifting of property from private ownership and that these shifts constituted a taking of sorts. Wherever possible, the Review Committee investigated the comment and could only identify programs in which there had been willing sellers.

ENDNOTES

1. A federal economist notes, in proposing an end to farm program payments, that major institutional changes can be very disruptive and transitions are important in order to minimize disruptions. "People make major investments based on market distortions introduced by subsidies. Eliminating existing subsidies is disruptive and equity requires that beneficiaries be given an opportunity to adjust to the correction of these distortions. However, not eliminating subsidies imposes an unfair burden on the rest of society. Living, working and investing in a floodplain is inherently risky. If people are not confronted with the full cost of such behavior, resources are misallocated and costly inefficiencies result. It is inequitable to ask Federal taxpayers to subsidize and finance such activities."

2. One economist notes, "The Federal Government should not be in the business of financing projects which produce local and/or regional benefits. The Federal Government should establish standards for management of the floodplain. Subject to budgetary constraints, if a proposed project has a benefit-cost ratio greater than one for Federal benefits, the Federal Government should pay for the provision of Federal benefits and locals should pay all other costs."

Chapter 15

INTO THE 21ST CENTURY

The Midwest Flood of 1993 was a significant hydrometeorological event. In some areas it represented an unusual event; in most others, however, it was just another of the many that have been seen before and will be seen again. Flood flows similar to those experienced by most of the Midwest will continue to occur.

Excessive rainfall, which produced standing water, saturated soils, and overland flow, caused major damages to upland agriculture and some communities. In turn, runoff from this rainfall created, throughout the basin, flood events that became a part of the nation's 1993 TV experience. Damages overall were extensive; $12-$16 billion that can be counted and a large amount in the unquantifiable impacts on the health and wellbeing of the population of the Midwest.

Human activities in the floodplains of the Midwest over the last three centuries placed people and property at risk. Loca and federal flood damage-reduction and floodplain management programs reduced the annual risk and, during the 1993 flood, prevented nearly $20 billion in potential damages. Some of these programs, however, have drawn the population to high-risk areas and created greater exposure for future damages. In addition, flood damage-reduction, navigation and agricultural activities have severely reduced available floodplain habitat and have compromised natural functions on which fish and wildlife rely.

Over the last 30 years the nation has learned that effective floodplain management can reduce vulnerability to damages and create a balance among natural and human uses of floodplains and their related watersheds to meet the social and environmental goals of the nation. The nation, however, has not taken advantage of this capability.

The Interagency Floodplain Management Review Committee proposes a better way to manage the nation's floodplains. The report begins with establishing that all levels of government, all businesses, and all citizens interested in the floodplain should have a stake in properly managing this resource. All of those who support the risk, either directly or indirectly, must share in the management and the costs of reducing the risk. The federal government must lead by example; state and local governments must manage the floodplains; and individual citizens must adjust their actions to the risk they face.

The Review Committee supports an approach to floodplain management that replaces a focus on structural solutions with a sequential strategy of avoidance, minimization and mitigation. In many cases, by controlling runoff, managing ecosystems for all their benefits, planning the use of the land, and identifying those areas at risk, the hazard can be avoided. Where the risk cannot be avoided, damage minimization approaches, such as elevation and relocation of buildings, and construction of reservoirs or flood protection structures, are carried out only when they can be integrated into an overall systems approach to flood damage reduction in the basin.

When floods occur, damages to individuals and communities can be mitigated with a flood insurance program that obtains its support from those who are protected. Full disaster support for those in the floodplain is contingent on participation in these self-help mitigation programs. By internalizing these risks, the moral hazard associated with full government support is reduced.

To ensure a long-term, nationwide approach to floodplain management, the Review Committee proposes legislation to develop and fund a national floodplain management

program with principal responsibility and accountability at the state level. It also proposes revitalization of the federal Water Resources Council to better coordinate federal activities, limited restoration of some basin commissions for basin-wide planning, and reissuance of a Presidential Executive Order requiring adherence to floodplain management principles by federal agencies and their programs.

Recognizing that the existing developed condition of the upper Mississippi River Basin includes individually authorized federal flood control projects and levees built by local groups and individuals, the Review Committee also proposes a plan to identify and evaluate the needs of the basin, to ensure the integrity of a flood damage reduction system that meets the needs of the basin, and to restore natural floodplain functions on appropriate lands.

THE 21ST CENTURY FLOODPLAIN

The vision of the 21st Century floodplain described in Chapter 4 can become a reality.

Human activity in the floodplain will continue, but with the clear understanding that any activity is subject to the residual risk of flooding and that the costs of this risk are to be borne by the sponsors of the activity. All new activity will be evaluated for its economic, social, and environmental impacts and its effects on other activities in the floodplain.

The threat to urban centers whose existence depends on the river for commerce or whose locational advantage is tied historically to the floodplain will be reduced by a combination of upstream land treatment, floodways, and floodproofing. In some cases, levees and floodwalls will continue to provide part of the vulnerability reduction. Many sections of these communities, where frequent flooding had been a way of life for the residents, will become river-focused parks and recreation areas as former occupants relocate to safer areas on higher ground. Adherence to strict land-use regulations by the community will stop unwise development.

Those whose homes were at risk in low lying areas outside the urban centers will have moved to higher ground. Outside of the urban areas, industry will protect its own facilities against major floods. The water and wastewater treatment plants, power plants, and major highways and bridges that serve these centers will be elevated out of the flood's reach or protected against it. Much of this infrastructure, as well as the homes, businesses, and agricultural activities located behind most levees, will be insured against flooding through full participation in commercial or federally supported insurance programs.

The floodplain of the 21st Century will be rich in both agriculture and natural systems. At the upstream end of well-maintained levees, federally built water-control structures will permit controlled passage of river waters to keep sloughs wet throughout the year, maintaining and restoring aquatic habitat with resultant benefits for fisheries, waterfowl, and other wildlife. Levees will be modified to provide for controlled overtopping in the event of high water, eliminating the catastrophic failures that occurred in the past. Participation in a federal crop insurance program will protect the agricultural investments.

Some of the lower land will be converted from row crops to alternative crops or silviculture or returned to a natural state under federal or state easements. Many levees that were frequently destroyed in the past by flood waters will be removed or relocated to ensure their integrity or provide for a floodway.

Upland of the floodplain, programs to improve the treatment of lands, control new runoff, and restore wetlands will reduce the flows during frequent floods and shave the peaks off larger events, improving conditions in the floodplain. Both commercial and recreational vessels will continue to ply the river's waters, operating in a navigation system that enhances riverine ecosystems through water-level adjustments and control.

The floodplain will meet the needs of both human and natural systems.

SHARING THE CHALLENGE

The Review Committee has suggested a bold yet realistic and straightforward approach to improving floodplain management:

- Share responsibility and accountability for accomplishing floodplain management among all levels of government and with the citizens of the nation. The federal government can not go it alone, nor should it take a dominant role in the process.

- Establish, as goals for the future, the reduction of the vulnerability of the nation to the dangers and damages that result from floods and the concurrent and integrated preservation and enhancement of the natural resources and functions of floodplains. These goals seek to avoid unwise use of the floodplain, mitigate vulnerability when floodplains must be used, and mitigate those damages that do occur.

- Organize the federal government and its programs to provide the support and the tools necessary for all levels to carry out and participate in effective floodplain management.

The tools, authorities and programs are available at the federal, state, tribal, and local level to move toward accomplishment of these goals. Many of the nation's past activities in the floodplain make sense, produce desirable results, and should be continued. Others do not and should be stopped. While many aspects of current programs are in need of modification, the problem is not one of lack of understanding of how to manage floodplains and their associated watersheds, it is a problem of will and organization. There are no silver bullets in the floodplain management business, no single actions that will suddenly reduce the vulnerability of those who are currently at risk or stave off placing others in the same position.

If the nation is to move ahead, it must do so in a manner that recognizes the many stakeholders in the floodplain management effort and appropriately divides the responsibilities among them. Many state and local governments have done a great job at floodplain management and the nation can build on that success; others need encouragement; all need support. Operating together with common goals, governments, businesses, and private citizens can make sound floodplain management a reality throughout the nation.

By giving the states and local governments more responsibilities and supporting their efforts, by improving the efficiency of federal efforts, and by ensuring that individuals recognize and assume their personal responsibilities for floodplain activities, the federal government can share the challenge of floodplain management and see to its accomplishment.

WHAT'S NEXT?

The Review Committee has proposed 60 actions and made recommendations concerning 28 other issues. These proposals represent a package whose interrelationship will continue to exist even if one or more of the components fails to be implemented. The Review Committee would caution that the strong linkages among the actions and recommendations require that, as any one is considered, it needs to be addressed in the context of those to which it relates.

Chapter 12 provided a road map for further action, assigning responsibilities to appropriate agencies for specific actions. Unless these actions are tracked by the Administration, the cohesion of the disparate actions could be lost.

The United States has a rare opportunity to make a change in floodplain management. It should not be missed.

Part V

REPORT OF THE SCIENTIFIC ASSESSMENT AND STRATEGY TEAM (SAST)

To be published separately

ACROMYMS & ABBREVIATIONS

ac-ft	Acre-feet
ACR	Acreage Conservation
ASCS	USDA Agricultural Stabilization and Conservation Service
BIA	DOI Bureau of Indian Affairs
BOR	DOI Bureau of Reclamation
CA	Cooperative Agreements
CDBG	Community Development Block Grant
CEA	EOP Council of Economic Advisors
CEQ	EOP Council on Environmental Quality
cfs	cubic feet per second
CFR	Code of Federal Regulations
CN	Curve Number
CNN	Cable New Network
CRP	Conservation Reserve Program
CVM	Contingent Valuation Method
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DOC	Department of Commerce
DOI	Department of the Interior
DOD	Department of Defense
DOT	Department of Transportation
EA	NEPA Environmental Assessment
EDA	DOC Economic Development Administration
EEP	Environmental Easement Program
EIS	NEPA Environmental Impact Statement
EMP	Environmental Management Program
EO	Executive Order
EOP	Executive Office of the President
EPA	Environmental Protection Agency
EROS	Earth Resources Observation System
ERS	Economic Research Service
ESA	Endangered Species Act
EWP	Emergency Watershed Protection Program
EWRP	Emergency WetlandsReserve Program
FAA	DOT Federal Aviation Administration
FACTA	Food, Agriculture, Conservation and Trade Act of 1990 (the 1990 Farm Bill)
FCIC	Federal Crop Insurance Corporation
FCO	Federal Coordinating Officer
FEMA	Federal Emergency Management Agency
FGDC	Federal Geographic Data Committee
FIPS	Federal Information Processing Standards
FIRM	Flood Insurance Rate Map
FmHA	USDA Farmers Home Administration
FMRC	Interagency Floodplain Management Review Committee
FR	Federal Register
FS	USDA Forest Service
FSA	Food Security Act
FWS	DOI Fish and Wildlife Service
FY	Fiscal Year
GIS	Geographic Information System
HEC	Hydrologic Engineering Center
HEL	Highly Erodible Land
HOME	HUD HOME Investment Partnership Program
HR	House of Representative Bill
HUD	Department of Housing and Urban Development
IFSARE	InterFerometric Syntheic Aperture Radar for Elevation
LAWCON	Land and Water Conservation Fund
LIDAR	Light Detection and Ranging
LTRMP	Long Term Resource Monitoring Program
MARC	Midwest Area River Coalition
MLRA	Major Land Resource Area
MM&MR	Major Maintenance and Major Rehabilitation
MR&T	Mississippi River and Tributaries Project
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MRC	Mississippi River Commission
NASA	National Aeronautics and Space Administration
NBS	National Biological Survey
NED	National Economic Development

NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NGO	Non-Governmental Organization
NHPA	National Historic Preservation Act
NOAA	DOC National Oceanic and Atmospheric Administration
NPR	National Performance Review
NPS	DOI National Park Service
NRI	National Resource Inventory
NWS	DOC National Weather Service
OMB	EOP Office of Management and Budget
P&G	Economic and Environmental Principles and Guidelines for Water and Related Land Resources
P&S	Principles and Standards For Planning Water and Related Land Resources
PL	Public Law
RCRA	Resource Conservation and Recovery Act
RDA	Rural Development Administration
RRSA	Refuge Revenue Sharing Act
S	Senate Bill
SAST	Scientific Assessment Team and Strategy (of the FMRC)
SAR	Synthetic Aperture Radar
SBA	Small Business Administration
SCS	USDA Soil Conservation Service
SPF	Standard Project Flood
TIGER	Topologically Integrated Geographically Encoded Reference
TVA	Tennessee Valley Authority
UCOWR	Universities Council on Water Resources
UMRBA	Upper Mississippi River Basin Association
UMRBC	Upper Mississippi River Basin Commission
UMRCC	Upper Mississippi River and Conservation Council
UMR&T	Upper Mississippi River and Tributaries Project
USACE	U.S. Army Corps of Engineers
USC	United States Code
USDA	U.S. Department of Agriculture
USGS	DOI U.S. Geological Survey
WRC	Water Resources Council
WRDA	Water Resources Development Act (of any year)
WRP	Wetland Reserve Program

GLOSSARY

100-year flood: A term commonly used to refer to the one percent annual chance flood. The 100-year flood is the flood that is equaled or exceeded once in 100 years on the average, but the term should not be taken literally as there is no guarantee that the 100-year flood will occur at all within a 100-year period or that it will not recur several times.

Acre-foot: A unit measure of volume equal to one acre covered to a depth of one foot; often used to describe reservoir capacity or the amount of water flowing past a point in a river over a specified time period. One acre-foot equal 43,560 cubic feet, or 326,700 gallons.

Actuarial rates: Insurance rates determined on the basis of a statistical calculation of the probability that a certain event will occur. Actuarial rates, also called risk premium rates, are established by the Federal Insurance Administration pursuant to individual community Flood Insurance Studies and investigations undertaken to provide flood insurance in accordance with the National Flood Insurance Act and with accepted actuarial principles, including provisions for operating costs and allowances.

Aggradation: The process of filling and raising the level of a streambed by deposition of sediment.

Agricultural levee: A levee for which the majority of benefits are derived from protection of agricultural lands.

Backwater lake: A lake connected to a river at its downstream end that fills principally from the rise of the river rather than from inflow from the lake's drainage area.

Backwater: a) A rise in upstream water level caused by an increase in flow downstream. b) An upstream water level rise caused by obstructions downstream, such as ice jams or debris.

Bank stabilization: Use of structural measures such as rock, concrete, or other material to stabilize channel banks against movement and erosion.

Bankfull stage: At a given location, the maximum elevation to which a river can rise without overflowing its banks. (*see* **Flood stage**)

Base flood: A flood of specific frequency and used for regulatory purposes. The NFIP has adopted the "100-year" flood as the base flood to indicate the minimum level of flooding to be used by a community in its floodplain management regulations.

Basin: A region or area drained by a river system. Also, the total land area that contributes runoff to any given point on a river or stream. Often called a watershed.

Biotechnical engineering: Channel or bank modification techniques that use vegetation in innovative ways, in contrast to traditional bank sloping and riprap protection.

Bluff line: A steep headland or cliff which in some topographical settings defines the edge of a floodplain.

Bottomland hardwoods: Tree species that occur on water-saturated or regularly inundated soils. Classified as wetlands, these areas contain both trees and woody shrubs.

GLOSSARY

cfs: The rate of flow (*see* **Discharge**) past a given point, measured in cubic feet per second. One cubic foot of water equals about 7 1/2 gallons.

Collaborative approach: A commitment to working collectively to solve complex, inter-related concerns. A collaborative effort requires more than consultation, coordination, and seeking public input.

Community Assistance Program (CAP): The program established by the Federal Emergency Management Agency and intended to assure that communities participating in the NFIP are carrying out the flood loss reduction objectives of the program. The CAP provides needed technical assistance to NFIP communities and attempts to identify and resolve floodplain management issues before they develop into problems requiring enforcement action.

Community Rating System (CRS): A program developed by the Federal Emergency Management Agency and intended to encourage -- by use of flood insurance premium reductions -- community and state activities that go beyond the basic NFIP requirements; the CRS gives communities credit for certain activities to reduce flood losses, facilitate accurate insurance rating, and promote the awareness of flood insurance.

Conservation tillage: Practices that reduce cultivation of soil, leave a protective vegetative layer on the surface, and thereby serve to reduce or minimize soil erosion.

Crest: The highest water level at a given location during a flood event.

Crop rotation: Growing crops in a cropping sequence designed to provide adequate residue for maintaining or improving soil condition.

Cumulative impacts: The impacts on the environment that result from the incremental impact of an action when added to other past, present and reasonably foreseeable actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Dam: A structure built across a waterway to impound water. Dams are used to control water depths for navigation or to create space to store water for flood control, irrigation, water supply, hydropower or other purposes.

Debris: Objects such as logs, trees and other vegetation, building wreckage, vehicles, shipping carts or dead animals carried by water in a flood (or by wind, as in a hurricane or tornado).

Degradation: A process of lowering the level of a streambed by scour and erosion.

Design flood: The maximum amount of water for which a flood control project will offer protection. Selection is based on engineering, economic and environmental considerations.

Dike: In most areas of the U.S., an earthen or rock structure built partway across a river for the purpose of maintaining the depth and location of a navigation channel. In others areas the term is used synonymously with levee.

Discharge: Rate of flow in a river or stream measured in volume of water per unit of time. (*See* **cfs**)

Drainage tiles: Short lengths of perforated pipe made of clay, concrete, or plastic installed in soil to remove free water for the purpose of crop production.

GLOSSARY

Drainage area: Total land area from which water drains to a point on a river. The upper Mississippi River *drainage area* comprises 23% of the land area of the 48 contiguous United States.

Ecosystem: Biological communities (including humans) and their environment (or watershed) treated together as a functional system of complementary relationships, including transfer and circulation of energy and matter.

Ecosystem integrity: Maintenance of the structural and functional attributes characteristic of a particular locale or watershed, including normal variability.

Ecosystem management: Management of the biological and physical resources of an ecosystem or watershed in an attempt to maintain the stability of its structural, functional, and economic attributes, including its normal variability.

Emergency spillway: *See* **Spillway.**

Emergency: Any instance for which, in the determination of the President, federal assistance is needed to supplement state and local efforts and capabilities to save lives and protect property and public health and safety or to lessen or avert the threat of a disaster in any part of the United Sates.

Encroachments: Activities or construction within the floodway, including fill, new construction, substantial improvements, and other development, that may result in an increase in flood levels.

Environmental assessment: An examination of the beneficial and adverse impacts on the environment of a proposed action, such as a water resources project, and alternative solutions.

Executive Order 11988: The floodplain Management Executive Order, issued in 1977, specifying the responsibilities of the federal agencies in floodplain management. EO 11988 directed federal agencies to evaluate and reflect the potential effects of their actions on floodplains and to include the evaluation consideration of flood hazards in agency permitting and licensing procedures.

Federal Interagency Floodplain Management Task Force: The Task Force established in 1975 to carry out the responsibility of the President to prepare for the Congress a Unified National Program for Floodplain Management; member agencies are the Department of Agriculture, Department of the Army, Environmental Protection Agency, Federal Emergency Management Agency, Department of the Interior, and the Tennessee Valley Authority.

Federal trust resources: As applied in this report, these resources include migratory birds, federally listed threatened and endangered species and species that are candidates for listing, interjurisdictional fisheries and wetlands. Such resources are protected by international treaty, and/or federal law in recognition of their ecological and/or commercial significance.

Field borders: A strip of perennial vegetation established on the edge of a field. It involves plantings of herbaceous vegetation or shrubs.

Flash flood: Flood with a very rapid rate of rise that is caused by intense rainfall. During flash floods the time between peak rate of rainfall and peak flow is very short.

Flood/flooding: A general and temporary condition of partial or complete inundation of normally dry land areas from the overflow of river and/or tidal waters and/or the unusual accumulation of waters from any source.

GLOSSARY

Flood control structures: Structures such as dams, dikes, levees, drainage canals, and other structures built to modify flooding and protect areas from flood waters.

Flood discharge: The quantity of water flowing in a stream and adjoining overflow areas during times of flood. It is measured by the amount of water passing a point along a stream within a specified period of time and is usually measured in cubic feet of water per second (**cfs**).

Flood frequency: The frequency with which a flood of a given discharge has the probability of recurring. For example, a 100-year frequency flood refers to a flood discharge of a magnitude likely to occur on the average of once every 100 years or, more properly, of a magnitude that has a one-percent chance of being equaled or exceeded in any year. Although calculation of possible recurrence is often based on historical records, there is no guarantee that a 100-year flood will occur at all or that it will not recur several times within any 100-year period.

Flood hazard: The potential for inundation that involves risk to life, health, property, and natural floodplain values.

Flood Hazard Mitigation Teams: Teams consisting of representatives of the 12 federal agencies that signed an interagency agreement to provide technical assistance to states and communities for nonstructural flood damage reduction measures. The teams are typically employed after each major flood disaster declared by the President to provide technical assistance and guidelines to communities and states affected by the disaster.

Flood Insurance Rate Map (FIRM): An official map of a community on which the Federal Emergency Management Agency has delineated both the special hazard areas and the risk premium zones applicable to the community. FIRMs typically identify the elevation of the one-percent annual chance flood and the areas that would be inundated by that level of flooding; they are used to determine flood insurance rates and for floodplain management.

Flood insurance: The insurance coverage provided through the National Flood Insurance Program.

Flood of record: The highest flood historically recorded at a given location.

Flood-pulse advantage: The amount by which fish yield is increased by a natural predictable flood pulse.

Floodplain management regulations: Zoning ordinances, subdivision regulations, building codes, health regulations, and special purpose ordinances that cover, for example, floodplains, grading, and erosion control and other regulations to control future development in floodplains and to correct inappropriate development already in floodplains.

Floodplain management: A decision-making process whose goal is to achieve appropriate use of the nation's floodplains. Appropriate use is any activity or set of activities that is compatible with the risk to natural resources and human resources. The operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to watershed management, emergency preparedness plans, flood control works, and floodplain management regulations.

Floodplain resources: Natural and cultural resources including wetlands, surface water, groundwater, soils, historic sites, and other resources that may be found in the floodplain and that provide important water resources, living resources (habitat), and cultural/historic values.

GLOSSARY

Floodplain: Low lands adjoining the channel of a river, stream, watercourse, lake, or ocean, that have been or may be inundated by floodwater and other areas subject to flooding.

Floodproofing: The modification of individual structures and facilities, their sites, and their contents to protect against structural failure, to keep water out, or to reduce the damaging effects of water entry.

Flood stage: A site-specific river level at which flood damage may start to occur; usually at or above the top of the riverbank. Flood heights are often measured relative to the flood stage elevation. (*See* **Stage**).

Flood storage pool: A volume of space in a reservoir reserved for storage of flood water.

Floodwall: Reinforced concrete walls that act as barriers against floodwaters thereby helping to protect floodprone areas. Floodwalls are usually built in lieu of levees where the space between developed land and the floodway is limited.

Floodway: The channel of a river or other watercourse and the adjacent land areas that must be reserved to discharge the flood without cumulatively increasing the water surface elevation more than a designated amount. The floodway is intended to carry deep and fast-moving water.

Flowrate: Rate of flow (discharge) at a specific location in a river or floodplain.

Freeboard: A factor of safety usually expressed in feet above a flood level for purposes of designing flood protection facilities and floor floodplain management. Freeboard tens to compensate for the many uncertain factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, bridge obstructions, and the hydrological effect of urbanization of the watershed.

Gated outlets: Conduits, such as pipes or box culverts, in which mechanical gates are placed for the purpose of controlling the discharge.

Geographic Information System (GIS): A computerized system designed to collect, manage, and analyze large volumes of spatially referenced and associated attribute data.

Greenway: A protected linear open-space area that is either landscaped or left in its natural condition. It may follow a natural feature of the landscape, such as a river or stream, or it may occur along an unused railway line or some other right of way.

High energy erosion zones: Areas on the floodplain, such as the location of a former channel, that are subject to extensive scour and sediment transport during overbank flows.

Hinge-control points: Points in slackwater navigation pools where the water level is used as an index to establish gate settings at navigation dams for maintaining navigable depths.

Hydraulics: The science dealing with the mechanical properties of liquids that describes the specific pattern and rate of water movement in the environment.

Hydrology: The science dealing with the properties, distribution, and circulation of water on and below the surface of the land and in the atmosphere.

GLOSSARY

Interjurisdictional Fisheries: Fish and shellfish resources whose habitat includes waters shared by two or more states.

Land treatment measures: Measures used to reduce runoff of water to streams or other areas; techniques include maintenance of trees, shrubbery, and vegetative cover; terracing; slope stabilization; grass waterways; contour plowing; and strip farming.

Levee: A linear earth embankment used to protect low-lying lands from flooding. A levee extends from high ground adjacent to a floodprone area along one side of a river to another point of high ground on the same side of the river.

Lock: A structure adjacent to a dam or in a canal to allow passage of vessels from one water level to another. The lock consist of a chamber with gates at either end, in which water is raised or lowered. Navigation lock and dams normally do not store flood water.

Lower Mississippi River Basin: The portion of the Mississippi River Basin that drains into the Mississippi River from its confluence with the Ohio River to the Gulf of Mexico.

Lower Mississippi River: The reach of the Mississippi River from the confluence of the Ohio River at Cairo, Illinois, to the Gulf of Mexico.

Major disaster: Any natural catastrophe or, regardless of cause, any fire, flood, or explosion in any part of the United States which, in the determination of the President causes damage of sufficient severity and magnitude to warrant major disaster assistance under the Robert T. Stafford Disaster Relief and Emergency Assistance Act.

Middle Mississippi River: The reach of the Mississippi River between its confluence with the Missouri River at St. Louis, Missouri, and its confluence with the Ohio River at Cairo, Illinois.

Mitigation: Any action taken to permanently eliminate or reduce the long-term risk to human life and property and the negative impacts on natural and cultural resources that can be caused by natural and technological hazards.

Mitigation lands: Lands acquired to offset adverse impacts of water resource (or other) projects

National Wetlands Inventory Project: Wetlands mapping on a national basis performed by the U.S. Fish and Wildlife Service to provide scientific information on the extent and characteristics of the nation's wetlands and consisting of detailed maps and status and trends reports.

Natural resources and functions of floodplains: Include, but are not limited to, the following: natural flood and sediment storage and conveyance, water quality maintenance, groundwater recharge, biological productivity, fish and wildlife habitat, harvest of natural and agricultural products, recreation opportunities, and areas for scientific study and outdoor education.

Navigation channel: The channel maintained in a body of water for the purpose of assuring a depth adequate for commercial vessels.

Nonstructural measures: A term originally devised to distinguish techniques that modify susceptibility to flooding (such as watershed management, land use planning, regulation, floodplain acquisition, floodproofing techniques and other construction practices, and flood warning) from the more traditional structural methods (such as dams, levees, and channels) used to control flooding.

GLOSSARY

One-percent annual chance flood: A flood of a magnitude that has a one-percent chance of being equaled or exceeded in any given year. Often referred to as the 100-year flood or base flood, the one-percent annual chance flood is the standard most commonly used for floodplain management and regulatory purposes in the United States.

Permanent vegetation: Perennial vegetation such as grasses, shrubs, and trees which provides cover to soil and prevent erosion.

Principles and Standards/Principles and Guidelines: "The Principles and Standards for Planning of Water and Related Land Resources" is a presidential policy statement issued in September 1973 that established a framework for improved planning for the use of water and related land resources based on the objectives of national economic development and environmental quality. the "Principles and Standards" were revised and issued in 1983 as the "Economic and Environmental Principles and Guidelines for Water and Related Land Resources for Implementation Studies."

Quad Cities: The metropolitan area comprised of Davenport, Iowa; Bettendorf, Iowa; Rock Island, Illinois; and Moline, Illinois.

Recurrence interval: The average interval in which a flood of a given size is equaled or exceeded as an annual maximum.

Regulatory floodplain: The area adjoining a river, stream, lake, or ocean that is inundated by a regulatory flood. In riverine areas the floodplain usually consists of a regulatory floodway and regulatory flood fringe (also referred to as a floodway fringe). In coastal areas the floodplain may consist of a single regulatory floodplain area or a regulatory high-hazard area and a regulatory low-hazard area.

Regulatory floodway: The area regulated by federal, state, or local requirements to provide for the discharge of the base flood so the cumulative increase in water surface elevation is no more than a designated amount (not to exceed one foot as the minimum standard set by the National Flood Insurance Program).

Repetitive loss: A flood-caused loss of more than $1,000 to a repetitive loss structure.

Repetitive loss structure: A structure for which two or more losses of more than $1,000 (building and contents combined) have been paid since 1978.

Riparian ecosystems: Distinct associations of soil, flora, and fauna occurring along a river, stream, or other body of water and dependent for survival on high water tables and occasional flooding.

Riparian vegetation: Hydrophytic vegetation growing in the immediate vicinity of a lake or river.

Riparian zone: The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The area is typically subject to frequent, short duration flooding.

Risk: The probability of being flooded.

Rock closing dams: In reaches of rivers where multiple channels are formed by islands, rock dikes that span the side channel, generally where it departs from the main channel, are called rock closing dams. They serve to direct flow to the main channel.

GLOSSARY

Scour hole: Erosional holes developed as a result of breached levees. Locally called blow, blew, or blue holes.

Scour: Process of eroding surface soil by flowing water which results in gullies in the landscape.

Section 409 Hazard Mitigation Plan: A plan prepared as required by Section 409 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 by any jurisdiction that receives federal disaster assistance.

Sediment and debris basin: Retention structure constructed on or adjacent to a watercourse to store sediment and debris.

Side channel: A stream or channel to the side of the major channel or stream.

Slackwater navigation dam: A dam placed across a river for the purpose of creating water depth sufficient for navigation. The term slackwater refers to the relatively low velocity in the navigation pool compared to an open river.

Slough: A swamp, march, bog or pond as part of a bayou, inlet or backwater.

Spillway: A feature of a dam allowing excess water to pass without overtopping the dam. Usually a spillway functions only in a large flood.

Stage: The height of the water surface in a river or other body of water measured above an arbitrary datum, usually at or near the river bottom.

Standard project flood: A very large (low frequency) design flood standard applied to the design of major flood control structures and representing the most severe recombination of meteorological and hydrological conditions considered reasonably characteristic of a particular region.

Strip cropping: Growing crops in a systematic arrangement of strips or bands along a contour.

Structural measures: Measures such as dams, reservoirs, dikes, levees, floodwalls, channel alterations, high-flow diversions, spillways, and land-treatment measures designed to modify floods.

Substantial improvement: Any repair, reconstruction, or improvements of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure either before the improvement or repair is started or if the structure has been damaged and is being restored, before the damage occurred.

Substantial damage: The amount of damage to a structure caused by flooding that may be sustained before certain regulatory and flood insurance requirements are triggered. As defined in NFIP regulations, a building is considered substantially damaged when the cost of restoring the building would exceed 50 percent of the market value of the structure.

Tailwater: The reach of stream or river located immediately below a water control structure such as a dam. In contrast, headwater is the term applied to the pool immediately above a dam.

Terrace: A raised bank of earth having vertical or sloping sides and a flat top used to control surface runoff.

GLOSSARY

Upper Mississippi River Basin: The portion of the Mississippi River basin that is above the confluence of the Ohio River. It includes the Missouri River Basin.

Upper Mississippi River: The reach of the Mississippi River from its confluence with the Missouri River at St. Louis, Missouri, upstream to its headwaters at outlet of Lake Itasca in Minnesota.

Watershed: A region or area contributing ultimately to the water supply of a particular watercourse or water body.

Wetlands: Those areas that are inundated by surface or groundwater with a frequency sufficient to support and, under normal circumstances, does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include bottomland hardwoods, swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflow, mud flats, and natural ponds.

Wing dikes: Rock wing dikes or dams, closing dams, wood pile dikes, and bendway weirs are types of channel training structures used to divert river flows toward a single main channel used for navigation. Generally constructed perpendicular to flow, and constructed to various submergent of emergent elevations, these structures usually function most effectively at lower flows.

APPENDIX A

CHARTER OF THE FLOODPLAIN MANAGEMENT REVIEW COMMITTEE

THE WHITE HOUSE

WASHINGTON

TO: BG Gerald E. Galloway, Jr.

FROM: Administration Floodplain Management Task Force --
T.J. Glauthier, Associate Director, Office of Management and Budget
Kathleen McGinty, Director, White House Office of Environmental Policy
James R. Lyons, Assistant Secretary of Agriculture for Natural Resources

SUBJECT: Directive on the Establishment of an Interagency Floodplain Management Review Committee

The purpose of this directive is to establish an Interagency Floodplain Management Review Committee and to designate you as Executive Director of the Committee. The Committee will undertake an intensive review to: Determine the major causes and consequences of the Great Flood of '93; evaluate the performance of existing floodplain management and related watershed management programs; and make recommendations as to what changes in current policies, programs, and activities would most effectively achieve risk reduction, economic efficiency, and environmental enhancement in the floodplain and related watersheds. As appropriate, the Committee should identify legislative initiatives that might be proposed by the Administration.

Because floodplain management involves a complex intergovernmental system of Federal, State, tribal, and local responsibilities, you will ensure outreach to and consultation with other levels of government and the public. You should conduct your activities and deliberations in an open environment.

The Review Committee will include a multi-disciplinary and interagency group of experts in fields relevant to floodplain management. The individuals listed at Attachment 1 have been assigned by their agencies to the Committee. As necessary, you are authorized to request additional assistance, on an ad-hoc basis, from those agencies and from activities not currently represented on the Committee. The Council of Economic Advisors staff will assist in coordination of economic analysis support. The Justice Department will provide legal assistance. FEMA will coordinate public affairs and Congressional and intergovernmental relations for the Committee. The Scientific Assessment and Strategy Team, which was established by a White House directive dated November 24, 1993, (Attachment 2), is further assigned to the Review Committee and will operate under the Committee's direction.

Resources to support the salaries of individuals assigned to the Committee will be provided by parent agencies. You will be provided an appropriate budget to support the travel and other activities of the committee. As coordinated by OEP and OMB, you will be provided a three-person administrative support staff, office space, and supporting equipment.

For the period of this study, you will be assigned to the White House and will report directly to us. You will serve as the primary representative of the Committee for purposes of public outreach and communications and will have executive responsibility for organizing and executing the work of the Committee.

Not later than February 1, 1994, you will submit to us for approval a detailed mission statement for the Committee and a time-phased work plan. The mission statement should reflect coordination with as broad a segment of interested activities as possible. Not later than May 1, 1994, you will provide a preliminary report to us on the results of the review. A final report will be issued to the public by June 1, assuming expeditious review by the Administration. Every 3 weeks, or more frequently if required, you will provide us with in-process-reviews of the effort.

Attachments (2)

APPENDIX B

FLOODPLAIN MANAGEMENT REVIEW COMMITTEE MEMBERSHIP AND ACTIVITIES

COMMITTEE MEMBERS AND ACTIVITIES

Washington, DC-based Members

U.S. Military Academy
BG Gerald E. Galloway -- Executive Director

U.S. Department of Agriculture
Dr. Margriet Caswell, Economic Research Service, Washington, DC
Thomas Wehri, Soil Conservation Service, Washington, DC

U.S. Department of Army (Army Corps of Engineers)
Richard DiBuono, Washington, DC
Arnold Robbins, Vicksburg, MS
Harry Shoudy, Washington DC

U.S. Department of the Interior
Robert Clevenstine, Fish and Wildlife Service, Rock Island, IL
Jerry Rasmussen, Fish and Wildlife Service, Columbia, MO

Environmental Protection Agency
Shannon Cunniff, Washington, DC
Joseph Ferrante, Washington, DC
Lewis Rosenbluth, Washington, DC

Federal Emergency Management Agency
Mary Jean Pajak, Washington, DC
Michael Robinson, Washington, DC

Sioux Falls, SD-based Members Scientific Assessment and Strategy Team

U.S. Geological Survey
Dr. John Kelmelis, Reston, VA, Team Leader

U.S. Department of Agriculture
David Buland, Soil Conservation Service, Huron, SD
Dr. Maurice Mausback, Soil Conservation Service, Lincoln, NE
James Reel, Soil Conservation Service, Des Moines, IA

U.S. Department of Army (Corps of Engineers)
Dr. Gary Freeman, Vicksburg, MS
S.K. Nanda, Rock Island, IL
Tim Peterson, Omaha, NE

U.S. Department of the Interior
Dr. John Dohrenwend, U.S. Geological Survey, Menlo Park, CA
Ron Erikson, Fish and Wildlife Service, Twin Cities, MN
John Evans, U.S. Geological Survey, Reston, VA
Dr. David Galat, National Biological Survey Columbia, MO
Dr. William Kirby, U.S. Geological Survey, Reston, VA
Mark Laustrup, National Biological Survey, Onalaska, WI
Tim Liebermann, U.S. Geological Survey, Carson City, NV

Thomas Owens, National Biological Survey, Onalaska, WI
Wayne Rohde, U.S. Geological Survey, Sioux Falls, SD

Environmental Protection Agency
Milo Anderson, Chicago, IL
Cathy Tortorici, Kansas City, KS

Federal Emergency Management Agency
Mark Whitney, Washington, DC

Additional Support Provided to the FMRC by:

Council on Environmental Quality
Kathleen Gallagher
Patty Leppert-Slack

U.S. Department of Agriculture
Valerie Parich
Tammy Short

U.S. Department of Commerce
Alma Ripps

US Department of the Interior
Yvette Pryor

U.S. Department of Justice
Ted Bolling

Environmental Protection Agency
Charlynne Boddie

Federal Emergency Management Agency
Daniel Cotter
Paige Darden
Mary Jo Vrem
Mark Whitney

Tennessee Valley Authority
Curt Goff

Additional Support Provided to the SAST by:

Federal Emergency Management Agency
Daniel Cotter, Washington, DC

U.S. Geological Survey
Byron Stone, Reston, VA
Charles Trautwein, Sioux Falls, SD

Hughes STX Corporation
Norman Bliss, Sioux Falls, SD
Ron Risty, Sioux Falls, SD

INFORMATION GATHERING ACTIVITIES

Meetings with Federal Agencies

Department of Agriculture – Agricultural Stabilization and Conservation Service
Department of Agriculture – Farmers Home Administration
Department of Agriculture – Federal Crop Insurance Corporation
Department of Agriculture – Rural Development Administration
Department of Agriculture – Soil Conservation Service
Department of the Army – Corps of Engineers
Department of the Army – Institute for Water Resources
Department of Commerce – Economic Development Administration
Department of Commerce – National Weather Service
Department of Health and Human Services
Department of Housing and Urban Development
Department of the Interior – Bureau of Indian Affairs
Department of the Interior – Bureau of Reclamation
Department of the Interior – Fish and Wildlife Service
Department of the Interior – U.S. Geological Survey
Department of the Interior – National Biological Survey
Department of the Interior –National Park Service
Department of Transportation
Environmental Protection Agency
Federal Emergency Management Agency
General Accounting Office
Office of Management and Budget
Small Business Administration

APPENDIX B

Meetings with National and Regional Organizations

Advisory Council on Historic Preservation
American Farm Bureau Federation
American Rivers
American Society of Civil Engineers
Association of American State Geologists
Association of State Flood and Stormwater Managers
Association of State Floodplain Managers
Association of State Wetland Managers
Coalition to Restore Aquatic Ecosystems
Coalition to Restore Urban Waterfronts
Environmental Defense Fund
Interstate Council on Water Policy
National Association of Conservation Districts
National Association of Home Builders
National Association of Realtors
National Corn Growers Association
National Fish and Wildlife Foundation
National Governors Association
National Trust for Historic Preservation
National Wildlife Federation
Natural Disaster Coalition
MARC 2000
Sierra Club
The Nature Conservancy
Upper Mississippi River Basin Association
Working Group on Sustainable Redevelopment
World Wildlife Fund

OUTREACH ACTIVITIES

Attendance at Conferences, Meetings and Workshops

Association of State Floodplain Managers Conference – Tulsa, OK
Fish and Wildlife Interagency Committee Meeting – Rock Island, IL
Governor's State Floodplain Workshop – Springfield, IL
Governor's Task Force on Floodplain Management – Jefferson City, MO
Illinois Association for Floodplain and Stormwater Management Conference – Lisle, IL
Iowa Flood Recovery Workshop – Davenport, IA
Lower Mississippi River Conservation Committee – Little Rock, AR
Mississippi Interstate Cooperative Resource Association – Overland, KS
Minnesota Water '94 Conference – Minneapolis, MN
SCS State Conservationist Meeting – Kansas City, MO
State Floodplain Task Force Meeting – Madison, WI
State Floodplain Task Force Meeting – Minneapolis, MN
State Flood Task Force Meeting – Des Moines, IA
State Task Force Meeting – Lincoln, NE
State Task Force Meeting – Pierre, SD
Technical Workshop – St. Louis, MO
Upper Mississippi River Basin Association Meeting – St. Louis, MO
Upper Mississippi River Conservation Committee – LaCrosse, WI
USACE Floodplain Management Assessment Public Meeting – St. Paul, MN
USACE Floodplain Managers Meeting – Reno, NV
USACE Floodplain River Flood Control Association – Quincy, IL
World Wildlife Fund Conference – Jefferson City, MO
World Wildlife Fund Conference – Rock Island, IL
World Wildlife Fund Conference – Winona, MN

Visits with State, Count and City Officials and Other Local Interests

Iowa

Governor Terry Brandstad
Ames, Iowa
Audubon, Iowa
Audubon County, Iowa
Carter Lake, Iowa
Cherokee, Iowa
Council Bluffs, Iowa

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Des Moines Water Works, Des Moines, Iowa
Dickinson County, Iowa
Eddyville, Iowa
Hamburg, Iowa
Iowa Department of Economic Development
Iowa Department of Natural Resources
Iowa Levee District 16
Keokuk, Iowa
Lee County, Iowa
Marshall County, Iowa
Marshalltown, Iowa
Ottumwa, Iowa
Pottawattamie County, Iowa
Sibley, Iowa
Spirit Lake, Iowa
Wappello County, Iowa

Illinois

Governor Jim Edgar
Alexander County, Illinois
Beardstown Coutny, Illinois
Brown County, Illinois
Calhoun County, Illinois
Fults, Illinois
Grafton, Illinois
Greene County, Illinois
Havana, Illinois
Hull, Illinois
Illinois Farm Bureau
Jackson County, Illinois
Jeresy County, Illinois
Maeystown, Illinois
Mason County, Illinois
Monroe County, Illinois
Morgan County, Illinois
Niota, Illinois
Pere Marquette State Park, Illinois
Pike County, Illinois
Pulaski County, Illinois
Quincy, Illinois
Randolph County, Illinois
Shawnee College, Illinois
Southwest Illinois Planning Commission
Sny Levee District, Illinois
Springfield, Illinois
Valmeyer, Illinois

Kansas

Governor Joan Finney
Elwood, Kansas
Kansas State Legislators Flood Recovery Task Force
Manhattan, Kansas
Topeka, Kansas

Minnesota

Austin, Minnesota
Cottonwood County, Minnesota
Mower County, Minnesota
Windom, Minnesota

Missouri

Governor Mel Carnahan
Jefferson City, Missouri
MARC 2000 – St. Louis, Missouri
Missouri Agricultural and Land Management Resources Institute
Missouri Department of Conservation
Missouri Department of Natural Resources
Missouri Farm Bureau
Missouri Levee Districts
St. Charles County, Missouri
St. Louis County, Missouri
St. Joseph, Missouri
Ste. Genevieve, Missouri

Nebraska

Beatrice, Nebraska
Lincoln, Nebraska
Papio-Missouri River Natural Resources District, Nebraska
Sarpy County, Nebraska

North Dakota

Fargo, North Dakota
State Hazard Mitigation Team, North Dakota

South Dakota

Madison, South Dakota
Montrose, South Dakota

Wisconsin

Black River Falls, Wisconsin
Darlington, Wisconsin
Eau Claire, Wisconsin
Eau Claire District Office, Wisconsin Department of Natural Resources

APPENDIX B

Options Review Meetings

Kansas City, MO
Springfield, IL
St. Paul, MN

CONGRESSIONAL BRIEFINGS AND MEETINGS

U.S. Senate – Members

Senator Bond (R – MO)
Senator Simon (D-IL)

U.S. Senate Members Represented by Staff

Kathy Ruffalo/Senator Baucus (D – MT)
Committee on Environment and Public Works

Steve Knorr/Senator Bond (R – MO)

Rocky Kuhn/Senator Bumpers (D – AR)
Committee on Appropriations, Subcommittee on Agriculture, Rural Development and Related Agencies

Sue Masica/Senator Byrd (D – WV)
Committee on Appropriations, Subcommittee on Interior and Related Agencies

Jean Louver, Dan Delish/Senator Chaffee (R – RI)
Committee on Environment and Public Works

Eric Terrel/Senator Daschle (D – SD)

Ira Paull/Senator D'Amato (R – NY)
Committee on Banking, Housing and Urban Affairs, Subcommittee on Housing and Urban Affairs

Greg Schnecke/Senator Dole (R – KS)

Jeff Harrison/Senator Durenberger (R – MN)

Stephen Kohasi/Senator Gramm (R – TX)
Committee on Appropriations, Subcommittee on Veterans Affairs, Housing and Urban Development, and Independent Agencies

Doug Stout/Senator Grassley (R – IA)

Paul Reinecke/Senator Harkin (D – IA)

Proctor Jones/Senator Johnston (D – LA)
Committee on Appropriations, Subcommittee on Energy and Water Development

Jonathan Wyner/Senator Kerry (D – MA)
Committee on Banking, Housing and Urban Affairs, Subcommittee on Housing and Urban Affairs

Patrick Westoff/Senator Leahy (D – VT)
Committee on Agriculture, Nutrition and Forestry

Carrie Apostolou/Senator Mikulski (D – MD)
Committee on Appropriations, Subcommittee on Veterans Affairs, Housing and Urban Development, and Independent Agencies

Maria Petaros/Senator Moseley-Braun (D – IL)

Sherrie Cooper/Senator Nickles (R – OK)
Committee on Appropriations, Subcommittee on Interior and Related Agencies

Jafar Kardu/Senator Pressler (R – SD)

Kriss Warren/Senator Sarbanes (D – MD)
Committee on Banking, Housing and Urban Affairs, Subcommittee on Housing and Urban Affairs

Tricia Haneghan/Senator Simon (D – IL)

U.S. House of Representatives – Members

Representative Calvert (R – CA)
Representative Costello (D – IL)
Representative Danner (D – MO)
Representative Durbin (D – IL)

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Representative Emerson (R – MO)
Representative Ewing (R – IL)
Representative Furse (D – OR)
Representative Kennedy (D – MA)
Representative Leach (R – IA)
Representative Lightfoot (R – IA)
Representative Marzullo (R – IL)
Representative McKeon (R – CA)
Representative Mineata (D – CA)
Representative Minge (D – MN)
Representative Nussle (R – IA)
Representative Regula (R – OH)
Representative Skeen (R – NM)
Representative Skelton (D – MO)
Representative Smith (D – IA)
Representative Talent (R – MO)
Representative Volkmer (D – MO)
Representative Weldon (R – PA)

US House of Representatives Members Represented by Staff

Ken Kopocis, Scott Slesinger/Representative Applegate (D – OH)
Committee on Public Works and Transportation, Subcommittee on Water Resources and Environment

Bob Schmidt/Representative Bevill (D – AL)
Committee on Appropriations, Subcommittee on Energy and Water Development

Darby Becker/Representative Costello (D – IL)

Beth Phillips/Representative Danner (D – MO)

Dan O'Grady/Representative Durbin (D – IL)

Roxanne Smith/Representative Evans (D – IL)

Tom Meluis/Representative Fields (R – TX)
Committee on Merchant Marine and Fisheries, Subcommittee on Environment and Natural Resources

Miguel Gonzalez/Representative Glickman (D – KS)

Sarah Dahlin/Representative Johnson (D – SD)

Barry Scanlon, Brian Doherty/Representative Kennedy (D – MA)
Committee on Banking, Finance, and Urban Affairs, Subcommittee on Consumer Credit and Insurance

Frank Purcell/Representative Lightfoot (R – IA)

Ann Swartz/Representative Marzullo (R – IL)

Bill Warfield/Representative McDade (R – PA)
Committee on Appropriations, Subcommittee on Interior

Lara Battles/Representative Skelton (D – MO)

Dan Ashe, Barbara Polo/Representative Studds (D – MA)
Committee on Merchant Marine and Fisheries, Subcommittee on Environment and Natural Resources

APPENDIX C

U.S. FARM PROGRAM

PRODUCTION ADJUSTMENT/PRICE SUPPORT

The Food, Agriculture, Conservation, and Trade Act of 1990 (The 1990 Farm Bill) continued the market orientation of its predecessor, the Food Security Act of 1985. The stated goals of the 1990 Farm Bill were to ease financial stress for farmers, reduce government costs, reduce crop surpluses, maintain export competitiveness, and enhance environmental quality. The most widely known features of farm policy are the Production Adjustment/Price Support Programs administered by the Agricultural Stabilization and Conservation Service of the USDA. These programs are aimed at supporting farm income and keeping agricultural production in line with anticipated needs. In general, farmers enrolled in the program are given a price support for growing specified commodities. Not all agricultural crops are included. If an acreage reduction program is in effect, farms are required to place a specified proportion (set-aside) of their acreage based on previous cropping history (base acres) in conservation uses (acreage conservation reserve - ACR). Two major floodplain crops, wheat and corn, are in the acreage reduction program, but soybeans are not.

Price support programs were first authorized in 1933. Support can be through loans, purchases, payments, or a combination of these methods. A deficiency payment rate is calculated as the difference between the "target" price which is currently set by the Secretary of Agriculture at the statutory minimum level, and the higher of the actual market price per crop unit or the loan rate. The total payment to the farmer is the payment rate multiplied by the eligible production. The eligible production is calculated as the payment acres (base acres minus set-aside/ACR acreage minus 15 percent normal flex acres) times the program yield which is a fixed amount based on past production averages.

Even in its most simplified form, the program is complex. There are other important factors that determine profitability for an individual farmer. For example, there may be a cost associated with maintaining a cover crop on the set-aside acres. A farmer can grow a crop other than corn on the normal flex acres (15 percent) which would change the per-acre calculations. If land quality and productivity vary on the farm then the average yield per acre may differ when the farmer participates in the program. Such consideration are important to individuals, but make discussions of federal farm programs unnecessarily confusing. Therefore, the following example is presented to illustrate the importance of farm productivity, market prices, and farm program parameters such as the set-aside rate, target price, and program yield in determining whether a farmer will participate and the level of government payments. Table C.1 shows a simplified example of how a corn farmer would compare his/her income with and without participation in the USDA Commodity Program.

APPENDIX C

Table C.1 Example of Accounting Method for Evaluating Participation in the Federal Farm Program for Corn.

		Not Participating in Program	Participating in Program
Production Calculations			
Base acres	acres	100	100
Set-aside/ACR	acres	NA	10
Permitted acres	acres	NA	90
Maximum pay. acres	acres	NA	75
Planted acres	acres	100	90
Actual yield	bu/acre	135	135
Total production	bushels	13,500	12,150
Market price	$/bu	2.10	2.10
Revenue from sale	$	28,350	25,515
Total production cost	$175/acre	17,500	15,750
Payment Calculations			
Program yield	bu/ac	NA	115
Program production	bushels	NA	8,625
Deficiency pay. rate	$/bu	NA	.65
Program payment	$	NA	5,606.25
Farmer Income			
Total net income	$	10,850.00	15,371.25

Notes: "NA" means not applicable for farmer not enrolled in Commodity Program. Calculations were made using parameters similar to those used in the 1993 Corn Program: Set-Aside rate = 10%; Program Yield = 115 bushels per acre based on a national average; and Target Price = $2.75 per bushel. Program production is [(100*0.85) – (100*0.10)]*115. The deficiency payment rate is the target price minus the market price (2.75-2.10 = 0.65). For simplicity, the loan rate is not included in the analysis. Planted acres are equal to the base acres less the set-aside acres.

APPENDIX D

FLOODPLAIN MANAGEMENT ACT

FUNDAMENTAL COMPONENTS OF PROPOSED LEGISLATION

The Interagency Floodplain Management Review Committee recommends that the Administration propose enactment of a law with the following components:

1) A national policy on floodplains and floodplain management which:

a) Encourages actions to avoid or minimize vulnerability to floods, and to mitigate flood losses;

b) Recognizes that fundamentally, floodplain management must be implemented from the bottom up;

c) Promotes comprehensive systems approaches to floodplain management;

d) Encourages participation in the National Flood Insurance Program;

e) Encourages linkage between state emergency floodplain, natural resource, and coastal zone managers;

f) Recognizes and encourages the link between management of watersheds, ecosystems, and floodplains;

g) Establishes that all federal agencies will address the new vision of floodplain management in undertaking their activities; and

h) Recognizes and encourages the link between pre-disaster planning and hazard mitigation in floodplain management.

2) Incentives for states to develop a capacity for and commitment to floodplain management including:

a) Multi-hazard mitigation grants to states for planning and implementation activities. States could pass grants along to communities.

b) Research and technical assistance grants for floodplain management to assist states in carrying out research, including mapping, and training required with respect to floodplain management. States could pass grants along to communities.

c) Federal projects would have to be consistent, to the maximum extent practicable, with state floodplain management plans.

d) Participation in on-going, non-disaster flood damage reduction and mitigation activities could be withheld from those states that do not undertake floodplain management planning.

3) Guidelines for states as to what essential elements are required for a state floodplain management plan to receive federal approval (establishes a 5-year period to complete a floodplain management plan). Essential elements for federal approval of state floodplain management plans include:

a) Use of the standard project flood and one percent per annum floodplain to set priorities for planning and decisionmaking;

b) Consistency with NFIP requirements;

c) Mechanisms to achieve greater participation in NFIP by individuals;

d) Definition of what constitutes appropriate land and water uses within the floodplain that have a direct, significant impact on flood stage (level of significance to be defined by states but not less than NFIP floodway requirements);

e) An inventory and designation of areas of particular concern within the floodplain and watersheds (inclusive of aquatic areas) affecting flooding;

f) Identification of the means by which states propose to exert control over the land and water uses referred to above (such as a state permit program);

g) Broad guidelines on priorities of land uses in particular areas, including those uses of lowest priority; and,

h) Watershed management plans.

4) Cost-sharing. Establishes the amount of any grant made pursuant to this Act as initially not exceeding 80 percent of the state's cost of undertaking the activity of the grant and will decrease over ten years to a 50 percent share. Establishes greater funding priority given to states with documented individual participation in NFIP in excess of a minimum percentage, e.g., 50 percent.

ESTIMATED RESOURCE REQUIREMENTS

It is estimated that implementations of the Act would require an increase of the FEMA staff by 15 individuals nationwide to distribute grants and oversee the program. The total annual federal cost of the program, for staffing and grants, is estimated as $70 million. Grants would be used to supplement state efforts and would therefore represent a sharing of the costs of building and implementing floodplain management programs meeting federal standards.

APPENDIX E

FEDERAL POLICIES AND PROGRAMS FOR FLOODPLAIN MANAGEMENT

ADMINISTRATIVE GUIDELINES

Floodplain Management

Executive Order 11988, 24 May 1977, requires federal agencies to provide leadership and take action to: (1) avoid development in the base (100-year) floodplain unless it is the only practicable alternative; (2) reduce the hazards and risk associated with floods; (3) minimize the impact of floods on human safety, health and welfare; and (4) restore and preserve the natural and beneficial values of the floodplain.

Protection of Wetlands

Executive Order 11990, 24 May 1977, directs federal agencies to provide leadership in minimizing the destruction, loss, or degradation of wetlands. Section 2 of this order states that, in furtherance of the National Environmental Policy Act of 1969, agencies shall avoid undertaking or assisting in new construction located in wetlands unless there is no practicable alternative.

Principles and Guidelines

The Principles and Guidelines established by the Water Resources Council and approved by the President on February 3, 1983, prescribe a single federal objective, national economic development (NED), and do not specifically characterize other plans that must be in the array of alternatives considered by federal agencies in planning water resources development projects. They do, however, allow for display of potential impacts in four accounts: NED, environmental quality (EQ), regional economic development (RED) and other social effects (OSE). Alternative plans formulated must include a plan that reasonably maximizes net national economic development benefits, consistent with the federal objective. This plan is identified as the NED plan and is the one to be recommended for federal action, unless the Secretary of a department or head of an independent agency grants an exception to this rule. Exceptions may be made when there are overriding reasons for recommending another plan, based on other federal, state, local and international concerns. The Principles and Guidelines are applicable to USACE implementation studies for civil works water project plans and to similar plans of the SCE, TVA, and BOR. They have no standing as Administrative Rules.

U.S. DEPARTMENT OF AGRICULTURE

Agricultural Stabilization and Conservative Service

Agricultural Conservation Program: The Soil Conservation and Domestic Allotment Act of 1936 provides cost sharing to farmers and ranchers to encourage them to carry out conservation and environmental practices on agricultural land that result in long-term public benefits. Practices eligible for cost sharing include: establishment or improvement of permanent vegetative cover, contour or strip-cropping systems, and terrace systems; development

of springs, seeps and wells; installation of pipelines, storage facilities, and other measures intended to provide erosion control on range or pasture land; installation of water impoundment reservoirs for erosion control, conservation, and environmental and wildlife enhancement; planting trees and shrubs and improving timber stands for protection against wind and water erosion and for timber production; and development of new or rehabilitation of existing shallow water areas to support Food, habitat, and cover for wildlife. Practices that are primarily production-oriented are not eligible for cost-sharing.

Agricultural Water Quality Protection Program: The Food Security Act of 1990 authorizes USDA to enter into 3- to 5-year agreements with farm owners and operators to develop and implement plans to protect water quality. These agreements do not preclude crop production on the enrolled acreage. Eligible lands include wellhead protection areas within 1,000 feet of public wells, areas of karst topography where sinkholes convey runoff water directly into groundwater, critical areas having priority problems resulting from agricultural non-point sources of pollution, areas where agricultural non-point source pollution is adversely affecting threatened or endangered species habitats, and other environmentally sensitive areas identified by the USDA, the EPA, DOI, or state agencies.

Conservation Reserve Program: The Food Security Act of 1985, as amended, encourages farmers through 10- to 15-year contracts with USDA, to stop growing crops on cropland subject to excessive erosion or that contributes to a significant water quality problem and plant it to a protective cover of grass or trees. A conservation plan describing the conservation measures and maintenance requirements to be carried out by the owner or operator during the term of the contract must be agreed to by the participant and the district conservationist.

Disaster Payments: The Agriculture Consumer Protection Act of 1973 authorized disaster payments to compensate farmers for prevented plantings and unusually low yields due to natural disasters, adverse weather, and other conditions beyond a producer's control. The program covered wheat, barley, corn, sorghum, rice and cotton. Prior to enactment of the Federal Crop Insurance Act of 1980, the disaster payments program compensated eligible farmers for losses due to natural disasters. The Act ended the disaster assistance program for those counties in which Federal Crop Insurance was available. However, the Secretary of Agriculture has the discretion to issue disaster type payments to counties if he thinks the situation warrants it. Disaster payments to an individual under the wheat, feed grains, upland cotton, and rice programs combined cannot exceed $100,000.

Emergency Conservation Program: The Agricultural Credit Act of 1978 provides emergency funds for sharing with farmers and ranchers the cost of rehabilitating farmland damaged by wind erosion, floods, hurricanes, or other natural disasters, and for carrying out emergency water conservation measures during periods of severe drought. The natural disaster must create new conservation problems, which, if not treated, would (1) impair or endanger the land; (2) materially affect the productive capacity of the land; (3) represent unusual damage which, except for wind erosion, is not the type likely to recur frequently in the same area; and (4) be so costly to repair that federal assistance is or will be required to return the land to productive agricultural use. Conservation problems existing prior to the disaster involved are not eligible for cost-sharing assistance. Cost-share agreements are required, and federal assistance cannot exceed 65 percent of the actual, average, or estimated cost of performing the emergency induced work.

Forestry Incentives Program: The Cooperative Forestry Assistance Act of 1978 encourages landowners to plant trees on suitable open lands or cut over areas and to perform timber stand improvement work for production of timber and other related forest resources. Cost-share agreements between the landowner and the Secretary of Agriculture are based on forest management plans developed by the landowner in cooperation with and approved by the State forestry agency. Cost-sharing assistance cannot exceed 65 percent of the cost of work under approved plans.

APPENDIX E

Price and Income Support Programs: Commodity Credit Corporation (CCC) programs support and stabilize farm prices and income and maintain stable levels of supply. These goals are accomplished through CCC payments, purchases, and acreage reduction programs. Price and income support programs began with the Agricultural Adjustment Act of 1933 which introduced a number of new policies including payments to farmers for voluntary acreage reductions, on-farm storage, and marketing agreements. All subsequent farm legislation has continued to emphasize price and income supports for major crops.

a) *Nonrecourse Commodity Loans:* Congressionally-established loan rates provide minimum crop prices through nonrecourse loans to farmers. A nonrecourse loan is one which farmers are not obligated to repay; they can simply forfeit the collateral (the crop). A farmer can place the crop in storage and receive a loan from the government based on the established loan rate. If the market price rises above the loan rate, the farmer can sell the crop on the market and repay the loan, interest, and storage costs. If the market price does not rise above the loan rate, the farmer can default on the loan (without penalty) and turn the crop over to the government. Consequently the loan rate places a floor under the commodity price for a participant.

b) *Deficiency Payments:* Congressionally established target prices for certain crops enable participating farmers to receive "deficiency payments" from the CCC for eligible program commodities when commodity prices fall below the target price for specified periods of time. The legislative deficiency payment rate is the target price for specified periods of time. The legislative deficiency payment rate is the target price minus the higher of: (1) the loan rate, or (2) the national average market price for the first five months of the marketing year. Deficiency payments are based on "program yields" rather than actual yields. Program yields are established by the Agricultural Stabilization and Conservation Service (ASCS) county committees and are a function of the farm's historical yields. Deficiency payments are multiplied by a program allocation factor. In years when program expenditures are high, the Secretary of Agriculture can invoke the program allocation factor in order to reduce expenditures. The program allocation factor is legislated to be between 0.8 and 1.0, but its actual value is not known by farmers at sign-up time.

Sodbuster Provision: The Food Security Act of 1985, as amended, discourages the conversion of highly erodible land to agricultural production. If highly erodible grassland or woodland is used for cropland production, producers may lose eligibility for: price and income supports, crop insurance, FmHA loans, CCC storage payments, farm storage facility loans, and other programs under which USDA makes payments. Sodbuster applies to highly erodible land which was not planted to annually tilled crops from 1981-85. To maintain eligibility for USDA program benefits, producers must have a conservation plan approved by their local conservation district for any highly erodible land broken out for crop production after that date.

Supply Restriction Programs: Acreage reductions, set-asides, paid land diversions, and payment-in-kind programs have been the primary means of restricting supply. The general goal of these policies is to reduce the number of acres planted and thus reduce crop production. If an acreage reduction or set-aside is in effect, producers must reduce their plantings by a specified percentage of the acreage base for each enrolled commodity to be eligible for CCC loans, purchases, and payments.

Swampbuster Provision: The Food Security Act of 1985, as amended, discourages the conversion of natural wetlands to cropland use. With certain exceptions, if producers converted a wetland area to cropland after December 23, 1985, they lose eligibility for several USDA program benefits (see list above under sodbuster provision).

Wetlands Reserve Program: The Food Security Act of 1990 provides financial incentives for restoration and protection of wetlands if farmers agree to long-term (30-year or permanent) easements. Farmed or converted

wetlands (must have been converted prior to December 23, 1985), adjacent functionally related lands, and riparian areas that link wetlands are eligible for enrollment. In addition, farmed wetlands and adjoining lands enrolled in the conservation reserve may be permitted to be enrolled if they have high wetland functions and values, were not planted to trees under a Conservation Reserve Program (CRP) contract, and are likely to return to production after they leave the CRP. The federal government will provide not less than 75 percent cost-share for restoration, plus lump sum payment for easement.

Water Bank Program: The Water Bank Act of 1970, as amended, provides for preservation and improvement of major wetlands as habitat for migratory waterfowl and other wildlife; conservation of surface waters; reduction of runoff, soil and wind erosion; flood control; improved water quality; improved subsurface moisture; and enhancement of the natural beauty of the landscape. Under this program, wetland owners enter an agreement with the ASCS promising not to drain, burn, fill, level, or use the wetland for a 10-year period. The Water Bank Program agreements extend protection to and require conservation measures on adjacent upland habitat. In exchange, the landowner receives an annual payment designed to reflect local real estate values. If the land is also under FWS agreement, the annual payment is reduced by 20 percent. When accepting an area into the program, ASCS tries to maintain a 3:1 or 4:1 ratio of uplands to wetlands. The term "wetlands," for purposes of carrying out the program, includes: seasonally flooded basins or flats, fresh meadows, shallow fresh marshes, deep fresh marshes, open fresh water, shrub swamps, and wooded swamps. Participants in the program enter in to 10-year agreements, with provisions for renewal, and receive payments for approved conservation work.

Soil Conservation Service

Cooperative River Basin Program: Section 6, PL 83-566, provides for technical assistance to Federal, State, regional, and local governments in formulating and carrying out plans for conservation use treatment measures, nonstructural measures, and development. Plans may include management and structural measures, or combinations thereof. There are no cost sharing requirements.

Emergency Watershed Protection Program: Section 216, PL 81-516 and Section 404, Title IV, PL 95-331 provided the Soil Conservation Service with authorization for disaster relief funding in repairing damages to waterways and watersheds. Work includes debris removal and erosion control for waterways, levee repair and relocations.

Emergency Wetland Reserve Program: The same authority as Emergency Watershed Protection Program provides for the purchase of easements from persons owning cropland who voluntarily agree to restore farmed, converted, or potential wetlands. The combined cost of restoring the land and levees must exceed the fair market value of the affected cropland to be eligible for the program. The easements are purchased to promote wetland values such as hydrology and vegetation, and protect the functions and values of wetlands or wildlife habitat, water quality improvement, flood water retention, floodway enhancement, environmental education, and other values determined appropriate by SCS. Use of the easement lands for cropland is prohibited.

Watershed Protection: Section 3, Watershed Protection and Flood Prevention Act of 1954; PL 83-566 provides for technical assistance to state and local governments in planning and carrying out works of improvement to protect, develop, and utilize the land and water resources in small watersheds under 250,000 acres in size. Conservation land treatment, structural, and nonstructural measures are used to address problems related to watershed protection, flood prevention, and agricultural and nonagricultural water management. Nonstructural measures are preferred. Projects must be sponsored by entities legally organized under state law, or any Indian tribe or tribal organization, having authority to carry out, operate, and maintain works of improvement. Cost-sharing requirements are variable, depending on the nature of the project.

Farmers Home Administration

Debt Cancellation Conservation Easements: FmHA can forgive debt in exchange for conservation easements on environmentally sensitive portions of a borrower's property. A conservation easement may be obtained for a period of not less than 50 years. A perpetual easement will usually be recommended. Both current and delinquent FmHA borrowers are eligible to participate in the dept restructuring conservation easement program. The borrowers must have loans secured by real estate. The easements can be established for conservation, recreational, and wildlife purposes on farm property that is wetland, wildlife habitat, upland, or highly erodible land. Non-program borrowers are not eligible to participate. There is no cost sharing.

Loans: Below market rate ownership and operating loans are available directly to farmers through FmHA. The relatively low rates reduce the cost of capital and may encourage farmers to expand the size of their operations. The loans are made primarily to family farmers who cannot obtain private credit to finance operations or make farm improvements. In addition the FmHA increasingly has been providing disaster emergency loans that can reduce the risk of farming in floodprone areas. The FmHA issued regulations in 1983 (7 CFR Part 1940.301) stating that FmHA loans are not to be allowed for activities that would directly or indirectly affect wetlands, unless there is "no practical alternative." In addition, FmHA will soon publish regulations implementing the farm debt restructure and conservation set-aside provisions of the Food Security Act of 1985 (section 1318). This program will allow a farmer who is unable to repay his loan to have a portion of his FmHA loan cancelled in exchange for a conservation easement of at least 50 years. The percentage of the debt forgiven will be equal to the percentage of the farm acreage (secured by the loan) which is placed under easement.

Transfers of Inventory Farm Properties to Federal and State Agencies for Conservation Purposes: Under the Consolidated Farm and Rural Development Act, FmHA can transfer certain inventory farm properties to Federal and State agencies. The transfer must be for conservation purposes. The property must have marginal value for agricultural production, be classified as environmentally sensitive, or be of special management importance. Properties containing important resources such as wetlands, floodplains, riparian zones, historical sites or endangered species may qualify. Inventory farm properties that are inholding, lie adjacent to, or occur in proximity to, federally- or state-owned lands may qualify. There is no cost share involved.

DEPARTMENT OF THE ARMY, U.S. ARMY CORPS OF ENGINEERS (USACE)

Fish and Wildlife Enhancement: Section 906, Water Resource Development Act of 1986, PL 99-662 provides that for any project measures recommended to enhance fish and wildlife, costs will be entirely federal when the benefits have a national character and, where they do not, non-federal interests shall reimburse 25 percent of the costs. The non-federal share of operations, maintenance and rehabilitation costs will, in all cases, be 25 percent.

Flood Emergency Operations and Disaster Assistance: PL 84-99 covers emergency activities pursuant to PL 99-84, as amended by the Flood Control the Flood Control Act of 1962 and further amended by PL 93-252 and PL 99-51. It provides for floodfighting and rescue operations; post-flood response; emergency repair and restoration of flood-damaged or destroyed flood-control works such as levees; emergency protection of federally authorized hurricane and shore protection works being threatened; the repair or restoration of federal hurricane- or shore-protection structures damaged or destroyed by wind, wave, or water action of other than an ordinary nature; emergency supplies of clean water to any locality confronted with a source of contaminated water causing or likely to cause a substantial threat to the public health and

welfare of the inhabitants of the locality; and emergency water supplied for human and livestock use in areas determined to be drought distressed. Provision of advance flood damage-reduction measures by the USACE is supplemental to individual and local community efforts, rather than a replacement for them. USACE protective and preventive measures are generally of a temporary nature designed to meet an imminent flood threat. Permanent rehabilitation work to protect against the threat of future disasters is considered separately from advance measures. A declaration of a state of emergency or written request by the governor of a state is a prerequisite to furnishing advance measures under PL 84-99. Local interests are required to remove temporary works provided as advanced measures.

It is USACE policy to obtain local assurances for assistance. Local cooperation for accomplishment of advance measures and rehabilitation works require local assurances to: (1) provide without cost to the United States all lands, easements, and rights-of-way necessary for the authorized emergency work; (2) hold and save the United States free from damage due to the authorized emergency work; and (3) maintain and operate all the rehabilitation work after its completion. Under PL 84-99, emergency funds may be expended directly by the USACE for authorized purposes. PL 84-99 does not authorize reimbursement of local interests for any of their costs for emergency operations accomplished on their behalf. Also, PL 84-99 authority and funds are not used in lieu of other USACE authorities. The Corps may perform emergency work on public and private lands and waters for a period of ten days following a governor's request for assistance. This work must be essential for the preservation of life and property, including, but not limited to, channel clearance, emergency shore protection, clearance and removal of debris and wreckage endangering health and safety, and temporary restoration of essential public facilities and services. In the event of a Presidential declaration of a major disaster or emergency declared by the Director of the Federal Emergency Management Agency, the USACE can provide assistance to state and local governments in essential recovery operations when and as directed by the President through FEMA under provisions of PL 93-288. The Corps fully responds to all requests from the FEMA director or regional director.

Flood Plain Management Services Program: Section 206, Flood Control Act of 1960, as amended, provides for the USACE to furnish floodplain information and technical assistance to states, counties, and cities for prudent use of land subject to flooding from streams, lakes, and oceans. Services include: developing and interpreting flood and floodplain data such as flood hazard mapping; providing a broad assessment of the impact of structural and nonstructural flood damage-reduction measures; providing technical assistance on floodproofing systems and techniques; and assessing the possible impacts of land-use changes on the physical, socio-economic, and environmental conditions of the floodplain.

Planning Assistance to States: Section 22, Water Resources Development Act of 1974, PL 93-251 authorizes cooperation with states and federally recognized Indian Tribes in the preparation of comprehensive plans for the development, utilization, and conservation of the water and related resources of drainage basins located within the boundaries of the state and submitting to Congress reports and recommendations with respect to appropriate federal participation in carrying out the plan. Typical activities studied under this program are flood damage reduction, water supply, water conservation, water quality, hydropower, erosion, navigation, and methodologies to evaluate wetlands or other resources. Expenditures in any one state cannot exceed $300,000 in any one year, as amended by Section 921 of the Water Resources Development Act of 1986. Federal input to the state planning program is on an effort- or service-sharing basis in lieu of an outright grant. The non-federal share of costs in 50 percent; in-kind services are not accepted.

Project Modifications to Improve Environment: Section 1135, Water Resources Development Act of 1986; PL 99-662 provides for modifications of the operation of completed USACE projects for the purpose of improving environmental quality. The program can be used to protect, restore or create wetlands, provided the work involves modification of water resources projects for the purpose of improving environmental quality. The program can be used to protect, restore, or create wetlands, provided the work involves modification of a water resources project constructed by the USACE. Type of projects that could be considered include: installation of gaged culverts in USACE levees; opening oxbows cut off by USACE levees or navigation features; or realignment of a levee to allow areas between the levee and the channel to

revert to historic floodplain habitat. The non-federal sponsor is responsible for 25 percent of the cost of study and implementation, which includes any necessary lands, easements, rights-of-way, relocations, and disposal areas. No work-in-kind is creditable. The non-federal sponsor is also responsible for 100 percent of incremental operation and maintenance costs.

Regulation of Dredged or Fill Material into U.S. Waters: Section 404, Clean Water Act of 1977 requires a USACE permit for discharges of dredged or fill materials into the waters of the United States. Such discharges, to qualify for a permit, must be in compliance with the guidelines published by the Environmental Protection Agency to implement Section 404(b)(1) of the Clean Water Act. Section 404(c) of the Act authorizes the Administrator of EPA to prohibit or restrict the use of a disposal site whenever it is determined that the discharge of such materials will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas, wildlife, or recreational areas.

Regulation of Navigable Waters: Section 10, River and Harbor Act of 3 March 1899 prohibits the unauthorized obstruction or alteration of any navigable water of the United States. A USACE permit is required for the construction of any structure in or over any navigable water of the United States or the accomplishment of any other work affecting the course, location, condition, or physical capacity of such waters.

Water Resources Development Projects: The USACE is the principal Federal agency with responsibility for flood control and navigation projects, which in some cases include other purposes such as water supply, recreation, hydroelectric power, and fish and wildlife enhancement. Such projects, with certain exceptions, require specific authorization by Congress. Examples of exceptions include small, single-purpose projects for flood control or navigation which can be carried out under several continuing authorities such as Section 205 of the Flood Control Act of 1948, as amended, and Section 107 of the Rivers and Harbors Act of 1960, as amended. For flood control projects, the minimum local cost-share is 25 percent. The value of any lands, easements, and rights-of-way count as part of the 25 percent, but a minimum cash contribution must be made for structural flood control projects and must be equal to five percent of the construction cost. Since all lands, easements, and rights-of-way necessary for the construction of a project are the on-federal sponsor's responsibility, it is possible for the non-federal share of a structural flood control project to exceed 25 percent; however, the non-federal share cannot exceed 50 percent. The non-federal cost-share for navigation projects varies, depending upon project depth. The Water Resources Development Act of 1986 (PL 99-662), which established current cost sharing for Federal water resources development projects, also requires 50-50 sharing of costs of feasibility studies conducted by the USACE which lead to the development of water projects, and makes the non-federal sponsor responsible for all operations and maintenance costs of flood control projects authorized in and after the 1986 Act. Reconnaissance studies leading to feasibility studies are conducted at full federal expense. Under the Pick-Sloan Missouri River Basin Program (authorized by the Flood Control Act of 1944), the USACE constructed five large dams and reservoirs along the main stem Missouri River during the 1950s and 1960s. Four of these are in South Dakota, while Garrison is in North Dakota. The USACE operates these main stem dams and reservoirs for multiple purposes: flood control, irrigation, navigation, recreation, wildlife, municipal and industrial water supplies, and hydroelectric power. Tributary projects are constructed and operated by both the USACE and the Bureau of Reclamation.

U.S. DEPARTMENT OF COMMERCE, ECONOMIC DEVELOPMENT ADMINISTRATION (EDA)

The EDA flood relief program provides for grant awards to assist communities, industries, and firms adversely impacted by the flood of 1993 and other disasters to assist in the long-term economic recovery of the affected area.

Grant awards can be used to respond to emergency infrastructure needs as well as unmet needs for public infrastructure improvements that are not adequately addressed by FEMA or other federal agencies. The 1993 Supplemental Appropriation provided $200 million to EDA through September 30, 1995, to carry out this effort. Non-federal cost sharing requirements are 25 percent for economic adjustment and technical assistance grants, and 20 percent for public works direct grants.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

Control of Non-point Pollution: Section 319, Clean Water Act provides for grants to state agencies to implement restoration activities that control non-point pollution. There is a 40 percent state match.

Wastewater Treatment Plants: Capitalization grants for state revolving funds provide for loans to local municipalities to repair, replace, or relocate wastewater treatment plants damaged by the floods of 1993. There are no cost sharing requirements. The municipalities receive loans against state revolving funds and repay 100 percent plus interest.

Wetland Protection: State development grants provide for grants to states and federally recognized Indian tribes to develop new or refine existing state and tribal wetlands protection programs. Only state agencies and federally recognized Indian tribes are eligible. Some funds can be passed through by state and other entities, but the state must have a major role in the project. Funds cannot be used for relocation of farm or urban structures or to support construction activities. The project sponsor must provide 25 percent of total cost.

FEDERAL CROP INSURANCE CORPORATION (FCIC)

Federal crop insurance was established by the Federal Crop Insurance Act of 1938, but essentially operated as a pilot program for four decades. The Federal Crop Insurance Corporation Act of 1980 greatly expanded the program to make it the major policy for protection from crop failure. The federal government subsidizes the premiums and administrative costs of the insurance program. A variety of coverage levels are available. The higher the yield guarantee level and the higher the price election, the higher will be the premium the farmer will pay. If at harvest time, farm yields are below the yield guarantee level, an insurance adjuster will visit the farm and determine the indemnity which the farmer is entitled to receive. Crop insurance reduces the risks involved in agricultural production, protecting farmers against yield losses from a variety of natural causes, including flooding, which is likely to occur on cleared bottom land areas. Under Swampbuster farmers who plant on newly converted wetlands are ineligible for crop insurance coverage on all planted acreage.

FEDERAL EMERGENCY MANAGEMNT AGENCY (FEMA)

Hazard Mitigation Grant Program: Section 404, Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended, provides for grants to state and local governments, certain private non-profit organizations or institutions, and Indian tribes for hazard mitigation actions after a Presidentially declared disaster. Funds can be used for projects to protect either public or private property. Examples of projects include: structural hazard control, such as debris basins; retro-fitting, such as elevation or flood proofing to protect structures from future damage; acquisition and relocation of structures from hazard-prone areas; and development of state or local standards to protect new and substantially improved structures from disaster damage. The non-federal sponsor is required to pay 25 percent of the project's total eligible costs.

National Flood Insurance Program (NFIP): The National Flood Insurance Act of 1968, as amended, makes flood insurance available to protect the individual in participating communities from financial loss in the event of a flood. Under the NFIP insurance is subsidized, up to an amount specified, for existing buildings in areas designated as flood hazard areas by FEMA. New buildings pay the full actuarial cost of flood insurance. The land-use control measures required of communities to gain and maintain eligibility for flood insurance are complementary to other floodplain management efforts. Section 202 of PL 93-234 states that no federal officer or agency shall approve any financial assistance for acquisition or construction purposes after July 1, 1975, for use in any area identified by FEMA as an area having special flood hazards unless the community in which such area is situated is then participating in the National Flood Insurance Program. Section 402 of WRDA 1986 expands the prohibition against federal participation in flood hazard areas by including federal participation in construction of local flood control projects.

Purchase of Floodplain Property: Section 1362 of the National Flood Insurance Act of 1968 provides for federal acquisition of previously flood-damaged property owners the opportunity to relocate to non-flood-prone areas. To be eligible, the property owner must have a flood insurance policy in force when the damage occurs, and at least one of the following criteria must be met: (1) the currently damaged structure must have been damaged by at least three previous floods over a 5-year period, with an average damage of 25 percent or more of the value of the structure; (2) a single flood has damaged the structure 50 percent or more of its value or beyond repair to its pre-flood condition; and (3) any single event has left the structure damaged and irreparable, either due to local ordinance limitations or significantly increased building costs. Communities participating in the program must agree to accept title to purchased property and manage it for open space or other non-development purposes. The property owner may retain ownership of buildings by moving them to another location.

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD)

Community Development Block Grant Program: This program provides for formula grants to metropolitan cities and urban counties and to States for use in non-entitlement areas which do not receive entitlement grants. All funded activities must meet one of three broad national objectives: to benefit low and moderate income persons, to eliminate slums and blight, or to meet urgent community development needs.

HOME Program: This program provides for formula grants to states and larger cities and urban counties for permanent housing for low-income persons. Funds can be used for acquisition, new construction, rehabilitation, and tenant-based rental assistance.

Section 108 Loan Guarantee Program: This program provides for loan guarantee assistance to states to finance: acquisition of real property; relocation of property, homes, and businesses; rehabilitation of publicly owned real property, including repair and reconstruction of public utilities, such as water and sewer systems; housing rehabilitation, including elevation of properties; and economic development.

U.S. DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

Established by the Reclamation Act of 1902, the Bureau constructs, operates, and maintains multipurpose water projects in the 17 western States, primarily for irrigation, hydroelectric power generation, and municipal and industrial water supply. Projects also provide flood control and recreational benefits, but these are generally not primary project purposes. The Bureau also manages any

water distribution facilities associated with the USACE projects constructed under the Pick-Sloan Missouri River Basin Program. As with the USACE projects, the non-federal cost burden has increased recently for Bureau projects. On new projects the Bureau requires the non-federal sponsors to contribute 50 percent of feasibility study costs and finance up-front a portion of the construction costs for the project (as opposed to delaying reimbursement until after construction is completed and the project is operating, as was the historical practice). Further, the Bureau's approach to any new hydroelectric projects has been tightened significantly: the entire construction cost must be paid by the non-federal sponsor during the construction period.

Fish & Wildlife Service (FWS)

North American Wetlands Conservation Fund: Provides for Federal cost-share funding on a 50-50 basis to states, local governments, businesses, and individuals to protect, restore, and manage a diversity of wetland habitat for migratory birds and other wildlife.

Partners for Wildlife: This program provides for grants and technical assistance to private landowners interested in restoring wetlands and riparian habitats on their land. Landowners enter into a binding agreement with the FWS to restore and protect the site. Agreements are for a minimum 10-year period, but landowners are given a higher priority for funding if they intend to protect the area perpetually. Cost sharing is negotiated. The FWS can cost share with the Agricultural Stabilization and Conservation Service, State agencies, conservation organizations, and others.

Small Wetlands Acquisition Program (SWAP): Under this program the FWS can either purchase wetlands and surrounding upland areas outright or enter into a perpetual easement agreement which places restrictions on the wetlands. In the case of an outright fee purchase, the FWS buys the land at the current market value. This valuation is performed by examining recent land sales where land sold contained wetlands. When purchasing a wetlands area, the FWS seeks to obtain a ratio of 2:1 upland to wetland. In the case of an easement purchase, the landowner gives up rights and responsibilities to drain, fill, burn, or level the wetlands. All other ownership rights and responsibilities remain. Uplands are not restricted with a FWS lease as in the purchase. Easement payments are made on a one-time, lump sum basis, with the payment varying according to land values in the immediate area and the development potential of the wetlands.

National Park Service (NPS)

Federal Land Transfer, Federal Land-to-Parks Program: This program provides for technical assistance and transfer of available surplus federal real property to states and local governments for the purpose of establishing state and local parks for recreation and open space. Properties must be made available by the General Services Administration.

Rivers and Trails Conservation Program: This program provides for NPS staff assistance to communities for river and trail corridor planning and open space preservation efforts. Cost-sharing is variable, usually in the form of in-kind services.

SMALL BUSINESS ADMINISTRATION (SBA)

SBA makes disaster loans to non-farm, private sector owners of disaster damaged property for uninsured losses, including homeowners and renters, businesses of all sizes, and nonprofit organizations. Loans can be used by a property owner to restore any property, including wetlands damaged by flooding. Owners of non-farm, flood damaged properties may use loan funds to help fund acquisition of a replacement property at a different site. In cases of forced relocation of substantial damage (as defined by the National Flood Insurance Program administered by the Federal Emergency Management Agency) in a special flood hazard area, the damaged property may be treated as a total loss, making the property owner eligible for full replacement value. Loans generally have an

interest rate of 4 percent and terms up to 30 years, depending on borrowers' ability to repay. Borrowers, such as businesses, able to use their own resources to meet disaster needs without hardship pay a higher interest rate (generally 8 percent) and their loans are limited to a three-year term. Business loans and those to nonprofit organizations are limited to a statutory maximum or $1.5 million, except that SBA has authority to grant a waiver for businesses that are major sources of employment. Loans to homeowners are limited to $100,000 for real estate, $20,000 for personal property, $100,000 for refinancing of prior liens, and $24,000 for additional mitigation devices not required by code.

RURAL DEVELOPMENT ADMINISTRATION

Water and Water Disposal Loans and Grants: This program provides for loans and grants (75 percent of project costs) to public entities such as municipalities, counties, special-purpose districts, Indian tribes, and non-profit corporations to develop water and waste disposal systems in rural areas and towns with a population less than 10,000. It also provides for technical assistance and training grants, solid waste management grants, and emergency community water assistance grants. The emergency community water assistance grants can be made in rural areas and cities or towns with a population not in excess of 5,000 and a median household income not in excess of 100 percent of a state's non-metropolitan median household income. Additional funds are available through June 30, 1994, to assist rural areas and cities and towns, with a population not in excess of 15,000, to cover costs that are a consequence of the Midwest floods or other Presidential declared disasters that occurred in 1993.

Business and Industrial Guaranteed Loans: Business and industrial guaranteed loans may be made in any area outside the boundary of a city of 50,000 or more and its immediate adjacent urbanized areas with population density of no more than 100 persons per square mile. Priority is given to applications for projects in open country, rural communities, and towns of 25,000 and smaller. Any legal entity, including individuals, public and private organizations and federally recognized indian tribal groups, may borrow. Additional funds are available to guarantee loans made by private lenders to cover costs arising from the consequences of Presidential declared disasters. The maximum loan amount that can be guaranteed is $10 million.

Community Facility Loans: This program provides for loans to public entities such as municipalities, counties, special purpose districts, nonprofit corporations, and Indian Tribes to construct, enlarge, or improve community facilities for health care, public safety and public services.

TENNESSEE VALLEY AUTHORITY (TVA)

Among other objectives, the 1933 TVA Act charged the agency with controlling destructive floodwaters along the Tennessee River and its tributaries. TVA has a unique dual approach to flood risk reduction that combines a system of dams and reservoirs with proactive floodplain management. TVA's Flood Risk Reduction Program reduces flood damage potential in a manner which reduces property damage and the threat to loss of life, supports appropriate economic development, preserves natural floodplain values, and enhances effective multipurpose reservoir operations. TVA develops and provides flood risk data which includes flood flows, flood elevations, and flood risk mapping. It conducts engineering analyses to determine impacts of proposed floodplain development and evaluate the effectiveness of proposed flood damage reduction alternatives. Where appropriate, TVA designs and implements flood damage reduction projects. It supports state and local floodplain management efforts through educational and technology transfer activities.

APPENDIX F

STATE FLOODPLAIN MANAGEMENT PROGRAMS

The text and table in this appendix are taken from a special report by the Association of State Floodplain Managers, Inc., entitled *Floodplain Management, 1992, State and Local Programs,* and were reprinted by permission.

The Nature of State Floodplain Management

State governments derive their authority to plan and implement floodplain management actions from the police power that is vested in them by the U. S. Constitution. The principal roles played by states in floodplain management today include coordination of the National Flood Insurance Program (NFIP) for the activities within their jurisdictions; planning and implementing programs and projects for managing their own floodplains, including state-level regulations; providing technical expertise of all kinds to individuals and to other levels of governments, especially localities; coordinating local and regional programs within their jurisdictions; entering into agreements with other states to cope with multi-jurisdictional flood problems; and acting as liaisons with the federal government. Sometimes states compensate for the inability or unwillingness of local governments to take certain actions to reduce their flood risk or preserve the natural functions of their floodplains. Direct state regulation of some aspects of land use, of selected types of lands, and of certain kinds of activities is becoming more typical.

Most states have floodplain management programs that are a composite of varied activities undertaken by different agencies and other entities within the state. The central office is usually the one that coordinates the NFIP for that state. In 33 states that function is housed in a department for natural resources, water resources, or environmental protection. In nine states it is within an emergency preparedness agency, in six with a department of community affairs, and in two states with a state planning office. Two states manage their floodplains principally out of a transportation department. Sometimes, most or all of the activities related to floodplain management are organized into one office or department, and sometimes they are scattered throughout state government, necessitating careful coordination.

The myriad of programs that affect floodplain management -- emergency preparedness and response, natural resources protection, environmental quality, structural control measures, planning, and economic development -- along with the wide variety in local and regional efforts, makes the floodplain management picture of each state unique.

APPENDIX F

Table F.1: Summaries of State Floodplain Management Activities, 1991 (Source: Adapted from Association of State Floodplain Managers, 1992)

	Budget: State Contribution/Total (in $1000)	Programs for Mapping Floodplain Areas	Riverine Regulatory Standards Exceeding NFIP Minimums	Regulations for Areas Behind Levees	Programs for Acquisition & Relocation Program Funding	Cooperative Projects to Protect Floodplain Resources
Alabama	30/95					M,F,W,B,Q,O
Alaska	--				A/L	M,L,B,Q
Arizona	60/152	X	X		L	B,Q
Arkansas	21.3/85.3					M,Q
California	--		X			
Colorado	150/200	X			H	W,B
Connecticut	--		X			
Delaware	250/300	X				
District of Columbia	25/25					
Florida	63.9/246.9	X	X	X	P/S,L	M
Georgia	28/112					M,F,W,B,Q
Guam	--					
Hawaii	145/354	X				
Idaho	19.3/77.3					
Illinois	>150	X	X		H/L	
Indiana	--	X	X		H	W,B
Iowa	300/300		X	X		
Kansas	588/769		X			W
Kentucky	950/1034		X			M,W,B
Louisiana	44.1/176.4				P/S,L	M,B,Q
Maine	31.7/136.7	X	X		H	M
Maryland	--	X	X		H,P/S,L	M
Massachusetts	17.3/147.3		X		P,A	W,O
Michigan	546.8/857.4	X	X	X	H,P,A/L	M,F,W,B,Q,O
Minnesota	615/2400		X	X	H,P/L	M,F,W,B,Q,O
Mississippi	20.6/82.6	X			H,P	W
Missouri	34.4/137.4					W,Q
Montana	50/100	X	X			M
Nebraska	97/157	X	X	X		
Nevada	16/64.8					
New Hampshire	--		X			
New Jersey	97/546	X	X			M
New Mexico	--					
New York	620/780		X			M
North Carolina	--					
North Dakota	30/90	X	X			
Ohio	80/190					M
Oklahoma	30.7/122.9	X				M,W,O
Oregon	--		X	X		
Pennsylvania	200/260		X			M
Puerto Rico	--	X	X	X	A/S	
Rhode Island	26.6/45.9				P/L	
South Carolina	16.8/62					
South Dakota	0					
Tennessee	--					
Texas	54/216					M,W,B,Q,O
Utah	20/80		X	X		M,F,W,B,Q
Vermont	20/75					
Virgin Islands	--	X				
Virginia	200/320				P,A	M
Washington	2100/2190		X			M
West Virginia	0					
Wisconsin	1000/1108	X	X	X	A	M,Q,O
Wyoming	0					

-- =Data not available A = Other acquisition program (erosion-prone structures, etc.) B = Fish and Wildlife F = Forestry O = Other
M = Multi-objective management of watersheds P = Giver priority to floodplains in acquisition H = Help localities obtain 1362 funds
Q = Water quality L = Loans or grants for local purchase S = Direct state purchase W = Wetlands

APPENDIX G

EXECUTIVE ORDER ON FLOODPLAIN MANAGEMENT

Executive Order 11988, issued in 1977, represented an effort by the executive branch to coordinate federal activities to reduce the impact which federal activities have on the nation's floodplains. In the course of its work, the Review Committee determined that the Executive Order brought about a significant and beneficial change in federal floodplain activities. It also determined that certain weaknesses had become apparent which require a revised order to be issued. A new Executive Order would reaffirm the basic principles of the former order and address newly uncovered issues.

Content of the Revised Executive Order

The floodplains which adjoin the nation's inland and coastal waters have long been recognized as having special values to U.S. citizens. They have provided wildlife habitat, agricultural and forest products, vital ecosystem functions, and park and recreation areas. Unwise use and development of our riverine, coastal, and other floodplains, however, not only destroys many of the special qualities of these areas but can post a severe threat to human life, health and safety.

Since the adoption of a national flood control policy in 1936, the federal government has invested billions of dollars in structural protection from floods. The vulnerability of floodplain inhabitants and their property persist, federal expenditures for disaster relief and recovery do not diminish, river dependent ecosystems decline, and environmental deterioration continues.

The problem arises mainly from unwise land use practices. The federal government must acknowledge its influence over floodplain development and set the example for floodplain management. Federally funded or assisted construction and improvements, property management, financial and technical assistance, and permits and licenses for federally regulated activities must be consistent with the goals of floodplain management: reducing the vulnerability to damage and protecting and enhancing the environment.

In addition to minimizing danger to humans in floodplains and maintaining and enhancing natural resources, sound floodplain management protects the federal investment and represents responsible business practice. It seeks to avoid the potential loss of human and other natural resources and reduce the risk of flood damage to properties benefiting from federal assistance.

Because unwise floodplain development can lead to the loss of human and natural resources, it is simply a bad federal policy and should be avoided. In order to avoid, to the greatest extent possible, the adverse impacts associated with the occupancy and modification of floodplains, and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative, a revised Executive Order on floodplain management is necessary. The Review Committee recommends that the Administration should direct that:

Each agency provide leadership and take action to reduce the risk of flood loss; to minimize the impact of floods on human safety, health, and welfare; and to restore and preserve the natural and beneficial functions of floodplains in carrying out, in a manner which furthers national economic and environmental goals, its responsibilities for:

> (1) acquiring, managing, and disposing of federal lands and facilities;
>
> (2) providing federally undertaken, financed, or assisted construction and improvements;

(3) conducting federal activities and programs affecting land use and water resources planning; and

(4) permitting and licensing federally regulated activities.

Each agency would have a responsibility to prescribe procedures to implement the policies and requirements of the revised Order. These policies and procedures should evaluate the potential economic, social and environmental effects of any actions the agency may take in a floodplain and ensure that its planning programs and budget requests reflect consideration of flood hazards and the principles of sound floodplain management.

Each agency should determine whether a proposed action will occur in a floodplain. This determination should be made according to floodplain maps issued by the Federal Emergency Management Agency, or a more detailed map of an area, if available. If such maps are not available, the agency should develop the appropriate information to make the determination of the location of the floodplain and obtain FEMA's concurrence. For major federal actions significantly affecting the quality of the human environment, the evaluation will be included in any statement prepared under Section 102(2)(C) of the National Environmental Policy Act (NEPA).

Prior to undertaking or assisting in the repair, maintenance, improvement, or rehabilitation of any structure or facility in the floodplain, the agency should conduct an assessment of the vulnerability of that structure to flooding and the feasibility of lessening such impact through mitigation techniques.

The agency should consider all alternatives to avoid development in the floodplain for any activity the agency has determined to, or proposes to, conduct, support, or allow in a floodplain. If the head of the agency finds that the only practicable alternative consistent with the law and the Executive Order requires development in a floodplain, the agency should, prior to taking action, design or modify the action to reduce to the maximum extent practicable, the potential harm to or within the floodplain consistent with regulations issued in response to a revised Executive Order.

Each agency should send a notice, not to exceed three pages in length including a location map, to the state and appropriate area-wide clearinghouses for the geographic areas affected. The notice should include: (i) the reasons why the action is proposed to be located in a floodplain; (ii) a statement indicating whether the action conforms to applicable state or local floodplain protection standards; and (iii) a list of the alternatives considered. Agencies should endeavor to allow a brief comment period prior to taking any action.

Agencies should provide FEMA with a notice that includes: (i) the reasons why the action is proposed to be located in a floodplain; (ii) a statement indicating whether the action conforms to applicable state or local floodplain protection standards; and (iii) a list of the alternatives considered. Whenever practicable, agencies should provide this notice concurrent with a brief comment period prior to taking any action. If FEMA determines that the proposed action is inconsistent with the revised Executive Order, then FEMA can refer the issue to the Water Resources Council.

Each agency should also provide opportunity for early public review of any plans or proposals for actions in the floodplain in accordance with Section 2(b) of Executive Order No. 11514, as amended, including the development of procedures to accomplish this objective for federal actions whose impact is not significant enough to require the preparation of an environmental impact statement under Section 102(2)(C) of the NEPA of 1969, as amended.

Any requests for new authorizations or appropriations transmitted to the Office of Management and Budget should indicate, if the action proposed is located in a floodplain, that the proposed action has been reviewed for alternatives and minimization of adverse impact in accord with the revised Executive Order.

Each agency should require that: (1) all of its water and land use plans comply with the terms of this order; (2) its regulations and operating procedures require an evaluation and consideration of potential flood hazard prior to the issuance of licenses, permits, loans, or grants-in-aid for programs that they administer; and (3) its regulations provide appropriate guidance so that applicants for federal licenses, permits, loans, or grants can incorporate, in their applications, the evaluation required above.

APPENDIX G

Each agency should issue or amend existing regulations and procedures within one year to comply with the revised Executive Order. These procedures should explain the means that the agency will employ to pursue risk reduction and environmental enhancement in connection with its activities in the floodplain. To the extent possible, existing processes, such as NEPA, should be utilized to fulfill the requirements of the revised Executive Order. Agencies should prepare their procedures in consultation with the Water Resources Council, FEMA, and Office of Environmental Policy and should update such procedures as necessary.

All federal agencies with responsibilities for construction or operation of federal real property and facilities, or licensing or permitting of federally regulated facilities, should take the following measures:

The regulations and procedures established by the Executive Order should, at a minimum, require the construction of federal structures and facilities be in accordance with the standards and criteria of the National Flood Insurance Program, except that all facilities or infrastructure which can be reasonably considered as critical to the health and safety of the public and the environment should be required to have protection capable of withstanding the standard project flood. They should deviate only to the extent that the standards of the National Flood Insurance Program are demonstrably inappropriate for a given type of structure or facility, or its location.

If, after compliance with requirements of the Executive Order, it is determined that there is no practicable alternative to placing new construction or rehabilitating structures of facilities in a floodplain, at a minimum the requirements of the National Flood Insurance Program should be applied. To achieve flood protection, agencies should, wherever practicable, elevate structures above the base flood level rather than filling in land.

If property used by the general public has suffered flood damage or is located in an identified flood hazard area, the responsible agency should provide on such structures, and other places where appropriate, conspicuous delineation of past and probable future flood height in order to enhance public awareness of and knowledge about flood hazards.

When property in the floodplain is proposed for lease, easement, right-of-way, or disposal to non-federal public or private parties, the agency should (1) reference in the conveyance those uses that are restricted under identified federal, state, tribal, or local floodplain regulations; and (2) attach other appropriate restrictions to the uses of properties by the grantee or purchaser and any successors, except where prohibited by law; or (3) withhold such properties from conveyance.

Comply to the maximum extent practicable with state, tribal, or local rules or regulations for development in floodplains of each jurisdiction within which a federal facility is located or proposed to be located if such rules or regulations provide for more stringent levels of flood protection or require mitigation measures more extensive than those required by the National Flood Insurance Program.

Agencies which guarantee, approve, regulate, or insure any financial transaction which is related to an area located in a floodplain should, prior to completing action on such transaction, inform any private parties participating in the transaction of the hazards of locating structures in the floodplain.

The Water Resources Council should develop guidance for implementing the provisions of the revised Executive Order within six months of its being signed. The head of each agency should submit a report to the Office of Environmental Policy and the Water Resources Council regarding the status of their procedures and the impact of the Executive Order on the agency's operations. Thereafter, the Water Resources Council should periodically evaluate agency procedures and their effectiveness.

The proposed Executive Order should not apply to assistance provided for emergency work essential to save lives and protect property and public health and safety, performed pursuant to Sections 402 and 403 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended (PL 93-288). To the extent the provisions of the Executive Order would be applicable to projects covered by Section 104(h) of the Housing and Community Development Act of 1974, as amended (88 Stat. 640, 42 USC 5304(h)), the responsibilities under those provisions may be assumed by the appropriate applicant, if the applicant has also assumed, with respect to such projects, all of the responsibilities, for environmental review, decisionmaking, and action pursuant to the NEPA of 1969, as amended.

The executive order should apply to all federal agencies and federally owned corporations.

APPENDIX H

PROPOSED FEDERAL PROGRAM FOR MAJOR MAINTENANCE AND MAJOR REHABILITATION OF LEVEES

The concept of and the actions necessary for establishing a federal program to ensure the integrity of levees in the upper Mississippi River Basin are presented in Chapter 10 and in the Action Plan. Specific elements of the proposed program as it pertains to both federally built/locally maintained levees and locally built/locally maintained levees are presented here.

DETAILS OF THE PROGRAM

Levee districts/owners desiring to participate in the USACE major maintenance and major rehabilitation (MM&MR) program would submit requests, through their state, to the USACE within a three-month period following initiation of the program by the Administration. The USACE would then group these requests into a project that would be submitted to the Congress for authorization. Levees would be placed in an Upper Mississippi River and Tributaries (UMR&T) project, which includes the Missouri River Basin, to be established as a line item in the USACE program.

Federally Built, Locally Maintained Levees Currently in the USACE PL 84-99 Emergency Repair Program

Eligibility. On approval by the Congress. the USACE would become responsible for major maintenance and major rehabilitation (MM&MR) of levees. To become eligible for participation in these programs, states and local sponsors would agree to:

a. Participate in the National Flood Insurance Program (NFIP).
b. Continue responsibility for routine maintenance and control of the levees.
c. If the levee affords less than one percent annual chance (100-year) flood protection, require all development behind the levee to comply with provisions of the NFIP.
d. If levee provides less than standard project flood (SPF) level protection, require all structures and crops behind the levees be insured.
e. Not raise the height of the levee during floods without the agreement of the USACE.
f. In the event of any required repair, renewal, or realignment, pay 25 percent of the cost and provide the necessary borrow material and any required lands, easements, and rights-of-way. The non-federal share shall not exceed 50 percent of the total project cost.
g. In coordination with the appropriate federal and state agencies, assist in developing, at minimal cost to the land owners or the local sponsors, appropriate environmental enhancements to the land behind the levees.

Major Rehabilitation Survey. The USACE would conduct a review of all levees in the program to determine long-term rehabilitation requirements and potential for upgrade. The primary determinant of eligibility for major rehabilitation and/or upgrade would be the results of an expanded benefit-cost analysis under revised *Principles and Guidelines* which includes, in addition to economic factors, the social and environmental benefits and costs. The review would also include an assessment of the impacts of any rehabilitation on the hydraulics of the river. State and local sponsors would agree to:

a. Pay 25 percent of the expense of any major rehabilitation, renewal, or upgrade.
b. Include appropriate environmental enhancements or operating measures in any major rehabilitation or renewal projects. The costs of these enhancements would be shared by the non-federal sponsor only in so far as the benefits could be assessed as local. For enhancements that are of regional or national significance, the non-federal share would be provided by the state, private organizations, or other authorized federal agency.

Locally Built, Locally Maintained Levees Currently in the USACE PL 84-99 Emergency Repair Program or Designated by Either the SCS or the EDA for Inclusion

Initial Eligibility. Since locally built levees may not have been constructed in accordance with sound engineering practices and at hydraulically appropriate locations, the USACE initially would screen all levees proposed for inclusion in the MM&MR program to determine any potential problems. Levee sponsors whose levees failed to meet the USACE engineering standards would be required to bring those structures up to standards at sponsor expense prior to inclusion in the federal MM&MR program. Those located at hydraulically inappropriate locations would not be eligible. To become eligible, states and local sponsors would agree to:

a. Participate in the NFIP.
b. Continue responsibility for routine maintenance and control of the levees.
c. If the levee is determined by the USACE to provide protection against less than the one percent annual chance (100-year) flood, require all development to comply with the NFIP.
d. Require that all structures and crops behind the levees be insured.
e. Not raise the height of the levee during floods without the agreement of the USACE.
f. In the event of any required repair, renewal, or realignment, pay 25 percent of the cost and provide the necessary borrow material and any required lands, easements, and rights-of-way. The non-federal share shall not exceed 50 percent of the total project cost.
g. In the event of levee failure, share the cost (25 percent) and provide the lands, easements, and rights-of-way necessary to ensure the future stability of the levee.
h. In coordination with the appropriate federal and state agencies, assist in developing, at minimal cost to the land owners or the local sponsors, appropriate environmental enhancements to the land behind the levee.

Major Maintenance and Major Rehabilitation: On approval by the Congress, the USACE would become responsible for future major maintenance and major rehabilitation of those levees accepted into the federal MM&MR program.

Major Rehabilitation Survey. The USACE would conduct a review of all levees accepted into the program to determine long term rehabilitation requirements and potential for renewal. The primary determinant of eligibility for major rehabilitation would be the results of an expanded benefit-cost analysis under revised *Principles and Guidelines* which include, in

addition to economic factors, the social and environmental benefits and costs. The review would also include an assessment of the impacts of any rehabilitation on the hydraulics of the river. State and local sponsors would agree to:

a. Pay 25 percent of the expenses of any major rehabilitation, renewal, or upgrade.
b. Include appropriate environmental enhancements or operating measures in any upgrade or renewal projects. The costs of these enhancements would be shared by the non-federal sponsor only in so far as the benefits could be assessed as local. For enhancements that are of regional or national significance, the non-federal share should be provided by the state, private organization, or other authorized federal agency.

APPENDIX I

COORDINATION MECHANISMS

WATER RESOURCES COUNCIL

Purpose

The revitalized Water Resources Council should launch and promote cooperation among the federal agencies and the states. It should exist as a mechanism to bring together appropriate policymakers to address key water resources issues. The WRC should align federal floodplain management goals with other broad national goals; provide a single point of focus to assist coordination and resolution of interstate water resource management issues; serve as an innovative planning and technology center (including intergovernmental data gathering and dissemination activities); and resolve federal agency disputes. The WRC should operate under a clarified set of responsibilities compatible with Title I of the 1965 Act and capitalize on the experience of the previous Council. Should the WRC prove an ineffective organization for accomplishing these activities, it should be abandoned.

Membership

Participation in the Council, currently chaired by the Secretary of the Interior, needs to be broadened to include the Administrator of the EPA and the Director of FEMA -- two agencies that did not exist at the time the WRC was first conceived. The participation of these agencies is critical for addressing floodplain management issues. Because EPA's program responsibilities include restoration and enhancement of the nation's water quality, and FEMA's responsibilities include administration of the NFIP and flood recovery, they both merit a role in the Council. Therefore, the Secretary of the Interior should request that the Administrator of EPA and the Director of FEMA become full-time participants on the Council. In addition to the Secretary of the Interior, EPA and FEMA, membership of the Council should be the Secretaries of Army; Agriculture; Commerce; Housing and Urban Development; Health and Human Services and the Chair of the Federal Energy Regulatory Commission. Other agency heads may be called upon by the Chair when matters affecting their responsibilities are considered by the Council.

Staffing

The Secretary of the Interior, as Chair of the Water Resources Council, should restaff the Council. A small staff to support the Council's mandate is suggested. A Director, five professionals and one administrative support/secretary is suggested as the minimum desirable staffing level. Two professionals are envisioned for a Floodplain Management Division.

Budgeting

As authorized in the Act, the Council shall request a budget for professional and support staff and necessary office space, equipment, travel, and contract fund. A budget of $950,000 is envisioned for this purpose.

APPENDIX I

BASIN COMMISSIONS

Designation

The President should establish basin commissions as a forum for coordinated federal and state planning across basin(s) and within sub-basins (as determined appropriate). The WRC should, in coordination with states, define the geographic reach of the commissions. Section 201 of the Water Resources Planning Act of 1965 (PL 89-80) describes how basin commissions can be requested by either the Water Resources Council or states and then declared by the President.

Purpose

Each basin commission should serve as the principal agency for the coordination of federal, state, interstate, local, and non-governmental plans for their designated areas and operate under a clarified set of responsibilities compatible with Title II of PL 89-80, but building upon the lessons learned from the previous commissions. The basin commissions will actively lead collaborative efforts that focus beyond traditional water management challenges to undertake integrated examination of ecosystem management, biodiversity conservation, flood control, water supply, navigation, water quality, and sustainable development issues. The focus of these commissions is on action not on oversight.

Membership

The basin commissions would be co-chaired by a representative of a federal agency and a representative of a state governor. To clearly advance state leadership in floodplain management, the voting role of federal agencies should be limited. The Governor of each basin state shall appoint a member that serves at the pleasure of the Governor.

Staffing and Budgeting

Organization of the basin commissions using existing federal and state programs and budgets to accomplish tasks will increase coordination, cooperation and leveraging of limited funding and achieve a comprehensive approach to issue resolution. The basin commission would create an environment where agencies' activities are orchestrated to achieve multiple benefits for the basin. One means of ensuring this approach is to keep actual basin commission staffing to a minimum. A director and a staff of 3 to 4 full-time professionals is suggested; these would not be federal employees. Where appropriate, the current basin association staffs could assume this responsibility. Average annual budgets of $400,000 are estimated for the Upper Mississippi River Basin Commission and the Missouri River Basin Commission and would be cost-shared by the federal government. As special projects require additional funding to the federal and state agencies, the river basin commission may request appropriations from Congress and/or the state legislatures.

APPENDIX I

EXPANDED MISSISSIPPI RIVER COMMISSION

Purpose

The current Mississippi River Commission (MRC) provides a necessary connection between the public, a construction, operations and maintenance agency, and the executive branch of U. S. government, as well as implementation oversight of a range of water resources activities. The MRC has established a record of expertise and accomplishment, has a clear charter in the basin, and has established processes to make recommendations to the Administration and Congress, and to have funds appropriated for implementation. The purpose for the expansion is to link the entire Mississippi River Basin together to provide a system-wide approach. The composition of the Commission should be expanded to include the additional responsibility of program integration between the construction and environmental missions of the USACE and the ecosystem stewardship missions of the DOI.

Membership

The current Commission has, by Presidential appointment, seven members. There are 3 USACE and 3 civilian members and one member from the NOAA Coast and Geodetic Survey. The President should seek approval from Congress to add a member from DOI and should nominate a membership which ensures appropriate distribution of decision-making authority among action agencies, as well as ensuring representative authority to follow through on plans and projects approved by the Commission and authorized by Congress. A possible membership is provided on the next page.

APPENDIX I

EXPANDED MISSISSIPPI RIVER COMMISSION

Current MRC	Expanded MRC
Authorities from headwaters to Head-of-Passes, La., including all tributaries.	In consultation with Congress, include tributaries in the upper basin.
Current focus is MR&T project.	Include UMR&T.
Seven Presidentially appointed members – 3 USACE, 3 Civilians, 1 NOAA (C&GS).	Add DOI from Assistant Secretary level. NOAA should be at-large.
Advisory to the Chief of Engineers.	Advisory to both Chief of Engineers and the Secretary of the Interior.
President is a Corps officer who is responsible for MR&T and reports to the Chief of Engineers.	Add UMR&T responsibility.
USDA advises.	USDA and EPA advise.
Duties include: -Recommend policy and work program of MR&T. -Study and report on project modifications. -Comment on matters authorized by law. -Conduct inspection trips and hold public hearings.	Additional duties: -Integrate ecosystem and watershed management strategies into currently authorized projects for flood control and navigation. -Study and report on natural resource conditions and improvements realized by integrated river management.
Has established processes to recommend administrative approval and/or Congressional authorization of specific proposals, and to have funds budgeted and appropriated for implementation.	Include DOI proposals and programs.
Uses MRC/LMVD and District staffs to develop plans and implement actions.	Include Corps Divisions and Districts in the upper Mississippi River Basin. Also include FWS Regions III, IV, and VI; NBS; GS; BOR; and BLM staff to collaborate and integrate natural resource management plans. Develop recommendations for state application.
Activities include general investigations, design, construction, and operations and maintenance.	Add oversight of refuge operations, inter-jurisdictional fisheries, Migratory Bird Program, and research.

Appendix J

SUMMARY OF COMMENTS

The Review Committee provided a draft copy of its report to federal agencies, members of Congress from the flood-affected area and leading key committees and subcommittees involved with subjects addressed by the report, the governors of the nine Midwest states, and a number of non-governmental organizations that had worked with the Review Committee during its fact finding and outreach phases. This review was intended to seek feedback from the above parties and was not intended as a substitute for a broad-based public comment period. Considerable interest, however, was expressed in the draft document and over 650 copies were distributed. Despite the very brief comment period, nearly 100 comments were received via facsimile, mail, and telephone by June 16, 1994. Five of the nine Midwest governors commented to the Review Committee; other Midwest governors assigned a lead agency to provide state comments.

The nature of comment letters ranged from full endorsement to opposition. Many of those who commented endorsed the report, or a subset of the actions and recommendations, or requested clarification. Conversely, some of those who commented opposed the report or a subset of the actions and recommendations. Others provided their thoughts regarding certain general issues and asked that their concerns be considered by the Review Committee. Some comments indicated that the reviewer had misinterpreted the Review Committee's intended message. Many of those who commented provided additional data, technical corrections, or pointed out typographical errors. Some noted that their comments were limited to the Executive Summary or only sections of the report due to the short review period. Some comments were general in nature and not reflective of the themes and specific proposals contained in the draft report; the Review Committee is, therefore, led to believe that the comments are reflective of perceptions of the report based on inaccurate summaries of the report by the media or some group.

The Review Committee reviewed all comments and made corrections, clarifications, and additions where warranted. The comments led to development of a better report and the efforts made by those who provided comments were appreciated. Where appropriate the Review Committee responses to comments appear below, in italics, to guide readers to particular clarifications or changes made in the final document.

Many individuals and organizations endorsed the report's themes and vision for what needs to be done to implement floodplain management. Many more organizations and individuals endorsed large numbers of the recommendations and actions while raising questions, concerns and/or objections to others. Summarizing the nature of the comments is difficult because the absence of opinion expressed on particular proposals may indicate support.

There was nearly universal comment that the Review Committee developed, within a short time frame, a comprehensive report addressing a wide variety of improvements needed to enhance the nation's approach to floodplain management. Nearly all commented that additional time to review the draft report would have been appreciated. Several indicated a desire to comment on the final document.

Nearly all made comments on areas where they believed the report could be strengthened or where they perceived omissions. Many raised concerns regarding the costs associated with the report as a whole and with specific recommendations -- many indicating that their support was dependent, at least in part, on the cost trade-offs.

MAJOR THEMES OF COMMENTS

Several areas of the report generated the majority of the comments; however, not all comments reflected the same opinion.

Support for change

There was nearly universal support for a need to change the nation's approach to floodplain management; not surprisingly, there was a divergence of opinion regarding the means to achieve flood damage reduction. There was hesitation on the part of some reviewers to endorse the direction and approach made by the Review Committee. Nearly all agreed that a systems approach to floodplain management was needed to replace uncoordinated ad hoc efforts.

Treatment of watersheds

Many made comments regarding the draft report's treatment of watersheds. Some found that the report unduly emphasized the role, value, and significance of watershed and ecosystem planning with respect to achievement of floodplain management and flood damage reduction goals. Several of those who commented reflected concerns that the draft report did not adequately tie together preservation and restoration of aquatic ecosystems and watersheds with floodplain management. Several indicated that watershed management was not sufficiently integrated into floodplain management and that nonstructural alternatives to flood damage reduction were not given enough support.

Structural approaches

Many of those commenting felt that the existing structural approach to flood damage reduction had proven its value and not enough credit was given to the predominantly structural approach the nation has, in the past, taken to reduce flood damages. Many felt that nonstructural approaches were experimental and their merit uncertain. However, others were concerned that the report overemphasized structural solutions; some feared that the report might further broad interest in a widespread construction program consisting of large levees.

Administrative and organizational structures

Many comments reflected concern about the number of organizations proposed, the designation of leadership responsibilities, and the interaction and relationships among these organizations. These concerns reflected uncertainties about the costs of such proposals (which were not characterized in the draft) in comparison to the added value of these organizations. Other concerns reflected hesitation to endorse some or all of these proposals until a dialogue had been opened and charters proposed to further specify responsibilities, functions, and working relationships. While these concerns were expressed, many also recognized the need for better coordination at the federal and interstate levels.

Streamlining disaster relief and improvement of the NFIP

While not everyone commenting agreed with all of the proposals, support for streamlining disaster relief and the actions and recommendations aimed at improving the NFIP was widespread.

Infringement of property rights

Some of those who commented raised concerns that proposals in the Review Committee draft report would infringe on property rights.

> *[To clarify its intent and to address these concerns, the Review Committee added additional text in the report emphasizing the voluntary nature of buyouts and clarifying that limits to floodfighting would not prevent floodfights consistent with state and local floodplain management regulations.]*

APPENDIX J

COMMENTS ON ACTIONS AND RECOMMENDATIONS

Many of the comment letters reflected specific objections or concerns with proposed actions and recommendations; others focused on proposals that they supported. Summarized, below, are those actions and recommendations for which at least six of those commenting provided definitive statements of either support, concern or objection.

Basin Commissions, Upper Mississippi and Missouri River Basin Commissions (Actions 5.3 and 10.2)

No other proposal in the report generated so many specific comments as the basin commissions. Many of the comments expressed a desire not to create basin commissions in the same form as those that existed in the late 1960s and the 1970s.

> *[The Review Committee concurs that new basin commissions should take on a different function and approach and both learn from and build upon the lessons of the previous basin commissions. This was the basis for the proposed changes to the previous basin commissions' function and structure. The Committee has also altered Figures 5.1 and 10.1 to clarify the relationships among the Water Resources Council, the basin commissions, and the Mississippi River Commission.]*

Many of those who commented expressed confusion regarding the relationships between the Mississippi River Commission and the Upper Mississippi River Basin Commission. Some comments reflect further confusion in that they were considered the same organization.

> *[The Review Committee has made changes to further clarify the relationships between these organizations. Figure 10.1 has been changed to distinguish between lines of "command" or oversight and lines of coordination. It is unfortunate that the names of these organizations are so similar – to try to further distinguish them, the final document refers to basin commissions as opposed to river basin commissions.]*

Many of those who commented reserved endorsement of basin commissions until further dialogue on their purpose, functions, and methods of operation was pursued.

Increase the state role in all floodplain management activities (Recommendation 5.2)

This recommendation generated a large number of specific comments, with half supporting the recommendation and half against. The general reason for not supporting the recommendation reflected a concern that interjecting the states between levee districts or local communities would increase bureaucracy and slow response. Supporters generally expressed that states' need to exercise their responsibilities and their involvement would add value to efforts to achieve floodplain management goals.

Mississippi River Commission (Action 10.2)

Many comments were also received regarding the Mississippi River Commission. Overall, most comments expressed reservations about this proposal, but for a variety of reasons. Some comments arose from concerns about the nature of activities of the Commission in the past (prior to the last decade) and the Commission's ability or interest in taking on a broader nonstructural approach to floodplain management. Others arose from not wanting to broaden the Commission's membership and charter to address related ecological resource issues or not trusting the Commission's interest in pursing these issues. Others objected to extending the geographical extent of the Mississippi River Commission's authority.

> *[The Review Committee added new text to clarify the legislative authority of the Mississippi River Commission which already assigns the Commission's authorities to extend from the river's mouth near the Head of Passes to its headwaters. The Review*

Committee feels that further dialogue on the relationship between basin commissions and the Mississippi River Commission and the functions and duties of the Mississippi River Commission could allay some concerns and develop support for this action.]

Water Resources Council (Action 5.2)

The proposal to revitalize the Water Resources Council generated numerous comments. Generally there was broad support for the WRC or a similar entity to provide a mechanism for interagency, policy level coordination. Several were hesitant to support the proposal until further operational and administrative issues had been developed. Some questioned the political desire to renew the Council.

Floodplain Management Act (Action 5.1)

Several comments specifically indicated support for a floodplain management act to define governmental responsibilities, strengthen federal-state coordination and assure accountability and fund state floodplain management programs.

New Executive Order on Floodplain Management (Action 5.4)

Overall comments supported this action. Several comments, however, indicated that the executive order was an inappropriate Administration action circumventing Congress. Some comments indicated that FEMA oversight of compliance with the EO was unnecessary.

[The Review Committee notes that the existing Executive Order on Floodplain Management has been in place since 1977 without objection from Congress. The Review Committee's proposal is intended to reaffirm Administration support for floodplain management and to clarify certain federal responsibilities to undertake a sequence of avoiding floodplain development, minimizing the adverse effects from flooding and to the floodplain, and finally mitigating potential flood damages. It does not represent a departure from congressional policy on floodplain management. The Review Committee agreed with comments indicating that FEMA's role should include resolution of disagreements over EO compliance and that FEMA should only refer to the Water Resources Council those issues were significant attempts to reach resolution had failed.]

Principals and Guidelines (Actions 5.10 and 5.11)

Many of those specifically commenting on Actions 5.10 and 5.11 reflected support for establishing co-equal objectives for the *P&G*. A few expressed concern regarding the mechanism used to evaluate environmental quality and compare alternative courses of action. Several noted the difficulties inherent in both quantifying and monetizing attributes contributing to environmental quality. The establishment of an interdisciplinary, interagency review of other aspects (including application of the *P&G*) raised objections regarding the application of the *P&G* to specific types of actions, including those to which the current *P&G* now apply.

[The purpose of the interdisciplinary, interagency review is to discuss and address whether the revised P&G could and should be applied to a broader array of federal decisions and to develop guidelines for application of the principles.]

Develop common procedures for buyouts (Action 8.4)

Most comments registered support for this concept. Some expressed concerns regarding whether there could be common procedures for programs with different purposes.

Hazard Mitigation Grants as block grants (Action 8.5)

Most comments regarding this Action reflected support. Concern was raised regarding means to ensure that states used the funds appropriately.

Establishing the USACE as the principal levee construction agency (Action 8.1)

Of those commenting on this Action, nearly all supported it. Concern was raised regarding the continued role of the USDA with respect to agricultural levees.

> *[The Review Committee has added clarifying language to better reflect the relationship of the USACE to USDA and other federal agencies considering levee projects.]*

Extend 5-day waiting period for flood insurance coverage (Action 9.7)

All those commenting on this action supported the extension of the time period. Several supported further lengthening the time period beyond the 15 days recommended by the Review Committee to account for the potential for flood crests moving further downstream on the Mississippi. Concern was noted that the waiting period should not apply when a home is being purchased.

> *[Text was added to clarify that there would be no waiting period associated with purchase of flood insurance at closing after purchase of a home].*

Expansion of conservation and voluntary acquisition programs in 1995 Farm Bill (Action 6.3)

There was broad support for continuing these programs.

DOI coordinating environmental acquisition (Action 7.1)

Some concerns were raised regarding whether DOI had the in-house capability to perform this function. Others raised concerns regarding the extent of DOI responsibilities and applicability of this proposal to dual purpose acquisitions. Some pondered the federal interest in additional land management responsibilities.

> *[The Review Committee reviewed the language of this and related actions to ensure that DOI's function was one of coordination of acquisition. Agreements between agencies would be developed to determine specific procedures and applicability of those procedures. The text already indicates that lands acquired in fee will not necessarily be held or managed by the DOI or the federal government.]*

Limiting public assistance grants for communities not participating in the NFIP (Action 5.7)

Most all of those who commented on this Action indicated support.

Integration of flood response and recovery under FEMA (Recommendation 9.1)

Of those commenting, most supported the proposal. One suggested that FEMA needed Presidential support to achieve cooperation from cabinet-level agencies.

> *[The Review Committee believes that response and recovery require leadership from a single knowledgeable agency, just as land acquisition for environmental purposes and levee construction requires leadership and coordination by knowledgeable agencies. The Review Committee sees these delineations of clear responsibility as critical to providing a streamlined, responsive, and efficient program for response, recovery, and overall floodplain management.]*

Multi-objective watershed management task force (Action 6.1)

There was general support for this proposal although a few thought it was unnecessary.

ANALYSIS OF COMMENTS BY ORIGINATORS

Congress

Congressional reaction to the report was mixed. While all felt the report to be balanced, concern was raised by some members regarding the impact of the recommendations on their constituents. Some members indicated interest in sponsoring legislation to implement some of the proposals in the draft report.

Federal Agencies

Federal agencies provided comments ranging from full support to specific technical comments that indicated neither specific support nor opposition to the proposals in the draft report. A few comments reflected hesitation to alter current policies, approaches, and responsibilities without further dialogue with or guidance from Administration leadership.

States

Comments were received from all but one Midwest state and were generally supportive of the report and its vision. One state from outside the Midwest noted general support for the proposals. Several states indicated their readiness and willingness to take on the challenges and responsibilities articulated in the draft report. Some concerns were raised about organizational and administrative mechanisms. A few raised concerns about the level of funding and technical assistance that would be provided to states. A few comments were received from state legislators. These letters reflected that the report was recommending cessation of levee repair work in their jurisdiction and were concerned that the proposals in the report would adversely impact navigation and farming along the rivers.

Levee and drainage districts and individual farmers

Several reflected concerns that the Review Committee draft report was calling for a unilateral buyout of bottomland agriculture to restore wetlands. Many reflected a concern that the report emphasized environmental protection over flood hazard protection to bottomland activities. However, many also expressed support for recommendations and actions contained in the report. Some were deeply concerned with what they perceived in the report to be a prohibition against all floodfighting. Some noted that property rights of farmers and others needed to be more carefully considered. Several noted concerns about the impact of buyout and acquisition on the local and regional economy and the impact on tax roles.

Environmental non-governmental organizations

Strong support for reestablishment of the Water Resources Council was noted in all comments made by these organizations. While some environmental organizations supported the report, many expressed serious concernsthat the report did not sufficiently emphasize restoration of aquatic ecosystems, watershed management and nonstructural approaches to floodplain management. Many comments also reflected concerns about issues that the report failed to address including the role of federal programs influencing bottomland farming and navigation issues on the Missouri River. Concerns were raised about the efficacy of the Mississippi River Commission to pursue new mandates. Concerns were raised that the report appeared to support a new levee construction program on the Upper Mississippi and Missouri rivers.

Other non-governmental organizations

A number of non-governmental organizations, including several professional affiliation, and regional planning and coordination organizations commented on the draft. As might be expected, there was considerable divergence of opinion on specific proposals. The opinions summarized on the draft report reflect the differences of the many non-governmental organizations. Several indicated long-standing support for several of the recommendations in the report. Some commented that the report was "anti-agriculture" and one commented that the report was "anti-city".

Others

Comments were received from a wide variety of other organizational entities consisting of state agencies, cities, and individuals, including public school teachers; academics from across the nation in the fields of water resources, natural hazards, and hydrology; land-owners in the Midwest; and other interested parties. As with comments from other sectors, their were a variety of viewpoints expressed which ranged from endorsement of the report to objections to specific recommendations.

Appendix K

LIST OF PHOTOGRAPHS

Cover:	Missouri River: view from the Missouri state capitol, Jefferson City, Missouri (Source: Missouri Department of Conservation).
Page xxiv:	Chesterfield Valley, St. Louis County, Missouri (Source: Missouri Department of Conservation).
Page 2:	Hartsburg Bottoms, Boone County, Missouri (Source: Missouri Department of Conservation).
Page 5:	Hannibal Missouri (Source: Missouri Department of Conservation).
Page 7:	Eddyville, Iowa (Source: USDA-SCS).
Page 16:	Eddyville, Iowa (Source: USDA-SCS).
Page 17(L):	Muscatine, Iowa (Source: USDA-SCS).
Page 17(R):	Valley Junction, Iowa (Source: USDA-SCS).
Page 18:	Jefferson City, Missouri (Source: Missouri Department of Conservation).
Page 20:	Springfield, Minnesota (Source: FMRC).
Page 22:	St. Louis, Missouri (Source: USACE).
Page 36:	Des Moines, Iowa (Source: USDA-SCS).
Page 43:	Upland land treatment, unknown location (Source: USDA-SCS).
Page 44:	Wetland, unknown location (Source: USDA-SCS).
Page 48:	Agricultural levee, unknown location (Source: USDA-SCS).
Page 92:	Festus, Missouri (Source: USACE).
Page 96:	Watershed, Brown County, Kansas (Source: USDA-SCS).
Page 104:	Wetland, unknown location (Source: USDA-SCS).
Page 154:	Scientific activity at Sioux Falls, South Dakota (Source: SAST).

June 15,2007

RECEIVED
CLERK'S OFFICE
JUN 20 2007
STATE OF ILLINOIS
Pollution Control Board

PCB07-145

Patricia Wallace
17235 Liberty School Road
Marion, Illinois 62959

Donald E. Grant
17712 Dean Road
Johnston City, Illinois 62951

Randy Grant
17235 Liberty School Road
Marion, Illinois 62959

BY CERTIFIED MAIL
Return Receipt Requested

Cline Resource and Development Company
Attn: Christopher Cline
430 Harper Park Drive
Suite A
Burkley, West Virginia 25801

RE: Noise Pollution

Dear Mr. Christopher Cline,

We are righting this letter to inform you of the action we are taking in regards to the lack of concern of the Mach Mining Company in Johnston City, Illinois. I (Patricia) have been to see the land agent at Mach Mining (Gary Schmitz) a number of times to try and resolve the enclosed problems and at one point Mr. Schmitz offered to purchase ear plugs to remedy the noise problem we are facing, however cute that was it does not solve the problem. We have got the run around from the mine staff, hurry up and wait or sorry about your luck. I'm not sure they understand how bad this problem is to us who have to live here on a regular basis'.

The Grant family has lived in this rural area (property and roads) for the past 68 + years. This area is primarily rural farm homes and family. Normal traffic on our roads (Liberty School Rd and Dean Rd) were local's a proximally 15 - 20 cars per day, we were able to let our children walk, ride bikes and ride horses up and down these rural roads. I (Patricia) moved in this area about 10 years ago. The reason I moved here is because it was peaceful, quiet, safe and I could ride my horses up and down the roads and not worry.

All of these things changes when "Cline Resource and Development Company" purchased the old Zeigler property on Liberty School Road. Once ground was broke and the mining process was started back in spring of "2005" everything changed in our once quiet farming community. We no longer feel safe to ride our horses, or let our children ride there bikes or walk back and forth to each others homes because of the increase of traffic and heavy equipment using Liberty School Rd . Sitting outside to listen to nature is impossible because of the traffic, noise, dirt and dust created by Cline Resource and Development project adjunct to our property. In short this once quiet place is now riddled with, large buildings, massive coal and dirt piles, cranes, drilling rigs, hoist towers, coal towers, and the

noise from the mine vent fan, and a rail road track. Traffic increased due to employees, concrete trucks (some times running 24 hours a day), delivery trucks, heavy equipment (running at all hours using back up beepers), semi trucks using jake-breaks, and most every one speeding.

Mr. Cline, my primary concern is with the noise from the mine vent fan running 24/7 adjunct to our property, the location of said fan is North/East approximately 1/8 mile from the front door of Randy Grant and Patricia Wallace, the location to Donald Grant 's residents is South/East approximately 1/8 to ¼ mile. I believe the noise pollution generated by the operations at Mach Mining Coal Company on Liberty School Road in Williamson County, Johnston City, Illinois, may be over the limits set by Illinois Pollution Control Board.

We do not wish to move from our homes. We are hoping that you will consider our concerns and we can come up with an solution to satisfy all of us. We would rather work this problem out amicably, but if forced to we will pursue this matter through the legal system to obtain the relief we are seeking. I have enclosed all regulations pertaining to my formal complaint that I will be filing, if we do not resolve this problem with in the next (15) days, I will be filing a Formal Complaint with the Illinois Pollution Control Board, complaint enclosed.

Your prompt attention in this matter will be greatly appreciated.

Sincerely,

Donald Grant
Randy Grant
Patricia Wallace

Randy Grant
Donald Grant
Patricia Wallace

Enclosures: Formal Complaint

CC: Illinois Pollution Control Board

June 15,2007

Patricia Wallace
17235 Liberty School Road
Marion, Illinois 62959

Donald E. Grant
17712 Dean Road
Johnston City, Illinois 62951

Randy Grant
17235 Liberty School Road
Marion, Illinois 62959

BY CERTIFIED MAIL
Return Receipt Requested

Mach Mining LLC
Attn: Pete Hendrick
16468 Liberty School Road
Marion, Illinois 62959

RE: Noise Pollution

Mr. Pete Hendrick ,

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The Grant family has lived in this rural area (property and roads) for the past 68 + years. This area is primarily rural farm homes and family. Normal traffic on our roads (Liberty School Rd and Dean Rd) were local's a proximally 15 - 20 cars per day, we were able to let our children walk, ride bikes and ride horses up and down these rural roads. I (Patricia) moved in this area about 10 years ago. The reason I moved here is because it was peaceful, quiet, safe and I could ride my horses up and down the roads and not worry.

All of these things changes when "Cline Resource and Development Company" purchased the old Zeigler property on Liberty School Road. Once ground was broke and the mining process was started back in spring of "2005" everything changed in our once quiet farming community. We no longer feel safe to ride our horses, or let our children ride there bikes or walk back and forth to each others homes because of the increase of traffic and heavy equipment using Liberty School Rd . Sitting outside to listen to nature is impossible because of the traffic, noise, dirt and dust created by Cline Resource and Development project adjunct to our property. In short this once quiet place is now riddled with, large buildings, massive coal and dirt piles, cranes, drilling rigs, hoist towers, coal towers, and the

RECEIVED
CLERK'S OFFICE
JUN 20 2007
STATE OF ILLINOIS
Pollution Control Board

State of Illinois
Pollution Control Board
James R. Thompson Center
100 W. Randolph Street, Suite 11-500
Chicago, Illinois 60601
http://www.ipcb.state.il.us/

FORMAL COMPLAINT

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

In The Matter Of:)
)
Randy Grant)
Donald Grant)
Patricia Wallace)
)
)
Complainant(s),) PCB 2007-145
)
)
V.)
)
Mach Mining LLC)
Attn: Pete Hendrick)
P.O. Box 300)
Johnston City, Illinois 62951)
)
)
)
Respondent(s),)

Note: If you do not use this formal complaint form and instead draft and type your own, it must contain all of the information requested by this form. All items must be completed. If there is insufficient space to complete any item, you may attach additional sheets, specifying the number of the items you are completing. Once completed, you must file the original and nine copies of the formal complaint, notice to respondent, and certificate of service with the Clerk of the Board at the above address.

ATTACHMENT A
NAMES OF ALLEGED POLLUTERS

Cline Resource and Development Company
430 Harper Park Drive, Suite A
Berkley, West Virginia 25801

Mach Mining LLC
16468 Liberty School Road
Marion, Illinois 62959

ATTACHMENT B
NAMES AND ADDRESSES OF RESPONDENTS

Mr. Christopher Cline
Cline Resource and Development Company
430 Harper Park Drive
Berkley, West Virginia 25801

Mach Mining LLC
Pond Creek 1 Mine
16468 Liberty School Road
Marion, Illinois 62959

MSHA#11-30141
Permit # 355
NPDES # IL007766

1. ***Your Contact Information***

Name:	Donald E. Grant	Randy Grant
Street Adderss:	17712 Dean Road	17235 Liberty School Rd
	Johnston City	Marion
County:	Williamson	Williamson
State:	Illinois 62951	Illinois 62959
Phone Number:	618-983-8293	618-983-8866

Name:	Patricia Wallace
Street Address:	17235 Liberty School Rd
	Marion
County:	Williamson
State:	Illinois 62959
Phone Number	618-922-5969

2. ***Place where you can be contacted during normal business hours (if different from above)***

Name: *All of the above are the same for business hours.*
Street Address:
County:
State:
PhoneNumber:

3. ***Name and address of respondent (alleged polluter)***

Name:	Pete Hendrick
	Mach Mining LLC
Street Address:	P.O. Box 300
	Johnston City
County:	Williamson
State:	Illinois 62951
Phone Number:	618-983-3020

(Name and address of the location of the alleged polluter)

Mach Mining LLC
Pond Creek 1 Mine
16468 Liberty School Road
Marion, Illinois 62959

MSHA#11-30141
Permit # 355
NPDES # IL007766
618-983-3020

4. ***Describe the type of business or activity that you allege is causing or allowing pollution (e.g., manufacturing company, home repair shop) and give the address of the pollution source if different than the address above.***

Operation of a coal mine and the operation of the coal mine ventilation fan and the heavy equipment operated at this site. This operation of this coal company is located at Liberty School Road Johnston City, Williamson County, Illinois 62951

5. ***List specific Sections of the Environmental Protection Act, Board regulations, Board order, or permit that you allege have been or are being violated.***

415 ILCS 5/24 (formerly Ill. Stat. 1991, Ch. 111 ½, Par. 1024)
35 IL Adm. Code, Subtitle H, Chapter I, Section 900.102
35 IL Adm. Code, Subtitle H, Chapter I, Section 901.102,A)
35 IL Adm. Code, Subtitle H, Chapter I, Section 901.102.B)
35 IL Adm. Code, Subtitle H, Chapter I, Section 901.106

6. ***Describe the type of pollution that you allege (e.g., air, odor, noise, water, sewer back-ups, hazardous waste) and the location of the alleged pollution. Be as specific as you reasonably can in describing the alleged pollution.***

Low rumble, echoing whirl noise coming from an air shaft exhaust fan (temporary fan) located on Dean Road in Williamson County Illinois, approximately 1/8 mile N.E. of Randy Grant and Patricia Wallace's home and farm property on Liberty School Rd, the proximity to Donald Grant is S.E. about 1/8 to less than ¼ mile from his home and farm property on Dean Road. Additional noise at the same location are as follows back-up beepers from heavy equipment, coal droppping from the raw coal tower, train cars banging together and the train whistle, Additional traffic noise at all hours of the day and night from employees of the coal company, delivery trucks to the coal company, semi trucks hauling material, rock and miscellaneous material, and concrete trucks. The lights from the coal company property shine in our house all night long.

7. ***Describe the duration and frequency of the alleged pollution. Be as specific as you reasonably can about when you first noticed the alleged pollution, how frequently it occurs, and weather it is still continuing (include seasons of the year, dates, and times of day if known).***

The noise from the coal company started in the summer of 2005. This includes, at least a 75% increase of traffic (semi's, concrete trucks, on a few occasions the concrete trucks were 24 hours a day, heavy equipment, back-up beepers, dirt, dust). The fan noise started on 9-16-06, this is the temporary fan, according to the land agent for Mach Mining (Gary Schmitz). It is the sole source of air for their long wall operation belonging to the Respondent at this time, Mr Schmitz did inform us that the permanent fan will be in operation by the end of Janurary 2007. The temporary fan noise started on 9-16-06 and runs 24/7 unless there is a power failure or shut-down. There is not one place on our property adjunct to this coal company that the fan can not be heard.

8. ***Describe any bad effects that you believe the alleged pollution has or has had on human health, on plant or animal life, on the environment, on the enjoyment of life or property, or on any lawful business or activity.***

The effect on the complainants personal health has been numerous, lack of restful sleep, headaches, unable to relax in our own homes, irritability and fatigue, At time's I (Patricia) have the uncontrollable urge to just cry because the noise is never ending. We can not enjoy sitting outside any more because of the fan noise. Donald has gone to the expence of adding a room on the other side of his home to try to get away from the noise from the fan. All this is due to the noise from the Respondent's property.

9. ***Describe the relief you seek from the Board (e.g., an order that the respondent stop polluting, take pollution abatement measures, perform a cleanup, reimburse cleanup cost, change its operation, or pay a civil penalty (note that the Board cannot order the respondent to pay your attorney fees or ant out-of-pocket expenses that you incur by pursuing an enforcement action))***

Complainants request that the Board order the Resopndents to cease and desist from further violations of applicable statutes and regulations and, more specially, order the Respondents to permanently reduce the noise level to a point that it no longer causes a disturbance to the Complainants personal and emotional health and or their property. We feel that a silencer installed on the fans will greatly reduce the noise levels.

10. ***Identify any identical or substantially similar case you know of that is already pending before the Board or in another fourm against this respondent for the same alleged pollution (note that you need not include and complaints made to the Environmental Protection Agency or any of local government).***

A suit has been filed in Williamson County Court by, Attorney Jay Schafer of 111 West Main Street, Marion, Illinois 618-997-5611 he is under retainer for the family's of Phil Anderson, Shirley Davies, and Roland Rogers all located on Liberty School Road in Williamson County, Marion, Illinois. This Suite was filed in the early 2006.

11. ***State weather you are representing (a) yourself as an individual or (b) your unincorporated sole proprietorship. Also, state whether you are an attorney and, if so, whether you are licensed and registered to practice law in Illinois. (Under Illinois law, an association, citizens group, unit of local government, or coporation must be represented before the Board by an attorney. Also, an individual who is not an attorney cannot represent another individual or other individuals before the Board. However, an individual who is not an attorney is allowed to represent (a) himself of herself as an individual or (b) his or her unincorporated sole proprietorship, though the individual may prefer having attorney representation.)***

The complaintants all representing themselves.

12.

(Complainant's signature)

CERTIFICATION

I, Randy Grant , Donald Grant, Patricia Wallace, on oath or affirmation, state that I have read the foregoing and that it is accurate to the best of my knowledge.

Donald Grant
Randy Grant
Patricia Wallace

Subscribed to and sworn befor me this 18 day of June ,2007

Notary Public Ginger Endrizzi My commission expires: 10-21-09

"OFFICIAL SEAL"
GINGER L. ENDRIZZI
Notary Public, State of Illinois
My Commission Expires 10/21/09

NOTICE TO RESPONDENT

NOTE: THIS STATEMENT MUST BE INCLUDED IN THE SERVICE OF THE FORMAL COMPLAINT ON THE RESPONDENT

INFORMATION FOR RESPONDENT RECEIVING FORMAL COMPLAINT

Please take notice that today I filed with the Clerk of the Illinois Pollution Control Board (Board) a formal complaint, a copy of which is served on you along with this notice. You may be required to attend a hearing on a date set by the Board.

Information about the formal complaint process before the Board is found in the Environmental Protection Act (Act) (415 ILCS 5/1 *et seq.*) and the Board's procedural rules (35 Ill. Adm. Code 101 and 103). These can be accessed at the Board's Web site (www.ipcb.state.il.us). The following is a summary of some of the most important points in the Act and the Board's procedural rules. It is provided for general informational purposes only and does not constitute legal advice or substitute for the provisions of any statute, rule, or regulation:

Board Accepting Formal Complaint for Hearing; Motions

The Board will not accept this formal complaint for hearing if the Board finds that it is either "duplicative" or "frivolous" within the meaning of Section 31(d) of the Act (415 ILCS 5/31(d)) and Section 101.202 of the Board's procedural rules (35 Ill. Adm. Code 101.202). "Duplicative" means that an identical or substantially similar case is already pending before the Board or in court. *See* 35 Ill. Adm. Code 103.212(a) and item 10 of the formal complaint.

"Frivolous" means that the formal complaint seeks relief that the Board does not have the authority to grant, or fails to state a cause of action upon which the Board can grant relief. For example, the Board has the authority to order a respondent to stop polluting and pay a civil penalty, to implement pollution abatement measures, or to perform a cleanup or reimburse cleanup costs. The Board does not have the authority, however, to award attorney fees to a citizen complainant. *See* 35 Ill. Adm. Code 103.212(a) and items 5 and 9 of the formal complaint.

If you believe that this formal complaint is duplicative or frivolous, you may file a motion with the Board, within 30 days after the date you were served with the complaint, requesting that the Board not accept the complaint for hearing. The motion must state the facts supporting your belief that the complaint is duplicative or frivolous. Memoranda, affidavits, and any other relevant documents may accompany the motion. If you need more time than 30 days to file a motion alleging that the complaint is duplicative or frivolous, you must file a motion for an extension of time within 30 days after service of the complaint. A motion for an extension of time must state why you need more time and the amount of additional time you need. Timely filing a motion

alleging that the complaint is duplicative or frivolous will stay the 60-day period for filing an answer to the complaint. *See* 35 Ill. Adm. Code 103.204, 103.212(b).

All motions filed with the Board's Clerk must include an original, nine copies, and proof of service on the other parties. Service may be made in person, by U.S. mail, or by messenger service. Mail service is presumed complete four days after mailing. *See* 35 Ill. Adm. Code 101.300(c), 101.302, 101.304.

If you do not respond to the Board within 30 days after the date on which the complaint was served on you, the Board may find that the complaint is not duplicative or frivolous and accept the case for hearing. The Board will then assign a hearing officer who will contact you to schedule times for telephone status conferences and for hearing. *See* 35 Ill. Adm. Code 103.212(a).

Answer to Complaint

You have the right to file an answer to this formal complaint within 60 days after you receive the complaint. If you timely file a motion alleging that the complaint is duplicative or frivolous, or a motion to strike, dismiss, or challenge the sufficiency of the complaint, then you may file an answer within 60 days after the Board rules on your motion. *See* 35 Ill. Adm. Code 101.506, 103.204(d), (e), 103.212(b).

The Board's procedural rules require the complainant to tell you as respondent that:

> **Failure to file an answer to this complaint within 60 days may have severe consequences. Failure to answer will mean that all allegations in the complaint will be taken as if admitted for purposes of this proceeding. If you have any questions about this procedure, you should contact the hearing officer assigned to this proceeding, the Clerk's Office or an attorney. 35 Ill. Adm. Code 103.204(f).**

Necessity of an Attorney

Under Illinois law, an association, citizens group, unit of local government, or corporation must be represented before the Board by an attorney. In addition, an individual who is not an attorney cannot represent another individual or other individuals before the Board. However, even if an individual is not an attorney, he or she is allowed to represent (1) himself or herself as an individual or (2) his or her unincorporated sole proprietorship. *See* 35 Ill. Adm. Code 101.400(a). Such an individual may nevertheless wish to have an attorney prepare an answer and any motions or briefs, and present a defense at hearing.

Costs

In defending against this formal complaint, you are responsible for your attorney fees, duplicating charges, travel expenses, witness fees, and any other costs that you or

your attorney may incur. The Board requires no filing fee to file your answer or any other document with the Board. The Board will pay any hearing costs (*e.g.*, hearing room rental, court reporting fees, hearing officer expenses).

If you have any questions, please contact the Clerk's Office at (312) 814-3629.

R05430

RECEIVED
CLERK'S OFFICE
JUN 20 2007
STATE OF ILLINOIS
Pollution Control Board

CERTIFICATE OF SERVICE

I, the undersigned, on oath or affirmation, state that on June 18, 2007, I served the attached formal complaint and notice on the respondent by

✓ certified mail (attach copy of receipt if available, otherwise you must file receipt later with Clerk)

____ registered mail (attach copy of receipt if available, otherwise you must file receipt later with Clerk)

____ messenger service (attach copy of receipt if available, otherwise you must file receipt later with Clerk)

____ personal service (attach affidavit if available, otherwise you must file affidavit later with Clerk)

at the address below:

RESPONDENT'S ADDRESS:

Name Clerk of the Board

Street 100 W. Randolph St. Suite 11-500

City, state, zip code Chicago, IL 60601
(list each respondent's name and address if multiple respondents)

Patricia Wallace
Complainant's signature

Street 17235 Liberty School Rd.

City, state, zip code Mason, IL 62959

Subscribed to and sworn before me

this 18 day

of June, 2007

Ginger Endrizzi
Notary Public

"OFFICIAL SEAL"
GINGER L. ENDRIZZI
Notary Public, State of Illinois
My Commission Expires 10/21/09

My commission expires: 10/21/09

RECEIVED
CLERK'S OFFICE
JUN 2 0 2007
STATE OF ILLINOIS
Pollution Control Board

CERTIFICATE OF SERVICE

I, the undersigned, on oath or affirmation, state that on _____, 20___, I served the attached formal complaint and notice on the respondent by

✓ certified mail (attach copy of receipt if available, otherwise you must file receipt later with Clerk)

_____ registered mail (attach copy of receipt if available, otherwise you must file receipt later with Clerk)

_____ messenger service (attach copy of receipt if available, otherwise you must file receipt later with Clerk)

_____ personal service (attach affidavit if available, otherwise you must file affidavit later with Clerk)

at the address below:

RESPONDENT'S ADDRESS:

Name Mach Mining LLC

Street 10450 Liberty Sch. Rd

City, state, zip code Marion, IL 62959

(list each respondent's name and address if multiple respondents)

Patricia Wallace

Complainant's signature

Street 17235 Liberty Sch Rd

City, state, zip code Marion, IL 62959

Subscribed to and sworn before me

this 18 day

of June, 2007

Ginger Endrizzi

Notary Public

"OFFICIAL SEAL"
GINGER L. ENDRIZZI
Notary Public, State of Illinois
My Commission Expires 10/21/09

My commission expires: 10/21/09

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CLERK'S OFFICE
JUN 20 2007
STATE OF ILLINOIS
Pollution Control Board

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_____ messenger service (attach copy of receipt if available, otherwise you must file receipt later with Clerk)

_____ personal service (attach affidavit if available, otherwise you must file affidavit later with Clerk)

at the address below:

RESPONDENT'S ADDRESS:

Name Clinic Resources + Dev Co.

Street 430 Harper Park Dr. Suite A

City, state, zip code Beckley, W. Virginia 25801

(list each respondent's name and address if multiple respondents)

Patricia Wallace

Complainant's signature

Street 17235 Liberty Sch Rd

City, state, zip code Marion, IL 62959

Subscribed to and sworn before me

this 18 day

of June, 2007

"OFFICIAL SEAL"
GINGER L. ENDRIZZI
Notary Public, State of Illinois
My Commission Expires: 10/21/09

Ginger Endrizzi

Notary Public

My commission expires: 10/21/09

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DEC 03 2007
STATE OF ILLINOIS
Pollution Control Board

ORIGINAL

ILLINOIS POLLUTION CONTROL BOARD
CASE # PCB 2007-135
GEORGE R. STRUNK vs. WILLIAMSON ENERGY LLC.s POND CREEK MINE #1
.BOARD MEMBER; MOORE,A.S. HEARING OFFICER; WEBB C.

.DECEMBER 3, 2007

. RESPONSE TO WILLIAMSON ENERGY LLC,s SECOND MOTION TO DISMISS;
BY AND FOR GEORGE R. STRUNK, A PRIVATE CITIZEN OF THE STATE OF ILLINOIS-HAVING TO LIVE NEXT DOOR TO THIS NIGHTMARE CALLED A COAL MINE.

. I HAVE HONESTLY AND IN GOOD FAITH SENT IN EVIDENCE AND RECORDS OF PERSONAL LOGS AND NOTES OF WILLIAMSON ENERGY`S CONTINUED VIOLATION OF ILLINOIS POLLUTION LAWS. I CONTINUE TO SEE AND HEAR THE VIOLATIONS OF MY RIGHT TO A CLEAN ENVIRONMENT.

. THEIR ATTORNEYS CONTINUE TO SEEK DISMISSAL OF MY COMPLAINT. BUT THEY HAVE OFFERED NO EVIDENCE CONTRARY TO MY COMPLAINTS. JUST THEIR RETORICAL LEGAL MUMBO-JUMBO OF HOW I HAVE WRITTEN AND TRIED TO PRESENT MY COMPLAINTS. THE FACTS SHOULD CLEARLY SPEAK FOR THEMSEVES!

1. THEY CONTINUE TO POLLUTE THE AIR WE BREATHE BY ALLOWING DUST TO BE BLOWN FROM THEIR MINE SITE.
2. THEY CONTINUE TO POLLUTE THE QUIETNESS OF OUR RURAL RESIDENCE WITH NOISE OF THEIR EQUIPMENT{FANS-CONVEYORS-PREP PLANT-MOBILE EQUIPMENT-COAL TRUCKS-TRAINS}, OFTEN WAKING US IN THE NIGHT. ALWAYS DISTURBING OUR ATMOSPHERE. I ONLY WISH YOU WOULD WITNESS THIS FIRSTHAND.
3. THEY CONTINUE TO LIGHT UP OUR NIGHT SKY WITH ADDING EVEN MORE "SECURITY LIGHTS". SEEMINGLY DIRECTED AWAY FROM THE MINE AND TOWARD MY HOME. WE HAVE TO KEEP THE CURTAINS CLOSED TO GET SOME SLEEP.
4. AS FOR WATER POLLUTION; I AM STILL WAITING FOR THE I.E.P.A. TO PROVIDE ME WITH RECORDS I REQUESTED THROUGH THE F.O.I.A. I AM SURE YOU COULD ACCESS THEM A LOT QUICKER.
5. THIS IS AND SHOULD BE A VERY SIMPLE CASE; POND CREEK MINE #1 IS IN VIOLATION OF THE IEPA LAWS OR THEY ARE NOT. LET THE HARD EVIDENCE SPEAK FOR ITSELF. NO AMOUNT OF LEGAL RETORIC SHOULD BE ALLOWED TO INTERFERE WITH JUSTICE OR CHANGE THE TRUE FACTS. IS IT O.K. FOR THE MINE TO DESTROY THE ENVIRONMENT WE SO DEARLY LOVE AND NOT BE HELD RESPONSIBLE? THIS IS WHERE YOU THAT SIT ON THE ILLINOIS POLLUTION CONTROL BOARD COME INTO PLAY. I URGE YOU TO SEE THE TRUE FACTS AND HARD EVIDENCE AND COME TO A QUICK DECISION. WILLIAMSON ENERGY LLC,s POND CREEK MINE #1 IS VIOLATING OUR ENVIRONMENTAL LAWS.

. THANK YOU FOR YOUR TIME,
. GEORGE R. STRUNK

ILLINOIS POLLUTION CONTROL BOARD
JOHN THERRIAULT
CASE # PCB 2007-135
ATTN. BOARD MEMBER;MOORE,A.S. HEARING OFFICER; WEBB,C.
FROM; GEORGE R. STRUNK-16172 LIBERTY SCHOOL ROAD,MARION,ILL.62959

W1998590001

06K

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020 Fax: 618-983-3017

July 15, 2019

Illinois Environmental Protection Agency
BOW CAS #19
1021 North Grand Ave. East
Springfield, IL 62794-9276

RE: Second Quarter 2019 Reports – Permit 375 – Pond Creek Mine

To whom it may concern:

Enclosed please find the Groundwater Monitoring Report for the 2nd quarter of 2019. The Discharge Monitoring Report has been submitted electronically.

A copy of the report above has been sent to the Marion office.

Please contact me if you need any further information.

IEPA - DIVISION OF RECORDS MANAGEMENT
RELEASABLE

AUG 27 2019

REVIEWER: RDH

Sincerely,

Brenton Mumford
Mach Mining, LLC

Enclosures

W1998590001-7

0-Rec

06K

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020 Fax: 618-983-3017

July 15, 2019

IEPA - DIVISION OF RECORDS MANAGEMENT
RELEASABLE

AUG 27 2019

REVIEWER: RDH

Illinois Environmental Protection Agency
BOW CAS #19
1021 North Grand Ave. East
Springfield, IL 62794-9276

RE: Annual pH and Settleable Solids Tests for Ponds 001-008

To whom it may concern:

In accordance with NPDES Permit No. IL0077666 please find reported below results of annual pH and settleable solids tests for ponds 001 through 008.

Pond 001 pH 7.2 Settleable Solids <0.25 mg/L
Pond 002 pH 7.8 Settleable Solids <0.25 mg/L
Pond 003 pH 7.4 Settleable Solids <0.25 mg/L
Pond 004 pH 7.8 Settleable Solids <0.25 mg/L
Pond 005 pH 7.4 Settleable Solids <0.25 mg/L
Pond 006 pH 8.2 Settleable Solids <0.25 mg/L
Pond 007 pH 8.1 Settleable Solids <0.25 mg/L
Pond 008 pH 8.1 Settleable Solids <0.25 mg/L

Please contact me if you need any further information.

Sincerely,

Brenton Mumford
Mach Mining, LLC

Groundwater Monitoring Plan
Williamson Energy, LLC - Pond Creek Mine - Unit No. 1224
Quarterly Monitoring Reports Due: 1st Qtr - May 1; 2nd Qtr - Aug. 1; 3rd Qtr - Nov 1; 4th Qtr - Feb. 1

Water Quality Measures = *mg/l*
Water Elevation = True Elevation *(ft)*
Stream Flow = *cfs*

Groundwater Monitoring

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Elev
GW-1	5/28/19	7.5	452	140	<10	328	92	0.145	<0.050	<0.020	<0.020	436.24
GW-4	5/28/19	7.3	592	172	<10	172	140	1.044	<0.050	0.027	<0.020	460.08
GW-8	5/28/19											Plugged 11/13/12
GW-8R	5/29/19	6.3	5028	4500	200	344	2240	15.52	6.952	4.173	3.643	485.50

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev	
GW-2	5/28/19	7	488	336	<10	252	137	0.265	<0.050	0.023	<0.020	<0.050	40	0.53	430.58	done

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
<0.001	<0.050	<0.001	<0.050	0.0001	<0.001	<0.001	0.003	<0.02	0.002	<0.0002	0.002	<0.002	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-5	5/28/19														

Not enough sample to perform analysis

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-9***	5/28/19	7.4	2148	1600	28	440	967	2.727	0.183	0.094	0.073	<0.050	65	0.93	446.32

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
<0.001	<0.050	<0.001	1.163	<0.0002	0.001	<0.001	0.012	<0.02	<0.001	<0.0002	0.035	<0.002	<0.002	<0.0004	<0.001	<0.01

Groundwater Monitoring Plan
Williamson Energy, LLC - Pond Creek Mine - Unit No. 1224
Quarterly Monitoring Reports Due: 1st Qtr - May 1; 2nd Qtr - Aug. 1; 3rd Qtr - Nov 1; 4th Qtr - Feb. 1

Water Quality Measures = *mg/l*
Water Elevation = True Elevation *(ft)*
Stream Flow = *cfs*

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-10***	5/28/19	7.0	3288	1910	26	456	880	6.264	0.051	0.225	<0.020	<0.050	1350	1.09	437.7

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
0.002	<0.050	<0.001	<0.050	0.0003	0.005	0.001	0.025	<0.02	<0.002	<0.002	0.026	0.005	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-11***	5/28/19	7.1	706	350	<10	408	177	0.116	<0.050	<0.020	<0.020	<0.050	80	0.65	437.50

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
<0.001	<0.050	<0.001	<0.050	<0.0002	<0.001	<0.001	0.005	<0.02	0.007	<0.002	0.001	0.004	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-12	5/28/19	6.6	648	330	24	312	310	0.093	<0.050	<0.020	<0.020	<0.050	74	0.51	436.83

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
<0.001	<0.050	<0.001	<0.050	<0.0002	<0.001	<0.001	0.003	<0.02	<0.002	<0.002	0.004	<0.002	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-13	5/28/19	7.1	936	550	26	372	240	1.154	<0.050	3.065	2.469	<0.050	30	0.61	438.36

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
0.001	<0.050	<0.001	<0.050	<0.0002	<0.001	0.003	0.004	<0.02	<0.002	<0.002	0.003	<0.002	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-14															Plugged 1/21/16

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-28	5/28/19	6.9	5237	4802	32	684	3420	1.184	<0.050	2.297	0.835	<0.050	46	1.34	464.43

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
<0.001	<0.050	<0.001	<0.050	0.0004	<0.001	0.003	0.003	<0.02	<0.002	<0.002	0.015	0.002	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-29	5/28/19														

Not enough sample to perform analysis

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-30	5/28/19														
Not enough sample to perform analysis															

	As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW 31	5/28/19														
Not enough sample to perform analysis															

	As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-32	5/28/19														
Not enough sample to perform analysis															

	As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-33	5/28/19	7.1	920	880	20	604	180	0.06	<0.050	<0.020	<0.020	<0.050	129	0.67	451.86

	As	Be	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
	<0.001	<0.050	<0.001	<0.050	<0.0002	<0.001	<0.001	0.005	<0.02	<0.002	<0.002	<0.001	<0.002	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-34	5/28/19	7.1	544	80	<10	220	97	<0.050	<0.050	<0.020	<0.020	<0.050	84	0.73	442.42

	As	Be	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
	0.001	<0.050	<0.001	<0.050	<0.0002	<0.001	<0.001	0.002	<0.02	<0.002	<0.002	<0.001	<0.002	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-35	5/28/19	6.7	2228	930	58	648	540	<0.050	<0.050	0.032	<0.020	<0.050	494	0.72	443.71

	As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
	<0.001	<0.050	<0.001	<0.050	<0.0002	0.001	<0.001	0.01	<0.02	<0.002	<0.001	0.002	0.007	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-36	5/28/19	7.2	526	180	<10	196	117	<0.050	<0.050	0.023	<0.020	<0.050	72	0.77	452.20

	As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
	<0.001	<0.050	<0.001	<0.050	<0.0002	<0.001	<0.001	0.003	<0.02	<0.002	<0.002	<0.001	<0.002	<0.002	<0.0004	<0.001	<0.01

*** GW-9, GW-10, GW-11 have been sampled six times - Now on quarterly sampling

GW-5 was subsided on 3-05-12. New elevations are as follows: Top of pipe - 477.30 Ground - 475.30

Water Quality Measures = *mg/l*
Water Elevation = True Elevation *(ft)*
Stream Flow = *cfs*

Pond Creek Stream Monitoring

Name/Id	Date	pH	Tds	Hard ($CaCo_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	TSS	Dis Mn	Cl	Flow
PC-1	5/29/19	8.1		290	<10	96	140	0.495	<0.050	0.088	10.000	<0.020	16	13.30
PC-2	5/29/19	8.5		193	<10	756	1050	0.978	<0.050	0.098	33.000	0.022	868	150.00
PC-3	5/29/19	8.3		170	<10	428	1150	1	<0.050	0.101	25.000	<0.020	1400	34.60
PC-4	5/29/19	7.5		360	<10	76	143	0.887	0.062	0.353	32.000	0.052	<10	5.80

Groundwater Monitoring Plan
Williamson Energy, LLC - Pond Creek Mine - Unit No. 1224
Quarterly Monitoring Reports Due: 1st Qtr - May 1; 2nd Qtr - Aug. 1; 3rd Qtr - Nov 1, 4th Qtr - Feb. 1

Water Quality Measures = *mg/l*
Water Elevation = True Elevation *(ft)*
Stream Flow = *cfs*

Groundwater Monitoring

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Elev	
GW-1	5/28/19	7.5	452	180	<10	328	92	0.143	<0.050	<0.020	<0.020	436.24	
GW-4	5/28/19	7.3	532	172	<10	172	340	1.041	<0.050	0.027	<0.020	460.08	
GW-8	5/28/19												Plugged 11/13/12
GW-8R	5/29/19	6.8	5028	4500	200	344	2240	15.52	6.250	4.179	3.643	485.50	

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev	
GW-2	5/28/19	7	488	196	<10	252	137	0.206	<0.050	0.023	<0.020	<0.050	40	0.53	430.58	done

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
<0.001	<0.050	<0.001	<0.050	0.0001	<0.001	<0.001	0.003	<0.02	0.002	<0.0002	0.002	<0.002	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-5	5/28/19														

Not enough sample to perform analysis

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-9***	5/28/19	7.4	2148	1600	28	440	987	2.727	0.183	0.084	0.079	<0.050	56	0.93	446.32

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
<0.001	<0.050	<0.001	1.163	<0.0002	0.001	<0.001	0.012	<0.01	<0.002	<0.002	0.003	<0.002	<0.002	<0.0004	<0.001	<0.01

Groundwater Monitoring Plan
Williamson Energy, LLC - Pond Creek Mine - Unit No. 1224
Quarterly Monitoring Reports Due: 1st Qtr - May 1; 2nd Qtr - Aug. 1; 3rd Qtr - Nov 1; 4th Qtr - Feb. 1

Water Quality Measures = *mg/l*
Water Elevation = True Elevation *(ft)*
Stream Flow = *cfs*

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-10***	5/28/19	7.0	5238	1910	25	486	580	6.264	0.051	0.225	<0.020	<0.050	<0.50	1.09	437.7

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
0.002	<0.150	<0.001	<0.050	0.0035	0.005	0.001	0.015	<0.02	<0.002	<0.002	0.006	0.005	<0.001	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-11***	5/28/19	7.1	796	380	<10	408	177	0.116	<0.050	<0.020	<0.020	<0.050	66	0.65	437.50

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
<0.001	<0.050	<0.001	<0.050	<0.002	<0.001	<0.001	0.005	<0.02	0.007	<0.002	0.001	0.004	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-12	5/28/19	6.6	848	580	24	312	310	0.093	<0.050	<0.020	<0.020	<0.050	74	0.59	435.83

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
<0.001	<0.050	<0.001	<0.050	<0.0002	<0.001	<0.001	0.003	<0.02	<0.002	<0.002	0.004	<0.002	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-13	5/28/19	7.1	978	650	26	377	249	1.154	<0.050	3.062	2.469	<0.050	30	0.61	438.36

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
0.001	<0.050	<0.001	<0.050	<0.0002	<0.001	0.003	0.004	<0.02	<0.002	<0.002	0.003	<0.002	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-14															Plugged 1/21/16

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-28	5/28/19	6.9	5232	4800	30	684	2440	1.184	<0.050	3.292	0.385	<0.050	46	1.34	464.43

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
<0.001	<0.050	<0.001	<0.050	0.0004	<0.001	0.002	0.008	<0.02	<0.002	<0.002	0.015	0.002	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-29	5/28/19														

Not enough sample to perform analysis

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-30	5/28/19														
Not enough sample to perform analysis															

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-31	5/28/19														
Not enough sample to perform analysis															

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-32	5/28/19														
Not enough sample to perform analysis															

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-33	5/29/19	7.1	920	340	20	603	100	0.06	<0.050	<0.020	<0.020	<0.050	138	0.67	451.86

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
<0.001	<0.050	<0.001	<0.050	<0.0002	<0.001	<0.001	0.005	<0.02	<0.002	<0.002	<0.001	0.002	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-34	5/28/19	7.1	544	80	<10	220	97	<0.050	<0.050	<0.020	<0.020	<0.050	64	0.73	442.42

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
0.001	<0.050	<0.001	<0.050	<0.0002	<0.001	<0.001	0.022	<0.02	<0.002	<0.002	<0.001	<0.002	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-35	5/28/19	6.7	3238	910	58	645	560	<0.050	<0.050	0.032	<0.020	<0.050	494	0.72	443.71

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
<0.001	<0.050	<0.001	<0.050	<0.0002	0.001	<0.001	0.01	<0.02	<0.002	<0.002	0.002	0.007	<0.002	<0.0004	<0.001	<0.01

Name/Id	Date	pH	Tds	Hard ($CaCO_3$)	Acid	Alk	SO_4	Tot Fe	Dis Fe	Tot Mn	Dis Mn	Zn	Cl	F	Elev
GW-36	5/28/19	7.0	556	130	<10	196	117	<0.050	<0.050	0.023	<0.020	<0.050	72	0.77	452.20

As	Ba	Be	B	Cd	Cr	Co	Cu	Cn	Pb	Hg	Ni	Se	Sb	Tl	Ag	Phenol
<0.001	<0.050	<0.001	<0.050	<0.0002	<0.001	<0.001	0.003	<0.02	<0.002	<0.002	<0.001	<0.002	<0.002	<0.0004	<0.001	<0.01

*** GW-9, GW-10, GW-11 have been sampled six times - Now on quarterly sampling

GW-5 was subsided on 3-05-12. New elevations are as follows: Top of pipe - 477.30 Ground - 475.30

Water Quality Measures = *mg/l*
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Stream Flow = *cfs*

Pond Creek Stream Monitoring

Name/Id	Date	pH	Tds	Hard ($CaCo_3$)	Acid	Alk	SO_4	Tot Fe	Tot Fe	Tot Mn	TSS	Dis Mn	C.	Flow
PC-1	5/29/19	8.1		290	<10	96	140	0.495	<0.050	0.068	10.000	<0.020	16	13.30
PC-2	5/29/19	8.5		190	<10	356	1080	0.978	<0.050	0.058	33.000	0.022	858	156.00
PC-3	5/29/19	8.3		170	<10	428	1180	1	<0.050	0.101	25.000	<0.020	1400	34.60
PC-4	5/29/19	7.5		360	<10	76	143	0.882	0.062	0.856	32.000	0.052	<10	5.80

Illinois Environmental Protection Agency

Bureau of Water, Division of Water Pollution Control

DMR Search

Choose how you want to Search:

- (•) Npdes Id
- ( ) Npdes Permit Name

Permittee Name/ID

IL0077666

Monitoring Year

2018

Search | Export Data

This web application allows users the ability to search for historical Discharge Monitoring Report (DMR) data. Please select whether you want to search by permittee name or Id. You will also be required to select a monitoring year. Please note this searches millions of records and returns a large dataset. Response time may be several seconds between searches. Records can be sorted by clicking on any of the column headings.

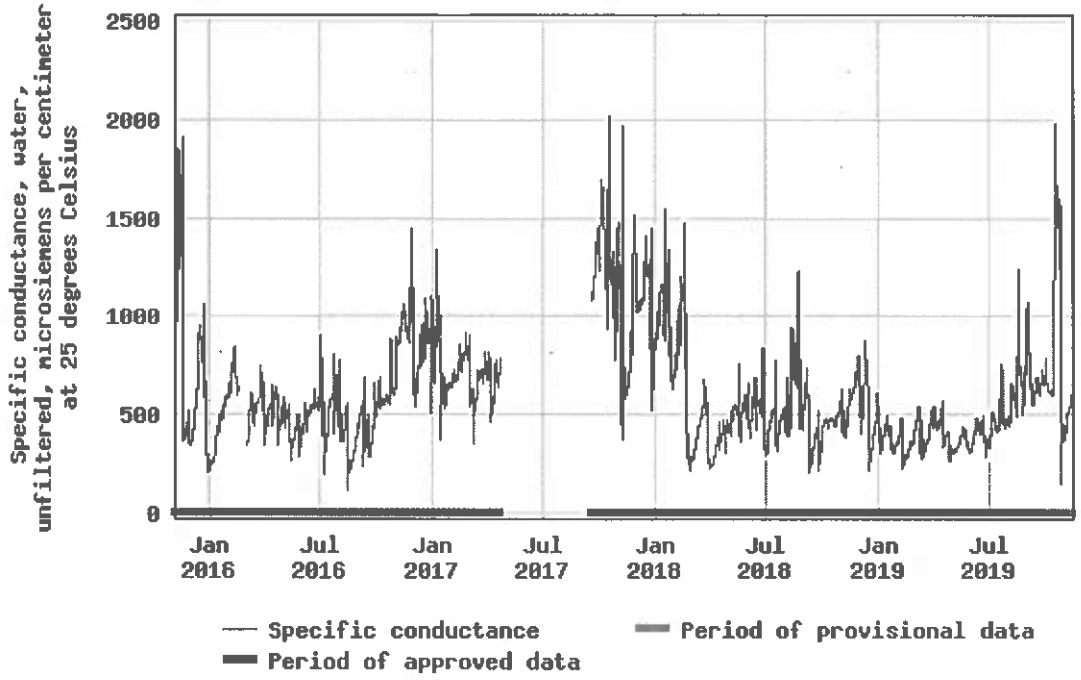
Npdes Id	Permit Name	Feature Id	Limit Set	Parameter	Location	Period End Date	DMR Value Qualifier Code	DMR Value	DMR Value Unit Desc	Statistical Base Desc	NODI Code	Violation Code	Limit Value Qualifier Code	Limit Value	Limit Unit Desc
IL0077666	WILLIAMSON ENERGY LLC	007	ACID MINE DRAINAGE	Sulfate, total [as SO4]	Effluent Gross	12/31/2018							Milligrams per Liter		
IL0077666	WILLIAMSON ENERGY LLC	007	QUARTERLY PRECIPITATION EVENTS	pH	Effluent Gross	03/31/2018	=	3.3	SU				Standard Units		
IL0077666	WILLIAMSON ENERGY LLC	007	QUARTERLY PRECIPITATION EVENTS	pH	Effluent Gross	03/31/2018	=	7.6	SU				Standard Units		
IL0077666	WILLIAMSON ENERGY LLC	007	QUARTERLY PRECIPITATION EVENTS	pH	Effluent Gross	03/31/2018	=	3.3	SU				Standard Units		
IL0077666	WILLIAMSON ENERGY LLC	007	QUARTERLY PRECIPITATION EVENTS	pH	Effluent Gross	03/31/2018	=	7.6	SU				Standard Units		
IL0077666	WILLIAMSON ENERGY LLC	007	QUARTERLY PRECIPITATION EVENTS	pH	Effluent Gross	06/30/2018	=	6.7	SU				Standard Units		
IL0077666	WILLIAMSON ENERGY LLC	007	QUARTERLY PRECIPITATION EVENTS	pH	Effluent Gross	06/30/2018	=	6.7	SU				Standard Units		
IL0077666	WILLIAMSON ENERGY LLC	007	QUARTERLY PRECIPITATION EVENTS	pH	Effluent Gross	12/31/2018							Standard Units		
IL0077666	WILLIAMSON ENERGY LLC	007	QUARTERLY PRECIPITATION EVENTS	pH	Effluent Gross	12/31/2018							Standard Units		
IL0077666	WILLIAMSON ENERGY LLC	007	QUARTERLY PRECIPITATION EVENTS	Solids, settleable	Effluent Gross	03/31/2018	<	0.25	mL/L				Milliliters per Liter		

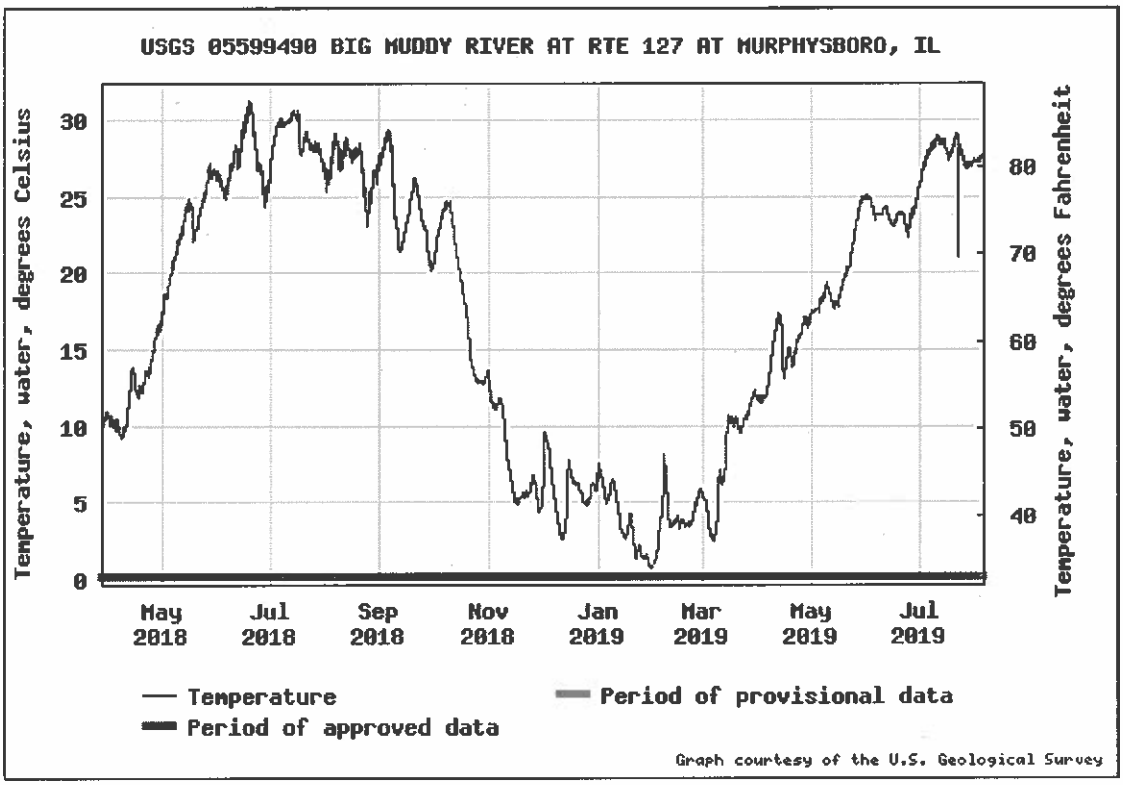
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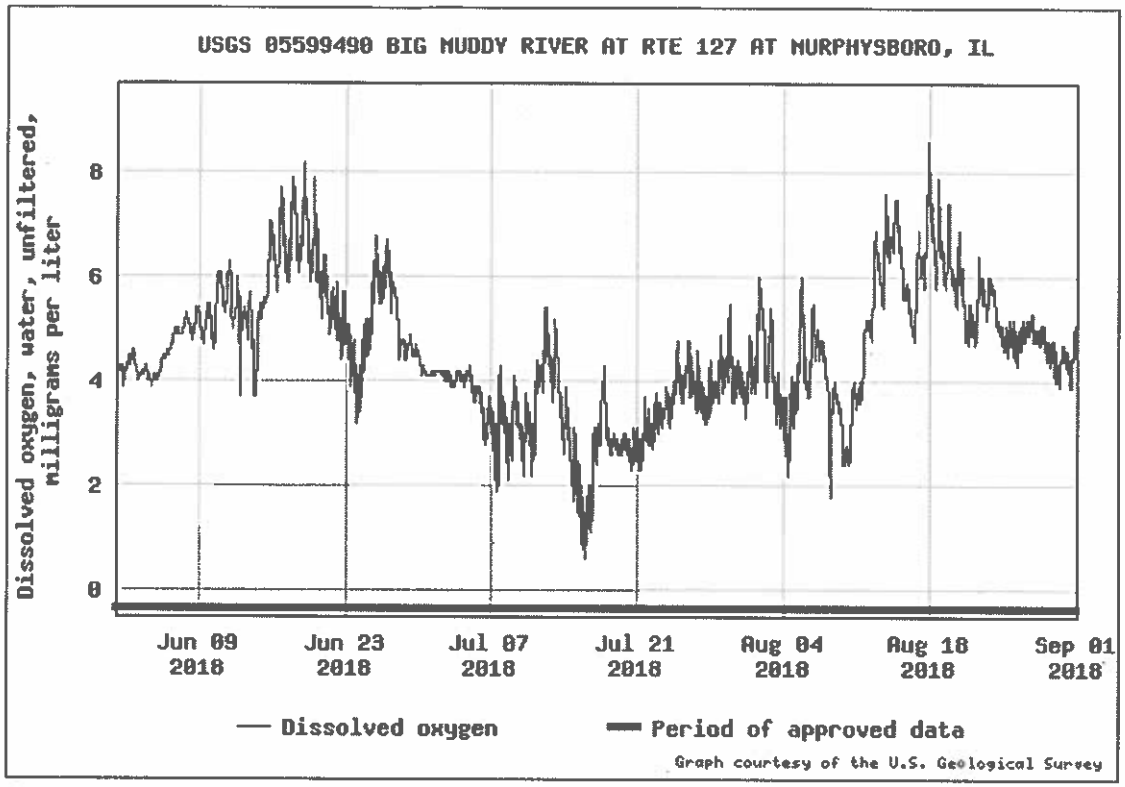
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USGS

USGS 05599490 BIG MUDDY RIVER AT RTE 127 AT MURPHYSBORO, IL




USGS 05599490 BIG MUDDY RIVER AT RTE 127 AT MURPHYSBORO, IL
Temperature, water, degrees Celsius
30
25
20
15
10
5
0
Temperature, water, degrees Fahrenheit
80
70
60
50
40
May 2018
Jul 2018
Sep 2018
Nov 2018
Jan 2019
Mar 2019
May 2019
Jul 2019
Temperature
Period of provisional data
Period of approved data
Graph courtesy of the U.S. Geological Survey


USGS 05599490 BIG MUDDY RIVER AT RTE 127 AT MURPHYSBORO, IL
Dissolved oxygen, water, unfiltered, milligrams per liter
8
6
4
2
0
Jun 09 2018
Jun 23 2018
Jul 07 2018
Jul 21 2018
Aug 04 2018
Aug 18 2018
Sep 01 2018
Dissolved oxygen
Period of approved data
Graph courtesy of the U.S. Geological Survey

Illinois Environmental Protection Agency
DWPC/FOS - Mine Pollution Control Program
Field Inspection Report

Company:	Williamson Energy, LLC
Mine:	Pond Creek Mine #1
County:	Williamson
Location:	Johnston City
NPDES #:	IL0077666
BOW ID:	W1998590001
Inspection Date:	August 29, 2019
Inspected by:	Brian Rodely
Type of Inspection:	Compliance Sampling
Contact Person(s):	Clayton Cross, Chris Skelton, Gary Vancil
Arrival Time:	9:15 AM
Departure Time	12:50 PM
Weather:	Sunny, 89°F.

Compliance Sampling Inspection

August 29, 2019 Compliance Sampling: A compliance sampling inspection was conducted at the above-referenced 540-acre NPDES permitted underground mine. The mine site includes drainage control structures, eight sediment basins, slope, preparation plant, coal stockpile, refuse disposal area, railroad loop, roads, ventilation shafts, parking areas, coal conveyors, and office/maintenance buildings.

Permitting: NPDES permit IL0077666 was issued/effective June 28, 2005 with an expiration date of July 1, 2010 has been administratively continued through timely renewal submissions and contains the discharge limitations for permitted outfalls at the site. The permit was modified February 7, 2013 reflect a name change to Williamson Energy, L.L.C., Pond Creek Mine No. 1.

Discharge Monitoring Reports: Quarterly DMR's are to be received by the Agency's DWPC, Compliance Assurance Section, by the 15th day of April, July, October, and January for the preceding three months. An annual storm water monitoring and sampling plan is due by November 1st of each year.

Drainage Control & Water Treatment: There are 8 NPDES permitted outfalls at this site each associated with a sedimentation basin. Outfalls 001, 002, 003, 004, and 005 are classified as Alkaline Mine Drainage. Outfalls 006, 007, and 008 are classified as Acid Mine Drainage. Sedimentation basins control runoff from three refuse disposal areas (RDA), coal stock piles, and approximately 2.7 million gallons per day of groundwater infiltration into the mine. All outfalls report to unnamed tributaries to Pond Creek.

Findings: The attached 7 photo pages, site plan, and water flow diagram should be consulted to clarify the following activities. I arrived at the unnamed tributary to Pond Creek crossing Dean Road about ½ mile east of the intersection of Dean Road and Liberty School Road at approximately 9:15 am. The stream appeared to have a small flow (approximately 100 gpm) of clear water. A nearby

property owner was working along Dean Road near the unnamed tributary bridge across Dean Road. The owner told me that I need to take samples on Saturday or Sunday when the ditch is rolling "dark gob water" released when the mine knows it will not be caught. I told the land owner that he could file a complaint. The land owner said that when he complained the last time the mine "gave him a hard time". Sample PCDR was taken in the unnamed tributary upstream (south) of Dean Road as documented in photo 1. I proceeded to pond 009 along Dean Road and turned into an actively used entrance to assess the emergency spillway at pond 009. I noted that the emergency spillway had over 2 feet of freeboard before discharge as shown in photo 2. Water was running into pond 009 from the direction of RDA3 and pumps appeared operational in the western end of the pond as shown in photo 3. I called Clayton Cross and was unable to make contact. Next, I called Gary Vancil and explained that I was at the Pond Creek Mine where I needed to conduct an NPDES inspection of the site. Vancil told me that Cross was with him but on another call. Vancil said that he would attempt to contact Brenton Mumford the Pond Creek Mine Engineer or someone to meet me at the Mine Gate. Vancil called back and told me that he was coming with Chris Skelton to meet me at the mine and take me where I needed to go. Cross then returned my call and said that he may be down to the mine later to meet with me.

Vancil and Skelton arrived at the mine and I explained that I needed to observe the mine's water collection and management system including collection ditches, sedimentation basins, and outfalls. We proceeded to outfall 002 that was observed to be non-discharging at the time of inspection as shown in photo 4. Pond 002 collects runoff from the raw coal pile and water is pumped to the freshwater for use in the prep plant. Photo 5 shows the non-discharging culvert outfall 006. It was noted that water has recently discharged from 006 due to water remaining in the corrugated pipe as indicated by the yellow arrow in photo 5. Sample PC006DS shown in the foreground of photo 5 was taken of standing water in the receiving stream of 006 as indicated by the white arrow. The receiving stream appeared to have slight staining on the stream bank vegetation that was recently lodged due to significant water flow with no recent precipitation. I then observed outfalls 008 and 007 that were not discharging as shown in photos 6 and 7. Clayton Cross met with us at outfalls 007 and 008 where we discussed the operations at Pond Creek Mine. Cross left the group and we proceeded to non-discharging outfalls 005, 003, 004, and 001 as shown in photos 8 through 11. I noted that newly constructed water holding cells located north of the mine office along Liberty School Road appeared to only contain storm water with no piping to receive or discharge mine process water. Finally, we walked the collection ditch south of RDA 3 progressing east from Dwina Road. The southern collection ditch is shown in photo 12 where water is actively pumped to the ditch from the southern cell of RDA 3. We walked east then approximately ¼ mile north to a retention dam with a large elevation change resulting in an approximate 15-foot waterfall as shown in photo 13. Vancil and Skelton advised me that specific information about the collection system and sedimentation ponds could be provided by Pond Creek Mine Engineer Brenton Mumford. I left the mine at approximately 12:50 pm.

Subsequent Information: 9/3/19: IDNR inspector Will Gillespie called and told me he heard there was a "leak" at the Pond Creek Mine. I told Gillespie that I conducted an inspection at the mine and found a wet culvert at 006 with standing water in the receiving stream that I sampled. I also discussed the possibility of mine discharges occurring during off hours as reported by a

nearby land owner. Gillespie indicated that he has received similar information about off-hour discharges from multiple sources. Gillespie also told me that he has been attempting to have the mine dredge some sedimentation ponds with limited results at this time.

09/19/19: Sample results were received at the Marion Regional Office for Sample PCDR taken at Dean Road and PC006DS taken downstream from outfall 006.

35 IAC Subtitle C Part 302 Subpart B General Use Water Quality Standards calculated or provided Acute Standard Water Quality Standard (ASWQS) are shown below with the reported sample results.

Sample results for PCDR are attached and provided below:

Parameter	Fe	Sulfates	Chlorides	Mn	Hardness
ASWQS (mg/L)	1.0	1391	500	9.24	N/A
PCDR (mg/L)	0.069	1790	1150	0.03	289

Sample results for PC006DS are attached and provided below:

Parameter	Fe	Sulfates	Chlorides	Mn	Hardness
ASWQS (mg/L)	1.0	1180	500	7.79	N/A
PC006DS (mg/L)	ND	1780	1140	0.04	230

General Use Water Quality Standards are exceeded for Sulfates and Chlorides as shown above. Sulfates are calculated using the maximum value of 500 for Chlorides.

Discharge Monitoring Report Submittal: Discharge monitoring reports have been evaluated for all outfalls from January 2018 through March 2019. DMR's appear to have been submitted with no discharge reported during non-precipitation events despite the daily influent of approximately 2.7 million gallons of underground mine water. The water mass balance of influent water and discharged water does not appear consistent.

Apparent Violations: The following apparent monitoring and effluent violations were noted during the CSI Inspection at Pond Creek Mine #1.

General Use Water Quality Standards are exceeded for 35 IAC Subtitle C Part 302 Subpart B Sections 302.203 (staining downstream) and 302.208 (numerical ASWQS).

Monitoring Violations: Analysis not conducted of discharges, inadequate frequency of sampling, and invalid/unrepresentative sample as required by permit.

Summary: All affected areas of the mine appear to drain to sedimentation ponds and the collection system appears adequate with no unpermitted discharges noted. Samples were taken in the unnamed tributary to Pond Creek downstream from the mine immediately south of Dean Road. A local land owner indicated that the unnamed tributary to Pond Creek has heavy dark flow during non-business hours due to mine water release. A sample was also taken of the unnamed tributary immediately downstream from outfall 006 that appeared to recently discharge due to water in the corrugated tile, staining on receiving stream vegetation, and remaining pools of water in the stream bed. No discharges have been reported from January 2018 through March 2019 during non-precipitation events despite the estimated 2.7 million gallons of daily mine water pumped to the surface collection system. Sample Results PCDR and PC006DS show excursions of General Use Water Quality Standards for Sulfates and Chlorides.

Brian Rodely

Brian Rodely
Environmental Protection Engineer
IEPA/DWPC/FOS
BER: pond creek mine insp 190829.doc

Attachments: 1 Site Plan Pages
7 Photo Pages
1 Williamson Energy, LLC Water Flow Diagram
7 Laboratory Results Pages

Original: BOW/MPCP/Marion
BOW/DWPC/CAS
IDNR/OMM

Exhibit 389D

From:	Andrew Rehn
To:	EPA.PublicHearingCom; Lieberoff, Barb
Cc:	Albert Ettinger; Cindy Skrukrud; Sabrina Hardenbergh; Jan thomas; Cameron J. Smith; Jane Cogie; Amanda Pankau; Jann.Stephen@epa.gov
Subject:	[External] (Exhibits 4/4) IL0077666 Pond Creek Mine Post-Hearing Comments from PRN, SC, SAFE
Date:	Friday, January 17, 2020 4:01:50 PM
Attachments:	Exhibit_R Detailed Facility Report__ECHO__US EPA.pdf Exhibit_U Leatherwood RO Report (Final)-1.pdf Exhibit_Q IPCB Case 2019-085.pdf Exhibit_S Rend Lake Water and mine company Adena.pdf Exhibit_T Reduction-of-Chlorides-from-Mine.pdf Exhibit_V - Treatment and disposal of saline wastewater from coal 1994.pdf

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Please find the Exhibits Q-V attached.

On Fri, Jan 17, 2020 at 3:56 PM Andrew Rehn <arehn@prairierivers.org> wrote:

> Dear Ms. Lieberoff and other Illinois EPA officials;
>
> On behalf of Prairie Rivers Network, Sierra Club and Southern Illinoisans Against Fracturing Our Environment, attached are post-hearing comments regarding the proposed NPDES Permit IL0077666 for the Pond Creek mine. As these comments will explain, the proposed permit plainly cannot be legally granted by the Illinois Environmental Protection Agency (IEPA) based on the current record. Please do not hesitate to reach out to us for further clarification.
>
> In 4 emails following this one, I will be including the exhibits to this comment letter. Please include those in the record with this submission.
>
> Thank you,
> Andrew
>
> --
> **Andrew Rehn**
> *Water Resources Engineer, Prairie Rivers Network*
> 1605 South State St, Suite 1, Champaign, IL 61820
>
> tel: 217.344.2371 x 8208
> www.prairierivers.org
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--
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Electronic Filing: Received, Clerk's Office 2/4/2019 **PCB 2019-085**

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

PEOPLE OF THE STATE OF ILLINOIS,	)	
	)	
Complainant,	)	
	)	
v.	)	PCB No. 19-
	)	(Enforcement - Water)
WILLIAMSON ENERGY, LLC, a Delaware limited liability company,	)	
	)	
	)	
Respondent.	)	

NOTICE OF FILING

TO: See attached service list (VIA ELECTRONIC FILING)

PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Illinois Pollution Control Board by electronic filing the following Notice of Filing and Complaint, copies of which are attached and hereby served upon you. You may be required to answer the charges of the Complaint at a hearing before the Board, at a date set by the Board.

Failure to file an answer to this complaint within 60 days may have severe consequences. Failure to answer will mean that all allegations in the complaint will be taken as if admitted for purposes of this proceeding. If you have any questions about this procedure, you should contact the hearing officer assigned to this proceeding, the clerk's office, or an attorney.

NOTIFICATION - YOU ARE HEREBY NOTIFIED that financing may be available through the Illinois Environmental Facilities Financing Act [20 ILCS 3515/1, et seq.] to correct the alleged violations.

Respectfully submitted,

PEOPLE OF THE STATE OF ILLINOIS,
KWAME RAOUL, Attorney General of the State of Illinois

By: _____

KEVIN BONIN, #6294877
Assistant Attorney General
Environmental Bureau
Illinois Attorney General's Office
500 South Second Street
Springfield, Illinois 62706
(217) 782-5055
kbonin@atg.state.il.us
ebs@atg.state.il.us

Date: February 4, 2019.

Electronic Filing: Received, Clerk's Office 2/4/2019 **PCB 2019-085**

Service List

For the Respondent

Illinois Corporation Service Company
801 Adlai Stevenson Drive
Springfield, IL 62703
Via Certified Mail

Nicholas S. Johnson
Bailey & Glasser LLP
1054 31st Street NW, Suite 230
Washington, DC 20007
NJohnson@baileyglasser.com

Electronic Filing: Received, Clerk's Office 2/4/2019 **PCB 2019-085**

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

PEOPLE OF THE STATE OF ILLINOIS,	)	
	)	
Complainant,	)	
	)	PCB No. 19 -
v.	)	(Enforcement – Water)
	)	
WILLIAMSON ENERGY, LLC, a Delaware limited liability company,	)	
	)	
	)	
Respondent.	)	

COMPLAINT

Complainant, PEOPLE OF THE STATE OF ILLINOIS, by KWAME RAOUL, Attorney General of the State of Illinois, complains of Respondent, WILLIAMSON ENERGY, LLC, a Delaware limited liability company, as follows:

COUNT I
WATER POLLUTION

1. This Count is brought on behalf of the People of the State of Illinois, by Kwame Raoul, Attorney General of the State of Illinois, on his own motion and at the request of the Illinois Environmental Protection Agency ("Illinois EPA"), pursuant to the terms and provisions of Section 31 of the Illinois Environmental Protection Act ("Act"), 415 ILCS 5/31 (2016).

2. Illinois EPA is an administrative agency of the State of Illinois, created pursuant to Section 4 of the Act, 415 ILCS 5/4 (2016), and is charged, *inter alia,* with the duty of enforcing the Act. Illinois EPA is further charged with the duty to abate violations of the National Pollutant Discharge Elimination System ("NPDES") Permit Program under the Federal Clean Water Act ("CWA"), 33 U.S.C. §1342(b)(7).

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3. The Illinois Pollution Control Board ("Board") is an independent board created by the Illinois General Assembly in Section 5 of the Act, 415 ILCS 5/5 (2016), and charged, *inter alia*, with the duty of promulgating standards and regulations under the Act.

4. Respondent, WILLIAMSON ENERGY, LLC, is a Delaware limited liability company in good standing and authorized to do business in the State of Illinois by the Illinois Secretary of State.

5. At all times relevant to this Complaint, Respondent has owned and operated Pond Creek Mine No. 1, a coal mine and coal preparation plant located at 18000 Dean Road, approximately 4 miles east-northeast of Johnston City, Williamson County, Illinois ("Facility").

6. The Facility consists of drainage control structures, eight sediment basins, slope preparation plant, coal stockpile, refuse disposal area, railroad loop, roads, ventilation shafts, parking areas, coal conveyors, and office and maintenance buildings.

7. On June 28, 2005, Illinois EPA issued NPDES Coal Mine Permit No. IL0077666 (the "Permit") to Steelhead Development Company, LLC, setting forth the terms and conditions for discharges from the Facility. On September 24, 2006, Steelhead Development Company, LLC, transferred the Permit to Respondent. On February 7, 2013, Illinois EPA reissued the Permit to Respondent. The Facility is currently authorized for discharges as specified in the Permit.

8. The Permit authorizes Respondent's discharges into an unnamed tributary of Pond Creek as follows:

Outfall	**Classification**
001, 002, 003, 004, 005	Alkaline Mine Drainage
006, 007, 008	Acid Mine Drainage

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9. On April 21, 2016, Illinois EPA conducted an inspection of the Facility in response to a complaint received by the Illinois EPA Emergency Response Unit, citing the existence of black tar-like material in an unnamed tributary of Pond Creek ("Unnamed Tributary") crossing Dean Road, located approximately half of a mile to the east of the intersection of Dean Road and Liberty School Road, downstream from the Facility ("Sample Location 1").

10. At the time of the April 21, 2016 inspection and at times better known to Respondent, the Unnamed Tributary had a substantial flow of approximately 3,000 gallons per minute of light gray-colored, turbid liquid containing slurry solids with dark staining on the stream bank and stream bed at Sample Location 1. Illinois EPA collected a sample ("Sample 1") from the Unnamed Tributary at Sample Location 1.

11. During the April 21, 2016 inspection, representatives of Respondent informed Illinois EPA that an unpermitted discharge had occurred at the Facility earlier that day during an inspection by the Illinois Department of Natural Resources ("DNR").

12. Respondent's facility maintains several sedimentation ponds as part of the Facility's water management operations. Pond 007/008 utilized a diesel pump to reroute acid mine drainage supernatant within the Facility as part of stormwater management and water recycling operations. The pump's suction line was held by a float and supernatant was pumped from near the surface of Pond 007/008.

13. At a time better known to Respondent, Respondent placed the Pond 007/008 diesel pump's discharging outlet end in Outfall 002. Outfall 002 is permitted to discharge alkaline mine drainage from Pond 002 into the Unnamed Tributary.

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14. During the inspection by DNR, a float failed on the suction line of the pump in Pond 007/008. The float failure caused the pump's intake to drop into slurry solids at the bottom of Pond 007/008. In addition to the slurry solids, Pond 007/008 contained and contains acid mine drainage liquids. Consequently, Respondent pumped slurry solids and acid mine drainage liquids out of Pond 007/008 and discharged them onto Outfall 002. As a result of the discharge, slurry solids and acid mine drainage liquids drainage liquids were discharged from Outfall 002 into the Unnamed Tributary and flowed in a generally northeastern direction, eventually reaching and flowing past Sample Location 1.

15. Upon information and belief, the float failure and pumping of slurry solids and acid mine drainage liquids from Pond 007/008 onto Outfall 002 lasted at least 30 minutes, at or before 11:00 a.m. on April 21, 2016, until approximately 11:30 a.m on April 21, 2016.

16. At dates and times better known to Respondent, Respondent pumped acid mine drainage liquid from Pond 007/008, through the suction pump, and discharged onto Outfall 002.

17. At the time of the April 21, 2016 inspection and at times better known to Respondent, dark staining and a thin, dark layer of solids were noted at and immediately downstream of Outfall 002, progressing down the Unnamed Tributary.

18. Section 12(a) of the Act, 415 ILCS 5/12(a) (2016), provides as follows:

> No person shall:
>
> (a) Cause or threaten or allow the discharge of any contaminants into the environment in any State so as to cause or tend to cause water pollution in Illinois, either alone or in combination with matter from other sources, or so as to violate regulations or standards adopted by the Pollution Control Board under this Act.

19. Section 3.315 of the Act, 415 ILCS 5/3.315 (2016), provides as follows:

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> "Person" is any individual, partnership, co-partnership, firm, company, limited liability company, corporation, association, joint stock company, trust, estate, political subdivision, state agency or any other legal entity, or their legal representative, agent or assigns.

20. Respondent, a limited liability company, is a "person" as that term is defined in Section 3.315 of the Act, 415 ILCS 5/3.315 (2016).

21. Section 3.165 of the Act, 415 ILCS 5/3.165 (2016), provides as follows:

> "Contaminant" is any solid, liquid, or gaseous matter, any odor, or any form of energy, from whatever source.

22. Acid mine drainage and slurry solids are "contaminants" as that term is defined in Section 3.165 of the Act, 415 ILCS 5/3.165 (2016).

23. Section 3.545 of the Act, 415 ILCS 5/3.545 (2016), provides as follows:

> "Water pollution" is such alteration of the physical, thermal, chemical, biological or radioactive properties of any waters of the State, or such discharge of any contaminant into any waters of the State, as will or is likely to create a nuisance or render such waters harmful or detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate uses, or to livestock, wild animals, birds, fish, or other aquatic life.

24. Section 3.550 of the Act, 415 ILCS 5/3.550 (2016), provides as follows:

> "Waters" means all accumulations of water, surface and underground, natural, and artificial, public and private, or parts thereof, which are wholly or partially .within, flow through, or border upon this State.

25. Pond Creek and the Unnamed Tributary are "waters" of the State as that term is defined in Section 3.550 of the Act, 415 ILCS 5/3.550 (2016).

26. At or before 11:00 a.m. on April 21, 2016, until approximately 11:30 a.m. on April 21, 2016, Respondent discharged acid mine drainage and slurry solids from Pond 007/008 onto Outfall 002, causing the discharge of acid mine drainage and slurry solids into the Unnamed

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Tributary, and thereby altering the physical, chemical, or biological properties of waters of the State in such manner likely to create a nuisance or to render the water harmful or detrimental to public health, safety, or welfare, or to other legitimate uses or users of the waters. Respondent's release of acid mine drainage and slurry solids into waters of the State caused or tended to cause "water pollution," as that term is defined by Section 3.545 of the Act, 415 ILCS 5/3.545 (2016).

27. On dates and at times better known to Respondent, Respondent discharged acid mine drainage from Pond 007/008 onto Outfall 002, causing the discharge of acid mine drainage into the Unnamed Tributary, and thereby altering the physical, chemical, or biological properties of waters of the State in such manner likely to create a nuisance or to render the water harmful or detrimental to public health, safety, or welfare, or to other legitimate uses or users of the waters. Respondent's release of acid mine drainage into waters of the State caused or tended to cause "water pollution," as that term is defined by Section 3.545 of the Act, 415 ILCS 5/3.545 (2016).

28. By causing, threatening, or allowing the discharge of contaminants into waters of the State so as to cause or tend to cause water pollution in Illinois, Respondent violated Section 12(a) of the Act, 415 ILCS 5/12(a) (2016).

PRAYER FOR RELIEF

WHEREFORE, Complainant, PEOPLE OF THE STATE OF ILLINOIS, respectfully requests that the Board enter an order in favor of the Complainant and against the Respondent, WILLIAMSON ENERGY, LLC, on Count I:

A. Authorizing a hearing in this matter at which time Respondent will be required to answer the allegations herein;

B. Finding that Respondent violated Section 12(a) of the Act, 415 ILCS 5/12(a) (2016);

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C. Ordering Respondent to cease and desist from any further violations of the Act and associated regulations;

D. Assessing against Respondent a civil penalty of $50,000.00 for each violation of Section 12(a) of the Act, 415 ILCS 5/12(a) (2016), and an additional civil penalty of $10,000.00 for each day such violations continued, pursuant to Section 42(a) of the Act, 415 ILCS 5/42(a) (2016);

E. Awarding to Complainant its costs, including expert witness, consultant, and attorney fees, expended in pursuit of this action, pursuant to Section 42(f) of the Act, 415 ILCS 5/42(f) (2016); and

F. Ordering such other and further relief as the Board deems appropriate and just.

COUNT II
WATER POLLUTION HAZARD

1-27. Complainant realleges and incorporates by reference herein paragraphs 1 through 17 and 19 through 28 of Count I as paragraphs 1 through 27 of this Count II.

28. Section 12(d) of the Act, 415 ILCS 5/12(d) (2016), provides as follows:

No person shall:

* * *

(d) Deposit any contaminants upon the land in such place and manner so as to create a water pollution hazard.

29. On April 21, 2016, at times better known to Respondent, Respondent's discharge of acid mine drainage and slurry solids onto Outfall 002 caused dark staining and left a thin, dark layer of solids in and around Outfall 002.

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30. On April 21, 2016, at times better known to Respondent, the dark staining and dark layer of solids progressed downstream from where Outfall 002 discharges into the Unnamed Tributary and caused staining and solids deposition along its stream banks.

31. The dark staining and dark layer of solids deposited on and around Outfall 002 and along the stream banks of the Unnamed Tributary constituted a water pollution hazard.

32. By depositing contaminants upon the land at and near the Facility in a place and manner so as to create a water pollution hazard, Respondent violated Section 12(d) of the Act, 415 ILCS 5/12(d) (2016).

PRAYER FOR RELIEF

WHEREFORE, Complainant, PEOPLE OF THE STATE OF ILLINOIS, respectfully requests that the Board enter an order in favor of the Complainant and against the Respondent, WILLIAMSON ENERGY, LLC, on Count II:

A. Authorizing a hearing in this matter at which time Respondent will be required to answer the allegations herein;

B. Finding that Respondent violated Section 12(d) of the Act, 415 ILCS 5/12(d) (2016);

C. Ordering Respondent to cease and desist from any further violations of the Act and associated regulations;

D. Assessing against Respondent a civil penalty of $50,000.00 for each violation of Section 12(d) of the Act, 415 ILCS 5/12(d) (2016), and an additional civil penalty of $10,000.00 for each day such violations continued, pursuant to Section 42(a) of the Act, 415 ILCS 5/42(a) (2016);

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E. Awarding to Complainant its costs, including expert witness, consultant, and attorney fees, expended in pursuit of this action, pursuant to Section 42(f) of the Act, 415 ILCS 5/42(f) (2016); and

F. Ordering such other and further relief as the Board deems appropriate and just.

COUNT III
VIOLATION OF WATER QUALITY STANDARDS

1-24. Complainant realleges and incorporates by reference herein paragraphs 1 through 22, 24, and 25 of Count I as paragraphs 1 through 24 of this Count III.

25. Section 12(f) of the Act, 415 ILCS 5/12(f) (2016), provides, in pertinent part, as follows:

> No person shall:
>
> * * *
>
> (f) Cause, threaten or allow the discharge of any contaminant into the waters of the State, as defined herein . . . without an NPDES permit for point source discharges issued by the Agency under Section 39(b) of this Act, or in violation of any term or condition imposed by such permit. . . .

26. Section 3.105 of the Act, 415 ILCS 5/3.105 (2016), provides the following definition:

> "Agency" is the Environmental Protection Agency established by this Act.

27. Section 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 309.102(a), provides as follows:

> (a) Except as in compliance with the provisions of the Act, Board regulations, and the CWA, and the provisions and conditions of the NPDES permit issued to the discharger, the discharge of any contaminant or pollutant by any person in the waters of the State from a point source or into a well shall be unlawful.

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28. Section 301.240 of the Board's regulations, 35 Ill. Adm. Code 301.240, provides the following definition:

> "CWA" means the Federal Water Pollution Control Act, as amended, (33 U.S.C. 1251 et seq., Public Law 92-500 enacted by Congress October 18, 1972 as amended by the "Clean Water Act", Public Law 95-217, enacted December 12, 1977, as amended.)

29. Section 502(14) of the CWA, 33 U.S.C. § 1362(14), provides the following definition:

> 14) The term "point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture.

30. Outfall 002 and Outfall 007/008 were and are "point sources," as that term is defined in Section 502(14) of the CWA, 33 U.S.C. § 1362(14).

31. Special Condition 1 of the Permit provides as follows:

> No effluent from any mine related facility area under this permit shall, alone or in combination with other sources, cause a violation of any applicable water quality standard as set out in the Illinois Pollution Control Board Rules and Regulations, Subtitle C: Water Pollution.

32. Illinois EPA analyzed Sample 1, collected from Sample Location 1 during the April 21, 2016 inspection, and testing provided the following results:

Constituent	Unit	Sample 1
Chloride	mg/L	752
Iron	mg/L	1.9

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33. Section 302.201 of the Board regulations, 35 Ill. Adm. Code 302.201, provides as follows:

> Subpart B contains general use water quality standards which must be met in waters of the State for which there is no specific designation (Section 303.201).

34. The Unnamed Tributary and Pond Creek are waters of the State for which there is no specific designation.

35. Section 302.208(d) of the Board's regulations, 35 Ill. Adm. Code 302.208(d), provides, in pertinent part, as follows:

> The standard for the chemical constituents of subsection[] (g) . . . shall not be exceeded at any time except for those waters in which the Agency has approved a mixing zone or in which mixing is allowed pursuant to Section 302.102.

36. Illinois EPA has not approved a mixing zone for Facility discharges, and the Permit does not authorize a mixing zone in which mixing is allowed pursuant to Section 302.102 of the Board's regulations, 35 Ill. Adm. Code 302.102.

37. Section 302.208(g) of the Board's regulations, 35 Ill. Adm. Code 302.208(g), provides, in pertinent part, as follows:

> g) Single-value standards apply at the following concentrations for these substances:

Constituent	Unit	Standard
Chloride (total)	mg/L	500
Iron (dissolved)	mg/L	1.0

38. Sample 1 contains concentrations exceeding the applicable water quality standards of 500 mg/L for Chloride and 1.0 mg/L for Iron.

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39. Upon information and belief, Respondent's discharge of acid mine drainage liquids and slurry solids from Outfall 002 into the Unnamed Tributary caused an exceedance of the applicable water quality standards for Chloride and Iron, 35 Ill. Adm. Code 302.208(d), (g).

40. By causing an exceedance of applicable water quality standards set out in Section 302.208(g) of the Board's regulations, 35 Ill. Adm. Code 302.208(g), Respondent violated Section 302.208(d) of the Board's regulations, 35 Ill. Adm. Code 302.208(d).

41. By violating Section 302.208(d) of the Board's regulations, 35 Ill. Adm. Code 302.208(d), Respondent caused or threatened or allowed the discharge of contaminants into the environment so as to violate regulations or standards adopted by the Board under the Act, and thereby violated Section 12(a) of the Act, 415 ILCS 5/12(a) (2016).

42. By causing an exceedance of applicable water quality standards set out in Subtitle C of the Board's Regulations, Respondent violated Special Condition 1 of the Permit.

43. By violating Special Condition 1 of the Permit, Respondent discharged contaminants or pollutants in the waters of the State from a point source in violation of the provisions and conditions of the Permit, and thereby violated Section 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 309.102(a).

44. By violating Special Condition 1 of the Permit, Respondent caused, threatened, or allowed the discharge of a contaminant into the waters of the State in violation of the terms or conditions imposed by the Permit, and thereby violated Section 12(f) of the Act, 415 ILCS 5/12(f) (2016).

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PRAYER FOR RELIEF

WHEREFORE, Complainant, PEOPLE OF THE STATE OF ILLINOIS, respectfully requests that the Board enter an order in favor of the Complainant and against the Respondent, WILLIAMSON ENERGY, LLC, on Count III:

A. Authorizing a hearing in this matter at which time Respondent will be required to answer the allegations herein;

B. Finding that Respondent violated Sections 12(a) and (f) of the Act, 415 ILCS 5/12(a), (f) (2016), Sections 302.208(d) and 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 302.208(d) and 309.102(a), and Special Condition 1 of the Permit;

C. Ordering Respondent to cease and desist from any further violations of the Act and associated regulations;

D. Assessing against Respondent a civil penalty of $50,000.00 for each violation of Section 12(a) of the Act, 415 ILCS 5/12(a) (2016), and Section 302.208(d) of the Board's regulations, 35 Ill. Adm. Code 302.208(d), and an additional civil penalty of $10,000.00 for each day such violations continued, pursuant to Section 42(a) of the Act, 415 ILCS 5/42(a) (2016);

E. Assessing against the Respondent a civil penalty of $10,000.00 for each day of violation of Section 12(f) of the Act, 415 ILCS 5/12(f) (2016), Section 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 309.102(a), and NPDES Permit No. IL0077666, pursuant to Section 42(b)(1) of the Act, 415 ILCS 5/42(b)(1) (2016);

F. Awarding to Complainant its costs, including expert witness, consultant, and attorney fees, expended in pursuit of this action, pursuant to Section 42(f) of the Act, 415 ILCS 5/42(f) (2016); and

G. Ordering such other and further relief as the Board deems appropriate and just.

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COUNT IV
OFFENSIVE CONDITIONS

1-31. Complainant realleges and incorporates by reference herein paragraphs 1 through 22, 24, and 25 of Count I and paragraphs 25 through 31 of Count III as paragraphs 1 through 31 of this Count IV.

32. Section 302.203 of the Board's regulations, 35 Ill. Adm. Code 302.203, provides, in pertinent part, as follows:

> Waters of the State shall be free from sludge or bottom deposits, floating debris, visible oil, odor, plant or algal growth, color or turbidity of other than natural origin. . . .

33. Section 406.202 of the Board's regulations, 35 Ill. Adm. Code 406.202, provides, in pertinent part, as follows:

> In addition to the other requirements of this Part, no mine discharge or non-point source mine discharge shall, alone or in combination with other sources, cause a violation of any water quality standards of 35 Ill. Adm. Code 302 or 303. . . .

34. Section 402.101 of the Board's regulations, 35 Ill. Adm. Code 402.101, provides, in pertinent part:

* * *

> "Mine Discharge": any point source discharge, whether natural or man-made, from a mine related facility. . . . The term mine discharge includes surface runoff discharged from a sedimentation pond. . . .

35. Respondent's discharge of acid mine drainage liquids and slurry solids from Outfall 002 constituted a "mine discharge" as that term is defined in Section 402.101 of the Board's regulations, 35 Ill. Adm. Code 402.101.

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36. At times better known to Respondent, Respondent discharged acid mine drainage liquids and slurry solids from Outfall 002, causing dark staining, sludge, bottom deposits, and color and turbidity of other than natural origin to accrue in the Unnamed Tributary, a water of the State, and thereby caused an "offensive condition" prohibited by Section 302.203 of the Board's regulations, 35 Ill. Adm. Code 302.203.

37. By discharging a "mine discharge" that caused a violation of water quality standards codified at 35 Ill. Adm. Code Part 302, Respondent violated Section 406.202 of the Board's regulations, 35 Ill. Adm. Code 406.202.

38. By violating Section 406.202 of the Board's regulations, 35 Ill. Adm. Code 406.202, Respondent caused or threatened or allowed the discharge of contaminants into the environment so as to violate regulations or standards adopted by the Board under the Act, and thereby violated Section 12(a) of the Act, 415 ILCS 5/12(a) (2016).

39. By causing an "offensive condition" prohibited by an applicable water quality standard set out in Subtitle C of the Board's Regulations, Respondent violated Special Condition 1 of the Permit.

40. By violating Special Condition 1 of the Permit, Respondent discharged contaminants or pollutants in the waters of the State from a point source in violation of the provisions and conditions of the Permit, and thereby violated Section 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 309.102(a).

41. By violating Special Condition 1 of the Permit, Respondent caused, threatened, or allowed the discharge of a contaminant into the waters of the State in violation of the terms or conditions imposed by the Permit, and thereby violated Section 12(f) of the Act, 415 ILCS 5/12(f) (2016).

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PRAYER FOR RELIEF

WHEREFORE, Complainant, PEOPLE OF THE STATE OF ILLINOIS, respectfully requests that the Board enter an order in favor of the Complainant and against the Respondent, WILLIAMSON ENERGY, LLC, on Count IV:

A. Authorizing a hearing in this matter at which time Respondent will be required to answer the allegations herein;

B. Finding that Respondent violated Sections 12(a) and (f) of the Act, 415 ILCS 5/12(a), (f) (2016), Sections 309.102(a) and 406.202 of the Board's regulations, 35 Ill. Adm. Code 309.102(a) and 406.202, and Special Condition 1 of the Permit;

C. Ordering Respondent to cease and desist from any further violations of the Act and associated regulations;

D. Assessing against Respondent a civil penalty of $50,000.00 for each violation of Section 12(a) of the Act, 415 ILCS 5/12(a) (2016), and Section 406.202 of the Board's regulations, 35 Ill. Adm. Code 406.202, and an additional civil penalty of $10,000.00 for each day such violations continued, pursuant to Section 42(a) of the Act, 415 ILCS 5/42(a) (2016);

E. Assessing against the Respondent a civil penalty of $10,000.00 for each day of violation of Section 12(f) of the Act, 415 ILCS 5/12(f) (2016), Section 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 309.102(a), and NPDES Permit No. IL0077666, pursuant to Section 42(b)(1) of the Act, 415 ILCS 5/42(b)(1) (2016);

F. Awarding to Complainant its costs, including expert witness, consultant, and attorney fees, expended in pursuit of this action, pursuant to Section 42(f) of the Act, 415 ILCS 5/42(f) (2016); and

G. Ordering such other and further relief as the Board deems appropriate and just.

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COUNT V
OFFENSIVE DISCHARGES

1-28. Complainant realleges and incorporates by reference herein paragraphs 1 through 22, 24, and 25 of Count I, paragraphs 29 and 30 of Count III, and paragraphs 34 and 35 of Count IV as paragraphs 1 through 28 of this Count V.

29. Section 406.107 of the Board's regulations, 35 Ill. Adm. Code 406.107, provides as follows:

> In addition to the other requirements of this Chapter, no mine discharge effluent shall contain settleable solids, floating debris, visible oil, grease, scum or sludge solids. Color, odor and turbidity shall be reduced to below obvious levels.

30. Respondent's mine discharge contained settleable solids, sludge solids, and color and turbidity above obvious levels, which caused dark staining, sludge, bottom deposits, and color and turbidity alterations in the Unnamed Tributary, and therefore constituted an "offensive discharge" in violation of Section 406.107 of the Board's regulations, 35 Ill. Adm. Code 406.107.

31. By violating Section 406.107 of the Board's regulations, 35 Ill. Adm. Code 406.107, Respondent caused or threatened or allowed the discharge of contaminants into the environment so as to violate regulations or standards adopted by the Board under the Act, and thereby violated Section 12(a) of the Act, 415 ILCS 5/12(a) (2016).

PRAYER FOR RELIEF

WHEREFORE, Complainant, PEOPLE OF THE STATE OF ILLINOIS, respectfully requests that the Board enter an order in favor of the Complainant and against the Respondent, WILLIAMSON ENERGY, LLC, on Count V:

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A. Authorizing a hearing in this matter at which time Respondent will be required to answer the allegations herein;

B. Finding that Respondent violated Section 12(a) of the Act, 415 ILCS 5/12(a) (2016), and Section 406.107 of the Board's regulations, 35 Ill. Adm. Code 406.107;

C. Ordering Respondent to cease and desist from any further violations of the Act and associated regulations;

D. Assessing against Respondent a civil penalty of $50,000.00 for each violation of Section 12(a) of the Act, 415 ILCS 5/12(a) (2016), and Section 406.107 of the Board's regulations, 35 Ill. Adm. Code 406.107, and an additional civil penalty of $10,000.00 for each day such violations continued, pursuant to Section 42(a) of the Act, 415 ILCS 5/42(a) (2016);

E. Awarding to Complainant its costs, including expert witness, consultant, and attorney fees, expended in pursuit of this action, pursuant to Section 42(f) of the Act, 415 ILCS 5/42(f) (2016); and

F. Ordering such other and further relief as the Board deems appropriate and just.

COUNT VI
NPDES PERMIT VIOLATIONS

1-30. Complainant realleges and incorporates by reference herein paragraphs 1 through 17 and 19 through 25 of Count I and paragraphs 25-30 of Count III as paragraphs 1 through 30 of this Count VI.

31. Standard Condition 5 of the Permit provides, in pertinent part, as follows:

> Proper operation and maintenance. The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with conditions of this permit. . . .

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32. The Permit authorizes Outfall 007 and Outfall 008 to discharge acid mine drainage. Section 402.101 of the Board's regulations, 35 Ill. Adm. Code 402.101, defines "Acid or Ferruginous Mine Drainage" as "mine drainage which, before any treatment, has a pH of less than 6.0 or a total iron concentration greater than 10 mg/L." *See also* 40 C.F.R. §§ 434.30-.35.

33. The Permit authorizes Outfall 002 to discharge alkaline mine drainage ("Alkaline Mine Drainage Effluent Limitations"). Section 402.101 of the Board's regulations, 35 Ill. Adm. Code 402.101, defines "Alkaline Mine Drainage" as "mine drainage which, prior to treatment, has a pH equal to or greater than 6.0 and a total iron concentration of less than 10 mg/L." *See also* 40 C.F.R. §§ 434.40-.45.

34. The discharge of slurry solids from the bottom of a sedimentation pond onto and through Outfall 002 constituted improper operation and maintenance of facilities and systems of treatment and control, and is therefore a violation of Standard Condition 5 of the Permit.

35. Respondent was and is not authorized to discharge slurry solids or acid mine drainage liquids through Outfall 002, which is permitted to discharge alkaline mine drainage liquids under the terms and conditions of the Permit.

36. By discharging slurry solids and acid mine drainage liquids through Outfall 002, Respondent violated the Alkaline Mine Drainage Effluent Limitations of the Permit.

37. By violating Standard Condition 5 and the Alkaline Mine Drainage Effluent Limitations of the Permit, Respondent discharged contaminants or pollutants in the waters of the State from a point source in violation of the provisions and conditions of the Permit, and thereby violated Section 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 309.102(a).

38. By violating Standard Condition 5 and the Alkaline Mine Drainage Effluent Limitations of the Permit, Respondent caused, threatened, or allowed the discharge of a

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contaminant into the waters of the State in violation of the terms or conditions imposed by the Permit, and thereby violated Section 12(f) of the Act, 415 ILCS 5/12(f) (2016).

PRAYER FOR RELIEF

WHEREFORE, Complainant, PEOPLE OF THE STATE OF ILLINOIS, respectfully requests that the Board enter an order in favor of the Complainant and against the Respondent, WILLIAMSON ENERGY, LLC, on Count VI:

A. Authorizing a hearing in this matter at which time Respondent will be required to answer the allegations herein;

B. Finding that Respondent violated Section 12(f) of the Act, 415 ILCS 5/12(f) (2016), Section 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 309.102(a), Standard Condition 5 of the Permit, and the Alkaline Mine Drainage Effluent Limitations of the Permit;

C. Ordering Respondent to cease and desist from any further violations of the Act and associated regulations;

D. Assessing against the Respondent a civil penalty of $10,000.00 for each day of violation of Section 12(f) of the Act, 415 ILCS 5/12(f) (2016), Section 309.102(a) of the Board's regulations, and NPDES Permit No. IL0077666, pursuant to Section 42(b)(1) of the Act, 415 ILCS 5/42(b)(1) (2016);

E. Awarding to Complainant its costs, including expert witness, consultant, and attorney fees, expended in pursuit of this action, pursuant to Section 42(f) of the Act, 415 ILCS 5/42(f) (2016); and

F. Ordering such other and further relief as the Board deems appropriate and just.

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COUNT VII
NPDES BYPASS VIOLATIONS

1-31. Complainant realleges and incorporates by reference herein paragraphs 1 through 17, 19 through 22, 24, and 25 of Count I and paragraphs 25 through 30 of Count III and paragraphs 32 and 33 of Count VI as paragraphs 1 through 31 of this Count VII.

32. Acid mine drainage discharges and alkaline drainage discharges are authorized under separate provisions of the Permit and have distinct effluent standards and limitations.

33. Section 305.102 of the Board's regulations, 35 Ill. Adm. Code 305.102, provides, in pertinent part, as follows:

> (a) Every person within this State operating a . . . wastewater source shall submit operating reports to the Agency at a frequency to be determined by the Agency. "Agency" means the Illinois Environmental Protection Agency. Such reports shall contain information regarding the quantity of influent and of effluent discharged, of wastes bypassed and of combined sewer overflows. . . .
>
> (b) Every holder of an NPDES (National Pollutant Discharge Elimination System) permit is required to comply with the monitoring, sampling, recording and reporting requirements set forth in the permit and this Chapter.

34. Standard Condition 12(b) of the Permit provides as follows:

> (b) Anticipated noncompliance. The permittee shall give advance notice to the Agency of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

35. Standard Condition 13(a)(1) of the Permit provides as follows:

> (a) Definitions.
>
> (1) Bypass means the intentional diversion of waste streams from any portion of a treatment facility.

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36. Pond 007/008 is a "treatment facility" as that term is used in Standard Condition 13(a)(1) of the Permit.

37. Respondent's intentional diversion of waste streams from Pond 007/008 to Outfall 002 constituted a "bypass" as that term is used in Standard Condition 13(a)(1).

38. Standard Condition 13(c)(1) of the Permit provides as follows:

> (c) Notice.
>
> (1) Anticipated bypass. If the permittee knows in advance of the need for a bypass, it shall submit prior notice, if possible at least ten days before the date of the bypass.

39. Standard Condition 13(d) of the Permit provides as follows:

> (d) Prohibition of bypass.
>
> (1) Bypass is prohibited, and the Agency may take enforcement action against a permittee for bypass, unless:
>
> (i) Bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;
>
> (ii) There were no feasible alternatives to bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of a reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventative maintenance; and
>
> (iii) The permittee submitted notices as required under paragraph 13(c).

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> (2) The Agency may approve an anticipated bypass, after considering its adverse effects, if the Agency determines that it will meet the three conditions listed above in paragraph 13(d)(1).

40. By failing to submit prior notice of the anticipated bypass, Respondent violated Standard Condition 13(c)(1) of the Permit.

41. Respondent's bypass was not approved by Illinois EPA or otherwise unavoidable, lacking in feasible alternatives, or properly noticed to Illinois EPA. Respondent's bypass was therefore prohibited and a violation of Standard Condition 13(d) of the Permit.

42. By failing to give advance notice of planned changes to the permitted facility or activity which resulted in noncompliance with permit requirements, Respondent violated Standard Condition 12(b) of the Permit.

43. By violating Standard Conditions 12(b) and 13(c)(1), (d) of the Permit, Respondent discharged contaminants or pollutants in the waters of the State from a point source in violation of the provisions and conditions of the Permit, and thereby violated Section 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 309.102(a).

44. By failing to submit operating reports to Illinois EPA containing information regarding the quantity of wastes bypassed, Respondent violated Section 305.102(a) of the Board's regulations, 35 Ill. Adm. Code 305.102(a).

45. By failing to comply with the reporting requirements of the Permit, Respondent violated Section 305.102(b) of the Board's regulations, 35 Ill. Adm. Code 305.102(b).

46. By violating Section 305.102 of the Board's regulations, 35 Ill. Adm. Code 305.102, and Standard Conditions 12(b) and 13(c)(1), (d) of the Permit, Respondent caused, threatened, or allowed the discharge of a contaminant into the waters of the State in violation of regulations adopted by the Board with respect to the NPDES program and the terms or

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conditions imposed by the Permit, and thereby violated Section 12(f) of the Act, 415 ILCS 5/12(f) (2016).

PRAYER FOR RELIEF

WHEREFORE, Complainant, PEOPLE OF THE STATE OF ILLINOIS, respectfully requests that the Board enter an order in favor of the Complainant and against the Respondent, WILLIAMSON ENERGY, LLC, on Count VII:

A. Authorizing a hearing in this matter at which time Respondent will be required to answer the allegations herein;

B. Finding that Respondent violated Section 12(f) of the Act, 415 ILCS 5/12(f) (2016), Sections 305.102(a) and (b) of the Board's regulations, 35 Ill. Adm. Code 305.102(a), (b), Section 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 309.102(a), and Standard Conditions 12(b), 13(c)(1), and 13(d) of the Permit;

C. Ordering Respondent to cease and desist from any further violations of the Act and associated regulations;

D. Assessing against the Respondent a civil penalty of $10,000.00 for each day of violation of Section 12(f) of the Act, 415 ILCS 5/12(f) (2016), Sections 305.102(a) and (b) of the Board's regulations, 35 Ill. Adm. Code 305.102(a), (b), Section 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 309.102(a), and NPDES Permit No. IL0077666, pursuant to Section 42(b)(1) of the Act, 415 ILCS 5/42(b)(1) (2016);

E. Awarding to Complainant its costs, including expert witness, consultant, and attorney fees, expended in pursuit of this action, pursuant to Section 42(f) of the Act, 415 ILCS 5/42(f) (2016); and

F. Ordering such other and further relief as the Board deems appropriate and just.

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COUNT VIII
FAILURE TO COMPLY WITH GOOD MINING PRACTICES

1-29. Complainant realleges and incorporates by reference herein paragraphs 1 through 17, 19 through 22, 24, and 25 of Count I and paragraphs 25 through 30 of Count III as paragraphs 1 through 29 of this Count VIII.

30. Section 406.204(b) of the Board's regulations, 35 Ill. Adm. Code 406.204(b), provides, in pertinent part, as follows:

> In determining whether an operator is utilizing good mining practices designed to minimize discharge of total dissolved solids, chloride, sulfate, iron and manganese, the Agency shall consider whether the operator is utilizing the following good mining practices, further defined in the Sections indicated:
>
> * * *
>
> (b) Retention and control within the site of waters exposed to disturbed materials (Section 406.206). . . .

31. Standard Condition 27 of the Permit provides, in pertinent part, as follows:

> The permittee shall comply with, in addition to the requirements of the permit, all applicable provisions of 35 Ill. Adm. Code, Subtitle C, Subtitle D, Subtitle E. . . .

32. Respondent failed to adequately retain and control on-site waters exposed to disturbed materials, resulting in the unpermitted discharge.

33. Because Respondent failed to comply with the Good Mining Practices of Section 406.204(b) of the Board's regulations, 35 Ill. Adm. Code 406.204(b), Respondent failed to comply with an applicable provision of 35 Ill. Adm. Code Subtitle D, and thereby violated Standard Condition 27 of the Permit.

34. By violating Standard Condition 27 of the Permit, Respondent discharged contaminants or pollutants in the waters of the State from a point source in violation of the

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provisions and conditions of the Permit, and thereby violated Section 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 309.102(a).

35. By violating Standard Condition 27 of the Permit, Respondent caused, threatened, or allowed the discharge of a contaminant into the waters of the State in violation of the terms or conditions imposed by the Permit, and thereby violated Section 12(f) of the Act, 415 ILCS 5/12(f) (2016).

PRAYER FOR RELIEF

WHEREFORE, Complainant, PEOPLE OF THE STATE OF ILLINOIS, respectfully requests that the Board enter an order in favor of the Complainant and against the Respondent, WILLIAMSON ENERGY, LLC, on Count VIII:

A. Authorizing a hearing in this matter at which time Respondent will be required to answer the allegations herein;

B. Finding that Respondent violated Section 12(f) of the Act, 415 ILCS 5/12(f) (2016), Section 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 309.102(a), and Standard Condition 27 of the Permit;

C. Ordering Respondent to cease and desist from any further violations of the Act and associated regulations;

D. Assessing against the Respondent a civil penalty of $10,000.00 for each day of violation of Section 12(f) of the Act, 415 ILCS 5/12(f) (2016), Section 309.102(a) of the Board's regulations, 35 Ill. Adm. Code 309.102(a), and NPDES Permit No. IL0077666, pursuant to Section 42(b)(1) of the Act, 415 ILCS 5/42(b)(1) (2016);

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E. Awarding to Complainant its costs, including expert witness, consultant, and attorney fees, expended in pursuit of this action, pursuant to Section 42(f) of the Act, 415 ILCS 5/42(f) (2016); and

F. Ordering such other and further relief as the Board deems appropriate and just.

Respectfully submitted,

PEOPLE OF THE STATE OF ILLINOIS,
ex rel. KWAME RAOUL, Attorney General
of the State of Illinois

MATTHEW J. DUNN, Chief
Environmental Enforcement/Asbestos
Litigation Division

BY: Andrew Armstrong
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ECHO
Enforcement and
Compliance History Online

Detailed Facility Report

Facility Summary

WILLIAMSON ENERGY LLC
18000 DEAN RD, JOHNSTON CITY, IL 62951

FRS (Facility Registry Service) ID: 110023026884
EPA Region: 05
Latitude: 37.841222
Longitude: -88.827944
Locational Data Source: NPDES
Industry: Bituminous Coal - Underground
Indian Country: N

Enforcement and Compliance Summary

Statute	CWA
Insp (5 Years)	--
Date of Last Inspection	09/09/2009
Current Compliance Status	Violation Identified
Qtrs with NC (of 12)	5
Qtrs with Significant Violation	0
Informal Enforcement Actions (5 years)	1
Formal Enforcement Actions (5 years)	--
Penalties from Formal Enforcement Actions (5 years)	--
EPA Cases (5 years)	--
Penalties from EPA Cases (5 years)	--

Regulatory Information

Clean Air Act (CAA): No Information
Clean Water Act (CWA): Minor, Permit Admin Continued (IL0077666)
Resource Conservation and Recovery Act (RCRA): No Information
Safe Drinking Water Act (SDWA): No Information

Other Regulatory Reports

Air Emissions Inventory (EIS): No Information
Greenhouse Gas Emissions (eGGRT): No Information
Toxic Releases (TRI): No Information
Compliance and Emissions Data Reporting Interface (CEDRI): No Information

Known Data Problems

Facility/System Characteristics

Facility/System Characteristics

System	Statute	Identifier	Universe	Status	Areas	Permit Expiration Date	Indian Country	Latitude	Longitude
FRS		110023026884					N	37.841222	-88.827944
ICIS-NPDES	CWA	IL0077666	Minor NPDES Individual Permit	Admin Continued		07/31/2010	N	37.84/778	-88.827083

Facility Address

System	Statute	Identifier	Facility Name	Facility Address
FRS		110023026884	WILLIAMSON ENERGY LLC	18000 DEAN RD, JOHNSTON CITY, IL 62951
ICIS-NPDES	CWA	IL0077666	WILLIAMSON ENERGY LLC	18009 DEAN ROAD, JOHNSTON CITY, IL 62951

Facility SIC (Standard Industrial Classification) Codes

System	Identifier	SIC Code	SIC Description
ICIS-NPDES	IL0077666	1222	Bituminous Coal - Underground

Facility NAICS (North American Industry Classification System) Codes

System	Identifier	NAICS Code	NAICS Description
No data records returned			

Facility Tribe Information

Reservation Name	Tribe Name	EPA Tribal ID	Distance to Tribe (miles)
No data records returned			

Enforcement and Compliance

Compliance Monitoring History (5 years)

Statute	Source ID	System	Activity Type	Compliance Monitoring Type	Lead Agency	Date	Finding (if applicable)
No data records returned							

Entries in italics are not counted in EPA compliance monitoring strategies or annual results.

Compliance Summary Data

Statute	Source ID	Current SNC (Significant Noncompliance) HPV (High Priority Violation)	Current As Of	Qtrs with NC (Noncompliance) (of 12)	Data Last Refreshed
CWA	IL0077666	No	03/31/2019	5	07/26/2019

Three-Year Compliance History by Quarter

Statute	Program Pollutant Violation Type	QTR 1	QTR 2	QTR 3	QTR 4	QTR 5	QTR 6	QTR 7	QTR 8	QTR 9	QTR 10	QTR 11	QTR 12	QTR 13+
CWA (Source ID: IL0077666)		04/01-06/30/16	07/01-09/30/16	10/01-12/31/16	01/01-03/31/17	04/01-06/30/17	07/01-09/30/17	10/01-12/31/17	01/01-03/31/18	04/01-06/30/18	07/01-09/30/18	10/01-12/31/18	01/01-03/31/19	04/01-07/26/19

Statute	Program Pollutant Violation Type				QTR 1	QTR 2	QTR 3	QTR 4	QTR 5	QTR 6	QTR 7	QTR 8	QTR 9	QTR 10	QTR 11	QTR 12	QTR 13+
	Facility-Level Status				**Unknown**	**Unknown**	**No Violation Identified**	**No Violation Identified**	**Violation Identified**	**No Violation Identified**	**Violation Identified**	**Violation Identified**	**No Violation Identified**	**Violation Identified**	**No Violation Identified**	**No Violation Identified**	**Violation Identified**
	Quarterly Noncompliance Report History				Undetermined	Undetermined	Resolved		Other Violation		Other Violation	Other Violation		Other Violation			
	Pollutant	**Disch Point**	**Mon Loc**	**Freq**													
CWA	Chloride [as Cl] E	002 - 0	Effluent Gross	NMth	620%				367%								38%
CWA	Sulfate, total [as SO4] E	002 - 0	Effluent Gross	NMth	430%				370%								108%
CWA	Chloride [as Cl] E	006 - 0	Effluent Gross	NMth										220%			
CWA	Sulfate, total [as SO4] E	006 - 0	Effluent Gross	NMth										220%			
CWA	Chloride [as Cl] E	007 - 0	Effluent Gross	NMth	510%												
CWA	Sulfate, total [as SO4] E	007 - 0	Effluent Gross	NMth	360%												
CWA	pH E	007 - P	Effluent Gross	Neither		LIMIT VIOLATION			LIMIT VIOLATION		LIMIT VIOLATION	LIMIT VIOLATION					
CWA	pH E	008 - P	Effluent Gross	Neither		LIMIT VIOLATION			LIMIT VIOLATION		LIMIT VIOLATION						
	Single Event Violations		**NPDES Violation ID**	**Agency**													
CWA	Effluent Violations - Numeric effluent violation		3604598554	State	**04/21/2016**												
CWA	Effluent Violations - Unapproved Bypass		3604598558	State	**04/21/2016**												
CWA	Effluent Violations - Unauthorized Discharge		3604598557	State	**04/21/2016**												
CWA	Management Practice Violations - Improper Operation and Maintenance		3604598559	State	**04/21/2016**												

Informal Enforcement Actions (5 Years)

Statute	System	Source ID	Type of Action	Lead Agency	Date
CWA	ICIS-NPDES	IL0077666	Letter of Violation Warning Letter	State	08/18/2016

Formal Enforcement Actions (5 Years)

Statute	System	Law Section	Source ID	Action Type	Case No	Lead Agency	Case Name	Issued Filed Date	Settlements Actions	Settlement Action Date	Federal Penalty	State Local Penalty	SEP Cost	Comp Action Cost
No data records returned														

Environmental Conditions

Water Quality

Permit ID	Combined Sewer System?	Number of CSO (Combined Sewer Overflow) Outfalls	12-Digit WBD (Watershed Boundary Dataset) HUC (RAD (Reach Address Database))	WBD (Watershed Boundary Dataset) Subwatershed Name (RAD (Reach Address Database))	State Water Body Name (ICIS (Integrated Compliance Information System))	Impaired Waters	Impaired Class	Causes of Impairment(s) by Group(s)	Watershed with ESA (Endangered Species Act)-listed Aquatic Species*
IL0077666			071401060501	Town of West Frankfort-Pond Creek	UNNAMED TRIBS TO POND CREEK	No			Yes

Water Body Designated Uses

Reach Code	Water Body Name	Exceptional Use	Recreational Use	Aquatic Life Use	Shellfish Use	Beach Closure Within Last Year	Beach Closure Within Last Two Years
07140106001290		No	No	No	No	No	No

Air Quality

Nonattainment Area?	Pollutant(s)	Applicable Nonattainment Standard(s)

Nonattainment Area?	Pollutant(s)	Applicable Nonattainment Standard(s)
No	Ozone	
No	Lead	
No	Particulate Matter	
No	Carbon Monoxide	
No	Nitrogen Dioxide	
Yes	Sulfur Dioxide	Sulfur Dioxide (2010)

Pollutants

Toxics Release Inventory History of Reported Chemicals Released in Pounds per Year at Site

TRI Facility ID	Year	Total Air Emissions	Surface Water Discharges	Off-Site Transfers to POTWs (Publicly Owned Treatment Works)	Underground Injections	Releases to Land	Total On-site Releases	Total Off-site Transfers
No data records returned								

Toxics Release Inventory Total Releases and Transfers in Pounds by Chemical and Year

Chemical Name
No data records returned

Demographic Profile

EJSCREEN EJ Indexes

Eleven primary environmental justice (EJ) indexes of EJSCREEN, EPA's screening tool for EJ concerns. EPA uses these indexes to identify geographic areas that may warrant further consideration or analysis for potential EJ concerns. Note that use of these indexes does not designate an area as an "EJ community" or "EJ facility." EJSCREEN provides screening level indicators, not a determination of the existence or absence of EJ concerns. For more information, see the EJSCREEN home page.

Census Block Group EJ Indexes (percentile)	
Particulate Matter (PM 2.5)	32.2
Ozone NATA Diesel PM	35.9
NATA Air Toxics Cancer Risk	38.6
NATA Respiratory Hazard Index (HI)	45.3
Traffic Proximity	56.3
Lead Paint Indicator	29.6
Superfund Proximity	39
Risk Management Plan (RMP) Proximity	46.2
Hazardous Waste Proximity	43.1
Wastewater Discharge Proximity	13.9

Number of EJ Indexes Above 80th Percentile
0

View EJSCREEN Report

Demographic Profile of Surrounding Area (3 Miles)

This section provides demographic information regarding the community surrounding the facility. ECHO compliance data alone are not sufficient to determine whether violations at a particular facility had negative impacts on public health or the environment. Statistics are based upon the 2010 US Census and American Community Survey data, and are accurate to the

extent that the facility latitude and longitude listed below are correct. The latitude and longitude are obtained from the EPA Locational Reference Table (LRT) when available.

General Statistics	
Total Persons	924
Population Density	33 sq mi
Percent Minority	2%
Households in Area	369
Housing Units in Area	410
Households on Public Assistance	1
Persons Below Poverty Level	40%

Geography	
Radius of Selected Area	3 mi
Center Latitude	37.841222
Center Longitude	-88.827944
Land Area	100%
Water Area	0%

Income Breakdown - Households (%)	
Less than $15,000	48 (12.66%)
$15,000 - $25,000	71 (18.73%)
$25,000 - $50,000	117 (30.87%)
$50,000 - $75,000	64 (16.89%)
Greater than $75,000	79 (20.84%)

Age Breakdown - Persons (%)	
Children 5 years and younger	50 (5%)
Minors 17 years and younger	195 (21%)
Adults 18 years and older	729 (79%)
Seniors 65 years and older	157 (17%)

Race Breakdown - Persons (%)	
White	912 (99%)
African-American	1 (0%)
Hispanic-Origin	12 (1%)
Asian Pacific Islander	1 (0%)
American Indian	3 (0%)
Other Multiracial	7 (1%)

Education Level(Persons 25 & older) - Persons (%)	
Less than 9th Grade	4 (.57%)
9th through 12th Grade	51 (7.32%)
High School Diploma	276 (39.6%)
Some College 2-year	218 (31.28%)
B.S. B.A. (Bachelor of Science Bachelor of Arts) or More	148 (21.23%)

REND LAKE WATER SUPPLY WITHDRAWAL AGREEMENT

between the

STATE OF ILLINOIS,
ADENA RESOURCES, LLC
and AKIN WATER DISTRICT

EXHIBIT A

Attached are the following documents:

1. Water Supply Agreement between the State of Illinois and Adena Resources, LLC effective September 21, 2007.

2. Amendment Number One to the September 21, 2007 Agreement between the State of Illinois and Adena Resources, LLC effective August 14, 2009.

WATER SUPPLY AGREEMENT

This agreement ("Agreement") is made and entered into as of the [21st] day of [September], 2007, by and between the **STATE OF ILLINOIS**, acting through and represented by the Illinois Department of Natural Resources (hereinafter referred to as "State of Illinois"), and **ADENA RESOURCES, LLC** (hereinafter referred to as "Adena"), (the State of Illinois and Adena Resources, LLC are also referred to herein individually as a "party" and collectively as the "parties").

RECITALS

WHEREAS, the Flood Control Act of 23 October 1962 (Public Law 874, 87th Congress), authorized the construction, operation, and maintenance of the Rend Lake Dam and Reservoir on the Big Muddy River in the vicinity of the city of Benton, Illinois (hereinafter referred to as "Rend Lake"); and

WHEREAS, the State of Illinois has entered into a written contract dated September 23, 1988 with the United States of America known as "Contract Between the United States of America and the State of Illinois for Water Storage Space in Rend Lake Reservoir" and designated as "Contract No. DACW43-88-C-0088" (such contract is hereinafter referred to as the "Rend Lake Contract"), a copy of which is attached hereto as Exhibit A; and

WHEREAS, pursuant to the Rend Lake Contract, the State of Illinois has rights to certain storage space for water impounded in Rend Lake and rights to distribute or otherwise assign rights to such water to be withdrawn from Rend Lake to be used for municipal and industrial water supply; and

WHEREAS, Adena has been authorized by Williamson Energy, LLC to serve as business agent in entering into an agreement for water supply for the Pond Creek #1 coal mine; and

WHEREAS, Adena has been authorized by Sugarcamp Energy, LLC to serve as business agent in entering into an agreement for water supply for the Sugarcamp coal mine; and

WHEREAS, Adena, as business agent for the coal mines, has requested an agreement from the State of Illinois to withdraw water directly from Rend Lake, for the purpose of supplying water for the Pond Creek #1 and Sugarcamp coal mines; and

WHEREAS, Adena is willing to make payments, as provided for in this Agreement, for the right to withdraw Rend Lake water under this Agreement; and

WHEREAS, Adena and the State of Illinois desire to enter into an agreement setting forth the terms and conditions under which Adena may withdraw water from Rend Lake.

STATEMENT OF AGREEMENT

NOW, THEREFORE, in consideration of the premises and the covenants and agreements herein contained, and intending to be legally bound, the State of Illinois and Adena agree as follows:

1. Incorporation of Recitals.

The foregoing Recitals are hereby incorporated by reference as if set forth fully herein.

2. **Water Withdrawal.**

(a) During the term of this Agreement, and subject to the terms and conditions of this Agreement, Adena shall have the right to withdraw up to the Daily Quota of water directly from Rend Lake.

(b) *Daily Quota.* The term *"Daily Quota"* as used in this Agreement means the summation of the *Pond Creek Quota* and the *Sugarcamp Quota.* The *Daily Quota* shall initially be set at 6.5 million gallons per day ("mgd") pursuant to subsections (c) and (d) of this Section. The *Daily Quota* will not increase in the future but may be decreased or eliminated in the future pursuant to the terms of this Agreement.

(c) *Pond Creek Daily Quota.* The term *"Pond Creek Daily Quota"* as used in this Agreement means the amount of water necessary to construct and operate the Pond Creek #1 coal mine, located in Williamson County, including but not limited to, the coal slurrying plant, dust suppression, or any other water requirements for the coal mine or any immediately adjacent support facilities necessary for the operation of the coal mine. The *Pond Creek Daily Quota* shall initially be set at 2.2 mgd based upon a water requirement for an annual coal production rate of 7 million raw tons per year. The *Daily Quota* will not increase in the future but may be decreased or eliminated in the future pursuant to the terms of this Agreement.

(d) *Sugarcamp Daily Quota.* The term *"Sugarcamp Daily Quota"* as used in this Agreement means the amount of water necessary to construct and operate the Sugarcamp coal mine, located in Franklin County, including but not limited to, the coal slurrying plant, dust suppression, or any other water requirements for the coal mine or any immediately adjacent support facilities necessary for the operation of the coal mine. The *Sugarcamp Daily Quota* shall initially be set at 4.3 mgd based upon a water requirement for an annual coal production rate of 14 million raw tons per year. The *Daily Quota* will not increase in the future but may be decreased or eliminated in the future pursuant to the terms of this Agreement.

(e) *Initial Withdrawal Date.* The term "Initial Withdrawal Date" as used in this Agreement means the first date that water is withdrawn for the construction and/or operation of the Pond Creek # 1 and the Sugarcamp coal mines.

3. Basis and Conditions for *Daily Quota* and Water Withdrawal Right

(a) Adena certifies that surface coal mining and reclamation operations Permit No. 375 from the Illinois Department of Natural Resources, Office of Mines and Minerals has been issued to Williamson Energy LLC for the Pond Creek #1 coal mine. Adena certifies that an application for a surface coal mining and reclamation operations Permit No. 382 for the Sugarcamp coal mine has been submitted to the Illinois Department of Natural Resources, Office of Mines and Minerals. Adena certifies that it has been authorized by Williamson Energy LLC to serve as business agent in entering into an agreement for water supply for the Pond Creek #1 coal mine. Adena certifies that it has been authorized by Sugarcamp Energy, LLC to serve as business agent in entering into an agreement for water supply for the Sugarcamp coal mine. Failure to possess the proper authorizations by Williamson Energy LLC and Sugarcamp Energy, LLC for Adena to serve as their business agent in this behalf is a breach of this Agreement and shall result in the termination of this Agreement.

(b) By January 1, 2008, Adena shall submit to the State of Illinois, evidence of an Illinois Department of Natural Resources, Office of Mines and Minerals "administratively complete application" for the Sugarcamp mine. The definition of "administratively complete application" is the same as that used in 62 Ill. Administrative Code 1700 through 1850. Failure to possess such application by the date set forth in this subsection is a breach of this Agreement and shall result in Adena's loss of the 4.3 mgd *Daily Quota* and water withdrawal right established for the Sugarcamp coal mine hereunder.

(c) By July 1, 2008, Adena shall submit to the State of Illinois, evidence of an Illinois Department of Natural Resources, Office of Mines and Minerals surface coal mining and reclamation operations permit for the Sugarcamp mine. Failure to obtain such permit by the date set forth in this subsection is a breach of this Agreement and shall result in Adena's loss of the 4.3 mgd *Daily Quota* and water withdrawal right established for the Sugarcamp coal mine hereunder.

(d) By July 1, 2010, Adena shall have completed construction activities for the Sugarcamp coal mine and have begun coal production. Failure to complete such construction activities and to begin coal production by the date set forth in this subsection is a breach of this Agreement and shall result in Adena's loss of the 4.3 mgd *Daily Quota* and water withdrawal right established for the Sugarcamp coal mine hereunder.

(e) By July 1, 2012, and by July 1 of each subsequent five-year period, Adena shall furnish to the State of Illinois an official annual coal production summary report for the Pond Creek #1 mine, identifying the annual raw coal production in tons for each of the previous five years. If for any such five-year period the highest annual raw coal production for one of the previous years is not at least 4 million tons, a reduction to the *Pond Creek Daily Quota* shall occur using the following *Pond Creek Daily Quota* adjustment formula:

Pond Creek Daily Quota = [highest annual raw coal production tonnage in last five-year period] divided by [4 million tons] multiplied by [2.2 mgd]

The *Pond Creek Daily Quota* may be reduced multiple times under the terms of this subsection. If use of the *Pond Creek Daily Quota* adjustment formula pursuant to the process set forth above does not result in a reduction of the current *Pond Creek Daily Quota*, the current *Pond Creek Daily Quota* shall remain unadjusted. Any reduction(s) under this subsection is permanent and cannot be subsequently reacquired. No increase to the *Pond Creek Daily Quota* is allowed. If a reduction to the *Pond Creek Daily Quota* is made under this subsection, the new *Pond Creek Daily Quota* shall become effective October 1 of that year.

(f) By July 1, 2015, and by July 1 of each subsequent five-year period, Adena shall furnish to the State of Illinois an official annual coal production summary report for the Sugarcamp mine, identifying the annual raw coal production in tons for each of the previous five years. If for any such five-year period the highest annual raw coal production for one of the previous years is not at least 8 million tons, a reduction to the *Sugarcamp Daily Quota* shall occur using the following *Sugarcamp Daily Quota* adjustment formula:

Sugarcamp Daily Quota = [highest annual raw coal production tonnage in last five-year period] divided by [8 million tons] multiplied by [4.3 mgd]

The *Sugarcamp Daily Quota* may be reduced multiple times under the terms of this subsection. If use of the *Sugarcamp Daily Quota* adjustment formula pursuant to the process set forth above does not result in a reduction of the current *Sugarcamp Daily Quota*, the current *Sugarcamp Daily Quota* shall remain unadjusted. Any reduction(s) under this subsection is permanent and cannot be subsequently reacquired. No increase to the *Sugarcamp Daily Quota* is allowed. If a reduction to the *Sugarcamp Daily Quota* is made under this subsection, the new *Sugarcamp Daily Quota* shall become effective October 1 of that year.

(g) At any time prior to or during the operation of the coal mines, Adena agrees to provide immediate notice to the State of Illinois of any changes in plans or circumstances which may result in a reduction in its Rend Lake water supply requirements. Notice of any changes in plans, request for *Daily Quota* reductions, or terminations in Adena's *Daily Quota*, shall be provided in accordance with Section 14.

(h) If Adena loses or the State of Illinois completely reduces the *Daily Quota* to zero pursuant to the terms of this Section, this Agreement shall terminate.

4. **Allocation of Available Water.**

(a) *No Over Allocations.* The parties acknowledge that the State of Illinois may, subsequent to the date of this Agreement, enter into agreements or other arrangements with, or may issue permits to, third parties relating to the allocation, extraction, withdrawal or use of water from Rend Lake. However, the State of Illinois expressly covenants that in no case and under no circumstances will the State of Illinois enter into such agreements or arrangements, issue such permits, or take any other actions which, when taken either individually or in aggregate, result in the actual or potential allocation, extraction, withdrawal or use of water in excess of the total amount of water under the control of the State of Illinois pursuant to the terms

and conditions of the Rend Lake Contract as of the date of this Agreement (any such action shall be referred to as an "Over Allocation").

(b) *Over Allocations.* In the event that the State of Illinois takes any action or fails to take any action resulting in, or which is likely to result in, an Over Allocation to any third party (each, an "Over Allocation Party"), the State of Illinois shall grant Adena priority rights to the storage, withdrawal and use of water over and against each and every Over Allocation Party for the term of this Agreement, and the State of Illinois will use its best efforts and legal authority to ensure that any Over Allocation does not materially affect Adena' rights under this Agreement. The State of Illinois acknowledges that Adena' right to withdraw its *Daily Quota* is critical to its industrial operations. Accordingly, the State of Illinois shall notify Adena of any Over Allocation, which notification shall include the name, address, and contact information of the Over Allocation Party.

(c) *Water Emergency.* The parties acknowledge that the State of Illinois may enter into agreements with other parties to allocate, secure or otherwise beneficially use water from Rend Lake for Domestic Water Use, as defined herein, and Non-Domestic Water Use, as defined herein, and that the State of Illinois is otherwise authorized and entitled to protect the health and safety of its citizens. Therefore, in the event of a declared water emergency, as declared by the Director of the Illinois Department of Natural Resources or other responsible state official, which results in an insufficient supply of water in Rend Lake to satisfy the water allocated and used for both Domestic Water Use, as defined herein, and Non-Domestic Water Use, as defined herein, and which deficiency of Rend Lake water would pose a direct threat to the public health or safety of communities relying upon water from Rend Lake (such an event is referred to as a "Water Emergency"), then the State of Illinois reserves its rights to prohibit or restrict, on an equal or pro-rata basis respectively, by volume of water used for Non-Domestic Water Use, the use of all Rend Lake water (except for the quantity of water which has been allocated to the Rend Lake Conservancy District under Contract RL-65-1, and existing and future amendments thereto) for all Non-Domestic Water Use until the Domestic Water Uses for which Rend Lake water has been allocated are otherwise satisfied. A "Water Emergency" shall also be deemed to exist, and the State of Illinois may proceed to exercise its rights to prohibit or restrict water use, if the Director of the Illinois Department of Natural Resources makes a reasoned determination in accordance with applicable law that such withdrawal of water from Rend Lake for Non-Domestic Use will result in imminent, substantial and irreparable damage to natural resources. If the Director of the Illinois Department of Natural Resources makes a Water Emergency determination, Adena may seek to alleviate the water shortage, seek approval of the Director to mitigate any damages to natural resources and continue water use, or seek reconsideration of the determination. Any prohibition or pro-rata reduction allocation, as more fully set forth in the following subsection, would apply on an equal percentage basis to the volume of all water used for Non-Domestic Use by each party receiving Rend Lake water; *provided, however,* that each and every Over Allocation Party shall reduce its Non-Domestic Use of water from Rend Lake to zero before any prohibition of pro-rata reduction shall be applicable to Adena.

(d) *Allocation of Mixed Use in Water Emergency.* Except for the water allocated to or may be allocated to the RLCD, if any party entitled to use water from Rend Lake has both Domestic Water Uses and Non-Domestic Water Uses (collectively "Total Water Use"), whether

supplied in whole or in part by Rend Lake water, then the pro-rata reduction allocation of Rend Lake water applicable to such party's Non-Domestic Water Use during a Water Emergency shall be determined based on the percentage of such party's Total Water Use that constitutes Non-Domestic Water Use. Thus, for example, if a party's Total Water Use is singularly supplied by 10 mgd of Rend Lake water and such party uses 50% of that water (*i.e.*, 5 mgd) for Domestic Water Use, then the remaining 50% of that water (*i.e.*, 5 mgd) used for Non-Domestic Water Use will be subject to the Rend Lake water pro-rata reduction. Likewise, if a party supplements its existing water usage with Rend Lake water, then the percentage of that party's total Non-Domestic Water Use will be used to determine that party's pro-rata Rend Lake water allocation reduction. For example, if such a party utilizes 30 mgd from a source other than Rend Lake and supplements that amount with 10 mgd from Rend Lake, for a total of 40 mgd, and 50% of that Total Water Use (*i.e.*, 20 mgd) is for Non-Domestic Water Use, then 50% of that party's Rend Lake water (*i.e.*, 5 mgd) would be subject to a water allocation reduction during a Water Emergency.

(e) *"Domestic" and "Non-Domestic" Water Use.* The term "Domestic Water Use" as used in this Agreement means use of water for household drinking, cooking, sanitary, health and similar purposes, as well as for medical facilities and fire protection; however, the parties agree that "Domestic Water Use" does not include use of water for any commercial or industrial uses, lawn sprinkling, commercial or non-commercial car washes, or recreation purposes (whether in a residential or other setting). The term "Non-Domestic Water Use" as used in this Agreement means any use other than Domestic Water Use. The term "Domestic Water Users" as used in this Agreement means those persons or entities using water solely for Domestic Water Use. The term "Non-Domestic Water Users" as used in this Agreement means those persons or entities using water for any use other than Domestic Water Use.

(f) *Notice of Water Emergencies.* The State of Illinois shall provide Adena notice of any anticipated or actual Water Emergency as soon as practicable, which notice shall include the dates and expected duration of any Water Emergency and whether or not the State of Illinois anticipates the prohibition or pro-rata reduction of any Non-Domestic Water Use in connection with the Water Emergency.

5. **Term of Agreement.**

This Agreement shall become effective upon execution by the parties and shall remain in full force and effect for a period of 40 years from the date first set forth above, unless otherwise terminated pursuant to the provisions of this Agreement.

6. **Payment and Metering.**

(a) Within 30 days of the parties' full execution of this Agreement, Adena shall pay to the State of Illinois the amount of $6,500, which represents a non-refundable payment to secure the water allocation set forth in this agreement.

(b) For purposes of maintaining an accurate record of the water withdrawn from Rend Lake by Adena, Adena agrees to furnish and install, prior to the Initial Withdrawal Date and at

Adena' sole cost, reasonably necessary meters or measuring devices satisfactory to the State of Illinois and the U.S. Army Corps of Engineers (USACE). Such meters or devices shall be available for inspection by the State of Illinois and the USACE, at their expense, at all reasonable times and upon reasonable notice to Adena.

(c) Following the Initial Withdrawal Date, Adena shall prepare monthly withdrawal statements and provide such statements to the State of Illinois and USACE in accordance with Article 4A of the Rend Lake Contract.

(d) Upon full execution of this Agreement, Adena shall be billed by the State of Illinois for Adena's proportionate share of the Water Supply Costs (as defined below) incurred by the State of Illinois pursuant to the Rend Lake Contract. Billing shall commence when the USACE bills the State and shall continue on an annual basis thereafter for the term of this Agreement, unless otherwise terminated. Adena' proportionate share of actual experienced Water Supply Costs shall be based on the amount of the *Daily Quota* allocated to Adena, relative to the available yield (currently 70 mgd) of water assigned to the State of Illinois' control under Article 1 of the Rend Lake Contract. For purposes of this Agreement, "Water Supply Costs" shall mean all charges to the State of Illinois calculated pursuant to the formulas set forth in Articles 5B, 5C, 5D and 5E of the Rend Lake Contract in the form attached hereto as Exhibit A.

(e) For charges pursuant to Article 5C of the Rend Lake Contract (*i.e.*, "Annual Operation and Maintenance Costs"), Adena shall make a check payable to the Finance & Accounting Office, USACE and submit this check to the State of Illinois within 30 calendar days of receipt of its annual bill. For charges pursuant to Articles 5B and 5D of the Rend Lake Contract (*i.e.*, "Major Replacement Cost" and "Major Rehabilitation Costs," respectively), Adena shall submit payment (check payable to the Finance & Accounting Office, USACE) to the State of Illinois in accordance to repayment arrangements established by the Contracting Officer pursuant to Article 7B of the Rend Lake Contract. If Adena shall fail to make any of the aforesaid payments when due, then Adena shall be responsible for all delinquent payments incurred pursuant to Article 5E of the Rend Lake Contract.

(f) The State of Illinois has identified potential operational and recreational impacts associated with water supply withdrawals from Rend Lake. The parties recognize the State of Illinois' interests in the protection of other lake resources as well as to supply water for industrial and other purposes. The State of Illinois may pursue a feasibility study in conjunction with a project cooperation agreement with the Corps of Engineers or other competent party. The study will address water supply impacts along with other impacts associated with the economic development, mining, and wildlife management. The study may specifically examine the costs, benefits and feasibility of installing a spillway control gate and fish barrier. Adena is willing to support the State of Illinois' efforts to implement these studies, mitigation activities or other improvements to Rend Lake which may be determined beneficial. Therefore, Adena agrees to pay $148,590 to the State of Illinois, or a designee of the State's choice, which shall be applied to pay the cost of these studies and/or construction measures which may be determined beneficial, or shall be applied to pay for habitat activities at Rend lake as the State of Illinois determines to be appropriate. Payment will be made as follows; (i) $74,295 on or before the first

anniversary of the parties full execution of this Agreement and (ii) $74,295 on or before the second anniversary of the parties full execution of this Agreement.

(g) The payment obligations set forth in this Section 6 include all payments required by Adena for the water storage, withdrawal and use rights set forth under this Agreement. Adena shall not be required to make any other payment(s) to any other party (including without limitation any other governmental entity or private party) in consideration for the rights set forth under this Agreement. Adena shall not be responsible for any outstanding or unpaid fees owed by the State of Illinois or any other party prior to the date of this Agreement.

7. Termination.

(a) Prior to the Initial Withdrawal Date, Adena may terminate this Agreement for any reason and in its sole discretion upon 30 days' written notice to the State of Illinois. Such termination shall release Adena from all obligations under this Agreement.

(b) If the Initial Withdrawal Date does not occur by December 31 of the third year after the year in which this Agreement is executed (which date shall be referred to as the "Pre-Operation Termination Date"), this Agreement shall terminate; provided, however, that Adena may extend the Pre-Operation Termination Date by one (1) year upon payment by Adena to the State of Illinois the amount of $6,500 and upon the agreement of the State of Illinois, which agreement shall not be unreasonably withheld. Thereafter, the parties may agree to further extensions of the Pre-Operation Termination Date upon such terms and conditions as the parties may mutually agree. Any termination under this subsection shall release Adena and the State of Illinois from any and all obligations under this Agreement.

(c) After the Initial Withdrawal Date, Adena may terminate Adena' obligations under this Agreement upon 30 days' written notice to the State of Illinois if, prior to such termination, Adena identifies a party: (i) that is willing to accept assignment of all of Adena' rights, duties, and obligations under this Agreement; and (ii) that meets with the approval of the State of Illinois, which approval shall not be unreasonably withheld. If Adena satisfies the conditions for termination of this Agreement as provided in this subsection (c), Adena shall be released from its obligations under this Agreement.

8. Changes in Law.

The parties acknowledge that statutory changes or judicial clarifications in applicable federal or state law after the date of this Agreement may affect the rights of the parties to this Agreement. In the event of such a change or clarification in applicable law, Adena or the State of Illinois may request amendment of this Agreement to conform to such a change, or to clarify the rights of the parties as a result of such a change.

9. Limitations.

The parties agree that the State of Illinois will act subject to the terms and provisions of the Rend Lake Dam and Reservoir on the Big Muddy River Act, and other applicable laws.

10. **Right to Transfer or Assign.**

Subject to pre-approval by the State of Illinois, which approval shall not be unreasonably withheld, conditioned or delayed, Adena may transfer or assign any or all of its rights and obligations under this Agreement at any time during the term of the Agreement, whether before or after the Initial Withdrawal Date, as herein defined, to any of the following parties:

(a) Any subsidiary, parent or other related corporate entity of Adena;

(b) Any lending institution providing financing in whole or in part to the construction and operation of the Pond Creek #1 and Sugarcamp coal mines.

11. **Successors and Assigns.**

Notwithstanding anything to the contrary, this Agreement shall be binding upon and inure to the benefit of the parties hereto and their respective successors and assigns.

12. **Water Quality.**

Adena recognizes that this Agreement provides for storage space for use of raw water only. The State of Illinois makes no representation with respect to the quality of water and assumes no responsibility therefore, or for treatment of the water.

13. **Force Majeure.**

Neither party shall be liable to the other for failure to perform its obligations hereunder if and to the extent that such failure to perform is caused by or results from causes beyond its control, including, without limitation, strikes, lockouts, or other industrial disturbances; civil disturbances; fires; floods; acts of God; acts of a public enemy; but excluding the financial inability of such party to perform its obligations under this Agreement and excluding the acts or omissions of such party's agents or subcontractors.

14. **Notices.**

Any notice required or permitted to be given to either party shall be deemed to be received by such party (i) three (3) days after deposit in the United States Registered or Certified Mail, Return Receipt Requested, or (ii) one (1) business day after deposit with a nationally recognized overnight delivery service for next day delivery, or (iii) upon personal delivery to the party to whom addressed provided that a receipt of such delivery is obtained, or (iv) upon successful transmission by telecopy, in any case addressed to the parties at the following addresses:

If to State of Illinois:	Illinois Department of Natural Resources Office of Water Resources One Natural Resources Way Springfield, Illinois 62702-1271 Attention: Director Telecopy No.: (217) 785-5014
If to Adena:	Adena Resources, LLC P.O. Box 1829 1107 W: DeYoung, Suite E Marion, Illinois 62959 Attention: Matt Fifield Telecopy No.: (618) 998-8012
	(with a copy not constituting notice to):
	Brian A. Glasser, Esq. Bailey & Glasser, LLP 227 Capitol Street Charleston, WV 25301 Telecopy No.: (304) 342-1110

or to the parties at such other addresses or telecopy numbers as they may designate by notice to the other party as herein provided.

15. **Governing Law.**

This Agreement and the legal relations of the parties shall be governed by the laws of the State of Illinois applicable to agreements negotiated, executed, delivered, and fully performed in such state.

16. **Captions.**

Headings of particular sections are inserted only for convenience and are in no way to be construed as part of this Agreement or as a limitation of the scope of the sections to which they refer.

17. **Severability.**

The various terms, provisions and covenants herein contained shall be deemed to be separate and severable, and the invalidity or unenforceability of any of them shall in no manner affect or impair the validity or enforceability of the remainder hereof.

18. **Waiver.**

(a) No waiver of the terms, conditions and covenants of this Agreement shall be binding and effective unless the same shall be in writing signed by the parties.

(b) A waiver of any breach of the terms, conditions and covenants of this Agreement shall be for the one time only and shall not apply to any subsequent breach.

19. **Authority to Execute.**

Each of the undersigned certifies, by his/her signature, that he/she is authorized to execute this Agreement on behalf of his/her respective party and that he/she possesses authority to bind his/her party to the terms and conditions set forth herein. Execution of this Agreement does not indicate and shall not be construed as a waiver by either party of any statutory, common law, or other rights which either party has or may have under applicable law.

[REMAINDER OF PAGE INTENTIONALLY BLANK]

IN WITNESS WHEREOF, the parties have caused this Agreement to be executed and to become binding and effective as of the day and year first set forth above.

STATE OF ILLINOIS

RECOMMENDED:

[redacted]

Gary R. Clark, Director
Office of Water Resources
Department of Natural Resources
Date: 8/30/2007

APPROVED:

[redacted]

Sam Flood, Acting Director
Department of Natural Resources
Date: 9-12-07

APPROVED:

[redacted]

Ellen King-Pietrzak, Acting Chief Fiscal Officer
Department of Natural Resources
Date: 9/10/07

[redacted]

William Richardson, General Counsel
Department of Natural Resources
Date: August 30, 2007

Adena Resources, LLC

[redacted]

Matt Fifield, Managing Director
Date: Sept 19 2007

ATTEST

[redacted]

(Adena Resources, LLC)
Date: 9/19/07

APPROVED

Rod R. Blagojevich, Governor
State of Illinois
Date: September 21, 2007

EXHIBIT A

Contract Between the United States of America and the State of Illinois for Water Storage Space in Rend Lake Reservoir

("Rend Lake Contract")

Contract No. DACW43-88-C-0088 dated 23 September, 1988

AMENDMENT NUMBER ONE
to the
SEPTEMBER 21, 2007 AGREEMENT
between the
STATE OF ILLINOIS
and
ADENA RESOURCES, LLC

THIS AMENDMENT is made between the **STATE OF ILLINOIS**, acting through and represented by the State of Illinois, Department of Natural Resources (hereinafter referred to as "State of Illinois"), and **ADENA RESOURCES, LLC** (hereinafter referred to as "Adena"), (Adena and the State of Illinois are also referred to herein individually as a "party" and collectively as the "parties").

WITNESSETH:

WHEREAS, the State of Illinois and Adena entered into an agreement, (hereinafter referred to as **"AGREEMENT"**), effective September 21, 2007, which provides that Adena, pursuant to the terms and conditions of the AGREEMENT, may withdraw from Rend Lake; and,

WHEREAS, Adena failed to meet the July 1, 2008 deadline requirement to obtain a surface coal mining and reclamation operations permit for the Sugarcamp mine as cited under Section 3(c) of the AGREEMENT, and,

WHEREAS, Adena obtained a surface coal mining and reclamation operations permit for the Sugarcamp mine on August 19, 2008; and,

WHEREAS, Adena has requested waiver of the Section 3 (c) July 1, 2008 deadline requirement, citing the permit delay as an unforeseen circumstance; and

WHEREAS, the State of Illinois has determined that 1) the circumstances necessitating this AMENDMENT were not reasonably foreseeable at the time the AGREEMENT was executed, 2) this AMENDMENT is germane to the AGREEMENT as originally executed, and 3) this AMENDMENT to the AGREEMENT is in the best interest of the State of Illinois.

NOW, THEREFORE, the parties hereto, being the same parties as to the September 21, 2007 AGREEMENT, agree to the following amendments thereto:

1. Section 3(c) of the AGREEMENT is hereby removed.

2. All other covenants under terms of the September 21, 2007 AGREEMENT remain unchanged and in full force and effect.

AMENDMENT NUMBER TWO
TO THE
SEPTEMBER 21, 2007 AGREEMENT
between the
STATE OF ILLINOIS/ DEPARTMENT OF NATURAL RESOURCES,
and the
ADENA RESOURCES, LLC

THIS AMENDMENT is made between the **STATE OF ILLINOIS**, acting through and represented by the State of Illinois, Department of Natural Resources (hereinafter referred to as the "State of Illinois"), and ADENA RESOURCES, LLC (hereinafter referred to as "Adena"), (Adena and the State of Illinois are also referred to herein individually as a "party" and collectively as the "parties").

Witnesseth:

WHEREAS, the State of Illinois and Adena entered into an agreement, (hereinafter referred to as "AGREEMENT"), effective September 21, 2007, which provides that Adena, pursuant to the terms and conditions of the AGREEMENT, may withdraw from Rend Lake; and

WHEREAS, Section 3(c) of the said agreement was amended on August 14, 2009; and

WHEREAS, The United States Army Corp of Engineers has notified the State of Illinois on November 24, 2014 that payments from an entity that does not have an agreement or contract directly with the U.S. Army Corps of Engineers will not be accepted, and the DEPARTMENT has determined that this notification necessitates the amendment of Paragraph 6(e) to the AGREEMENT.

NOW THEREFORE, the parties hereto mutually agree that Paragraph 6(e) of said agreement be amended to read as follows:

(e) For charges pursuant to Article 5C of the Rend Lake Contract (i.e., "Annual Operation and Maintenance Costs"), Adena shall make a check payable to the State of Illinois, mailed directly to the Illinois Department of Natural Resources, Attn: OWR – Water Supply Engineer, One Natural Resources Way, Springfield, IL 62702-1271within 30 calendar days of receipt of its annual bill. For charges pursuant to Articles 5B and 5D of the Rend Lake Contract (i.e., "Major Replacement Cost" and "Major Rehabilitation Costs," respectively), Adena shall submit payment payable to the State of Illinois, mailed directly to the Illinois Department of Natural Resources, Attn: OWR – Water Supply Engineer, One Natural Resources Way, Springfield, IL 62702-1271 in accordance to repayment arrangements established by the Contracting Officer pursuant to Article 7B of the Rend Lake Contract. If Adena shall fail to make any of the

aforesaid payments when due, then Adena shall be responsible for all delinquent payments incurred pursuant to Article 5E of the Rend Lake Contract.

STATE OF ILLINOIS/DEPARTMENT OF NATURAL RESOURCES

RECOMMENDED:

[redacted] by [redacted]

Daniel A. Injerd, Director
Office of Water Resources
Date: 5/28/15

APPROVED:

[redacted]

Wayne A Rosenthal, Director
Department of Natural Resources
Date: 5/26/15

APPROVED:

[redacted]

Brent Krebs
General Counsel
Date: 5/26/15

[redacted]

Doug Florence
Chief Fiscal Officer
Date: 5/26/15

ADENA RESOURCES, LLC

ATTEST:

[redacted]

Adena Resources, LLC
Date: 5-21-2015

APPROVED:

[redacted]

Mike Beyer
Chief Executive Officer
Date: 5/21/15

FOR EXECUTION
Date: 5/26/15
Legal [redacted]

Case history on the reduction of chlorides from mine water

by Srikanth Muddasani, Kathleen Lagnese, Kashi Banerjee and Carla Robinson

Mine water generated from underground coal mining operations contains both dissolved and particulate solids. Dissolved solids primarily consist of sodium, calcium, magnesium, potassium, chlorides and sulfates. When discharged to a receiving stream without treatment, these constituents create a potentially toxic environment for aquatic life.

A case study is presented to discuss how a centralized treatment plant treats mine water from six locations to meet discharge limitations for chlorides. Located in West Virginia, this facility consistently achieves less than the National Pollutant Discharge Elemenation System (NPDES) permit limitation of 218 mg/L chlorides in the discharge while generating almost zero liquid waste. The dissolved solids concentration in the influent ranges between 5,000 and 10,000 mg/L, with chloride concentrations of 1,000 to 2,000 mg/L and sulfate concentrations of 2,000 to 6,000 mg/L.

The mine water is treated using advanced treatment technology to produce clean water for discharge or reuse. The treatment process comprises aeration, softening, filtration, reverse osmosis (RO) reject softening, evaporation, crystallization, final effluent remineralization and sludge dewatering. The solid waste generated in the treatment process is landfilled on site. The leachate is sent back to the facility's thermal treatment process. Because no liquid waste leaves the property, this plant is termed a zero liquid waste (ZLW) facility.

The advanced water treatment system was built to meet a new 218 mg/L regulatory limitation imposed by the West Virginia Department of Environmental Protection for chlorides discharged to surface waters. The system is designed to treat a maximum flow of approximately 795 m^3/h (5 million gpd) of mine water. The treatment process utilizes RO membrane treatment to achieve the effluent criteria, and evaporation and crystallization technology to manage the RO concentrate from the water treatment process. As a result, the system produces clean water for discharge while generating zero liquid waste. The effluent water can be used for industrial purposes or discharged to a receiving stream. A water impact index (WIIx) study indicated that discharge of this high-quality water into the

Srikanth Muddasani, Kathleen Lagnese, Kashi Banerjee and Carla Robinson are process engineer, senior process engineer, senior technical director, and marketing manager, Veolia Water Technologies, Pittsburgh, PA, email srikanth.muddasani@veolia.com.

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Monongahela River watershed may improve the water quality for downstream water users. The waste produced in the treatment process, including softening sludge and salt, is disposed of in an onsite landfill.

Currently, the plant is treating at an average flow of 490 m^3/h (3.1 million gpd) of mine water with an average influent chloride concentration of 1,530 mg/L and an average effluent chloride concentration of 11 mg/L.

Design basis versus current feed condition

Table 1 shows the design condition versus current average condition, while Table 2 shows the key effluent

Table 1

Design assumptions.

Parameter	Design condition	Current avg feed condition [3]
Design flow, GPM	3,500 Max (1750 Min, 2,300 Avg)	2142
pH, S.U.	5 – 10	7.54
Temperature, ° F	38 – 85	72
Calcium, mg/L as ion	300	226
Magnesium, mg/L as ion	200	102
Chlorides, mg/L as ion	1,500	1,530
Sulfates, mg/L as ion	5,500	2,700 [1]
Iron as $Fe+^2$, mg/L as ion	150	0.27 [2]
Parameter	**Design condition**	**Current average feed condition [3]**
Manganese, mg/L as ion	2	0.27 [2]
Aluminum, mg/L as ion	8	0.01 [2]
Alkalinity, mg/L as $CaCO_3$	700 - 1200	897
TDS (estimated), mg/L	10,000	7,900

Notes:

[1] Average value based on the data collected between Aug. 20 – Sept. 5, 2014.

[2] Average value based on the data collected during startup (March 19 – May 31, 2013).

[3] Other average values were based on the data collected between Jan. 21 – May 31, 2014.

water quality requirements.

The differences between the design basis and the current average feed water concentrations of iron, manganese, aluminum, sulfate and total desolved solids (TDS) are related to the fact that pretreatment is performed at some of the six mine locations prior to discharging to the centralized water treatment plant. The design basis was developed assuming no pretreatment at the upstream sources. The existing pretreatment systems, however, do not significantly impact the feed water chloride concentration. As a result, it is very close to the original design value.

The treatment process consists of the treatment steps described in this article.

Figure 1

Aerial photo of centralized mine water treatment plant located in West Virginia.



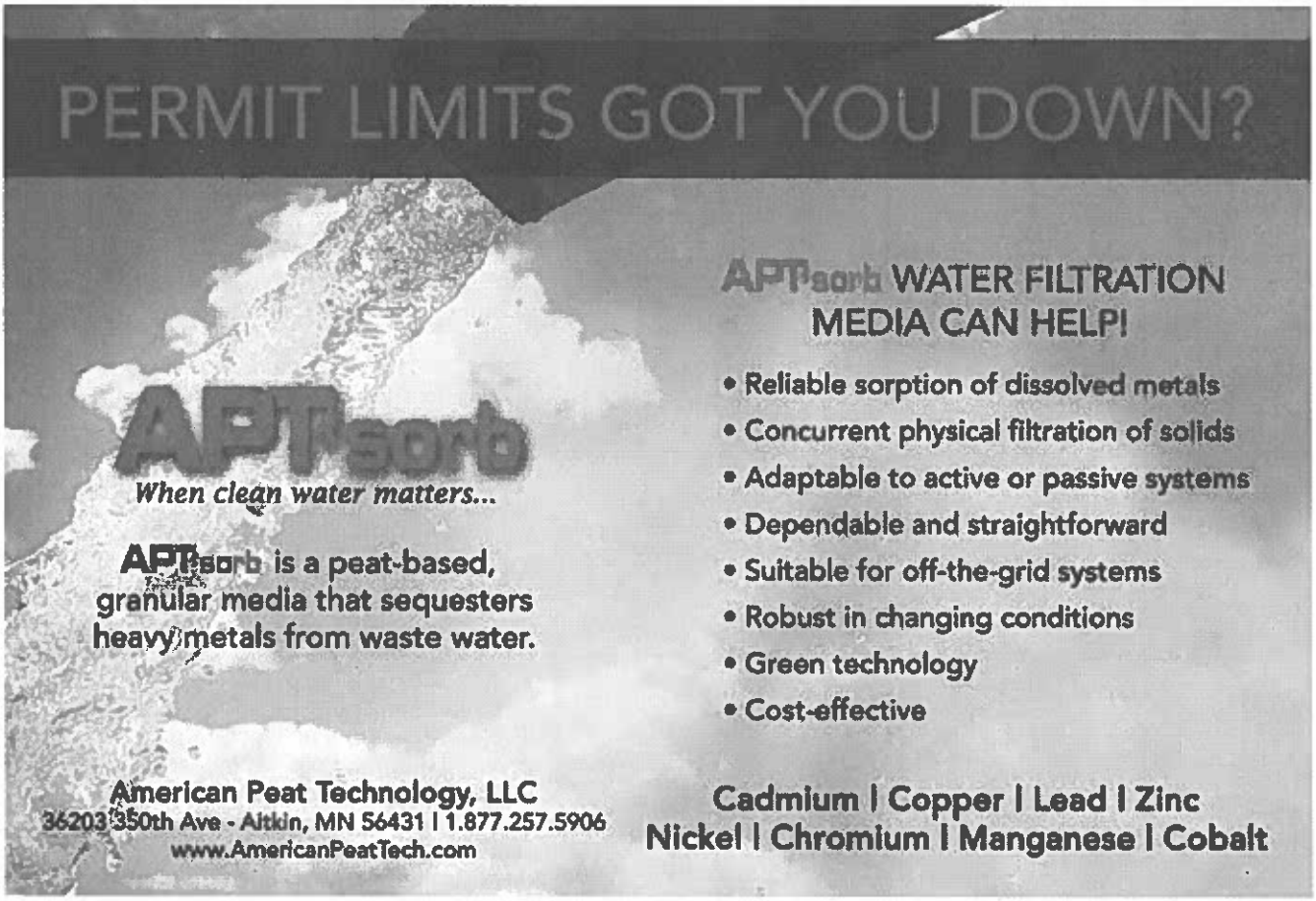


Figure 2

Full flow softening clarifier.

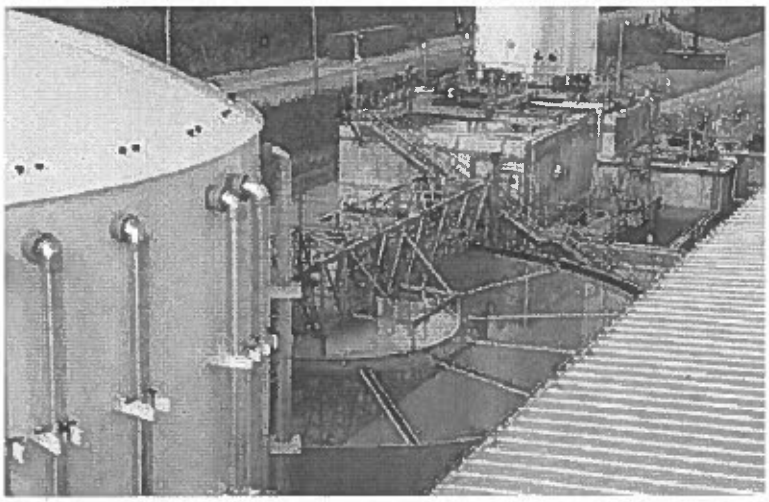


Figure 3

Multimedia filters.



Table 2

Effluent water quality requirements.

Parameters	Maximum effluent concentration
Chlorides, mg/L	<218 [1]
TDS, mg/L	<150 [2]
pH	6 - 9
Minimum hardness, mg/L as $CaCO_3$	≥50

Note:
[1] NPDES permit requirement for outfall discharge.
[2] Consent decree requirement applied to product water prior to remineralization.

Raw water pretreatment

Equalization. The influent to the treatment system is water from three mines collected at six different sites. As noted previously, pretreatment for metals removal is performed at some of these sites prior to conveyance to the water treatment plant. Two separate pipelines convey the water to the 11,360 m^3 (3 million gal) raw water feed tank shown in the upper right corner of Fig. 1. Backwash water from the multimedia filters is also directed to the raw water tank, along with discharges from various collection sumps at the site. Residence time in the tank is approximately 12.5 hours at maximum design flow conditions. Jet mixing accomplished by a grid at the bottom of the tank prevents total suspended solids (TSS) from settling out in the tank and promotes equalization of the influent to the treatment process.

Aeration. From the raw water tank, the water is pumped to an aeration tank, where the air oxidizes dissolved iron to form a ferric hydroxide precipitate. Effluent from this aeration tank overflows into a second aeration tank where the pH can be increased with caustic soda (NaOH) to promote the precipitation of dissolved manganese, if needed (this is not the case currently).

Softening. The second aeration tank overflows into an adjacent full flow softening tank (Fig. 2), where water is lime soda ash softened. Based on the design condition, softening is required prior to RO to reduce calcium hardness and to avoid potential calcium sulfate precipitation at high recovery. The softening tank is equipped with a draft tube reactor to ensure thorough solids contact with the recycled sludge and treatment chemicals. The softening tank effluent flows to a solids contact clarifier that removes the precipitated solids. A majority of the precipitated sludge is recycled back to the crystallization tank at a specified sludge recycle ratio to promote crystal growth kinetics and improved settling. The excess sludge is wasted from the system and pumped to the sludge holding tank.

Aluminum precipitation and filtration. The clarifier effluent flows into an aluminum precipitation tank where the pH is adjusted to 6.5 to 7.2 S.U. for removal of aluminum. Based on the design condition mentioned, aluminum removal is required to avoid potential downstream RO fouling. Sodium hypochlorite

is also added here to inhibit bacterial growth in the downstream filters.

The aluminum precipitation tank overflows into an adjacent concrete multimedia filter feed (MFF) tank. Based on economic considerations, an MMF system was selected instead of ultrafiltration. The MMF system consists of seven vertical multimedia filters operated in parallel (Fig. 3). Each filter vessel is 3.6 m (12 ft) in diameter and 2 m (6 ft) high. Filtration of suspended solids is provided by a 1-m (3-ft) deep bed comprised of layers of garnet, sand and anthracite with a gravel underdrain. A filter aid is used to enhance the removal of suspended and colloidal particles. The MMF system effluent is pumped to the RO feed tank, and filter backwash water is directed to raw water feed tank.

Reverse osmosis membrane system

The RO feed tank effluent is pumped through a 5-micron cartridge filtration system to remove any fine colloidal particles. Antiscalant and sodium bisulfite are added prior to RO to protect the membranes from scaling and from residual free chlorine that can damage the membranes. The single-pass, reverse-osmosis process is a three-stage system design with 18 x 9 x 4 – 7 M array. The main objective of the RO system is removal of chlorides and other dissolved solids present in the water. The RO system consists of five parallel skids, each sized for 25 percent of the design flow with one standby unit. The RO system is designed to operate at a flux rate of 10-12 GFD (17-20 LMH). The RO system is designed to operate at a high water recovery rate of 85 percent. The clean permeate produced by the RO system is sent to the product water tank where it combines with distillate from the evaporation/crystallization process prior to being remineralized.

Final effluent remineralization. The final effluent water is remineralized using carbon dioxide and lime water to meet the effluent requirement for total hardness (50 mg/L as $CaCO_3$), which protects the aquatic life in the receiving stream. The treated water flows into Hibbs Run, a tributary to Buffalo Creek that ultimately discharges to the Monongahela River. In addition, final effluent water can also be sent to onsite truck loading stations for reuse in other industrial operations.

RO reject softening. An evaporator feed tank collects the RO reject as well as leachate from the onsite landfill for subsequent processing through the facility's thermal

Figure 4

Reverse osmosis system.

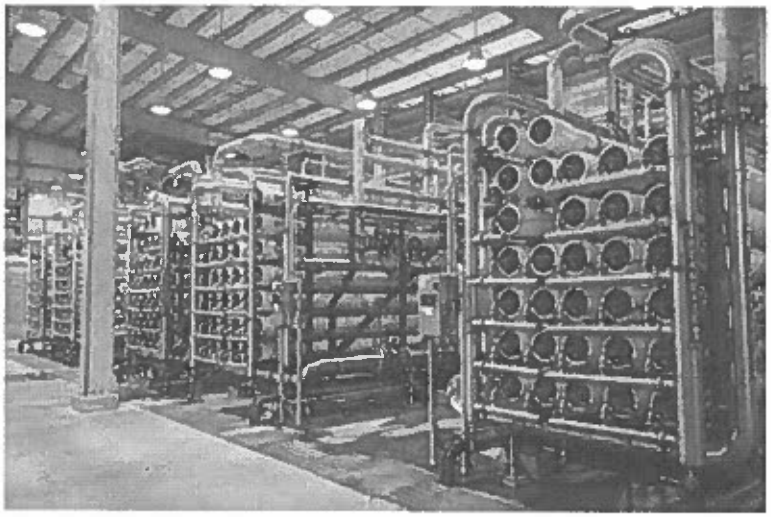


Figure 5

RO reject softening clarifier.

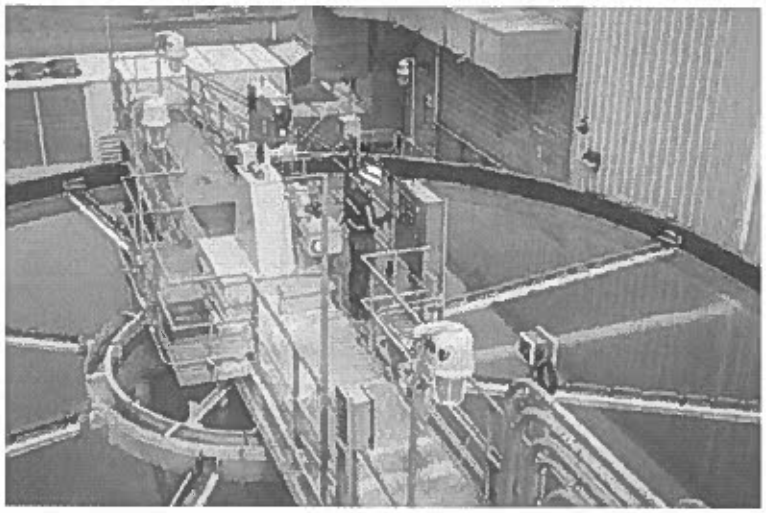


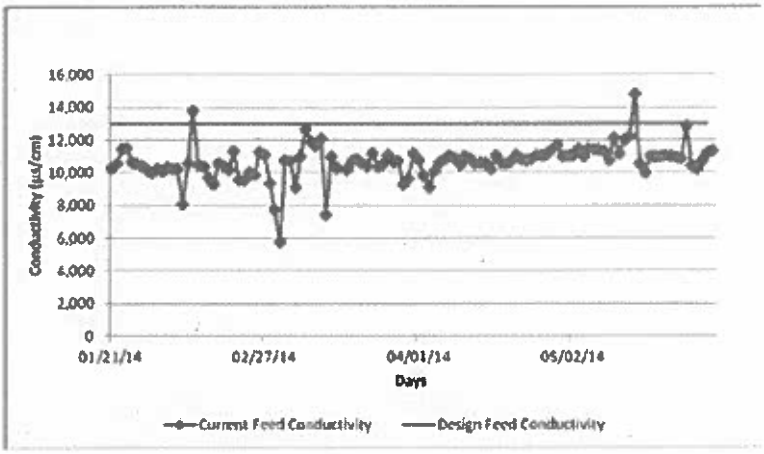
Figure 6

Evaporator and crystallizer.



Figure 7

Feed water conductivity.



treatment process. The evaporator/crystallizer system is designed to handle corrosive materials with high salt concentrations. However, it must first be treated to prevent fouling of the heat transfer surfaces within the evaporator. Treatment consists of chemical softening in a second RO reject softening tank followed by solids settling in a second flocculating clarifier, acidification, preheating and deaeration/ decarbonation. Sludge from the reject softening process is sent to the sludge holding tank.

Evaporator and crystallizer

The evaporator concentrates the RO reject by removing water in an energy-efficient, economical manner prior to the crystallization system. The evaporator is a concentric falling film unit divided into two sections, a low concentration side and a high concentration side. The split design reduces the overall power consumption of the system by allowing a portion of the evaporation to occur at a lower boiling point rise than the final concentration leaving the evaporator.

The evaporator operates as a mechanical vapor recompression system. Vapors created by concentrating the feed brine are recompressed by the evaporator fan to a higher pressure and, consequently, a higher temperature. These vapors are then recycled back into the heater shell to provide the heat source for concentrating the brine. This design eliminates constant steam use from auxiliary sources. The vapor that condenses on the outside of the evaporator heater tubes leaves the evaporator shell side and gravity drains to the distillate tank. The evaporator distillate combines with distillate from the crystallizer unit and is pumped through the feed preheater for heat transfer to incoming brine. This cools the distillate, which is then conveyed to the product water tank. The high-solids brine from the evaporator is sent to the crystallizer feed tank for further concentration in the crystallizer unit.

The crystallizer has a vapor body, a recirculation pump and a forced circulation heat exchanger. Similar to the evaporator, the vapors created by concentrating the slurry within the crystallizer are recompressed by fans. Heat from the mechanically recompressed vapors is transferred through the tubes of the heater to the brine. The concentrated brine collects in the vapor body and is recirculated through the heater. As the evaporation process continues, the concentration of the brine contained in the vapor body increases. As the concentration increases, the solution becomes supersaturated and salts precipitate from solution, resulting in a brine slurry.

A slipstream of the recirculating crystallizer slurry is sent to two centrifuges for dewatering. The two centrifuges are located in a dewatering building as are two filter presses dedicated to the softening sludge. The dewatered salt cake produced by the centrifuges is disposed in the on-site landfill together with the dewatered softening sludge filter cake. The liquid from the centrifuges is returned to the crystallizer feed tank.

Sludge dewatering. Wasted sludge from the full flow softening and RO reject softening process is combined and dewatered using two plate-and-frame filter presses housed in the dewatering building. The filter cake produced by the presses is collected in trucks for transport to the on-site landfill for disposal.

Operating results and discussion

The effluent water quality requirements for TDS and chlorides were provided in Table 2. Operating data for conductivity, as well as recent sampling results for chlorides and sulfates, were used to evaluate the treatment plant performance in achieving these treatment

Table 3

Estimated waste generation in treatment process based on current average and design condition.

Waste	Design condition	Current average condition
Softening sludge (on a 100% dry basis)	6,666 lb/hr	2,500 lb/hr
Salt (on a 100% dry basis)	17,500 lb/hr	8,460 lb/hr
Total waste generated (on 100% dry basis)	24,166 lb/hr	10,960 lb/hr

goals.

TDS removal

The consent decree limit for TDS is 150 mg/L. Figure 7 illustrates the variation of actual feed water conductivity measurements recorded from Jan. 21, 2014 to May 31, 2014, relative to the design influent concentration. The current average feed water conductivity is 10,270 µs/cm, compared to the design assumption of 13,000 µs/cm.

Figure 8 illustrates product water conductivity level measured prior to the remineralization process, as well as the current final discharge conductivity measured after the remineralization process. The required TDS concentration prior to remineralization is less than 150 mg/L. The average product water conductivity before remineralization is 67 µs/cm (approximately 42 mg/L TDS). The average final effluent conductivity after remineralization is 140 µs/cm (approximately 88 mg/L TDS). The remineralization process adds dissolved calcium and carbonate ions to the water that are responsible for the increase in conductivity.

Chloride removal

The principal driver for this project was to meet the NPDES effluent discharge chloride limit of less than 218 mg/L. Figure 9 shows the current feed chloride concentration versus current effluent concentration as measured in grab samples collected and analyzed in the facility's onsite lab from Aug. 20-Sept. 5, 2014. The current average feed water chloride concentration is 1,530 mg/L and average final effluent water chloride concentration is 11 mg/L.

Waste generated

The wastes generated in the treatment plant (softening sludge filter cake and salt cake) are disposed in an onsite landfill. Table 3 shows the estimated amount of softening sludge and salt produced based on the design feed condition and the current average feed condition (Table 1). The waste generated currently is less than designed, resulting in less frequent dewatering cycles and/or centrifuge use.

Conclusion

The centralized mine water treatment plant located in West Virginia was built to meet a new regulatory limit of <218 mg/L for chlorides. The advanced water treatment system utilizes state-of-the-art membrane technology to achieve the chloride limit and energy-efficient evaporation and crystallization technology for brine management. The plant performance consistently exceeds the design requirements. Solid waste generated in the treatment process is disposed in an onsite landfill and the leachate generated at the landfill is sent back to the facility's thermal treatment process. Because no liquid waste leaves the property, this facility is termed a ZLW facility. ■

Figure 8

Product water conductivity.

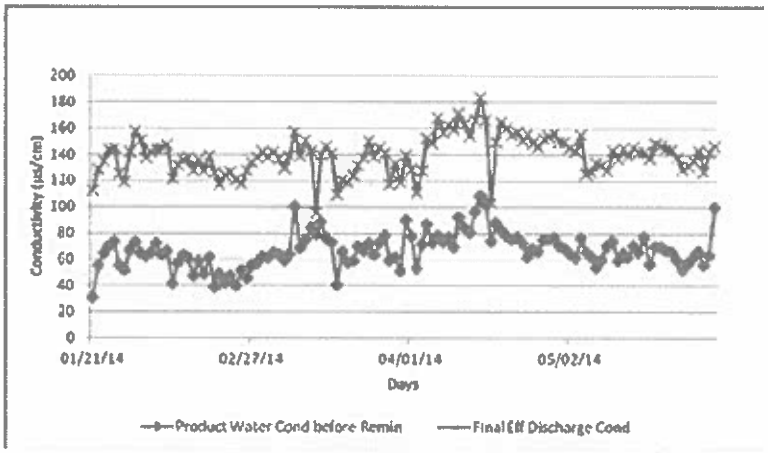
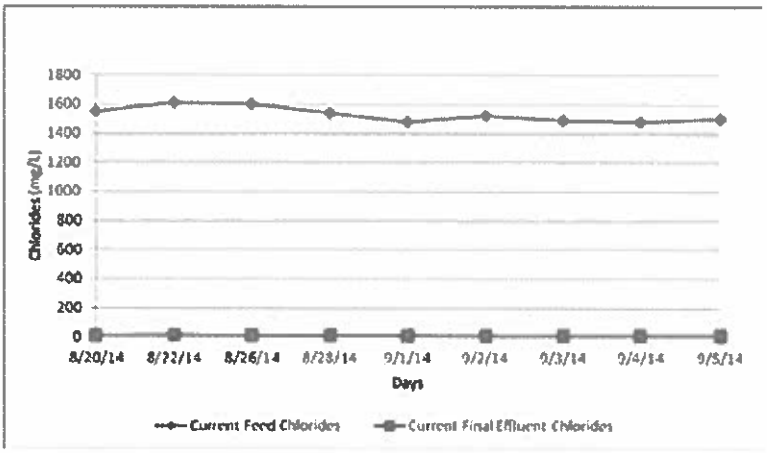


Figure 9

Feed water chloride versus final effluent chloride.



Acknowledgment

The authors thank Chris Miller and Alex Seago of Veolia North America's operations team at this facility, as well as Charles Blumenschein, Michael Pietropaoli and Robert Zick of Veolia Water Technologies for their contributions to this work.

Reference

J. Swearman, R. Zick, M. Pietropaoli and C. Robinson, "Zero liquid waste: A regulatory – driven approach to mine water treatment," IWC, San Antonio, TX, November 2012.

OBG

REPORT

REPORT ON THE CURRENT AND PROPOSED USE OF REVERSE OSMOSIS TREATMENT IN SURFACE AND UNDERGROUND COAL MINE SITES

United States District Court, Southern District of West Virginia
Huntington, WV

10/5/2016

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REPORT TO THE UNITED STATES DISTRICT COURT FOR THE SOUTHERN DISTRICT OF WEST VIRGINIA ON THE CURRENT AND PROPOSED USE OF REVERSE OSMOSIS TREATMENT IN SURFACE AND UNDERGROUND COAL MINE SITES

EXECUTIVE SUMMARY

Pursuant to Federal Rule of Civil Procedure 53(a)(1)(C), Mr. James H. Kyles was appointed as Special Master of Engineering in CIVIL ACTION NO. 2:13-21588 (consolidated with 2:13-16044) by the Honorable Robert C Chambers. As part of the Memorandum Opinion and Order Regarding Injunctive Relief (Order), Mr. Kyles was directed to provide information on the current and proposed use of Reverse Osmosis (RO) treatment of water from surface and underground coal mine sites. The report presents a summary of available information related to the current and proposed use of RO to treat Mine Drainage (MD) water from surface and underground coal mine sites.

Reverse Osmosis (RO) has been successfully used to treat municipal and industrial wastewaters for several decades, and RO has been found to be an efficient process technology that can remove Total Dissolved Solids and reduce conductivity in streams well below the 300 µS/cm target as applied to MD water discharges in West Virginia under current court cases. However, the feasibility of applying RO in a technically efficient and cost effective manner is directly related to the target water quality and the selection of pretreatment unit operations upstream of the RO system.

Reported systems from literature were reviewed and evaluated with consideration applied to the specific quality of the Leatherwood Creek MD water. To validate the information available in literature, a review of current MD water RO plants was conducted. Interviews were conducted with the operation and engineering staff associated with these systems, and design, performance, operation, and maintenance items were discussed. As part of this evaluation, the total installed and operating cost as a function of system hydraulic capacity was considered and, again, validated against real world examples treating MD water. Total installed and operating costs for different flow rates have been identified and have been reported. It is expected that the total operating cost for a properly designed RO treatment system, including required pretreatment, would range from $10 to more than $18/1,000 gallons of MD water treated. Pretreatment accounts for approximately 20% of the operating costs, while the RO treatment accounts for 28%, with the balance (52%) being attributed to residual solids handling.

Discharge of RO water, with an absence of conductivity, may be as problematic as the current discharge of high conductivity water, as aquatic habitats cannot thrive in a system with low or no conductivity. As such, in order to meet effluent discharge requirements, a small portion of untreated raw MD water (<5%) may need be blended with the RO permeate in order to not negatively impact the receiving water quality.

It is concluded based on literature, actual operating data, and experience that RO treatment of MD water is technically and economically feasible. Key elements affecting feasibility are proper design and operation of RO pretreatment and reject management systems. In addition, novel RO applications, Ettringite/nanofiltration (NF) technology, and/or coupling of active treatment of concentrated and segregated valley fill underdrain flows should be explored further to minimize overall life cycle cost of the system.

REPORT TO THE UNITED STATES DISTRICT COURT FOR THE SOUTHERN DISTRICT OF WEST VIRGINIA ON THE CURRENT AND PROPOSED USE OF REVERSE OSMOSIS TREATMENT IN SURFACE AND UNDERGROUND COAL MINE SITES

1 INTRODUCTION

Pursuant to Federal Rule of Civil Procedure 53(a)(1)(C), Mr. James H. Kyles was appointed as Special Master of Engineering in CIVIL ACTION NO. 2:13-21588 (consolidated with 2:13-16044) by the Honorable Robert C Chambers. As part of the Memorandum Opinion and Order Regarding Injunctive Relief (Order), Mr. Kyles was directed to provide information on the current and proposed use of Reverse Osmosis (RO) treatment of water from surface and underground coal mine sites.

Specifically, the Leatherwood site Mine Drainage (MD) water requires treatment to reduce conductivity to below a target conductivity of 300 µS/cm. During trial, various approaches were proposed by the Parties, including Water Management (routing impacted water around sensitive receiving water bodies to larger, more robust waters) and RO. The Court directed the development of this report to become better acquainted with the "state of the industry" associated with the use of RO for the treatment of MD water.

This report presents a data summary of typical MD water quality, and provides a literature review of RO technology with specific application to MD water treatment. A literature review was conducted as part of this investigation. The literature search identified data from operating RO facilities and articles published in peer-reviewed academic journals. A discussion of RO pre-treatment, RO performance, and generation and treatment of residual RO reject is presented, along with RO applicability to MD water treatment and cost. Alternative treatment technologies are also identified.

2 DATA SUMMARY

Data from various operating RO facilities were analyzed and, while the resulting treated water quality meets the effluent quality requirements, the feasibility of the treatment is dependent on the volume of water treated, cost, and reliability of operation and maintenance. It is important to note that the influent quality of the mine discharge depends upon many factors, such as the mineral being mined, and geological and topographical characteristics such as catchment hydrology etc. (Miller, 2014)[1]. compares the influent water quality from Leatherwood Creek tributaries and Leatherwood Creek with those associated with the Buchannan Wastewater Treatment Plant (BWTP), the Northern West Virginia Water Treatment Plant (NWVTP), and MD observed at Boardtree and Stillhouse Branches. The data for these sites were supplied by FOLA. Additional data were obtained from Internet based research platform which was published by Veolia[2] and the Bingham Canyon Water Treatment Plant (BCWTP)[9] for studies conducted on high sulfate MD water.

Since NWVTP, Boardtree Branch, Stillhouse Branch, and South Africa sites have similar influent water characteristics, specifically elevated sulfate concentration and high sulfate/TDS ratio (i.e, >0.5), they are suitable for comparative treatability analysis with Leatherwood Creek due to high sulfate concentration.

Of specific interest to the feasibility of RO treatment are scale-forming compounds. The two major categories of scale forming compounds present in MD are sulfate-based and carbonate-based compounds. Metal-sulfate and metal-carbonate salts are sparingly soluble. Because an RO system concentrates the MD wastewater as a function of treatment, the solubility of these salts is exceeded and the formed precipitate scales the RO membrane surface, causing increased operation and maintenance.

Table 1: MD water influent Quality data for the entire treatment operation

Parameter	FOLA Site							Veolia	Utah
	Leatherwood Creek Tributaries		Leatherwood Creek	BWTP[3]	NWVTP[4], [11]	Boardtree Branch	Stillhouse Branch	South Africa Site[2]	BCWTP[9]
	Cogar Hollow Mouth	Fork Road Mouth							
Conductivity	2160 - 2900	2210 - 2830	2500	13,900	n/a	2800	2800	n/a	2600
Total Dissolved Solids	2440 - 2960	2240 - 2870	2750	8620	9765	2900	2870	3070	2000
Sodium (mg/L)	38 - 46	13 - 19	26	2950	3016	7.32	8.42	104	n/a
Chloride (mg/L)	5 - 6	6 -7	8	4750	1356	5.8	10	70	n/a
Sulfate (mg/L)	1760 - 1940	1460 - 2520	1600	n/a	4962	1850	2100	1830	1200
pH	7 – 8.3	6.8 – 8.3	8	7.3	7.1	7.74	7.94	7.4	3.5
Calcium	265 -314	265 - 318	300	153	268	310	310	690	n/a
Barium	0.01 - 0.02	0.02	n/a	8.7	0.1	0.01	<0.01	n/a	n/a
Total Alkalinity (as $CaCO_3$) (mg/L)	75 - 93	162 - 185	100	593	1045	205	228	n/a	n/a
Sulfate/TDS Ratio	0.64 – 0.72	0.53 – 0.97	0.56	n/a	0.51	0.66	0.73	0.59	0.6
Design Flow (GPM)	n/a	n/a	n/a	1600	3500	n/a	n/a	n/a	3200

Notes:
n/a – Data not available
Single sulfate data point for Cogar Hollow with value greater than TDS was excluded

3 RO APPLICATIONS IN MINE DRAINAGE WASTEWATER TREATMENT

The RO membrane acts as a barrier to all dissolved salts and inorganic molecules, as well as organic molecules with a molecular weight greater than approximately 100 g/mol. Water molecules, on the other hand, pass freely through the membrane creating a purified product stream (permeate). Rejection of dissolved salts across the membrane into the permeate stream is typically 95% to >99%. The remaining concentrate (reject) is a concentrated brine solution of lower volume. Permeate salinity is proportional to the average feed salinity at the membrane surface. Therefore, an increase in feed salinity will result in a correspondingly higher permeate salinity.

Osmotic pressure is the pressure phenomena resulting from the difference of salt concentrations across an RO membrane. In order to transport water across the membrane, the osmotic pressure must be overcome through high pressure pumping. Osmotic pressure is a direct function of total dissolved solids (TDS) concentration. Hence, increased TDS levels result in increased osmotic pressure. Therefore, higher feed salinity will require higher feed pressure to produce a given permeate flow.

The recovery ratio (volume of permeate/volume of reject) is limited by the required permeate salinity and feed pressure limitations. Increasing system recovery ratio results in higher average salinity at the membrane surface with a proportional increase in the average feed osmotic pressure. Increasing the recovery ratio also increases the concentrate of salt in the reject stream.

The performance of membrane elements operating in a reverse osmosis system is affected by the feed water composition, feed temperature, feed pressure, and permeate recovery ratio. In practice, the recovery ratio is limited by the solubility of salts in the reject stream. As salts are concentrated, they exceed their solubility limit and precipitate from solution. When salts are present at high concentrations and/or have low solubility, recovery is lowered to minimize membrane scaling issues.

RO systems are designed to operate at a constant flux rate (i.e., to produce a constant permeate flow). Over operating time, the feed pressure is adjusted to compensate for fluctuation of feed water temperature, salinity and permeate flux decline due to fouling or compaction of the membrane (which is caused by increased feed pressure). When the flux has been reduced to less than the minimum required treatment flowrate, the RO membrane is cleaned in place with acid, caustic, or detergent, and then placed back in service. However, each time a membrane is cleaned, the resulting flux rate is decreased. Once the recovered flux rate is less than the required flux rate for treatment operations, the membrane element must be replaced. Membranes replacement can represent a significant operating cost for RO operation.

To minimize reject, systems can be configured as two stage. In a two stage system, the concentrate from the primary stage will re-pressurized and treated through an additional (second stage) RO system. The permeate from the second stage is returned to the influent of the primary stage and the concentrate from the second stage is the overall reject from the system. This arrangement can greatly reduce the reject volume to be treated or disposed.

3.1 RO TECHNOLOGY

Modern RO membranes are constructed of either cellulose acetate (CA) or polysulfone-based thin-film composite (TFC) membrane material. Table 2 below describes the material tolerance comparison and relative costs between CA and TFC membranes.

Table 2: Comparison between different membrane materials

Feature	CA	TFC	Reference
Flux	-	+	5
Salt rejection	-	+	
pH Tolerance	4-8	2-11	
Temperature Stability	<35 C	<45 C	
Chlorine tolerance	0.5mg/L⁺	0.1 mg/L*	5, 6
Operating pressure	600 psi	1000 psi	
Mechanical Strength	+	-	6
Resistance to hydrolysis	-	+	
Capital Cost	+	-	

There are differences in material formation and assembly within each category that can affect flux or operating pressure, and to a lesser extent, fouling potential due to surface smoothness treatment (specifically on TFC membranes). However, in general, one can consider RO membrane a commodity product with little difference in material or performance for similar membranes provided across the industry.

These elements are generally provided in two major configurations: spiral wound and tubular. Spiral wound elements have advantages of large surface area per membrane element, and thus are relevant to large flowrate systems. However, spiral windings have a small annular space for flow, so providing a solids-free feed is critical.

Tubular RO systems have large lumen space within the tubes, and can accommodate higher solids. However, due to the configuration, the surface area per element is much lower than the spiral wound units. Therefore, a much larger system is required, and becomes less cost effective for large flowrates.

The major difference in RO design to improve scaling resistance and/or reduce the potential pretreatment requirements is focused on improvements in the mechanical design of the RO unit. Three examples that may be relevant to MD wastewater are:

- Vibratory Shear Enhanced Processing (VSEP)
- ROChem Spacer Tube (ST) Technology

The VSEP technology utilizes reverse osmosis membrane leaf elements in a stacked-disk configuration that is configured as a single vertical element. The disk stack is oscillated in a motion similar to the agitator of a washing machine, but at a much faster speed. The oscillation produces a shear at the membrane surface of about 150,000 /s, which, according to the manufacturer, is approximately ten times the shear rate of the best conventional cross-flow systems. In a cross-flow membrane, the fluid velocity is greatest away from the membrane surface and a low shear region above the membrane surface exists. This low shear region promotes fouling and pore blockage along the membrane surface. In contrast, the shear in a VSEP System is focused at the membrane surface where it is most useful in preventing fouling, while the bulk fluid between the membrane disks moves very little.

The ROChem Spacer Tube (ST) technology is modification to the standard spiral wound (SW) membrane configuration. The ST module combines the open tube resilience with the efficiency and throughput of a conventional SW module to treat wastewater with high potential of fouling and scaling. Similar to the spiral wound module, the membrane envelopes are made of two flat membranes, between which an internal fabric collects permeate. However, the membrane envelopes are set apart by feed side spacers, creating open channels. The feed spacers used in the ST modules consist of two types of filaments with different diameters. The thick filaments (parallel to the channel axis) have direct contact with the membrane. The thin filaments (perpendicular to the channel axis) are of smaller diameter and have no contact with the membrane surface, allowing small particles to pass through on either side. According to the manufacturer, this allows the ST module to tolerate high dissolved solids and high turbidity, providing a greater resistance to scaling and fouling. This system allows for direct treatment of wastewater with minimal or no pre-filtration.

The spiral wound, tubular, VSEP, and ROChem units are all considered applicable to MD wastewater. Based on review of available literature, tubular RO, VSEP and ROChem do not appear to have applications (pilot or full-scale) operating on MD wastewater.

4 REPRESENTATIVE RO PRETREATMENT

The feasibility of RO operation in a technically efficient and cost effective manner is a related to the target water quality and the selection of pretreatment unit operations upstream of the RO system. If proper pretreatment is not implemented the RO may be prone to excessive scaling due to inorganic precipitate formation or fouling due to organic or biological growth on the membrane surface[7,14]. Both of these conditions decrease flux rates of water across the membrane, which increases operating pressure and lowers the throughput volume. This, in turn, requires increased membrane cleaning which reduces the membrane longevity. Scaling and fouling increase operation and maintenance of the system and causes more frequent membrane replacement. As such, a key aspect of efficient RO operation is proper pretreatment unit operation selection and operation[12].

Based on experience and literature review there are several potential options for pretreatment to maximize efficiency of RO units treating MD wastewater. These pretreatment systems are each designed to remove

specific constituents from the influent waste stream, as described below. A pretreatment system usually consists of multi-unit processing trains designed to remove specific inorganic and organic constituents that present membrane scaling and fouling potential.

The quality of MD water and the pretreatment offered impacts the characteristics of the RO feedwater. Water quality can vary with different pretreatment process. Some sites like NWVTP have high sulfates, calcium, and carbonate alkalinity which require complex pretreatment chemistry to remove sulfate and carbonate scale-forming salts. Other sites like BWTP are mainly calcium and carbonate rich. A comparison of pretreatment effluent characteristic for NWVTP and BTWP is presented in Table 3

Table 3: Characteristics of the pretreatment effluent at different sites

Constituent	BWTP[3] mg/L	NWVTP[4] mg/L
pH, standard units @ 20°C	11.7	7
Conductivity, µS/cm	13,900	n/a
Turbidity, NTU	5	n/a
Total Dissolved Solids (105°C)	8,270	9765
Sodium	3,120	3217
Calcium	12.3	20
Total Sulfur	1.3	n/a
Sulfate	n/a	5071
Chloride	4,730	1379
t-Alkalinity (as CaCO3)	239	18
Notes: *** - pretreatment effluent was not available. Data is from clarifier effluent upstream of UF.**		

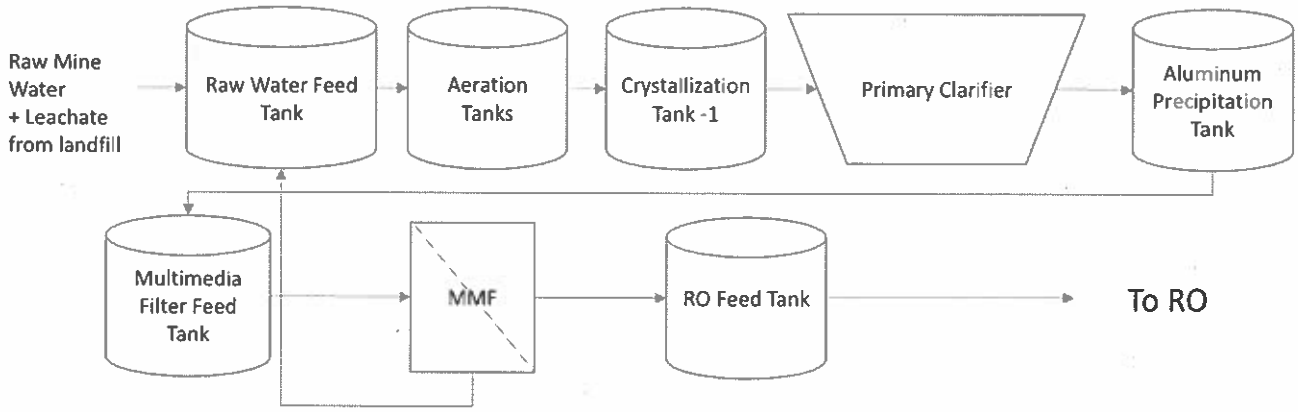
It is expected that the MD water from the Leatherwood site will have high concentration of sulfates and be most similar to NWVTP (see Table 1). A pretreatment system description for NWVTP is provided below. Additionally, descriptions of pretreatment systems for BWTP, BCWTP, and South Africa are provided for comparison.

4.1 NWVTP

The influent at NWVTP is characterized by high sulfate/TDS ratio which is what is observed at the tributaries to Leatherwood Creek. Figure 1 presents the NWVTP pretreatment process flow diagram. The NWVTP pre-treatment consists of aeration, chemical addition, chemical precipitation, gravity separation, and multimedia filtration (MMF) [10]. The MMF has a particle rejection of particles larger than 15µm[11].

The primary purpose of aeration is to oxidize dissolved ferrous iron to a more insoluble ferric iron thereby removing the dissolved iron from the influent water. During the aeration process, a portion of dissolved methane and carbon dioxide present in the feed water is also removed by the action of air stripping[10].

Figure 1: Pretreatment Process train at NWVTP



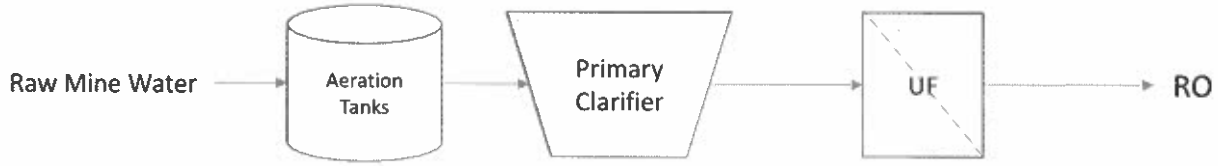
The effluent from the Aeration Tank overflows into a Crystallization Tank where dissolved manganese, along with remaining ferrous iron is oxidized and precipitated [as Manganese dioxide (MnO_2) and Iron hydroxide ($Fe(OH)_3$), respectively]. The effluent from the clarifier is transferred to secondary precipitation tank to remove dissolved aluminum. The effluent from this tank is sent to a MMF to remove residual aluminum solids[10,11].

Because of the effective pore size of the MMF, direct MMF to RO applications are not typically implemented in wastewater treatment applications.

4.2 BWTP

The influent at BWTP is characterized with high carbonate concentration. The process train as shown in Figure 2 consists of aeration tank, primary clarifier, and ultrafiltration (UF) unit. The UF has an effective pore size of 0.02µm, which provides excellent solids removal prior to the RO[3].

Figure 2: Pretreatment Process train at BWTP



4.3 SOUTH AFRICA

Veolia has conducted studies in South Africa wherein the pretreatment train consisted of iron coagulation, multimedia filters and Green Sand Filtration (dissolved iron and manganese removal). Several other pre-treatment steps were incorporated to extend membrane life: chlorination (to oxidize organic material), water softening (to remove dissolved calcium and magnesium hardness) and ion exchange (to reduce salt loading)[2]. As TFC membranes have a low tolerance to chlorine, a dechlorination step (either granular activated carbon, which provides a catalytic chlorination reduction on the carbon surface, or chemical dechlorination via sodium bisulfite injection) is required.

4.4 BCWTP

At BCWTP[9], the pretreatment system consists of bag and cartridge filters (particle rejection higher than 45 microns), ultraviolet system to prevent the biological fouling of the membranes from bacteria, and antiscalant system which injects a proprietary antiscalant compound used to prevent the scaling of gypsum (calcium sulfate) on the membranes.

4.5 PRETREATMENT USING ETTRINGITE FORMATION

Since the FOLA leatherwood Creek site is expected to contain high concentration of Sulfate, a potentially viable alternative is to precipitate sulfate via formation of Ettringite mineral. Ettringite is a mineral comprised of calcium oxide, calcium sulfate, aluminum oxide, and water ($3CaO{\cdot}3CaSO_4{\cdot}Al_2O_3{\cdot}31H_2O$). The mineral has very low water solubility and therefore can be precipitated out as solids readily. The advantage of forming Ettringite as a pretreatment step is that it removes both calcium and sulfate in a single process. Ettringite precipitation can be achieved in high-sulfate MD wastewater through addition of lime ($Ca(OH_2)$) and $Al(OH)_3$).

Currently FOLA has contracted Veolia to perform bench-scale testing to provide a proof-of-concept and establish the feasibility of the Ettringite precipitation process for removal of sulfate and TDS from the Stillhouse Branch[18], Boardtree Branch, or leatherwood Creek water. One of the goal of this study is to assess whether the Ettringite precipitation process may be applied as a cost-effective pre-treatment process to improve RO performance.

Additional discussion regarding this process are provided in Section 8.1.

5 EXAMPLE RO CASE STUDIES TREATING ACID MINE DRAINAGE WASTEWATER

Based on literature review (Juby, 2000)[7], most of the pilot trials have concluded that in order to improve membrane life, removal of turbidity from the raw mine water to less than 1 NTU and removal of oxidizing agents including chlorine to ensure a free residual of less than 0.1 mg/L is recommended. In addition to the other requirements of the membrane manufacturers, removal of strong acid, base, oxidants are required which can hydrolyze the RO cellulose acetate membrane. Moreover, as discussed in Section 4, selection of a proper pretreatment train is essential for sustainable operation of the RO unit.

The following subsections provide a description of RO system operations at NWVTP, BWTP, and BCWTP.

5.1 NWVTP

The ***NWVTP*** plant was designed to treat a flow of 3,500 gallons per minute. However, average operational flow during the first 6 months of operation was approximately 1,600 gallons per minute. The water recovery was reported to be 85% with 425 psi feeding the primary stage and 500 psi feeding the second stage. Reportedly, the reduced flow rate was due to the following reasons[8]:

1. High TOC levels in the influent feed.
2. Biological Fouling of the RO membranes resulting in lower recovery rates

These issues have been addressed over the past 2.5 years but several other problems including excessive maintenance of the thermal reject treatment (evaporator etc.) have occurred which have hampered daily operations. There have also been challenges in meeting the requirements of WET testing. It is possible that a TDS of 24 and pH of 5.7 may be contributing factors regarding the WET test. Blending effluent to maintain a reasonable ionic strength and neutral pH may be required. Further investigations need to be carried out as relevant information was not shared by personnel currently in charge of the operation.

The Table 4 below provides characteristics comparison for NWVTP at different sampling points. This data has been provided by FOLA. It should be noted that RO was effective in reducing the TDS at a flow of 3000 GPM

Table 4: Water quality at different sampling points across NWVTP[4]

Contaminant	Feed water	Permeate water	Reject water
Total Dissolved Solids (mg/L)	9765	24	62823
pH	7.1	5.7	7.54
Flow (GPM)	3500	2975	525

5.2 BWTP

Although the ***BWTP*** plant was designed to treat a flow of 1,600 gallons per minute, from 2011 – 2014, the facility treated an average flow of 484 gallons per minute. The system is configured as a two stage RO. The recovery of water was observed to be 80% with 400 psi feeding the first stage and 700 psi feeding the second stage. Reportedly, the decrease in actual operational flow was due to the following reasons[8]:

1. Persistent fouling of ultrafiltration (UF) membranes due to carryover of lime particulates from the clarifier, which suggests improper removal of the flocculated material. This also may be due to low cross-flow velocity within the UF membranes, which can lead to increased scale build-up due to a lack of mechanical scouring.
2. The secondary RO reject was returned to the mine pool, which increased the concentration of the dissolved solids and conductivity in the mine pool, leading to a buildup of pollutant load to the system.
3. Shutdown of RO units due to high operating second stage pressure.
4. Improper use of the diffuser discharge by blending in excessive amount of untreated wastewater
5. Inadequate materials of construction and sizing of the thermal treatment process.

5.3 BCWTP

BCWTP plant was designed to treat a flow of 3,500 gallons per minute. The plant has been in operation since 2011, first as a pilot-scale system (2011-2013) and then as a full-scale system (2013-current). The RO is a two stage system operating at 80% recovery. The learning notes from the operation include (Bacon, 2010)[9]

1. The RO unit treats water from shallow and deep wells which can also have high concentration of calcium and magnesium salts.
2. The membrane life was increased to 3-6 years (as compared to manufacturer specified 3 years) by optimizing cleaning schedule and reducing flux.

The following (Table 5) is a comparison of different streams within BCWTP. It may be observed that RO can be successfully used to improve MD water quality to meet treatment objectives.

Table 5: Water quality at different sampling points across BCWTP (Bacon, 2010)[9]

Contaminant	Feed Water	RO Permeate Water	RO Reject Water Quality
Specific Conductance (µS/cm)	2600	24	---
Total Dissolved Solids (mg/L)	2200	250	8,000
Sulfate (mg/L)	1500	250	3,800
pH	n/a	n/a	7.3
Flow (gpm)	3500	2800	700

5.4 EFFLUENT BLENDING TO MAINTAIN TARGET EFFLUENT CONDUCTIVITY

According to the documents provided by FOLA (Document titled: Water & Waste Production by BWTP 160101) BWTP has blended the Raw water with Treated water in ratio of 2:1 to 5:1, resulting in water quality that did not meet the discharge permit criteria for conductivity. The conductivity of raw water was 13,900 while the conductivity of treated water is 80 µS/cm. Flow-weighted calculation indicates that a maximum of 1.5% untreated water may be blended with 98.5% of treated water to be able to meet target conductivity of 300 µS/cm. Per Section 5.1, blending may be required to maintain a reasonable ionic strength and neutral pH in the discharge stream.

6 REJECT HANDLING

Reject handling is the single most expensive part of RO system operation and includes treatment of water from RO reject and subsequent disposal of solids and/or liquid. In most cases the reject handling aspect makes the RO applicability financially unattractive.

Proper consideration for treatment & disposal of the concentrated solid waste is essential for overall feasibility of RO treatment and several alternate disposal methods need to be identified based on the local resources.

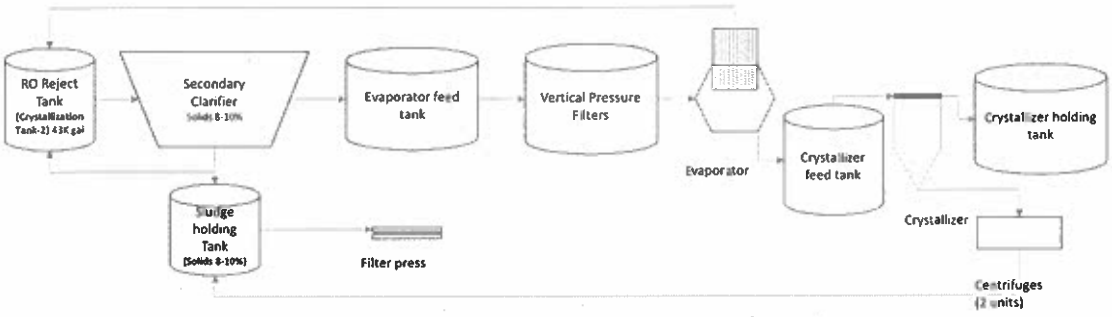
6.1 NWVTP

Figure 3 provides a process flow diagram of the RO concentrate management for NWVTP. The NWVTP is designed to be a zero liquid discharge system. The RO concentrate is primarily composed of sulfate salts. These salts are removed using a combination of chemical (cold lime softening) and thermal treatment. The supernatant from the softening process is directed to the facility's evaporator/crystallizer. Softening solids are dewatered in a plate-and-frame filter press. Crystallizer solids are dewatered in centrifuge[10].

The NWVTP facility produces approximately 110 tons of cold lime softening sludge and 240 ton of mixed salt per day[11]. This solid waste represents 0.121 lb / gal treated MD water. Considering the limited availability of landfills for disposal of sulfate sludge, NWVTP has invested in an on-site landfill to dispose the mixture of softener solids and crystallizer salts. The solids residuals have to meet end disposal requirements for a landfill.

The total capital cost of landfill was $12 Million with $800,000 specifically allocated towards leachate management and $4.6 million towards building the landfill. The balance of the cost was shared between various process units, construction of a building and equipment to address logistics of the solid waste handling at the landfill. The onsite disposal facility represents an operational cost of $4/ton in labor cost. It is important to note that the landfill capacity is about 288,000 tons and that this capacity is expected to be exhausted by December 2016[11, 16].

Figure 3: Downstream treatment of RO reject waste at NWVTP

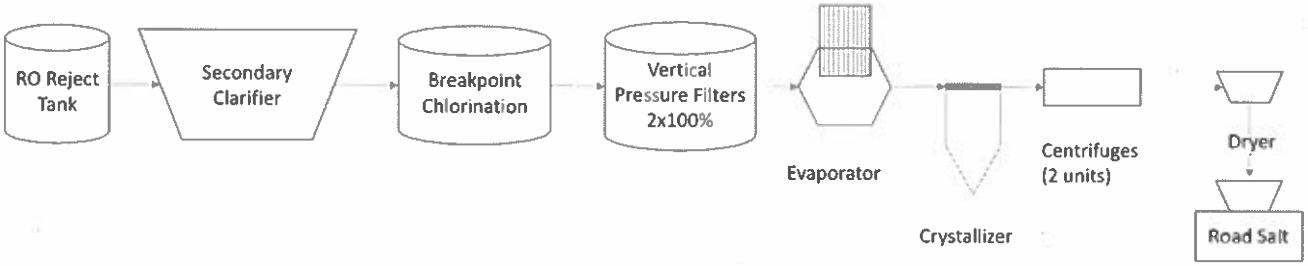


6.2 BWTP

BWTP (Figure 4) had a comprehensive waste management system (similar to NWVTP). It is understood that this system also experienced problems of corrosion and lack of throughput capacity. The RO concentrate is primarily composed of carbonate salts.

The reject handling system consists of a RO reject tank followed by a Secondary Clarifier, Chlorination vessel, Vertical pressure filters, evaporators, crystallizers, centrifuges and a dryer to manufacture road salt. Salt produced from the RO reject could only be used for its intended application of road salt for 4 months per year, considering the demand for such product. During the balance of its operational period the sludge and salt was landfilled off-site at a cost of $480,000 (80 tons/day x $50/ton for 4 months) for off spec salt and $600,000 (12 months) for Solid waste (per year basis)[15].

Figure 4: Downstream treatment of RO reject waste at BWTP[10]



7 COST ANALYSIS

Table 6 below compares the operating costs between BWTP and NWVTP. Pretreatment accounts for approximately 20% of the operating costs while the RO treatment accounts for 28%, with the balance (52%) being attributed to residual solids handling. NWVTP has reported that the overall cost of treatment per gallon of MD water is approximately $7.70/1000 gal while the cost of RO treatment is approximately $2.20 /1000 gallon[11].

Studies (Sandy & DiSante)[12] have indicated that the Total Installed (TIC) and Operating and Maintenance cost of a RO treatment system (Class 5 costs[1]) are dependent on the operating capacity installed. These costs have been normalized to current indexes and are represented in Figure 5 and Figure 6, respectively. The TIC estimate does not include flow equalization and diversion infrastructure which may be required. Operating costs include maintenance, labor, energy, cleaning, chemical and (non-hazardous) residual disposal costs. The maintenance costs do not include membrane replacement costs.

By comparison, reportedly the overall capital cost (excluding the MD pretreatment and conveyance) of NWVTP, designed for capacity of 3,500 gpm, was approximately $95MM. This is consistent with the capital cost information presented in Figure 6 below.

Consistent with the costs, above, literature reports RO costs for treatment of MD water at a Gold mine in South Dakota were reported as $10 to $18 /1000 gallons (Butler, June 24, 2010)[13] (Sobolewski, 2006)[14]. The RO unit was operated at a pressure of 250 psi. At feed rate of 200 gpm, the RO unit operated at 50% recovery.

Table 6: Comparison of operating costs between BWTP and NWVTP

	BWTP operating costs[15]	NWVTP[16]
Flow rate	1600 GPM	3500 GPM
Labor	$1,383,000	$1,414, 000
Utilities	$3,069, 000	Included in other costs
Chemicals	$2,100,000	$4,173, 000
Pretreatment Utilities & Maintenance	$70,000*	$1,039,000
RO Utilities & Maintenance	Included in other costs	$2,144,000
Contract Services	$305, 000	---
Evaporator and Crystallizer Utilities & Maintenance	$171,000*	$ 3,095,000

[1] AACE estimated costs for concept screening (-20% to +100%).

	BWTP operating costs[15]	NWVTP[16]
Salt Handling Utilities & Maintenance	$250,000*	$255,400
Disposal of Byproducts	$1,100,000	$ 2,029,000
Total Annual Operations and Maintenance Expenses	$8,450,000	$14,151,00
Notes: *** - Includes maintenance only**		

Figure 5: Total Installed Capital Cost Curve for Conventional Reverse Osmosis[12]

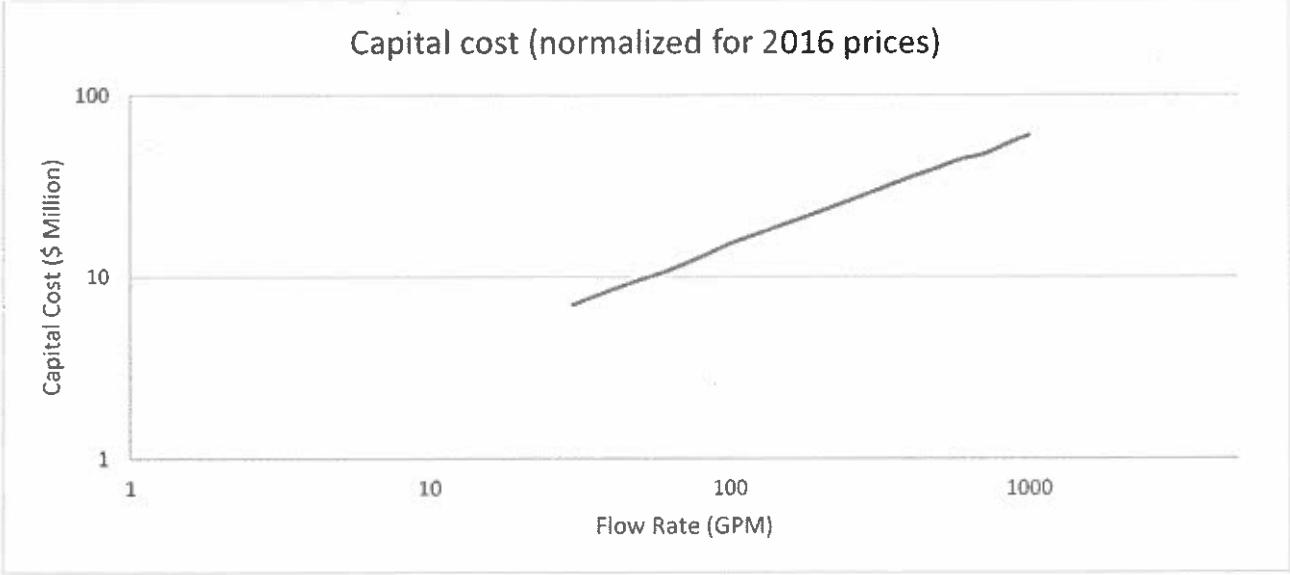
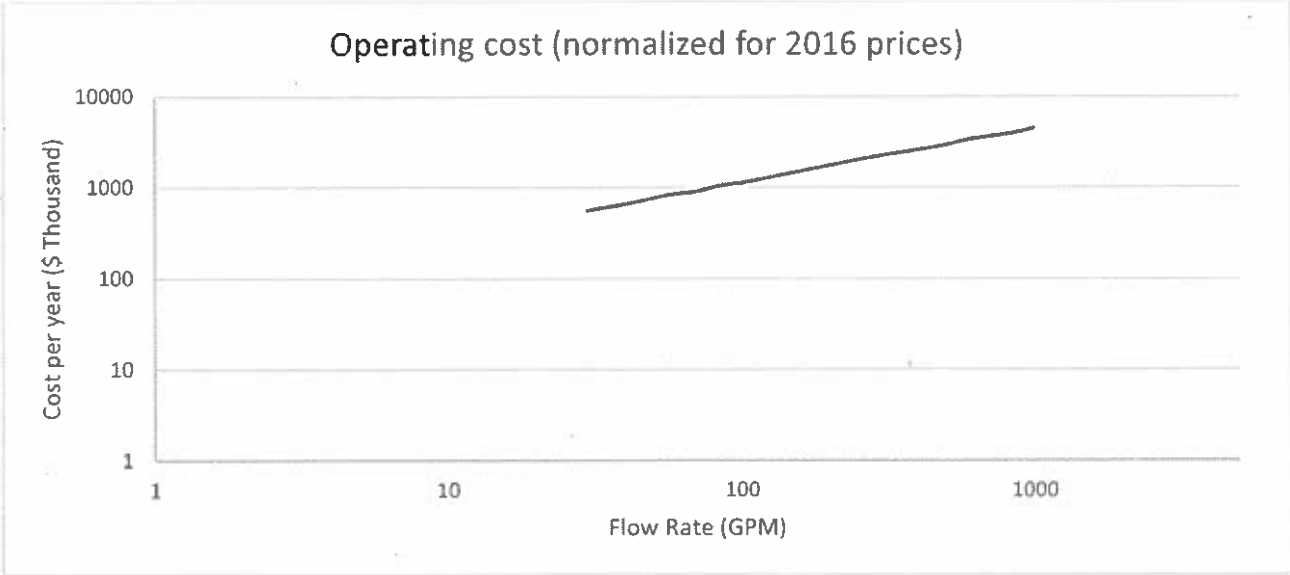


Figure 6: Operating Cost Curve for Conventional Reverse Osmosis[12]



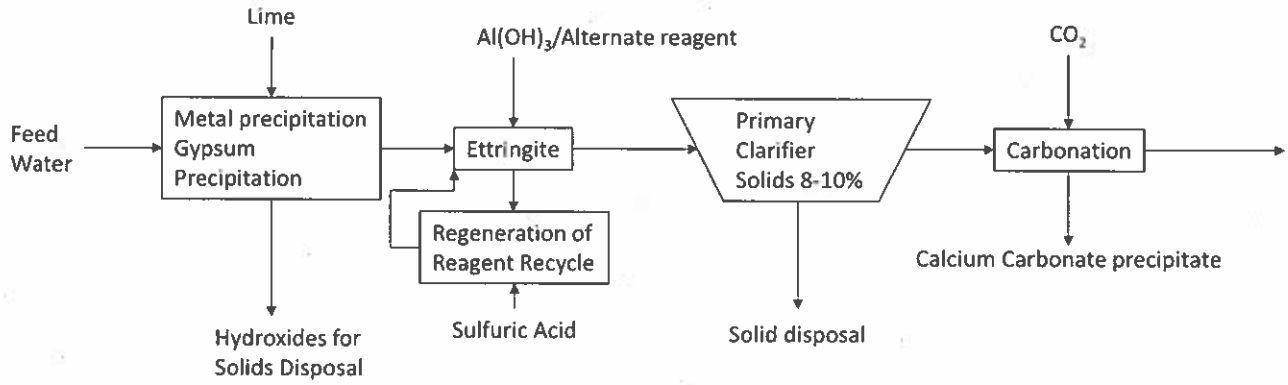
8 ALTERNATIVE TREATMENT CONSIDERATIONS

A literature review identified alternative pretreatment/membrane configurations applicable to MD wastewater. Each of these alternatives have been evaluated on a smaller scale, but neither have been implemented on the full-scale.

8.1 ETTRINGITE PRECIPITATION / NANOFILTRATION

Sulfate removal through the precipitation of Ettringite has been proposed as the SAVMIN process (Smit, 1999)[17]. Ettringite ($3CaO{\cdot}3CaSO_4{\cdot}Al_2O_3{\cdot}31H_2O$) has very low water solubility and therefore has the potential to remove both calcium and sulfate from MD wastewater. In addition to sulfate, metals can also be removed via co-precipitation with Ettringite. Figure 7 describes a potential treatment process train using the Ettringite process.

Figure 7: Potential SAVMIN treatment process chain for FOLA sites



The three stages of the process include:

1. Raising the pH with lime to range of 11.5-12
2. Addition of aluminum-based compound to remove residual calcium and sulfate as precipitated Ettringite sludge
3. pH-reduction of the treated water with CO_2 to meet effluent discharge criteria and precipitate residual $CaCO_3$

The Gypsum precipitation step of the SAVMIN process is valid for water that is super-saturated with sulfate.

According to the SAVMIN process Ettringite can either then be disposed of or dissolved in sulfuric acid to recover $Al(OH)_3$. Veolia[18] suggests that due to cost the aluminum coagulant needs to be regenerated to make the process feasible.

The resulting effluent can then be seeded with gypsum to produce more gypsum precipitate. Trials at a plant in South Africa successfully treated 500 m^3 of water with a sulfate concentration of 800 mg/L to <200 mg/L.

A variant on this process is the *Cost Effective Sulfate Removal* (CESR) process. CESR utilizes an alternate reagent in lieu of Aluminum hydroxide that does not require recovery[5].

As mentioned in Section 4.5, Veolia is conducting bench-scale testing of the Ettringite process for removal of sulfate and TDS. Preliminary results from Veolia suggest that the gypsum precipitation step is unlikely to be

useful for water from the Leatherwood Creek site due to the sulfate concentration being near its saturation concentration[18].

If the Ettringite precipitation process effectively removes divalent ions and does not impart additional monovalent ions in the process, it is conceivable that this pretreatment process could be coupled with a downstream nanofilter (NF). This is because Leatherwood Creek TDS primarily comprises divalent salts. The passage of the small amount of monovalent TDS may be acceptable to meet the 300 µS/cm conductivity threshold.

NF units are considered a "loose" RO. They spiral wound membrane units that allow significant passage of monovalent ions, yet retain divalent ions and organic molecules with molecular weights >200 to 1000 g/mol, depending on the specific material selected.

The advantage of utilizing a NF is that it would require much lower operating pressure due to the passage of monovalent salts resulting in lower operating cost.

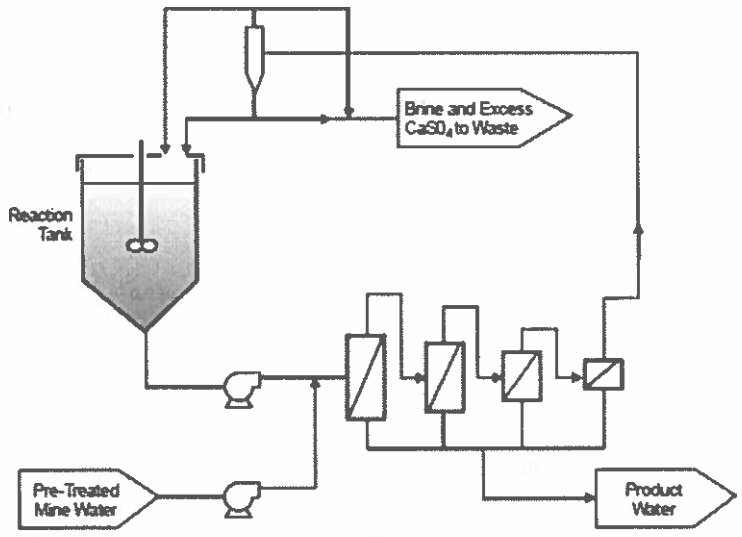
8.2 SEEDED REVERSE OSMOSIS (SRO):

A slurry of seed crystals from the downstream belt press (downstream from clarifier in the waste disposal system) can be recycled back to the primary clarifier. This seed can serve as a preferential growth sites for calcium sulfate, other calcium salts and silicates which begin to precipitate. The preferential growth of scale on the seed crystals prevents scale formation on the membrane surface. This technique is called the Seeded Reverse Osmosis (SRO) which actively promotes precipitation of $CaSO_4$ prior to RO membrane treatment, reducing the corrosion of the membrane walls and fouling by salt precipitation. The crystal slurry concentration is approximately 10% solids and a tubular reverse osmosis (TRO) membranes are required to mitigate fouling in this type of application (Bowell, 2004)[19].

SRO offers advantages in terms of high salt and water recovery and reduced costs. However, these benefits are usually offset by high energy consumption and poor control of $CaSO_4$ seed due to high slurry concentration and recycle.

A pilot plant for SRO has been operated in South Africa for 5000 hours and had a 96% water recovery reducing sulfate from approximately 6600 mg/L to 150 mg/L.

Figure 8: SRO/SPARRO process flow diagram[7]



8.3 SLURRY PRECIPITATION AND RECYCLE REVERSE OSMOSIS (SPARRO):

Redevelopment of the SRO process led to the patent of the Slurry Precipitation and Recycle Reverse Osmosis (SPARRO) process (Pulles, 1992)[20]. The novel features of this process are lower slurry concentration and recycle velocity, smaller reactor and a modified seed crystal and blow down system. SPARRO pilot plant test work has been conducted and includes the precipitation of metals by increasing effluent pH to 10 as a pretreatment step. This was followed by cooling, filtration and readjustment of pH 5 to 6 SU for protection of the membrane process[7].

9 SUMMARY AND CONCLUSIONS

Reverse Osmosis (RO) has been successfully used to treat municipal and industrial wastewaters for several decades, and RO has been found to be an efficient process technology that can remove Total Dissolved Solids and reduce conductivity in streams well below the 300 µS/cm target as applied to MD water discharges in West Virginia under current court cases. However, the feasibility of applying RO in a technically efficient and cost effective manner is directly related to the target water quality and the selection of pretreatment unit operations upstream of the RO system.

The influent composition, which is directly affected by the geographical topography and the type of product being mined, determines the process train to be selected. Data from various operating RO facilities treating MD water were analyzed and compared to the Leatherwood Creek MD water characteristics. Leatherwood Creek MD water contains elevated sulfates and carbonate hardness, which can make treatment challenging. The Leatherwood Creek MD water has a sulfate to total dissolved solids (TDS) ratio of that ranges between 0.56 and 0.97 with an average of 0.71, indicating that significant attention on pretreatment of influent MD water will be needed prior to any RO process. Other sites evaluated ranged from 0.51 to 0.73.

The key aspects of RO pretreatment on MD waters are to successfully reduce primary scale forming constituents, such as sulfate and carbonate hardness. Systems utilizing advanced membrane pre-filtration (i.e., ultrafiltration) are likely to provide acceptable RO feed water quality, if operated properly.

Reported systems from literature were reviewed and evaluated with consideration applied to the specific quality of the Leatherwood Creek MD water. To validate the information available in literature, a review of current MD water RO plants was conducted. Interviews were conducted with the operation and engineering staff associated with these systems, and design, performance, operation, and maintenance items were discussed. As part of this evaluation, the total installed and operating cost as a function of system hydraulic capacity was considered and, again, validated against real world examples treating MD water. Total installed and operating costs for different flow rates have been identified and have been reported. It is expected that the total operating cost for a properly designed RO treatment system, including required pretreatment, would range from $10 to more than $18/1,000 gallons of MD water treated. Pretreatment accounts for approximately 20% of the operating costs, while the RO treatment accounts for 28%, with the balance (52%) being attributed to residual solids handling.

Discharge of RO water, with an absence of conductivity, may be as problematic as the current discharge of high conductivity water, as aquatic habitats cannot thrive in a system with low or no conductivity. As such, in order to meet effluent discharge requirements, a small portion of untreated raw MD water (<5%) may need be blended with the RO permeate in order to not negatively impact the receiving water quality.

One of the more promising alternative approaches for Leatherwood Creek is Ettringite precipitation followed by nanofiltration (NF). Ettringite is a method of forming a crystalline calcium-aluminum-sulfate precipitate which can effectively remove the majority of divalent scale forming complexes and potentially reduce the overall TDS of the MD water. The resulting effluent may be acceptable to process through an NF membrane, which will reject all remaining divalent salts, but allow a certain passage of monovalent salts (i.e., sodium, chloride, etc.). This has the advantage of potentially meeting the effluent conductivity requirements at a lower operating pressure (and associated energy cost).

The coupling of technologies, including flow segregation of lower conductivity surface water and focusing treatment using RO or other technologies such as Ettringite precipitation followed by NF, may provide for a blended discharge of adequate quality. This approach may help minimize overall installation and operating costs by focusing treatment on the smaller, more impacted, portion of MD water, while utilizing the "water management" approach advocated by a number of mine owners (but avoiding long conveyance systems and potentially "moving the problem" from one receiving stream to another").

It is concluded based on literature, actual operating data, and experience that RO treatment of MD water is technically and economically feasible. Key elements affecting feasibility are proper design and operation of RO pretreatment and reject management systems. In addition, novel RO applications, Ettringite/NF technology, and/or coupling of active treatment of concentrated and segregated valley fill underdrain flows should be explored further to minimize overall life cycle cost of the system.

10 REFERENCES

[1] Miller, A. J., & Zégre, N. P. (2014). Mountaintop removal mining and catchment hydrology. Water, 6(3), 472-499.

[2] Banerjee, K., Blumenschein, C. H. C., & Buisson, H. (2015). An Innovative Process to Reduce Sulfate in Membrane Concentrate Enhances Mine Water Recovery. In The 10th international conference on Acid Rock drainage & IMWA Annual Conference (pp. 1-10).

[3] Buchanan RO Plant Process Stream Chemistry 03-18-11.pdf; Analytical Laboratory Report; Project: Consol Energy / Buchanan Samples; data supplied by FOLA for Chemistry of water composition; dated March 23, 2011

[4] NWV Influent_Intermediate_RO Permeate Composition.pdf; Analytical Laboratory Report; Project: Consol Energy / Northern West Virginia Samples; data supplied by FOLA for Chemistry of water composition; dated 10/15/10-3/15/11

[5] FILMTEC Membranes: A Comparison of Cellulose Acetate and FILMTEC FT30 Membranes

[6] SB20- Cellulose Acetate RO Elements- TRISEP

[7] Juby, G. J. G., & Schutte, C. F. (2000). Membrane life in a seeded-slurry reverse osmosis system. Water Sa, 26(2), 239-248.

[8] Leatherwood Supplemental Info Request 072916.pdf; Consol Energy, dated:07/29/2016

[9] ITRC (Interstate Technology & Regulatory Council). 2010. *Bingham Canyon Water Treatment Plant, Kennecott South Zone*. Mining Waste Treatment Technology Selection Web. Washington, D.C.: Interstate Technology & Regulatory Council, Mining Waste Team. www.itrcweb.org.

[10] Northern West Virginia Treatment Plant Process Design Description.pdf; Northern West Virginia Water Treatment Facility; Document given by FOLA.

[11] Personal Communication: Conference Call with Murray Energy re: Northern West Virginia RO; Date: 8/31/2016

[12] CH2M Hill (Sandy, Tom and Cindy DiSante). 2010. Review of Available Technologies for the Removal of Selenium from Water. Prepared for North American Metals Council, June 2010

[13] Barbara Butler, Selenium Treatment Technologies 2010 Mining NPDES, June 24, 2010

[14] Sobolewski, A. (2005). Evaluation of treatment options to reduce water-borne selenium at coal mines in west-central Alberta. Report, Microbial Technologies Inc, 2006, 32.

[15] Buchanan Treatment Plant Operating Costs Budget- document supplied by FOLA

[16] Annual Operating Cost Projections Includes Power- document supplied by FOLA

[17] Smit, J. P. (1999). The purification of polluted mine water. In *Proceedings of the International Symposium on Mine Water & Environment for the 21st Century, Seville, Spain*.

[18] Personal Communication: Veolia Benchscale Testing - Update Call; Date: 8/27/2016 and 09/07/2016

[19] Bowell, R. J. (2004). A review of sulfate removal options for mine waters. Proceedings of Mine Water, 75-88.

[20] Pulles, W., Juby, G. J. G., & Busby, R. W. (1992). Development of the slurry precipitation and recycle reverse osmosis (SPARRO) technology for desalinating scaling mine waters. *Water Science and Technology*, *25*(10), 177-192.

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Treatment and disposal of saline wastewater from coal mines in Poland

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SUMMARY

Some Polish coal mines are reviewed with respect to the disposal of saline wastewater into rivers and its environmental impact. The drainage water from mines has a daily contribution of, in the order of magnitude, 6,500 tons chlorides (Cl^-) and 0.5 tons sulphates (SO_4^{2-}) to the rivers Wisla and Odra. The river Wisla contributes to about 55 % of the water resources in Poland. This report is based on a part of a commission for the Ministry of Environmental Protection, National Resources and Forestry of Poland by COWI-VBB VIAK joint venture.

Different treatment and disposal schemes are described and compared from a technical-economical point of view, out of which methods for desalination with zero discharge as well as deep well injection are the most promising ones.

The desalination methods include reverse osmosis (RO) plant, thermal powered desalination and crystallization plant as well as facilities for dewatering and drying of sodium chloride (NaCl) to be sold in Poland and/or on the export market. The valuable main products are potable water, boiler feed water and sodium chloride. A special problem in this connection may be the radioactivity in the wastewater from some of the mines. Special treatment methods for radioactivity removal in the selected treatment and disposal scheme for the mine wastewater are discussed with respect to the effects of radioactivity on the saleability of the recovered salt.

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In addition methods for recovery of the by-products magnesium hydroxide, iodine and bromine are considered from the point of view of economy and environmental protection.

Finally, the desalination project in Katowice for the coal mines Debiensko and Budryk is now in the end of the construction phase. Some modifications of the original design are shown.

INTRODUCTION

The drainage water from mines in Poland has a daily contribution of. in the order of magnitude, 6,500 tons chlorides and 0.5 ton sulphates to the rivers Vistula (Wisla) and Oder. The largest amounts of these salts, about 78%, derive from 18 mines located mainly in the Katowice mine district. It has been estimated that the river Vistula contributes to about 55% of the water resources in Poland. About 35% of the water demand (about 5 x 10^9 m^3/y) is withdrawn from the river Vistula itself.

The high salt content in the water from Vistula prevents at present its use within agriculture and causes tremendous economical losses due to corrosion attacks on pipes as well as machines and other equipment within the industry. At present only around 4% of the river water can be classified as drinking water. One of the most important task in order to protect the fresh water resources in Poland will accordingly be to protect the river Vistula against discharge of highly saline mine wastewater.

REVIEW OF SOME INDUSTRIAL WATER PROBLEMS IN POLAND

A commission, including investigation of industrial plants in Poland, for the Ministry of Environmental Protection, National Resources and Forestry of Poland, was performed by COWI-VBB VIAK joint venture. The industrial plants reviewed in this paper are 2 coal mines (Piast and Siersza) and 3 power plants (Siersza, Chorzow and Laziska), located in the industrial area of Katowice, with particular emphasis on water problems at the coal mines.

The water problems at the power plants are relatively small in comparison with e.g. Piast coal mine. At Siersza Power Plant different SO_4^{2-}-concentration limits have been set for different wastewater flows, none of which has not been exceeded according to the results of the analyses. The wastewater from the cooling system may have too high concentration of sulphate at a normal concentration factor. Nanofiltration should be the preferred membrane method for removal of 2-valent ions as

sulphate. Such a treatment makes it possible to increase the number of cycles for the cooling water in the cooling towers considerably.

At Chorzow Power Plant the total dissolved solids (TDS) in cooling water will increase from about 1,700 mg/l to about 5,200 mg/l depending on the recirculation ratio for the cooling. The river water for cooling contains high concentrations of chloride and sulphate as well as suspended solids (SS). In addition to SS and TDS it is essential to control hardness forming ions (primarily calcium), soluble organic matter, dissolved oxygen and gases, algal nutrients and slime producing organisms in cooling water. Treatment of the river water by reverse osmosis in order to prevent corrosion problems in the cooling towers and to increase the recirculation ratio should be desirable.

Three wastewater flows are collected in a pond at Chorsow power plant before discharge into the municipal sewerage. The salinity of the mixed wastewater is between 4,000–5,000 mg/l TDS. RO desalination of this wastewater should be considered. After sewage treatment the saline effluent is discharged into a river.

The water conditions at Laziska Power Plant are similar to those at Chorzow Power Plant. The raw water used for cooling water has relatively high concentrations of sulphate (SO_4^{2-}) and hardness with a salinity up to about 1,200 mg/l.

In the wastewater from the cooling system (9,000 m^3/d) the discharge limit concentrations of (SO_4^{2-}) and Cl^- are 200 mg/l and 300 mg/l, respectively. These limits are exceeded, particularly for SO_4^{2-} (about 900 mg/l). RO desalination should be preferred due to the high chloride concentration.

As exemplified above it would be desirable to treat some water and wastewater flows at the power plants by RO desalination or nanofiltration for removal of mainly 2-valent ions (SO_4^{2-} and hardness). An obstacle could be, however, the treatment and disposal of RO brine due to the increased costs.

The water and wastewater problems at Siersza coal mine are relatively small in comparison with Piast coal mine (see below). The sulphate concentrations in raw mine water and wastewater discharged into the river exceed the discharge limit 150 mg/l SO_4^{2-} by 250–300 mg/l. A possible desalination method would be nanofiltration.

At Piast coal mine the raw water qualities are acceptable. The mixed wastewater (21,000–25,000 m^3/d) contains a very high salinity (TDS = 93 g/l), however, which will cause the primary environmental problem. This has to be solved as soon as possible. The wastewater discharged to Gostynka river also contains radioactivity. The options for wastewater treatment will be discussed below.

OPTIONS FOR SALINE MINE WASTEWATER TREATMENT

Salinity and radioactivity problems (Piast/Czeczott)

The graph in Fig. 1 shows the logaritmic chloride (Cl^-) concentration at increasing depth at Piast coal mine. The groundwater from 200 m depth has approved quality as drinking water according to Polish Standards, but bacteriological problems may occur. The mixed very high salinity mine wastewater from Piast (av. = 22,000 m^3/d) is pumped to a pond, where mine wastewater of similar quality from a nearby coal mine Czeczott is admixed before discharge into the river Gostynka – a tributary of the Vistula river. The total waste water flow from this pond is about 33,000 m^3/d and the salt content about 129 g/l (discharge of about 4.3 tons salt per day) (see Table I). The limits of radioactivity are also exceeded. According to the results of analysis during 1990–91 the concentration of Ra-226 has varied between 4.72–5.64 Bq/l and of Ra-228 1.25–2.46 Bq/l. The discharge limit for the combined wastewater is 0.7 Bq/l. The removal of radioactivity is a pre-treatment stage in the thermal desalination and crystallization process, as the economics of such a process depends very much on the sale of the produced sodium chloride (NaCl). Radioactivity is not allowed in household salt, but this requirement is missing for salt in industrial use.

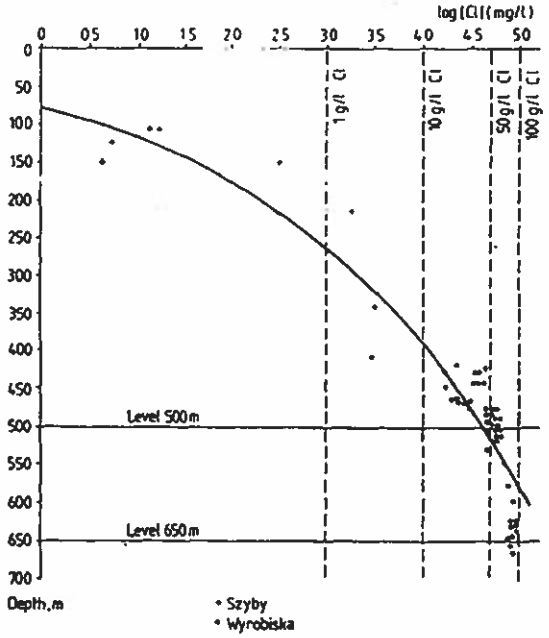


Fig. 1. Mine water salinity (as log (Cl^-) at different depth at Piast coal mine.

TABLE I

Average composition of combined wastewater from Piast/Czeczott coal mines.

	Average values
Temperature	18–20°C
pH	about 7
Suspended solids (SS)	200 mg/l
Total dissolved solids (TDS)	129 g/l
Alkalinity	2 meq./l
Total hardness	445 meq./l
Calcium	3,120 mg/l Ca^{2+}
Magnesium	3,400 mg/l Mg^{2+}
Sodium	40,930 mg/l Na^{+}
Potassium	670 mg/l K^{+}
Ammonium	17 mg/l NH_4^{+}
Manganese	12 mg/l Mn^{2+}
Total iron	2.2 mg/l Fe
Nitrate	12 mg/l NO_3^{-}
Chloride	75,600 mg/l Cl^{-}
Sulphate	3,350 mg/l SO_4^{2-}
Bromide	130 mg/l Br^{-}
Iodide	7.1 mg/l J^{-}
Wastewater flow	32,680 m^3/d (av.)

The following principal methods can be applied in order to eliminate the large salt discharge into the rivers:

- Zero discharge treatment with thermal desalination (vapour compression distillation according to the RCC method), crystallization for production of pure NaCl followed by heat drying of the crystals in e.g. rotary drums. The valuable products obtained from this treatment are mainly drinking water, distillate for boiler feed water and sodium chloride (NaCl).
- Deep well disposal for storage of the mine wastewater at a depth of 4,000–5,000 m.

- Pipeline transportation of salt water for discharge at a location of the receiving water, where the dilution is very high without any detrimental influence on the water quality.

The alternative with pipeline transportation to the Baltic Sea has not yet been evaluated but seems to be too expensive. This alternative will therefore not be discussed any further.

Thermal mine wastewater treatment for zero discharge

A pre-treatment plant for removal of radioactivity is required. Additional radioactivity may be removed more or less completely in the brine concentrators of the thermal powered desalination and crystallization plant and removed as a co-precipitate of calcium sulphate and radium sulphate (containing about 100 Bq/kg salt). This salt can be disposed in a mine hole.

Taking into account the very high salinity of the wastewater it will not be possible to apply reverse osmosis or ion exchange for removal of radioactivity. The remaining two methods are the following:

- Co-precipitation of radium and barium sulphate ($BaSO_4$).
- Lime or lime-soda softening.

The softening process implies the conversion of the hardness-forming and the radionuclide ions into insoluble compounds or precipitates. This method is, however, impractical due to the high hardness and consequently the large chemical demand.

The remaining method to be applied has been developed in Canada. The co-precipitation of barium and radium sulphate is accomplished by addition of barium chloride at an optimum pH-value of 7.0:

$$Ba^{2+} + Ra^{2+} + 2SO_4^{2-} \rightarrow BaSO_4 \cdot RaSO_4\ (S) \qquad (1)$$

The sludge separation stage is either sedimentation or filtration. The former includes dosage of ferric chloride and a polymer in separate flocculation tanks before the settling as well as recirculation of the radioactive chemical sludge from the settling tank to the first flocculation stage after dosage of ferric chloride. A part of this sludge is withdrawn and

disposed in e.g. a mine hole. If the other alternative is applied, a polymer is dosed before dual media filtration.

The main treatment stages in the thermal plant are the following (see Fig. 2):

- Thermal desalination and crystallization plant, including vapor compression distillation with seeded crystals technique (the RCC method), in order to concentrate the high-salinity wastewater to a maximum level without scaling in the condensor tubes. The crystallization of sodium chloride (NaCl), after separation of calcium sulphate (seed crystals), has probably to be performed as a 2-stage process. The crystallized salt is centrifuged and dried.
- Salt packaging and preparation plant (about 3,300 tons/day saleable NaCl salt).
- Potable water blending station for distillate (totally about 29,000 m^3/d) and well water. Some of the distillate will be used as boiler feed water.

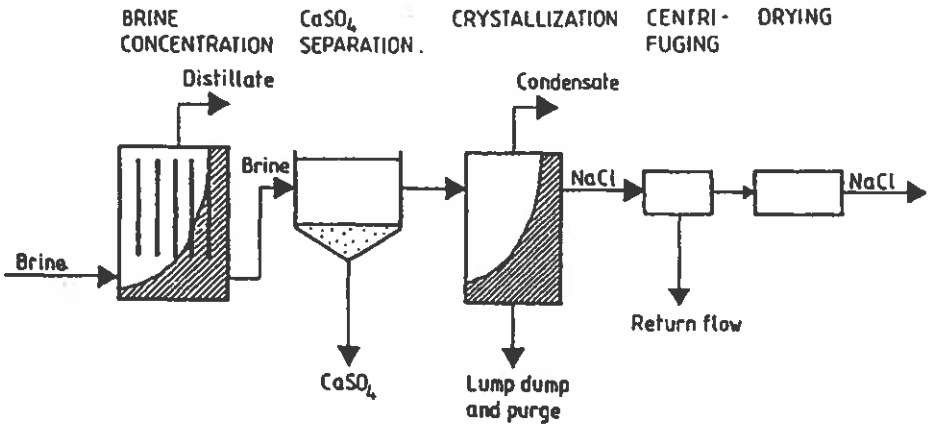


Fig. 2. Proposed flow scheme of the thermal plant for treatment of highly saline wastewater at Piast/Czeczott coal mines.

It is possible to recover some additional chemicals, viz. magnesium hydroxide (magnesium oxide), iodine and bromine, potassium chloride and calcium chloride. The recovery of magnesium oxide as well as of iodine and bromine by chlorine oxidation are strongly considered in Poland and may improve the economy. The yearly production of iodine and bromine is estimated to be 80 tons and 1,500 tons, respectively.

Magnesium oxide can be separated according to either the "dolomite process" or the "carnallite process". In the former process dolime (obtained by calcination of dolomite) is used for precipitation of magnesium hydroxide, in the latter process slaked lime (from limestone).

The dolomite process will produce about 128,000 tons MgO per year compared to about 60,000 tons/year for the carnallite process. The investment cost is higher for the dolomite process, but this process is evaluated to be more advantageous depending on the higher production rate of MgO for sale.

The thermal mine wastewater treatment method for zero discharge is realistic, if it is possible to sell the NaCl salt on the export market. This may be possible, as large salt dealers have paid in interest in the project. The reduced damage to the Vistula river has been estimated to save USD 860 million over the next 20 years. It should also be mentioned that waste coal from the two mines is planned to be used (fluid boilers) which improves the economy.

Deep well disposal

A pre-investigation for the Piast coal mine has been performed by Martech, USA. According to this report, based on current knowledge, deep well injection will be feasible if the wells are drilled to the approximate depth of 4,700 meters and the geological prerequisites are fulfilled. The judgment by geological and drilling experts is that this method is worth pursuing.

The proposal includes 10 wells in the Piast area, all located on safety piles to avoid subsidence. Subsidence could result in damage to the casings and tubings. The first well was planned to be drilled in 1992 near the existing mine water collection reservoir. The results are expected to be available a year later. Based on the findings and results of this test well and the tests on the existing shallow well, the total number of wells required to dispose the produced mine water as well as depth and configuration of future wells will be determined.

Centrifugal pumps will pump water from the mine wastewater pond through filters prior to being injected.

If the results will show the applicability of the deep well disposal method, it may be only a temporary solution and combined with the desalination method.

THE DESALINATION PROJECT IN KATOWICE

The desalination project in Katowice has been described by Masarczyk et al. [1].

This project in Katowice includes advanced treatment of wastewater for zero discharge from two adjacent coal mines, Debiensko and Budryk. The wastewater flow and salinity were designed for about 8 000 m^3/d and 22,600 mg/l, respectively, at Debiensko. The corresponding values of Budryk were about 3,500 m^3/d and 11,500 mg/l TDS. The complete treatment processes are divided into three main sections, viz.:

- Pre-treatment before reverse osmosis (RO)
- RO-plant including posttreatment of the RO permeate
- Thermal plant for brine concentration and separation of sodium chloride (NaCl) by crystallization.

As valuable main products drinking water, distillate and sodium chloride for household and industrial use are obtained.

This plant is now being taken into operation. The salinities of the two wastewater flows have been checked during the construction time in order to further investigate the yearly variation. The result turned out to be quite different from the values used for the design. The salinity of the wastewater from Debiensko has decreased considerably and that of Budryk wastewater increased. Therefore the intention is now to have a mixing station without need to change the original design of the two RO plants except for a pressure increase of the first stage permeate at Debiensko.

CONCLUSION

The most viable method at present for treatment and disposal of the highly saline mine wastewater seems to be the zero discharge desalination method for production of sodium chloride, potable water, boiler feed water, magnesium hydroxide (oxide), bromine and iodine as valuable products. The recent policy in Poland has been to increase the fines very much for such discharge into rivers.

The application of this method at Piast/Czeczott coal mines depends, however, on the possibilities to sell the very large amounts of NaCl produced (about 3,300 tons/d). If this problem is solved, preliminary cost calculations show that this method may be feasible. A similar plant is now being taken into operation in Katowice for zero discharge treatment of mine drainage water from Debiensko and Budryk coal mines.

An interesting alternative, if applicable, is the deep well disposal method, which also can be combined with the desalination method. An investigation at the Piast coal mine by drilling the first deep well to a depth

of about 4,700 meters is under progress. The results are expected to be available in a year.

An evaluation of the alternative with pipeline transportation to the Baltic Sea is expected to be presented in a feasibility study sponsored by the European Commission. At present it is considered to be too expensive.

REFERENCE

1 J. Masarczyk, C.-H. Hansson, R.L. Solomon and B. Hallmans, Desalination plant at KWK Debiensko, Poland: Advanced mine drainage water treatment engineering for zero discharge, Desalination, 75 (1989) 259–288.

From:	Andrew Rehn
To:	EPA.PublicHearingCom; Lieberoff, Barb
Cc:	Albert Ettinger; Cindy Skrukrud; Sabrina Hardenbergh; Jan thomas; Cameron J. Smith; Jane Cogie; Amanda Pankau; Jann.Stephen@epa.gov
Subject:	[External] Re: IL0077666 Pond Creek Mine Post-Hearing Comments from PRN, SC, SAFE
Date:	Friday, January 17, 2020 4:03:49 PM

Lastly, for your convenience, the letter and all exhibits can be downloaded from this Google Drive folder.
https://drive.google.com/drive/folders/17qh4GtlBnuzhmnZhBPtWL6am1Fpw_Mn8?usp=sharing

Thank you,
Andrew

On Fri, Jan 17, 2020 at 3:56 PM Andrew Rehn <arehn@prairierivers.org> wrote:

> Dear Ms. Lieberoff and other Illinois EPA officials;
>
> On behalf of Prairie Rivers Network, Sierra Club and Southern Illinoisans Against Fracturing Our Environment, attached are post-hearing comments regarding the proposed NPDES Permit IL0077666 for the Pond Creek mine. As these comments will explain, the proposed permit plainly cannot be legally granted by the Illinois Environmental Protection Agency (IEPA) based on the current record. Please do not hesitate to reach out to us for further clarification.
>
> In 4 emails following this one, I will be including the exhibits to this comment letter. Please include those in the record with this submission.
>
> Thank you,
> Andrew
>
> --
> **Andrew Rehn**
> *Water Resources Engineer, Prairie Rivers Network*
> 1605 South State St, Suite 1, Champaign, IL 61820
>
> tel: 217.344.2371 x 8208
> www.prairierivers.org
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--
Andrew Rehn
Water Resources Engineer, Prairie Rivers Network
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facebook | twitter

From: Wendy VanDyk Evans
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine comment
Date: Friday, January 17, 2020 4:19:52 PM

Dear EPA folks:

I would like to add my voice to the public outcry against Foresight Energy's proposal to add more mine effluent to local waterways. I found the untrue/misleading statement of the mine representative at the public hearing to be extremely worrying, especially when combined with the company's history of violations, which I was not previously aware of. In fact, I learned quite a lot in researching the matter, including the concept of the amount of time it takes for a particular concentration of pollutant to kill off half of a population of aquatic organisms. I am sure that as environmental scientists, you are very familiar with that type of metric and take it very seriously. Any possibility of such acute levels of poisoning must be avoided, and if the possibility is allowed, it must be for a very, very good reason. Increasing the profits or cutting the costs of an energy company, or even keeping such a company in business, does not qualify as a very good reason. We all know that coal is on its way out as an energy source. I would hate to consider that the EPA would allow any coal company to use its last throes to pollute the community's waterways on its way out.

I've seen what happened under the rule of declining but desperate coal companies over the last 20 years in central Appalachia. Approval for the coal companies there to pollute and degrade the landscape in the name of keeping jobs has resulted in ever-increasing poverty and hopelessness. The mountains are ruined and the people have nothing to show for it. Southern Illinois has a much better future, in my opinion, because we are not solely dependent on one industry. However, allowing coal to affect the waterways and the attendant fishing and recreation would be a serious mistake.

It would be helpful in situations like this for the EPA to issue a clearly written, easily understandable fact sheet with curated arguments for and against this type of proposal.

Thanks, and I look forward to hearing that the EPA has denied the permit.

Wendy Evans
2114 Market Road
Marion, IL 62959

Exhibit 391

From: SAFE Org
To: EPA.PublicHearingCom; Lieberoff, Barb
Subject: [External] NPDES Permit No. IL0077666, Notice 7516c- Williamson Energy, LLC
Date: Friday, January 17, 2020 4:31:15 PM
Attachments: NPDES Permit No. IL0077666 SAFE comment.pdf

Please see the attached document and exhibits as our comment for permit application NPDES Permit No. IL0077666, Notice 7516c- Williamson Energy, LLC.

We would appreciate acknowledgement of the comment and 9 exhibits as attachments.

Thank you.
SAFE

- Exhibit A-Dim-Future-for-Illinois-Basin-Coal_De...
- Exhibit B P456.find.pdf
- Exhibit C 8-K 401766554.pdf
- Exhibit D IEEFA Coal Analysts S_P article.pdf
- Exhibit E-P456 ORIG PART1.pdf
- Exhibit F 2009-2019 Pond Creek Pollutant Loadin...
- Exhibit G Pond Creek 08-30-18 inspection.pdf
- Exhibit H Pond Creek 08-29-19 inspection.pdf
- Exhibit I Hawthorne 12.5.19 EPA cuts.pdf

January 17, 2020

Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P. O. Box 19276
Springfield, IL 62794-9276

Sent via email to epa.publichearingcom@illinois.gov

Re: NPDES Permit No. IL0077666, Notice 7516c- Williamson Energy, LLC

Dear Ms. Lieberoff and other Illinois EPA officials;

These comments are submitted on behalf of Southern Illinoisans Against Fracturing Our Environment (SAFE) a volunteer, grassroots organization based in Southern Illinois. Our focus is upholding "the Law of the Land" Article XI of the Illinois Constitution, which provides that this and future generations have a right to a healthy environment. We oppose the issuance of the proposed permit to Williamson Energy, LLC.

Every pound of coal removed from IL and burned, adds carbon to the atmosphere, and that increases the instability of our climate, and our right to a safe and healthy environment for future generations. The impacts of this decision are cumulative and global. We plead to our state officials to consider the gravity of the matter of climate change and its severe implications to our health, our surrounding environment and the consequences of continuing to permit and concede to industries that undermine the transition to renewable energy by selling false hope and one sided economic benefits to rural, impoverished communities. The collective impacts on our community's health and the degradation to the surrounding environment were not taken into account when the mine purports their "value" of millions of dollars to Southern IL. Environmental justice starts with saying no to companies where stockholders and profits are the only priority of absentee business owners like this company.

We have many questions that were left unanswered or not adequately answered during the public hearing December 18, 2019.

General questions

Why would the IEPA issue a permit to a company when the company is going into bankruptcy and leave the burden of clean up on the backs of taxpayers? Please see the Institute for Energy Economics and Financial Analysis December 2019 at IEEFA.org (Exhibit A) We need only to look at the legacy of coal mines across Southern IL: Scarlet Mine in Stonefort, Saraha Woods and Rocky Branch outside of Harrisburg, and the mountains of overburden left

at Sugar Camp, Galatia, Ava, and impoundment ponds leaching into groundwater to see the burden of reclamation is quite the opposite of economic benefit.

Several documents state the pipeline is only for 10 years and then it will be removed. ***Is this the projected end of the date of the coal seam and mine closure?***

At the public hearing, a mine employee said the Company intends to operate at the site for another 50 years. (Transcript page 25, line 22) On page APP B-1 the IL DOA (Exhibit B) says the pipeline will be removed in 10 years. The citation "https" address given is grossly inaccurate as there are spelling errors within the link itself. With only a $500,000 bond as Foresight energy stocks are tanking, and on December 19, 2019 (the day of the public hearing) the company filed an 8-K Entry into a Material Definitive Agreement (Exhibit C) with "$1.25 billion in gross debt." (Exhibit D) ***Who is going to pay for the removal of this pipeline?***

EPA Enforcement concerns

We noticed on the IDNR permit application located here *https://www.dnr.illinois.gov/mines/LRD/Pages/PendingApplicationsDecisions.aspx* (Exhibit E) under Application Table 1.5.3 of document P456 ORIG PART1.pdf (page 54) A list of violations was submitted for the past 4 years, the IEPA was cited as giving one violation to Pond Creek and it was abated. There are several violations cited by IDNR.

- ***How many inspections has the IEPA completed since this mine has become operational? How many violations have been issued?***
- ***How many field inspectors does the Marion office currently have to call on for inspections?***
- ***Does IDNR Office of Mines and Minerals inspect or cover the same regulations the IEPA does?***

Monitoring

While researching the mining company on the EPA ECHO website, we noticed that the Pollutant loading report indicates:

- Loads for the current year are not based on a full reporting year because the data is not complete. The warning signs appear on all the reports since 2007. For the year 2014 the data is completely blank. ***Why is data incomplete? How does one know if the polluter has exceeded the allowable limits if the EPA is not requiring complete reporting data?*** *(Exhibit F)*

- In August of 2018 and 2019, EPA sampling (Exhibit G & H) showed minerals that exceed the reporting limit (Aluminum, Barium, Boron, Calcium, Magnesium, Nickel, Potassium, Sodium and Strontium) ***Please explain the excessive limits and lack of regulation of minerals that are cumulative and in large amounts, toxic to life.***

ECHO site issues:

- On Sunday, December 15, 2019, the ECHO site listed Williamson Energy LLC compliance status was yellow - "violation". On Wednesday, December 18- the day of the hearing-the Company's compliance status had changed to blue - "no violations identified". This was the case even though the Company's pollutant loading report lacked complete data, and even though the inspection report from 8.29.19 (Exhibit H) showed sulfates and chlorides greatly exceeding the permit limits. ***Please explain how, in a matter of days the Company's status on the ECHO site changed from yellow to blue?***

Citizen Monitoring

In a field inspection report for compliance sampling, dated 8.29.19, (Exhibit G) an EPA employee spoke to a nearby landowner who said "EPA should take sample on Saturday or Sunday when the stream is rolling dark gob water". This land owner was advised to make a formal complaint, to which he responded the mine gave him a hard time the last time he complained.

- ***What recourse should citizens take when they see a violation occurring and assume the risk of making a complaint, but yet the polluters are allowed to bully citizens into silence?***

- On 9/3/19, an IDNR inspector is cited in this report saying "he has received similar information from multiple sources about off hour discharges". ***Is this a recurring issue for the Company?***

- This same report states that despite the **daily** influent of approximately 2.7 million gallons of underground water seeping into the mine, there have been no discharge monitoring reports since March 2019, and the report goes on to say that the water mass balance of influent water and discharged water does not appear consistent.

- Sample results show the amounts of sulfates and chlorides greatly exceed the permit Water Quality standards. ***What measures of enforcement have been taken on this issue against the Company?***

- The report cites under Monitoring Violations: "Analysis not conducted of discharges, inadequate frequency of sampling, invalid/unrepresented sample as required by permit". ***How is it that a mine requesting a new permit to dump 2.9-3.5 million gallons per day of mining waste has no record of discharge for months at a time, no record of discharge release, and no water sampling data on public record? Where is the mining waste water going every day?***

Attorney General's office

Legislators can make all the rules in the world, but those rules are useless if there is no enforcement.Enforcement is pointless if the Attorney General's office does not prosecute civil or criminal cases. We expect Republican Governors to be lax on enforcement and prosecution, but we are dismayed by the few numbers of cases that Gov. Pritzker has sent to the AG's office- only 89, just a hair above Rauner's average. For comparison: Gov. Quinn's average was 144. (Exhibit I)

- ***If Pritzker cares about the environment, then why has the IEPA referred so few cases to the AG's office, even with all the consistent violations of this mine?***

Staff issues

Chicago Tribune article 12.05.19 (Exhibit I)

"Illinois also cut its environmental agency's workforce by 38% [in the past decade]—more than any other state."

"With a smaller staff and less money, the state agency has failed repeatedly to identify hazards to public health and hold polluters accountable, said Eric Schaeffer, a former top U.S. EPA enforcement official who directs the nonprofit Environmental Integrity Project and compiled one of the reports."

"We're jeopardizing the health and safety of Illinois citizens and the economic well-being of its businesses that rely on the Illinois EPA for timely permits and even-handed enforcement," said Mary Gade, who led the agency under former Republican Gov. Jim Edgar and later served as the regional U.S. EPA administrator under President George W. Bush."

"State inspections of air polluters have dropped 81% -"

- Has there been a drop in mining inspections since 2010? Of companies with NPDES permits? If so, by what percentage have the inspections dropped?

Conclusion

Based upon the evidence of multiple samples and reports of off hour discharge, in combination with less than ideal agency enforcement and oversight, SAFE's position is one of opposition to issuance of the NPDES permit as applied for, unless and until the company is willing to add real time data system (SCADA : Supervisory Control and Data Acquisition) that citizens may access 24 hours a day, 365 days a year and is overseen by an independent third party entity. If the company is willing to install a monitors for public access, we ask that the company provides a reclamation bond should any downstream pollution adversely impact the River, the residents and the environment. We ask the EPA to reduce the discharge to less than 500,000 gallons per day and that the state consider reducing the allowable amount to that of surrounding states to 500mg/l of sulfate and chlorides. We also ask that the state provide citizens with support and recourse when reporting illegal discharges from harassment. Unless and until these conditions are met, SAFE opposes the company's request to Discharge into the Big Muddy River, and ask the IL EPA stand with the citizens downstream and deny the permit.

On behalf of Southern Illinoisans Against Fracturing Our Environment,
Tabitha Tripp, Volunteer
Vito Mastrangelo, Steering Member
Rich Whitney, Steering Member
Jan Thomas, Steering Member
Cameron Smith, Steering Member
Mark Coats, Steering Member
Patti Walker, Steering Member
Ed Ford, Steering Member

Exhibits

Exhibit A - IEEFA report
Exhibit B - IDNR Application P 456
Exhibit C - Foresight Energy 8-K
Exhibit D - IEEFA Coal Analysts S&P article
Exhibit E - P456 Violations listing
Exhibit F - 2009-2019 Pond Creek ECHO DMR Pollutant Load Reports
Exhibit G -Pond Creek 8.30.18 Inspection Reports
Exhibit H -Pond Creek 8.29.19 Inspection Reports
Exhibit I- Hawthorne Article 12.5.19

Seth Feaster, IEEFA Data Analyst
Karl Cates, IEEFA Transition Policy Analyst
December 2019

Institute for Energy Economics and Financial Analysis
IEEFA.org

Dim Future for Illinois Basin Coal

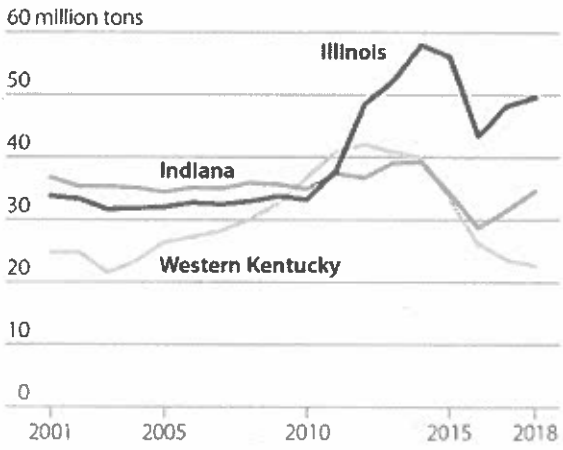
Market Forces and Shifting Preferences Are Eroding Customer Base Domestically and Abroad

Executive Summary

Twenty years from now, most of the Illinois Basin coal industry will be gone. Currently one of the major U.S. producing regions of thermal coal for domestic and foreign electricity generation, by 2040 it will have largely faded away as utilities shift to cleaner, cheaper generation resources.

In 2018, the Illinois Basin produced 106.8 million tons of thermal coal, about 14 percent of the total mined nationwide. Most of that total was used domestically, the remainder was exported. The Basin, which straddles the Ohio River in parts of three states—southern Illinois, southwest Indiana and western Kentucky—does not produce any of the metallurgical coal used in steelmaking, meaning it cannot escape the rapid transition now under way in the electric generation sector, both domestically and abroad.

Illinois Basin Coal Production by State



Source: Energy Information Administration

Domestic utilities, which bought nearly 80 percent of the region's coal in 2018, have already announced retirement dates for a significant number of plants over this period, as competitive electric markets compel a shift to newer, less expensive and cleaner wind, solar and gas generation, increasingly supported with energy storage. Notably, these retirements include the largest single purchaser of Illinois Basin coal, Duke's Gibson plant in Indiana, which will close in phases by 2038.

Gibson's closing will not be unique, however. From the beginning of 2019 through 2024, at least 15 U.S. plants that buy Illinois Basin coal—in Alabama, Florida, Georgia, Indiana, Kentucky, North Carolina and Tennessee—will be fully or partially retired. That number, which only reflects formal announcements by utilities, is likely to grow as the economics of coal-fired generation continue to deteriorate relative to renewables and gas.

Even those plants that remain online are likely to be used less and less, reflecting a trend that has seen capacity factors at most coal-fired power plants in the U.S. decline sharply over the past decade.

Coal exports, seen just a decade ago as a potential growth market, face the same market threats, particularly in Europe which is moving aggressively away from thermal coal. In addition, there is growing competition from foreign coal suppliers such as Russia and Columbia for this shrinking market.

These threats are already having a major impact in the region. Just in the past year, producers have closed or idled mines that produced almost nine million tons of coal in 2018. Further closures are likely, both in the near- and long-term.

The Illinois Basin will clearly be hit hard economically by the structural decline of the region's coal industry. Now is the time for local, state and federal policymakers to be planning for the transition in order to minimize the impact of additional coal mine closures, job losses and mining company financial hardships.

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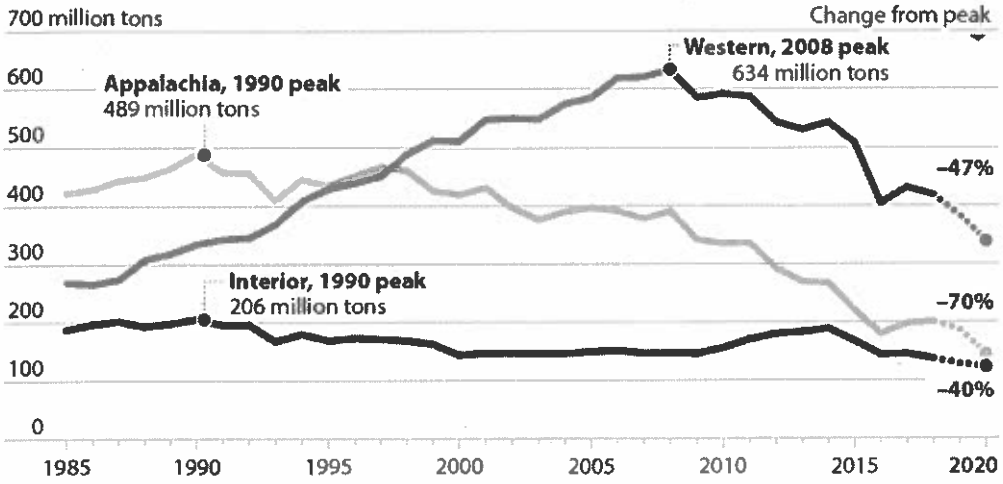
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Overview

By 2020, Illinois Basin production will have fallen 40 percent since its peak in 1990, part of a widespread decline in the U.S. (see the chart below). Other major coal-producing regions such as Appalachia[1] and the Powder River Basin[2] [3] are faring even worse, with the drop in Appalachian production expected to hit 70 percent by next year compared to its peak, also in 1990. In the West, the decline has been happening even faster, and on a bigger scale: peak production occurred only a decade ago, in 2008, but by the end of 2020 will have been cut almost in half. The entire U.S. coal sector—long dominant in terms of electricity generation market share—is losing out to cheaper forms of energy that include gas-fired power and renewables (wind and solar), and it is doing so at a quickening pace.[4]

U.S. Regional Coal Production, 1985-2018, With Estimates to 2020

Output has fallen sharply in all three major coal mining regions. From their peak years to 2020 (using the latest estimates from the U.S. Energy Information Administration), production is expected to have fallen by 40 percent in the Interior, which includes the Illinois Basin, 47 percent in the West, and 70 percent in Appalachia.



Source: Energy Information Administration (2019-2020 estimates from Nov. 2019 Short-Term Energy Outlook)

Power markets are modernizing, and traditional coal-fired generation is becoming increasingly anachronistic. In 2018, 15,500 megawatts (MW), or 6 percent of all coal-fired capacity in the U.S., was retired, with an additional 14,000MW retiring this year, and many plants that are still in operation are being used less and less frequently by utilities. This year alone, power generation from coal has fallen by 13.4 percent through September, compared to the same period in 2018.[5] The result has been widespread financial carnage over the past two years for the coal industry,

[1] S&P Global Market Intelligence. Coal production fell 15.1% quarter to quarter at top Northern Appalachia mines, November 2019.
[2] IEEFA. Powder River Basin Coal Industry Is in Long-Term Decline. March 2019.
[3] S&P Global Platts. Moody's expects Powder River Basin coal mine closures in early 2020s. October 2019.
[4] IEEFA. Data shows U.S. shift away from coal-fired generation is intensifying. November 2019.
[5] EIA, Electric Power Monthly, November 2019, table ES1.B.

in which 11 U.S. mining company bankruptcies have occurred. One recent news headline crystallized the trend and put the very future of American coal mining in question—"Bankrupt giants hand unwanted coal mines to unknown firms."[6]

In the Illinois Basin specifically, the pace of mine closure announcements has picked up in recent months. In addition, other Illinois Basin mines have been "temporarily idled," a misleading industry term that suggests those mines will reopen when economic conditions improve, but in fact likely will never return to production. Such idlings, can, however, serve as a way to stave off mandated reclamation.

Put bluntly, declining demand means more mines across the Illinois Basin will need to close in the months and years ahead—just as more coal mines will close nationally—and those closures will likely come at a faster rate than has previously been seen.

The decline of the American coal industry more generally is gaining momentum, pushed out by cheap gas from fracking and rapidly falling costs for wind, solar and storage. These trends are discussed in greater detail in IEEFA's annual coal-outlook report published eight months ago[7] and in regional IEEFA research published this year that has included analysis of the Powder River Basin of Montana and Wyoming and of coal-fired generation in the Southeast U.S. (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee and Virginia).[8]

The continuing rise of renewables, which are increasingly competitive and in many cases cheaper than coal-fired power, was detailed in a Lazard report published just this month.[9] "That phenomenon has increased this year," a Lazard representative said in a report follow-up.[10] "There are situations where the cost of building new wind and the cost of building new solar are cheaper than keeping a coal or nuclear plant operating. And even on an unsubsidized basis, we're starting to see those costs undercut the marginal cost of coal and nuclear."

Similar sentiments have even been voiced by executives within the coal-mining industry itself. Speaking generally of Illinois Basin coal mines, a Hallador Energy executive, for instance, said on an earnings report call in May of this year, "Some of these assets are not long for this world."[11]

Likewise, executives at big utility companies are openly acknowledging the phase-out of coal-fired generation. The CEO of Xcel Energy, for example, said in a June 2018 speech, "It's not a matter of if we're going to retire our coal fleet in this nation, it's just a matter of when."[12] Xcel is of note for two reasons. One, its size (Xcel sells power across the Upper Midwest and in the West), and, two, its aggressive renewable energy buildout, which S&P Global Market Intelligence concluded in a

[6] E&E News. Bankrupt giants hand unwanted coal mines to unknown firms. November 2019.
[7] IEEFA. Coal Outlook 2019: Domestic Market Decline Continues. March 2019.
[8] IEEFA. Coal-Fired Power Generation in Freefall Across Southeast U.S.. October 2019.
[9] Lazard: Lazard's Levelized Cost of Energy Analysis, Version 12.0. November 2019.
[10] S&P Global Market Intelligence. Renewable energy costs continue to abate, beating coal and nuclear, Lazard says. November 2019.
[11] Hallador Energy Company. First Quarter 2019 Earnings Conference Call. May 2017.
[12] Greentech Media. Xcel CEO Says Retiring the US Coal Fleet 'Just a Matter of When'. June 2018

September 2018 analysis "augers well" for Xcel to deliver on its goals of increasing long-term earnings per share by 5 to 6 percent annually and increase dividends annually by 6 to 7 percent.[13]

As the decline in Illinois Basin's coal-production continues, companies that have mines in the region will continue to face market pressure. They include (ranked by amount of Illinois Basin production) Alliance Resource Partners, Murray Energy and its partner Foresight Energy, Peabody Energy, Hallador, Arch Coal and White Stallion.

State-by-state reviews of these companies' utility customers offer another window on why the Illinois Basin coal industry is in such peril. As major customers in states like Florida, for instance, continue to move aggressively away from coal, demand for Illinois Basin coal will weaken further. And export markets aren't likely to be of much help, as Murray Energy executives conceded when the company filed for bankruptcy in October.[14]

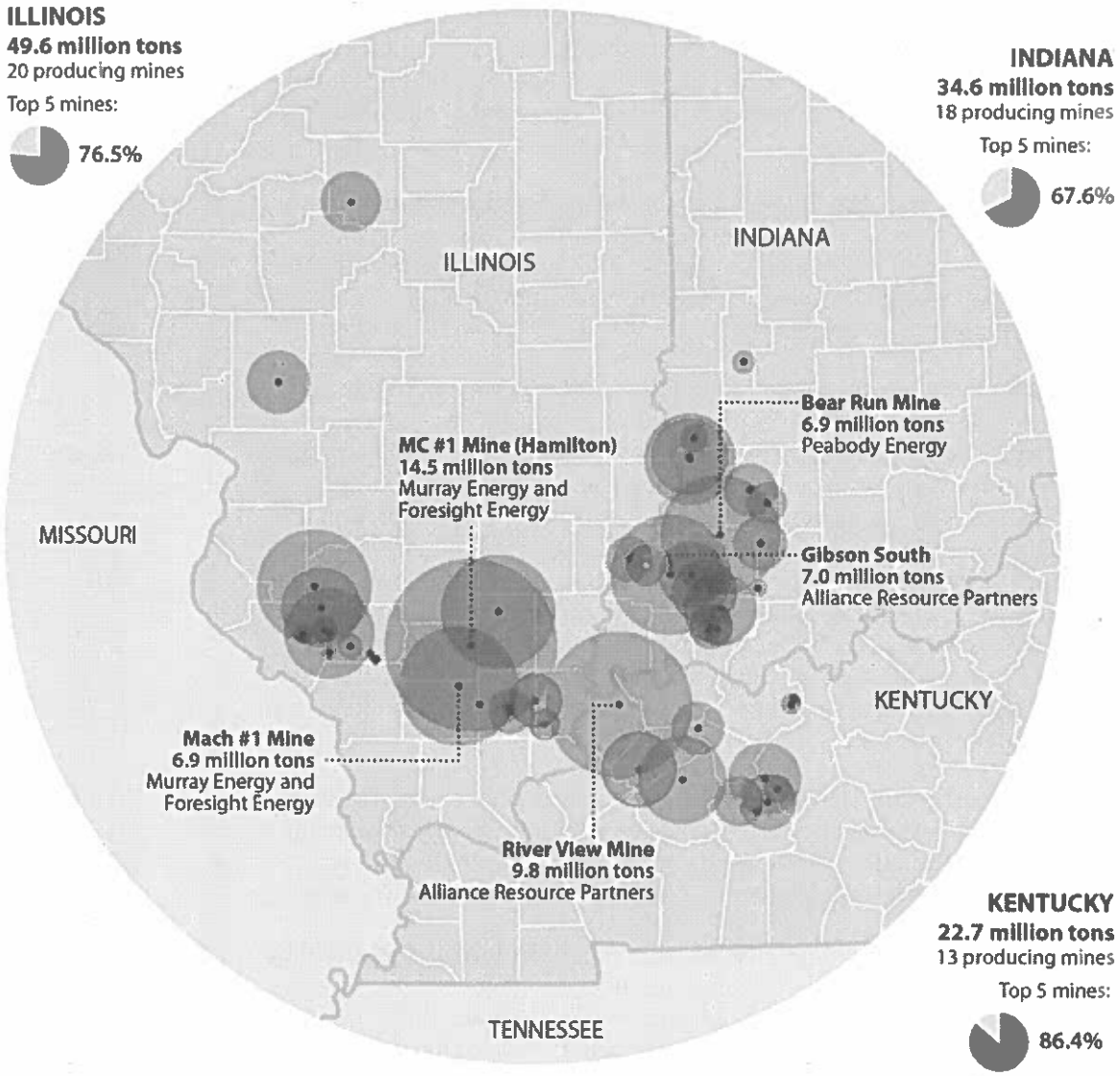
The map on page 7 shows recent coal-industry activity across the Illinois Basin.

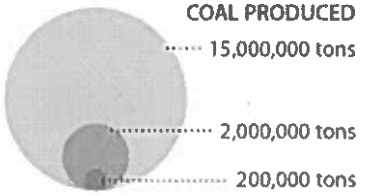
[13] S&P Global Market Intelligence. With wind at its back, Xcel Energy's renewables build-out augurs well for growth. September 2018.
[14] S&P Global Market Intelligence. Logistics chain adapting to US coal sector's decline, export volatility. November 2014.

Illinois Basin Coal Production, 2018

Total production: **106.8 million tons**

Market forces are beginning to work against the coal-mining industry in the Illinois Basin. Declines in export demand and gathering momentum around retirements of coal-fired plants will affect every state and every company in the basin. Recent mine closures and idlings are part of an emerging long-term trend that will likely result in fewer mines regionally and far less production. On this map, circle sizes are proportional to production; the top five regional mines are labeled.





COAL MINE STATUS
As of November 2019

- Active
- Temporarily idled
- Permanently closed

Institute for Energy Economics and Financial Analysis
IEEFA.org

Sources: Energy Information Administration; S&P Global Market Intelligence

The Company-by-Company View

Alliance, Murray-Foresight, Peabody, Hallador, Arch, White Stallion

The company-by-company maps on the following pages show the geographic presence of the six biggest producers in the basin. Ranked by Illinois Basin production in 2018, they are Alliance Resource Partners (29.9 million tons), Murray/Foresight Energy (28.6 million tons), Peabody Energy (18.6 million tons), Hallador Energy (7.6 million tons), Arch Coal (6.3 million tons) and White Stallion (5.6 million tons); together these companies produced 90 percent of all the coal mine produced in the basin in 2018.

Collectively, the maps suggest stability—that is, they show how most mines in the region remain open. But they also show a developing trend of either permanent closures or companies designating mines as "temporarily idled," a highly misleading term. The reality in today's rapidly changing electric generation market is that these idled mines will probably never reopen.

Thus, the "temporary" idling in November of the Gibson North Mine in Indiana by Alliance likely means this mine will never again produce coal; 185 workers were affected. Gibson North produced nearly 900,000 tons in 2018, and 1.7 million tons in the first nine months of 2019.[15] In August, Alliance permanently closed the Dotiki mine in Kentucky, affecting about 200 workers. At this mine, production in 2018 totalled 2.5 million tons.[16] Similarly, Murray Energy/Foresight Energy ceased production in April at Paradise #9 in Kentucky, which produced 1.1 million tons in 2018, and Peabody in October closed the Somerville Central Mine in Indiana, which produced 2.1 million tons in 2018. In December, Peabody will finish closing its Wildcat Hills mine complex in Illinois, which produced 1.7 million tons in 2018, and the company in the past year has closed two smaller mines—one each in Illinois and Indiana— that together produced 600,000 tons in 2018.

Collectively, then, almost 9 million tons, or 8.4 percent of the Illinois Basin's 106.8 tons of production in 2018 has been taken off the market in the past year or so for lack of demand, and additional production cuts are likely based on the EIA's short-term forecast for 2020, which sees production cuts increasing to 11 million tons.

The effect will be substantial on companies that operate in the Illinois Basin, and the recent mine closures noted above—by Alliance, by the recently bankrupt Murray/Foresight and by Peabody—signal a future in which Illinois Basin producers will continue to lose customers in the U.S. and in foreign markets alike.

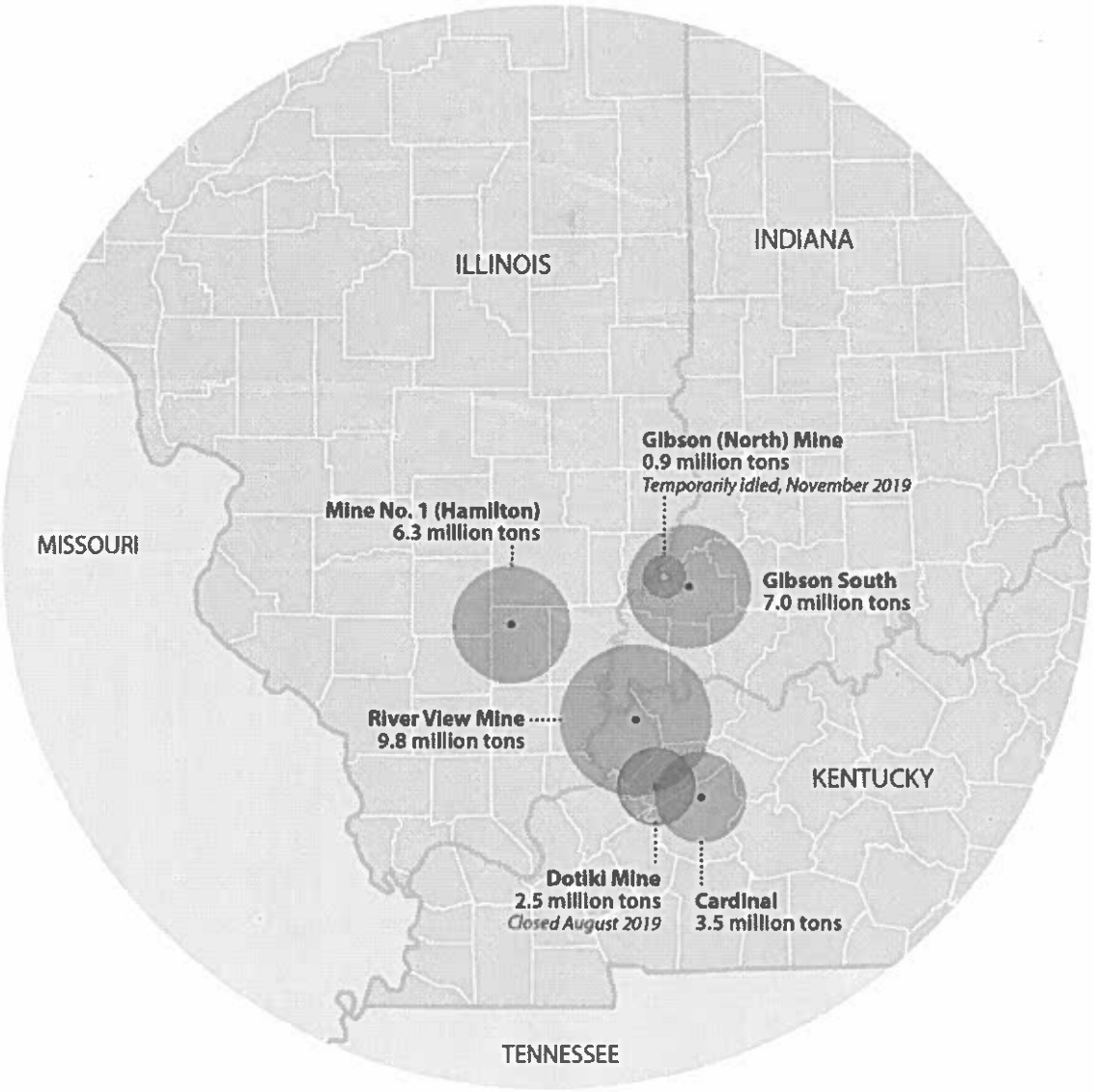
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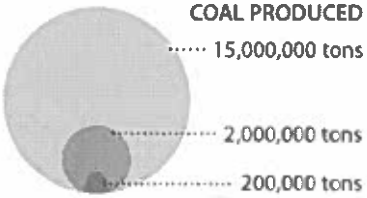
[15] Alliance Resource Partners. Alliance Resource Partners, L.P. Announces Issuance of WARN Act Notice at Gibson Complex. November 2019.

[16] Alliance Resource Partners. Alliance Resource Partners, L.P. Announces Coal Production Ceasing at Dotiki Mine, August 2019.

Alliance Resource Partners
29.9 million tons produced
6 mines

28.0% of Illinois Basin production, 2018





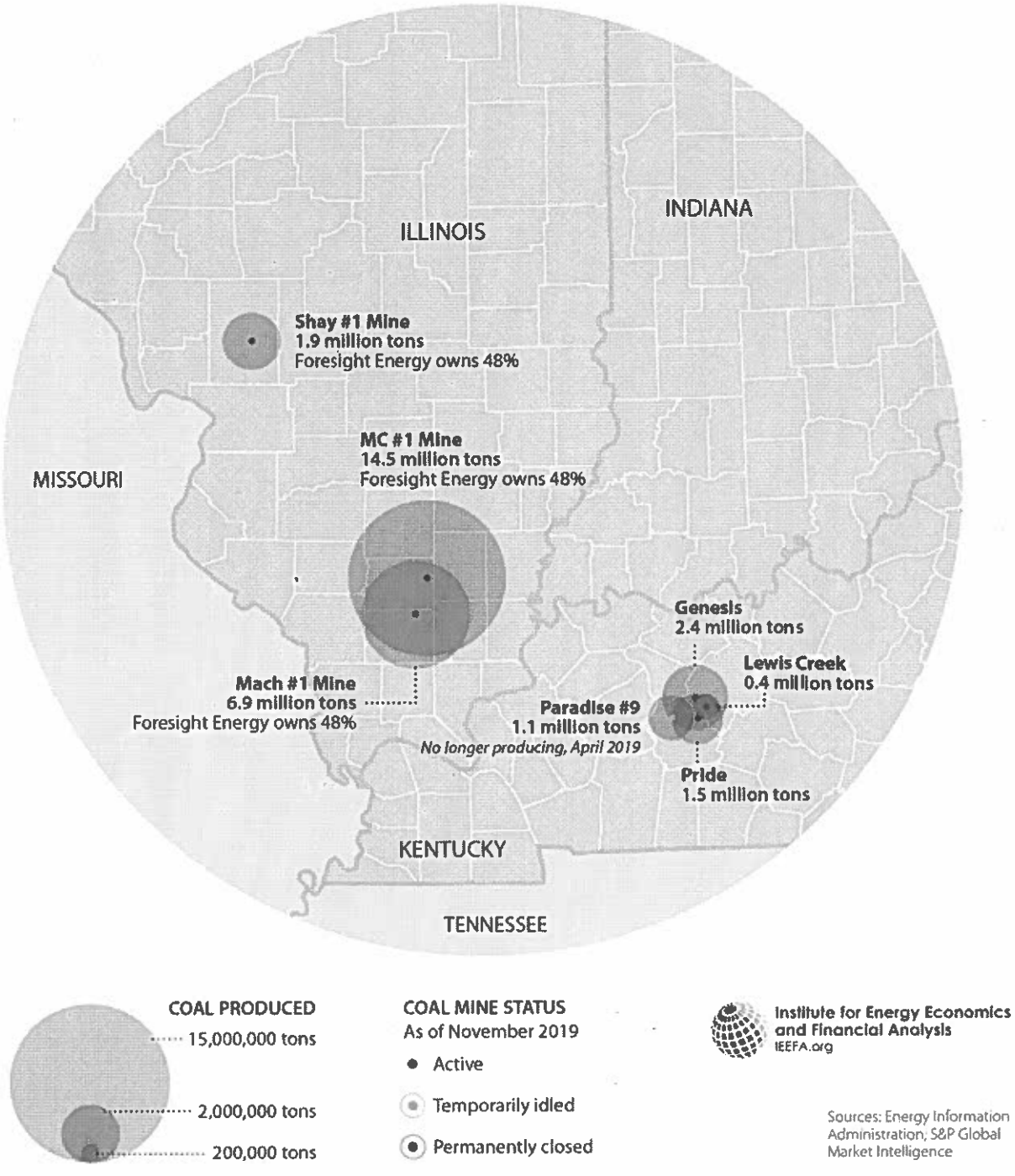
COAL MINE STATUS
As of November 2019

- Active
- Temporarily idled
- Permanently closed

Institute for Energy Economics and Financial Analysis
IEEFA.org

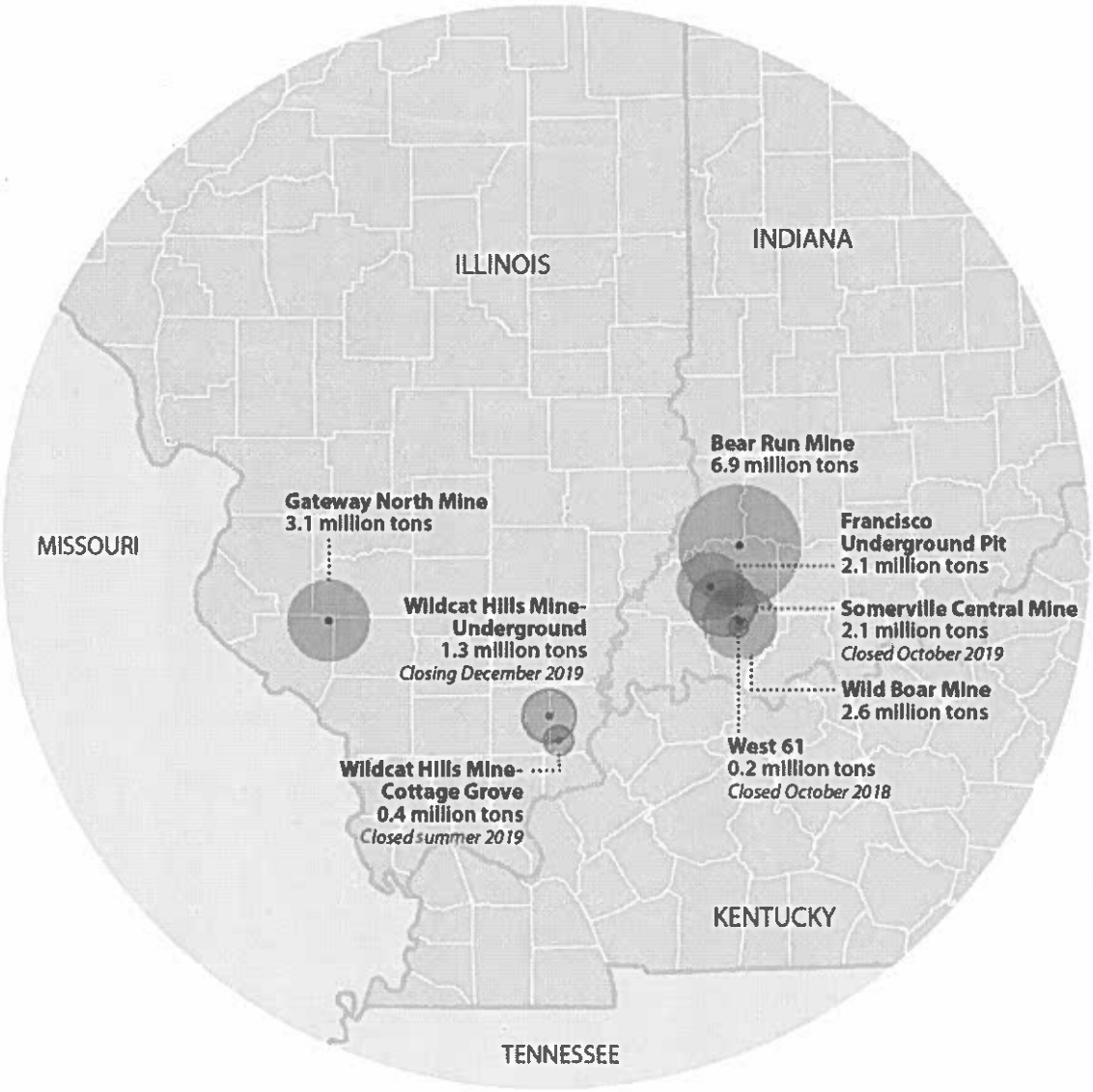
Sources: Energy Information Administration; S&P Global Market Intelligence

Murray Energy – Foresight Energy
28.6 million tons produced
7 mines *4 Murray Energy mines and 3 mines 48% owned by Foresight Energy*
26.8% of Illinois Basin coal, 2018



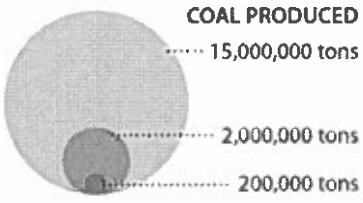
Peabody Energy
18.6 million tons produced
8 mines

17.4% of Illinois Basin production, 2018



Hallador Energy
7.6 million tons produced
4 mines
7.1% of Illinois Basin production, 2018





COAL MINE STATUS
As of November 2019
- Active
- Temporarily idled
- Permanently closed

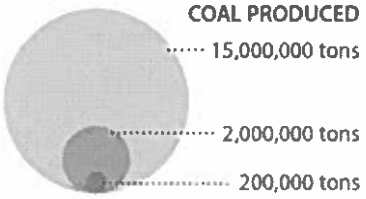
Institute for Energy Economics and Financial Analysis
IEEFA.org

Sources: Energy Information Administration; S&P Global Market Intelligence

Arch Coal
6.3 million tons produced
5 mines *Includes 4 mines 51% owned by CBR Investments*

5.9% of Illinois Basin production, 2018





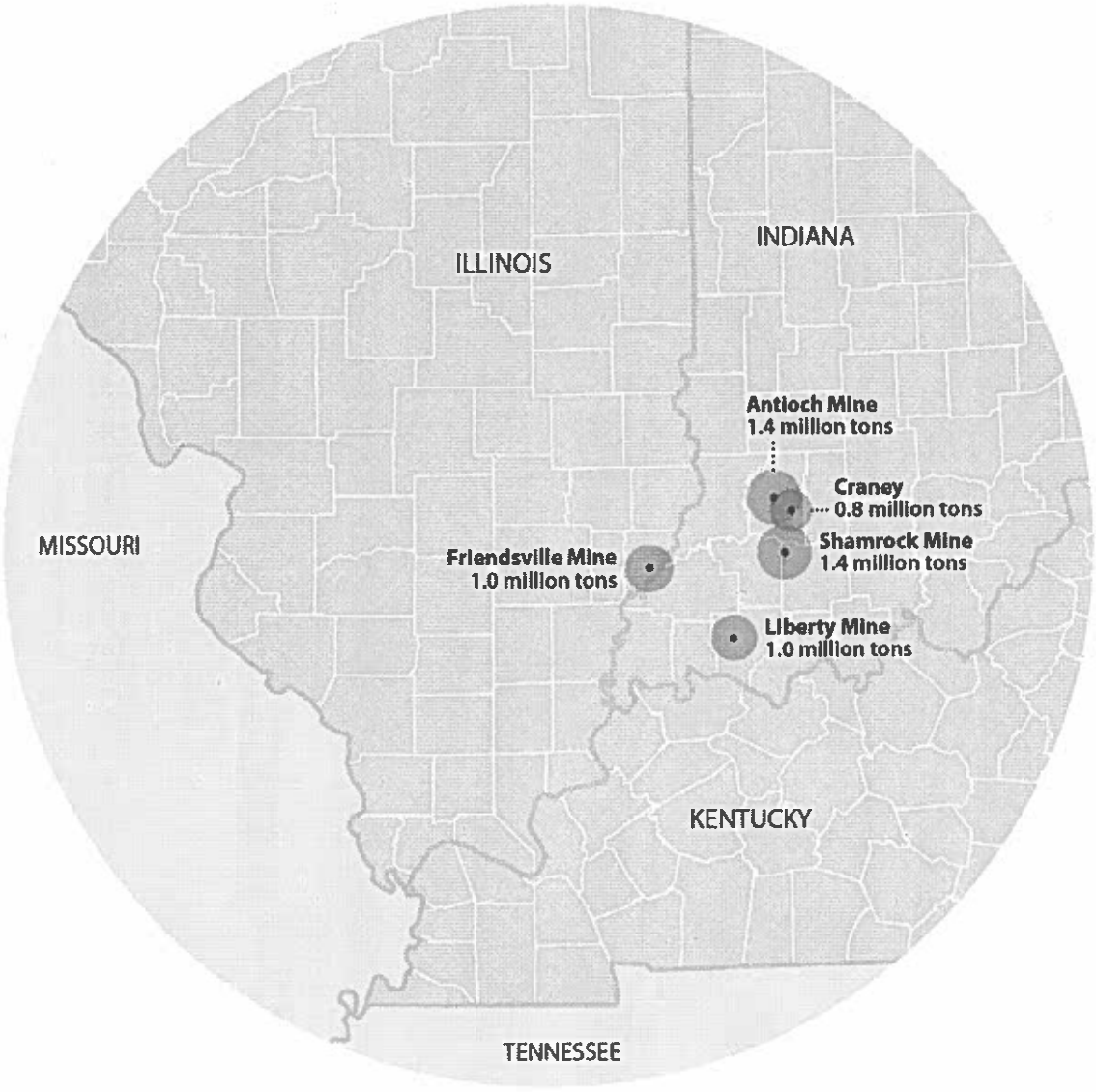
COAL MINE STATUS
As of November 2019

- Active
- Temporarily idled
- Permanently closed

Institute for Energy Economics and Financial Analysis
IEEFA.org

Sources: Energy Information Administration; S&P Global Market Intelligence

White Stallion
5.6 million tons produced
5 mines
5.2% of Illinois Basin production, 2018



COAL PRODUCED
15,000,000 tons
2,000,000 tons
200,000 tons

COAL MINE STATUS
As of November 2019
- Active
- Temporarily idled
- Permanently closed

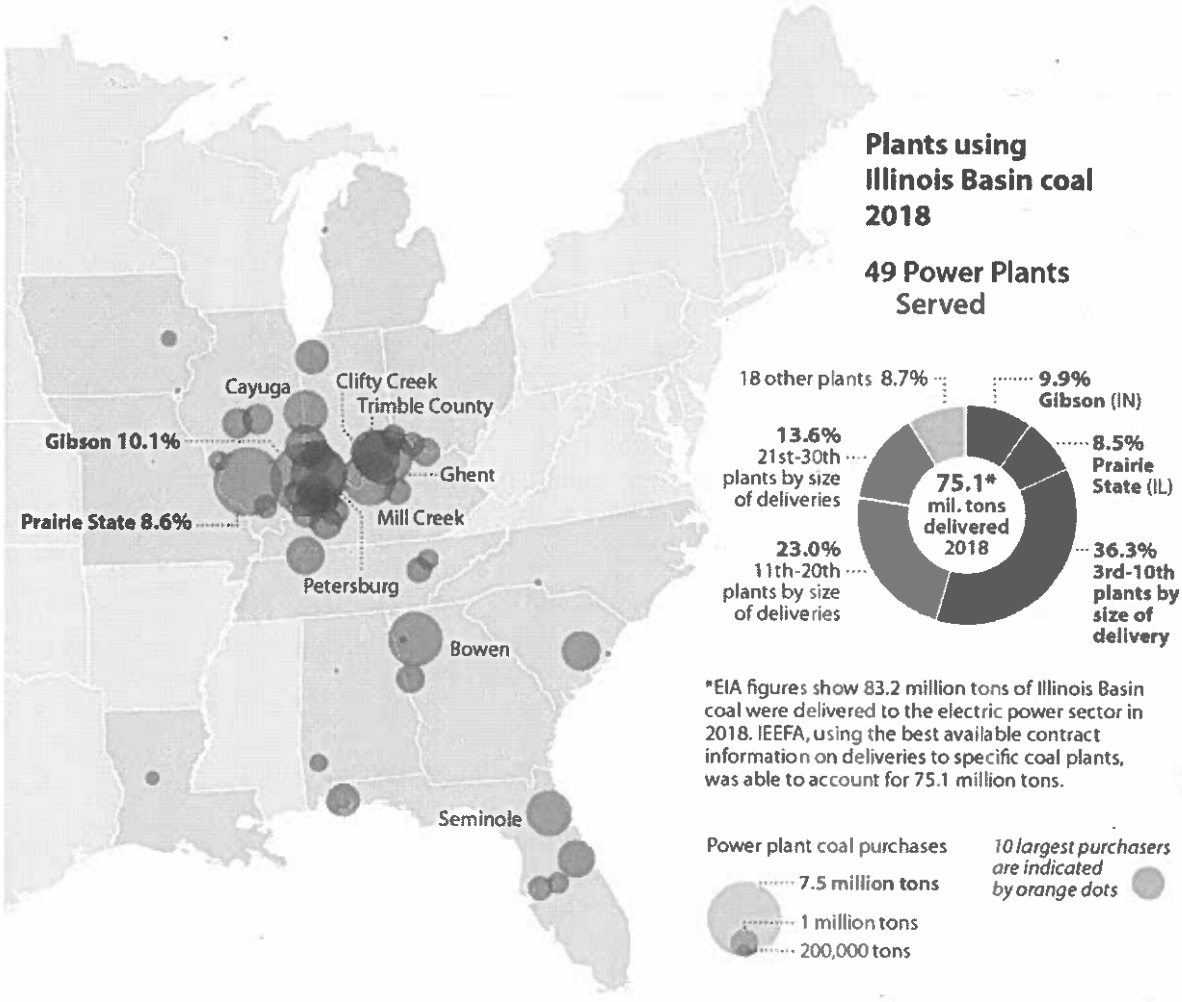
Institute for Energy Economics and Financial Analysis
IEEFA.org

Sources: Energy Information Administration; S&P Global Market Intelligence

State-by-State and Customer-Base Slippage

Retirement Dates Loom for More Coal Plants

The problem facing the Illinois Basin coal-mining industry is made clear by focusing on its 49 domestic power-plant customers, which collectively consumed nearly 80 percent of 2018 production and are scattered across states that run from the heart of the Midwest into the Deep South. The 10 largest customers, shown below with orange circles, stretch across Florida, Georgia, Illinois, Indiana and Kentucky, and together use more than half of the coal the basin delivers domestically. The other 39 customers are marked by purple circles. The size of the circles is proportional to the amount of Illinois Basin coal delivered.



Sources: S&P Global Market Intelligence; Energy Information Administration

A significant portion of this customer base will be phased out over the next five years, based on already-announced retirement plans (see the map on page 17).

A clear view of the future of the basin's customer base can be seen in Duke Energy Indiana's June announcement about its retirement plan for the Gibson coal-fired plant. The closure of this plant, the Illinois Basin's largest single coal customer, accounting for almost 10 percent of sales in 2018, almost certainly signals an end date for most of the Illinois Basin coal industry. Situated on the Wabash River across from Mt. Carmel, Ill., the Gibson plant is one of the largest power plants in the U.S., with more than 3,100MW of capacity, and it sits in the heart of Indiana's coal-mining area, very close to Alliance Resource Partners' Gibson coal mine complex.

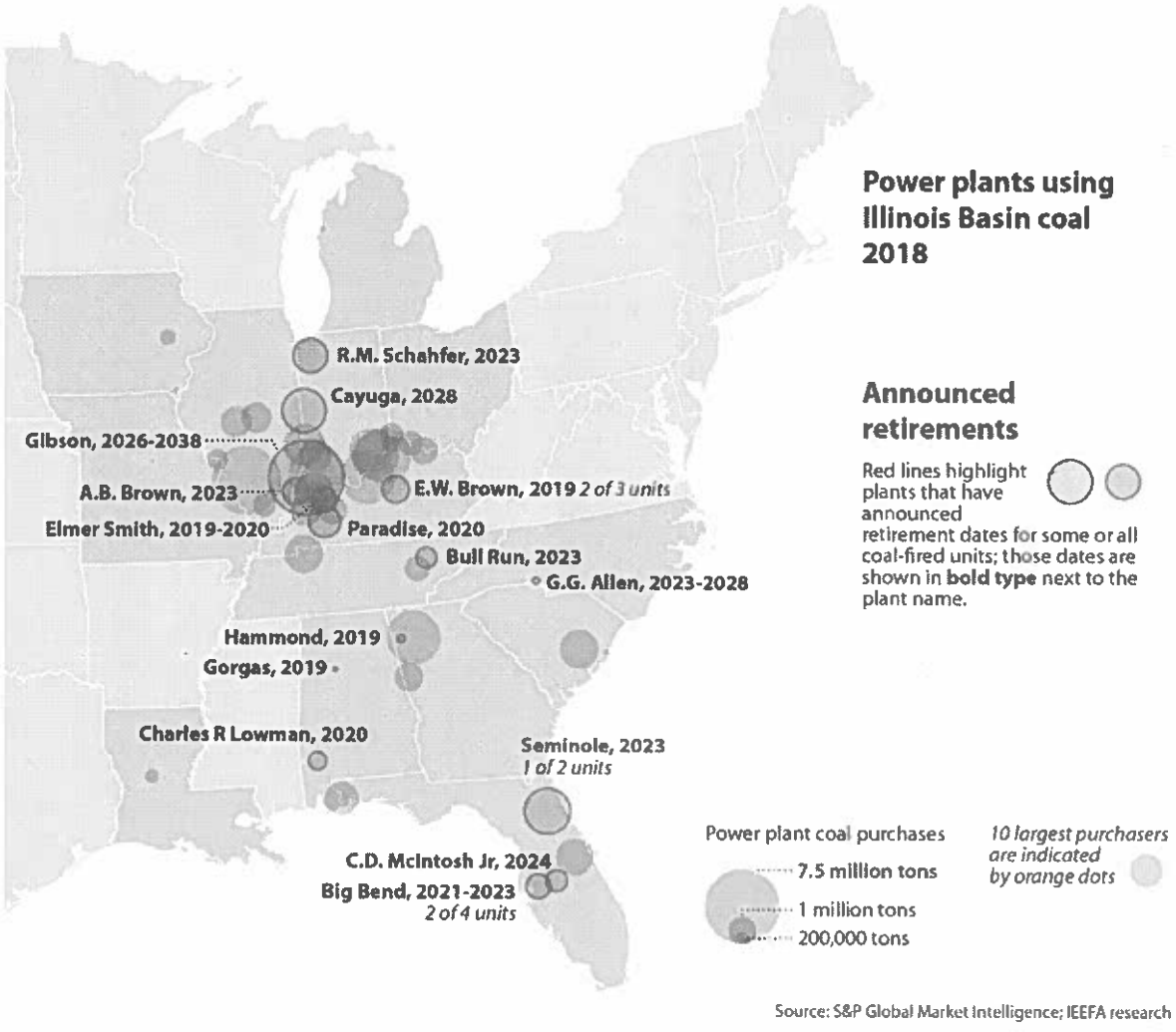
The dates of the planned closures of the plant's five units, each of which has a nameplate capacity of about 630MW, suggest the timeline the decline of the region's coal industry will follow as well. Unit 4, for example, will now be shut down in 2026, nearly 20 years earlier than its originally-planned retirement in 2044, according to Duke (all the units began operation between 1975 and 1982). Units 3 and 5 will now be shut in 2034, a decade before their previously expected retirements in 2043 and 2047, respectively. The last two units, Units 1 and 2, will be retired in 2038 instead of 2041 and 2040. Yet even these retirement dates may be optimistic: utilities have frequently accelerated their retirement timeframes as coal-plant economics have worsened.

Existing plants have been running less, too. As coal has become less competitive against gas and renewables, larger utilities have been able to fuel-switch across their generation fleets, favoring these cheaper sources whenever they can. As a result, Gibson has been running less than it could. In August, for example, the plant operated at just 33 percent of capacity, its lowest monthly level in at least two decades. In addition, as coal plants like Gibson age, they require more maintenance, and if they are run less, the overall cost of their power goes even higher, making such plants even less competitive.

With the economics of coal-fired power deteriorating, more and more utilities have been accelerating retirement dates. In northern Indiana, for instance, the utility NIPSCO recently said it would save $4 billion by retiring its coal plants early and passing those savings on to customers.

It is worth noting that the corporate and financial relationships between the coal-mining companies and the utilities that buy their coal plays a significant role in how quickly coal is being phased out in the Illinois Basin—and across the U.S., for that matter. For the most part, utilities do not have financial stakes in coal mining, and the coal plants they have are usually part of a larger fleet of generation assets that run on a mix of fuels. This encourages them—as is broadly required by state utility oversight agencies—to operate their plants in the most economically efficient way possible, freeing them to cut expensive coal generation without incurring losses when the mines they buy from are closed. They are usually just buyers of fuel, and not in the business of extracting and processing that fuel.

In Illinois, though, there is one major exception: the 1,624MW Prairie State Energy Campus in Washington County. Prairie State is owned by a group of municipalities, public authorities and rural electric cooperatives who also own the neighboring Lively Grove coal mine that supplies the generation station. This practically-new plant, opened in 2012, is the second-largest consumer of Illinois Basin coal, accounting for 8.6 percent of all production in 2018, but it comes entirely from the Lively Grove mine. This self-contained economic structure has locked the owners into very high power costs without much flexibility to shift to cheaper and cleaner generation resources, either from their own renewables or from regional power markets that are increasingly supplying low-cost wind power. IEEFA has written extensively about the situation in past reports.[17] [18]



[17] IEEFA. Cost of Coal From 'Mine-Mouth' Prairie State Plant Isn't the Bargain That Was Promised. April 2015.

[18] IEEFA. 2014, Another Year of Unmet Promises for the Prairie State Energy Campus. February 2015.

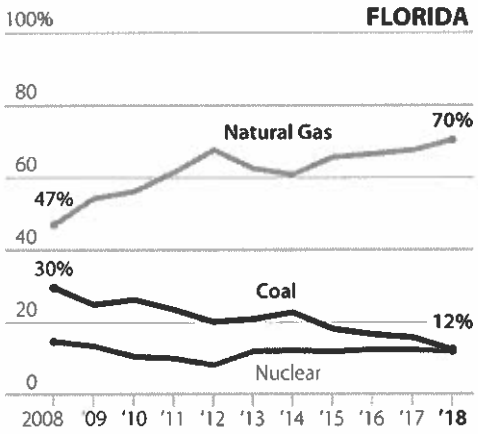
Florida, Georgia, Illinois, Indiana, Kentucky

FLORIDA

Coal-fired generation in the Sunshine State is on the way out, as can be seen in well-rooted trends that date back a decade at least. Gas-fired generation now accounts for 70 percent of all electricity production in Florida. Coal-fired plants contributed 30 percent to Florida's power mix as recently as 2008; that number had fallen to 12 percent by 2018.

The 2010 census put the state's population at 18.8 million, and by 2018 that number had risen 6 percent, to 21.3 million.[19] While electricity consumption in the state has climbed with its population boom, none of that demand increase was supplied by coal.[20]

Fuel Share for Electric Power Generation (Utility Scale, All Sectors)



Only fuels with 5% or more share in any year are shown.
Source: Energy Information Administration

While gas-fired generation has taken a bigger and bigger share of the market, the state's three biggest utilities—Duke Energy Florida, Florida Power and Light, and Teco Energy—have plans to install more than 11GW of solar over the next 10 years.[21] While the state comes belatedly to solar—a circumstance rich with irony, considering how Florida's nickname is the Sunshine State—it has recently made a hard pivot toward utility-scale solar. In 2018, the three major utilities brought a total of 876MW of utility-scale solar online,[22] roughly enough capacity to power almost a million homes. Simultaneously, battery storage is coming online in a fast-spreading advance that stands to bolster the uptake of solar.

Florida's coal-fired capacity has fallen by more than half over the past decade to 7,883MW, of which 2,094MW will be retired by 2024, according to utility-company announcements.

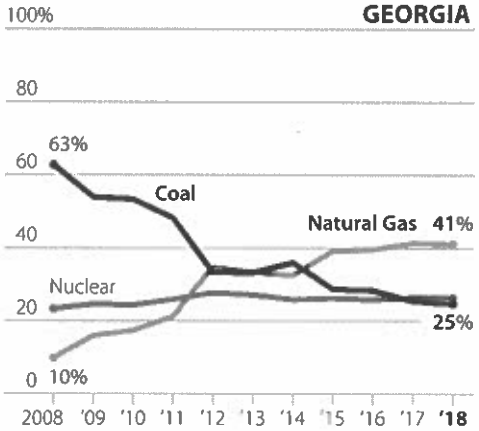
[19] U.S. Census Bureau. Quick Facts Florida, July 2018.
[20] IEEFA. Coal-Fired Power Generation in Freefall Across Southeast U.S., October 2019.
[21] Ibid.
[22] Smart Electric Power Alliance. SEPA's 2019 Solar Snapshot Report Finds Florida's Solar Market is Flourishing, June 2019.

GEORGIA

Electricity-generation trends in Georgia are similar to Florida's. Coal-fired generation market share fell from 63 percent in 2008 to 25 percent in 2018. That share will drop further in the near future— and for the same reasons seen in Florida. Gas-fired generation is cheaper, as is utility scale solar (Georgia Power plans to have 2,260MW of utility-scale and distributed solar online by 2024).

Georgia has only three coal-fired generation plants, although two are the largest in the U.S., the 3,392MW Plant Scherer and the 3,200MW Plant Bowen. The third, 1,744MW Plant Wansley, is very likely to follow in the footsteps of Plant McIntosh (142MW) and Plant Hammond (840MW),[23] both of which were retired this past July. Plant Bowen is an especially big Illinois Basin customer, ranking fifth among Illinois Basin users in 2018 (3.93 million tons). Its owner, the Southern Company subsidiary Georgia Power, published an updated integrated resource plan (IRP) this year noting "economic challenges"[24] facing the plant.

Fuel Share for Electric Power Generation (Utility Scale, All Sectors)



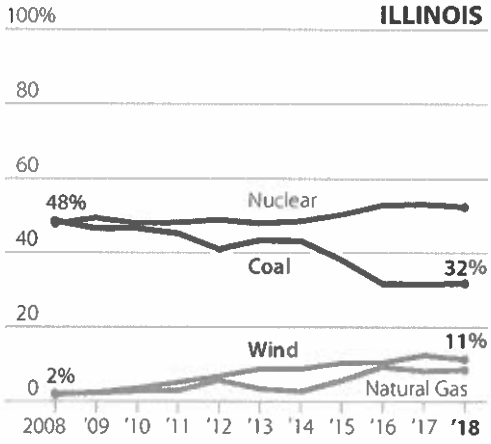
Only fuels with 5% or more share in any year are shown.
Source: Energy Information Administration

ILLINOIS

Illinois has the strongest renewable energy standards of the five states noted here, with a goal of getting 25 percent of its power from renewable sources by 2025.[25]

It is also where markets are driving a wave of coal plant closures that are very quickly reshaping the state's energy economy. Vistra Energy is the prime example, having recently announced that it would close the 585MW E.D. Edwards plant at the end of

Fuel Share for Electric Power Generation (Utility Scale, All Sectors)



Only fuels with 5% or more share in any year are shown.
Source: Energy Information Administration

[23] IEEFA. Coal-Fired Power Generation in Freefall Across Southeast U.S., October 2019.
[24] Georgia Power. 2019 IRP, Docket #42310, Section 1-7, Unit Retirements. December 2018, 1-7.
[25] National Conference of State Legislatures. State Renewable Portfolio Standards and Goals. accessed November 2019.

2022.[26] The company had already announced that it would close four other coal-fired plants in Illinois this year with a total capacity of about 2,000MW.

Vistra, an energy behemoth with 10 coal-fired plants in the U.S. that have a total of 11,000MW of generation capacity, in October announced new emissions-reduction goals in which executives at the company said it "anticipates retiring more coal assets."[27]

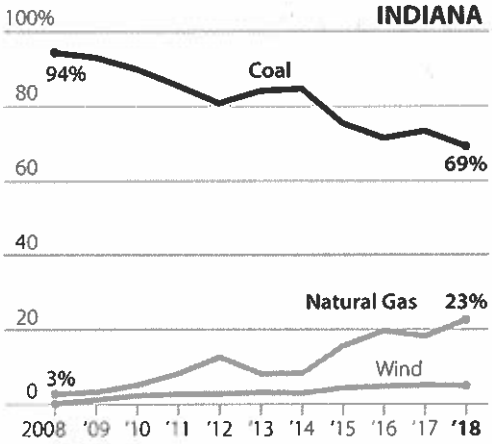
INDIANA

Indiana is not considered a leader in electricity-generation transition policy, but market-driven changes are occurring, nonetheless.

The state has a formal goal of getting 10 percent of its electricity from "clean energy" by 2025, but the parameters for meeting that target are loosely defined and favor "clean coal" technology and gas-fired generation.

Market changes may outpace state policy, however. The Northern Indiana Public Service Company (NIPSCO) this year announced plans to abandon coal-fired electricity generation entirely and to focus on utility-scale solar generation and other renewable generation. In October, NIPSCO published requests for proposals for development of 2,300MW of solar and 300MW of wind-powered generation.

Fuel Share for Electric Power Generation (Utility Scale, All Sectors)



Only fuels with 5% or more share in any year are shown.
Source: Energy Information Administration

"The driver for how we make decisions is really rooted in economics and costs for our customer," an executive at the company said when the RFPs were announced.[28]

KENTUCKY

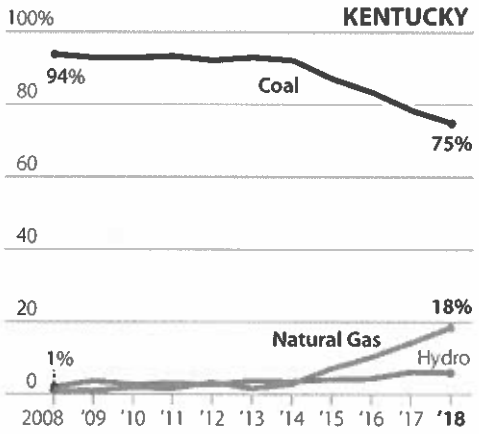
Even Kentucky, reliant on coal for 94 percent of its electricity generation a decade ago, is changing. Coal's share of the state's power-generation market dropped 19 points from 2008 to 2018, a shift owing almost entirely to the rise of gas-fired generation.

[26] Utility Dive. Judge OKs $8.6M Vistra coal plant closure settlement seen by NGOs as model for helping impacted communities. November 2019.
[27] Vistra Energy. Vistra Energy Announces Long-Term Emissions Reduction Targets and Support for Market-Based Carbon Reduction Regime. October 2019.
[28] Greentech Media. The Solar Boom Takes Off in the Industrial Midwest. October 2019.

Although Kentucky has deep cultural connections with coal, existing national power-generation trends will likely gain momentum in the state for purely economic reasons. They will be driven also by corporate policy initiatives, as U.S. companies that do business in Kentucky are adopting increasingly stringent requirements on where their electricity comes from.

Utility companies in Kentucky are also evolving. Kentucky Utilities and Louisville Gas & Electric are both subsidiaries of PPL Corporation, which last year announced plans to cut its carbon-dioxide emissions by 70 percent from 2010 levels by 2050. According to the corporation, among the measures that will be needed to reach that goal "include replacing Kentucky coal-fired generation over time with a mix of renewables and natural gas while meeting obligations to provide least-cost and reliable service to customers."[29]

Fuel Share for Electric Power Generation
(Utility Scale, All Sectors)



Only fuels with 5% or more share in any year are shown.
Source: Energy Information Administration

The Export-Market Problem

Market Forces Continue to Work Against Coal Overseas, Too

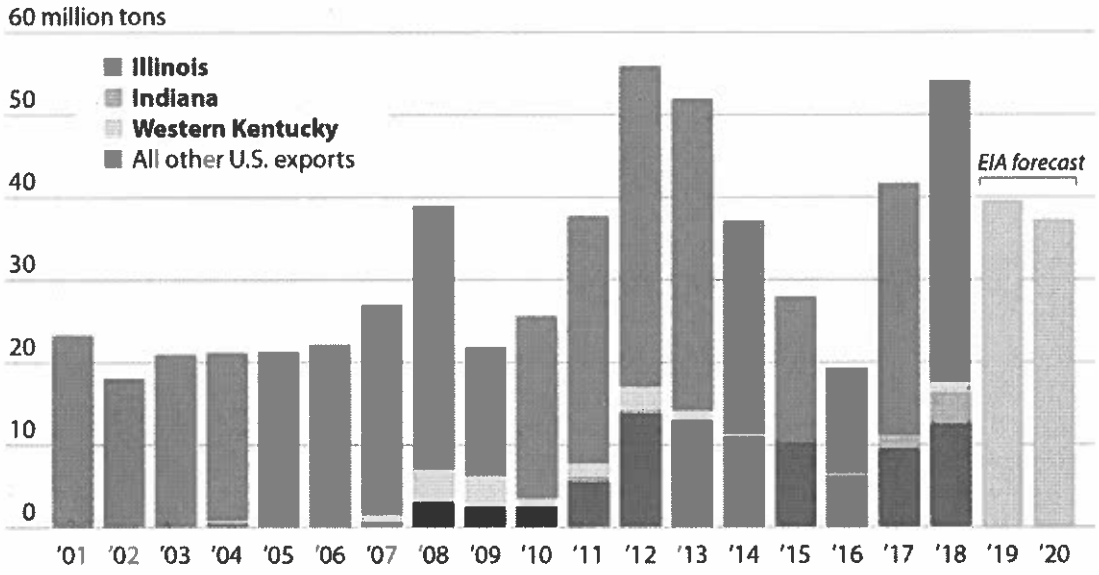
Beginning about a decade and a half ago, Illinois Basin producers saw potential in shipping coal to Europe, India and elsewhere for power-generation purposes.

These ambitions paid off as European demand for U.S. coal rose—for a while. But the same market forces that are moving against coal in the U.S. are working against European coal-fired generation too. A handful of countries in the 28-member European Union continue to rely heavily on coal-fired power but even nations like Poland, which in some ways is the Kentucky of Europe, are seeing change.[30]

[29] PPL Corporation. 2018 Sustainability Report.
[30] S&P Global Market Intelligence. A way back for onshore wind as Poland revises draft energy policy to 2040. November 2019.

U.S. Thermal Coal Exports, and Exports from the Illinois Basin

Exports from the Illinois Basin have surged over the past decade, rising to roughly one-third of all U.S. exports. Most of that volume is from mines in one state, Illinois.



Source: Energy Information Administration, Annual Coal Distribution Reports

An October report published by the Carbon Tracker Initiative showed how four of five coal-fired power plants in the EU are losing money.[31] The report put EU coal fleet losses at €6.6 billion (US$7.1 billion) in 2019 alone.

"Policymakers and investors should prepare to phase out coal by 2030 at the latest," Carbon Tracker concluded, and—indeed—financiers,[32] political leaders,[33] and even mining companies[34] continue to distance themselves from European coal-fired power.

In addition, competition from other thermal coal-exporting countries is increasing, and they may be better positioned than exporters in the Illinois Basin. For example, Platts recently reported that Colombian and Russian coal is more price competitive in European markets than Illinois Basin, Northern and Central Appalachian coal."[35]

Outside Europe, other countries that are big importers of U.S. thermal coal, including India, South Korea and Japan, are also accelerating their adoption of renewable power in an effort to both cut pollution and reduce dependence on imported energy. As demand for coal declines, it will be increasingly difficult to

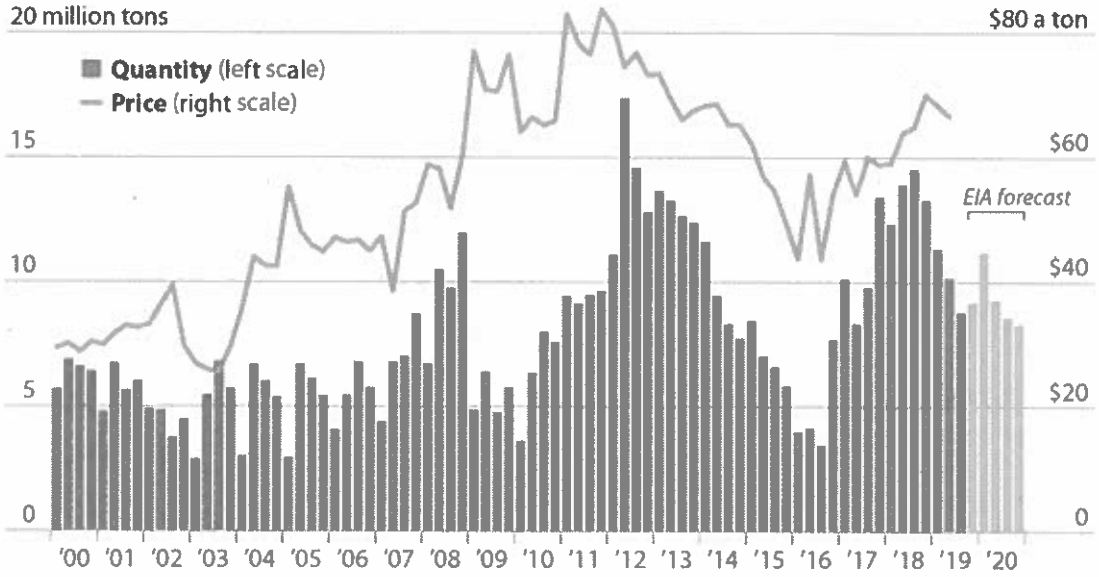
[31] Carbon Tracker Initiative. Four in five EU coal plants unprofitable as renewables and gas power ahead. October 2019.
[32] BBC News. European Investment Bank drops fossil fuel funding. November 2019.
[33] Reuters. Worried by climate change, EU moves to end fossil fuel funding. November 2019.
[34] Bloomberg News: Another Big Mining Company Hints at a Coal-Free Future. November 2019.
[35] Platts Coal Trader. "Russian, Colombian competition continuing to slow thermal coal exports". December 2, 2019. p.8.

sustain Illinois Basin exports.

All U.S. coal exports are highly dependent on international market prices, and volumes have waxed and waned with those price fluctuations, illustrating the fundamental volatility that defines the basin's export market.

U.S. Thermal Coal Exports, Quarterly

U.S. coal export volume has fluctuated considerably in recent years, but has tracked closely with market prices. Forecasts for the fouth quarter of 2019 and 2020 are from the EIA's November Short-Term Energy Outlook.



Source: Energy Information Administration

Conclusion

Structural and Permanent Decline; Opportunity in New Energy Models

The Illinois Basin's coal industry is entering a period of structural decline.

Within the next 20 years, virtually all of the U.S. coal-fired plants that currently buy the basin's coal will be either retired or little used, the result of an economic and technologically driven energy transition in the electric power industry that favors lower-cost and cleaner alternatives. In particular, wind, solar and battery storage—especially when combined—already offer utilities distinct advantages in grid resiliency, modernization and low maintenance, all with zero fuel expenses and declining construction costs. Inexpensive gas from hydraulic fracturing is also playing a major role in this transition, though the cost of renewables has already reached parity or undercut gas in many areas. No new American coal plants will be built.

As a result of this transition, a significant portion of the Illinois Basin's domestic power-plant customers now have dates for retirement within the next few years. IEEFA expects many more retirements beyond those over the next two decades. Further, coal consumption at existing power plants has begun to decline as they become less economically competitive, a trend that will accelerate as the difference in generation cost widens.

Growth in exports, which had masked declines in domestic demand until recently, appear to have peaked and turned lower. The same technology and market-based forces at work in the U.S. are at work as well in many of the basin's current or potential export markets, including Europe, India, Japan and South Korea, where utilities plan to cut coal use while increasing power generation from renewables. This will make it challenging for U.S. thermal coal exports over the long term. As demand in these markets starts to fall, international coal markets will likely be oversupplied, leading to intense price competition. The inherent volatility of the international export market, combined with permanently shrinking domestic demand and the generally weak financial condition of the coal-mining sector will necessarily lead to lower production and fewer companies (either from attrition or consolidation) operating in the region.

Twenty years from now, most of the Illinois Basin coal industry will be gone. While this may seem like a relatively far-off time, the economic impact from the constant drumbeat of coal-plant closures, mine closures and job losses will likely be significant in the region. Limiting the harm—and benefiting from the emerging economic opportunities—from this transition will require leadership, planning and support from federal, state and local officials.

And there are many real benefits, including long-term, non-agricultural income for farmers and counties from renewable power projects, lower electricity costs for individuals and businesses, economic activity from a regional buildout of renewables, improved power-grid resilience and construction and engineering jobs. Policymakers and communities that embrace this transition will be in the best position to gain a long-term advantage from these changes, and better able to offer lasting improvements that will be beneficial for everyone.

About IEEFA

The Institute for Energy Economics and Financial Analysis conducts research and analyses on financial and economic issues related to energy and the environment. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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Permanent Program Finding

Results of Review
Permanent Program Permit Application No. 456
Williamson Energy, LLC
Pond Creek No. 1 Mine

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The Illinois Department of Natural Resources, Office of Mines and Minerals, Land Reclamation Division (Department), the Regulatory Authority in Illinois under the Surface Mining Control and Reclamation Act of 1977 (Federal Act), 30 U.S.C. Section 1201 *et seq.*, has reviewed Permit Application No. 456 in accordance with the Surface Coal Mining Land Conservation and Reclamation Act (State Act), 225 ILCS 720, and the Department's regulations at 62 Ill. Adm. Code 1700-1850.

The applicant has submitted in writing the modifications required by the Department's letter dated December 20, 2018 (Appendix A). These modifications have been reviewed and approved by the Department. Pursuant to 62 Ill. Adm. Code 1773.19, the Department is approving the application as modified. The Department's decision is based upon a review of the record as a whole, and is supported and documented by the record. The findings and reasons for the Department's decision are set forth below. The period for administrative review under 62 Ill. Adm. Code 1847.3 commences as of the date of this decision.

I. SUMMARY OF APPLICATION

The application proposes a permit on 70.7 acres. The proposed permit area consists of 70.7 acres, of which all the acreage is are proposed to be used for support facilities.

The following is a summary of the pre-mining land uses and the proposed post-mining land uses. NOTE: Land uses are categorized under the definitions found in 62 Ill. Adm. Code 1701.5. Land use classifications under other regulatory programs and agencies may be different.

Land Use	Pre-Mining Acres	Post-Mining Acres
Cropland	16.4	16.4
Water Resources	0.2	0.2
Residential	0.1	0.1
Industrial/Commercial	8.2	8.2
Fish & Wildlife Habitat	45.8	45.8
Total	70.7	70.7

II. SUMMARY OF THE PUBLIC PARTICIPATION PROCESS

The Department finds that the public participation requirements of 62 Ill. Adm. Code 1773.13 and 1773.14 have been met.

The application was filed with the Department on May 25, 2017, and was deemed complete on July 13, 2017. The applicant placed a newspaper advertisement of the proposed operation in the Marion Republican and the Benton News, newspapers of general circulation in the area affected, once a week for four consecutive weeks, beginning on July 18, 2018. The applicant filed two (2) copies of the application with the County Clerks of Williamson County and Franklin County, in accordance with 62 Ill. Adm. Code 1773.13(a)(2), on July 18, 2018. Copies of the application were sent to the following State Agencies: Illinois Department of Agriculture (IDOA), and Illinois Environmental Protection Agency (IEPA), and the United States Department of Agriculture, Natural Resources Conservation Service (NRCS), and the United States Fish and Wildlife Service (USFWS) on July 13, 2018, for review and comment. In addition, copies were circulated with the appropriate Offices within the Illinois Department of Natural Resources (Department). Written notification of the application was given to those governmental agencies and entities required to receive notice under 62 Ill. Adm. Code 1773.13(a)(3).

State Agency comments on this application have been received by the Department, with the source and date of comments as follows: IDOA (September 21, 2018) and IEPA (August 30, 2018).

Comments on this application were also received from the NRCS dated September 12, 2018 and USFWS dated September 4, 2018 and October 2, 2019.

The Department received a request for a public hearing. The Department held a public hearing on October 23, 2018, in the Office of Mines and Minerals, Southern Illinois Regional Office in Benton, Illinois.

All comments received in writing and at the public hearing have been considered by the Department in reviewing this application. The Department's responses to these comments are set forth in Appendix B.

All comments received on this application have been furnished to the applicant, and have been filed for public inspection at the office of the County Clerk of the county in which the application is located.

III. SUMMARY OF THE DEPARTMENT'S FINDINGS

The Department, upon completing its review of the information set forth in the application, the required modifications submitted, if any, and information otherwise available, and made available to the applicant, and after considering the comments of State Agencies, and all other comments received, makes the following findings:

A. Findings Required by 62 Ill. Adm. Code 1773.15

REVIEW OF VIOLATIONS

Section 1773.15(b)(1): Based on a review of all reasonably available information concerning violation notices and ownership or control links involving the applicant, including information obtained pursuant to Sections 1773.22, 1773.23, 1778.13 and 1778.14, the Department has determined that the applicant or a person who owns or controls the applicant is currently in violation of the State Act, Federal Act or other law or regulation referred to in Section 1773.15(b)(1). Pursuant to this Section, the Department has determined that:

Section 1773.15(b)(1)(A): For the identified current violations, the applicant submitted proof that the current violations have been or are in the process of being corrected to the satisfaction of the agency that has jurisdiction over the violations.

Documentation provided by the applicant to comply with Section 1773.15(b)(1)(A) is attached as Appendix E.

Section 1773.15(b)(2): This permit is being conditionally issued on the basis of proof submitted under Section 1773.15(b)(1)(A) that the violation is in the process of being corrected. The conditional issuance is set forth in Part IV.

Section 1773.15(e): The Department received updated compliance information in the applicant's modifications response received October 21, 2019 and updated information on December 2, 2019. Based on the compliance review required by Section 1773.15(b)(1), a review of the OSM Applicant Violator System for outstanding violations, and in light of no new information submitted pursuant to Sections 1778.13(i) and 1778.14(e), the Department reconsidered its decision to approve the application and found that no change in its decision to issue the permit is necessary.

SECTION 1773.15(c)(1) FINDINGS

Section 1773.15(c)(1): The application, as modified, is accurate and complete and all requirements of the Federal and State Acts and the regulatory program have been met.

TOPSOIL SUBSTITUTION FINDING

Section 1817.22(b): The applicant has proposed the use of selected overburden materials as a substitution for, and a supplement to topsoil as delineated in the application. In accordance with Section 1817.22(b), the Department finds that the applicant has adequately demonstrated that the resulting soil medium is equal to, or more suitable for, sustaining vegetation than existing topsoil, and the resulting soil medium is the best available in the permit area to support vegetation. Permission is hereby granted to use the selected overburden as requested.

SEDIMENT POND EXEMPTION

Section 1817.46(e): A sediment pond exemption is requested for an area delineated in the application. The regulations at Section 1817.46(e) allow the Department to grant exemptions from the requirement to pass all disturbed drainage through a siltation structure when:

a. The disturbed drainage area within the total disturbed area is small; and

b. Alternate sediment control measures as described in Section 1817.45(b) are used in lieu of a siltation structure, and the applicant demonstrates that siltation structures are not necessary for drainage from the disturbed area to meet the effluent limitations and water quality standards for the receiving waters set forth in Section 1817.42.

The Department has determined that the area for which a sediment pond exemption is requested meets the criteria established in Section 1817.46(e) and hereby grants an exemption from the use of a sedimentation pond for this area.

STREAM BUFFER ZONE VARIANCE

Section 1817.57(a)(1): The applicant has requested a stream buffer zone variance for an area as delineated in the application. In accordance with Section 1817.57(a)(1), the Department finds that:

a. The original stream channel and its associated riparian vegetation will be restored; and

b. Surface mining activities will not cause or contribute to a violation of Section 1817.42 and will not adversely affect the water quantity and quality or other environmental resources of the stream.

Therefore, the Department authorizes surface mining activities closer than one hundred (100) feet of the top of the bank of the normal channel of the perennial or intermittent stream or through the stream.

SECTION 1773.15(c)(2) – (c)(13) FINDINGS

Section 1773.15(c)(2); The applicant has demonstrated that reclamation as required by the Federal and State Acts and the regulatory program can be accomplished under the reclamation plan contained in the application, as modified.

Section 1773.15(c)(3)(A): The proposed area is not within an area under study or administrative proceedings under a petition, filed pursuant to Section 1764, to have an area designated as unsuitable for surface coal mining operations.

Section 1773.15(c)(3)(B): The proposed area is not within an area designated as unsuitable for mining pursuant to Sections 1762 and 1764 or subject to the prohibitions or limitations of Section 1761.11.

Section 1761.11(a): The proposed area does not include any lands within the boundaries of the National Park System, the National Wildlife Refuge System, the National System of Trails, the National Wilderness Preservation System, the Wild and Scenic Rivers System, or National Recreation Areas designated by Act of Congress.

Section 1761.11(b): The proposed area is not on any Federal lands within the boundaries of any national forest.

Section 1761.11(c): The proposed surface coal mining and reclamation operations will not adversely affect any publicly owned park or any privately owned or publicly owned places included on the National Register of Historic Places.

Section 1761.11(d): The proposed area is within one hundred (100) feet measured horizontally of the outside right-of-way line of public roads in Williamson and Franklin Counties, described as follows: Interstate 57, State Route 37, Williams Prairie Road, Harris School Road, Old Ben Road, Old Frankfort Road, Eberhardt Road, Duncan Road, Monroe Road, Collin Road, Horseshoe Road, Freeman Spur Blacktop (Franklin Co. Rte. 6), Deason Road, Sandburg Road, Freemanspur Road, Gossage Road, Lake Creek Road, and Cheatman Road.

The proposed area is adjacent to the right-of-way of Interstate 57, State Route 37, Williams Prairie Road, Harris School Road, Old Ben Road, Old Frankfort Road, Eberhardt Road, Duncan Road, Monroe Road, Collin Road, Horseshoe Road, Freeman Spur Blacktop (Franklin Co. Rte. 6), Deason Road, Sandburg Road, Freemanspur Road, Gossage Road, Lake Creek Road, and Cheatman Road. The proposed activities in the application area include the installation of pipeline and boring underneath the roads

No approvals from the authority with jurisdiction over the roads were required for areas outside the right of way. The permittee shall be responsible for all permits required from the road authorities necessary for any access and operations performed within the right of way of said roads. See Condition K.

The applicant provided proper public notice and opportunity for a public hearing. A public hearing was held on October 23, 2018 and while many written comments were submitted to the Department, none of the written comments were concerning these roads.

The Department finds the interests of the public and affected landowners will be protected from the proposed mining operations as a result of the measures to be

taken by the applicant as described in the mining operations plan concerning these roads.

Section 1761.11(e): The proposed area is within three hundred (300) feet measured horizontally of several occupied dwellings.

The owners of the dwellings have provided written waivers pursuant to Section 1761.15 consenting to surface coal mining operations closer than three hundred (300) feet.

Section 1761.11(f): The proposed area is not within three hundred (300) feet measured horizontally of any public building, school, church, community or institutional building, or public park from which the applicant will be required to maintain a three hundred (300) foot buffer zone.

Section 1761.11(g): The proposed area is not within one hundred (100) feet measured horizontally of a cemetery.

Section 1773.15(c)(4): This section is applicable to surface mining operations only.

Section 1773.15(c)(5): The Department has assessed the probable cumulative impacts of all anticipated coal mining on the hydrologic balance in the cumulative impact area, in accordance with Part 1784 and finds that the operations proposed under the application have been designed to prevent material damage to the hydrologic balance outside the proposed area (see Appendix C).

Section 1773.15(c)(6): The applicant has not proposed the use of any existing structures in the application requiring compliance with Section 1700.11(d).

Section 1773.15(c)(7): The applicant will submit fees required by these regulations before the permit is issued. The fee required is $1,767.50 for the term of the permit, which may be paid in annual increments. The Department finds that the applicant has paid all reclamation fees from previous and existing operations as required by 30 CFR 870.

Section 1773.15(c)(8): See Part III – Subpart B.

Section 1773.15(c)(9): The applicant has satisfied the requirements for a long-term, intensive agricultural post-mining land use, in accordance with the requirements of Section 1817.111(d).

Section 1773.15(c)(10): The operation as approved will not affect the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitats, as determined under the Endangered Species Act of 1973 (16 USC 1531 *et seq.*, see Appendix F).

Section 1773.15(c)(11): The requirements of this section are not applicable as there are no proposed remining operations.

Section 1773.15(c)(12): The effect of the proposed permitting action on properties listed on or eligible for listing on the National Register of Historic Places has been taken into account by the Department.

Section 1773.15(c)(13): The requirements of this section are not applicable as there are no proposed remining operations.

B. Findings Required by 62 Ill. Adm. Code 1785 (Applicable Sections)

PRIME FARMLANDS

A soil survey was submitted by the applicant that shows prime farmland soils identified in this application which have been historically used as cropland. The soil survey prepared by the USDA provides the required soil information.

The applicant has, with respect to prime farmland, satisfied the requirements of Section 1785.17. (See Part B, below, and Appendices D and G.)

Section 1785.17(e)(1): The Department finds that the approved post-mining land use of the prime farmlands is cropland.

Section 1785.17(e)(2): The Department finds that the permit incorporates as specific conditions the contents of the plan submitted under Section 1785.17(c), after consideration of any revisions to that plan suggested by the State Conservationist under Section 1785.17(d).

Section 1785.17(e)(3): The Department finds that the applicant has the technological capability to restore the prime farmland, within a reasonable time, to equivalent or higher levels of yield as non-mined prime farmland in the surrounding area under equivalent levels of management.

Section 1785.17(e)(4): The Department finds that the proposed operations will be conducted in compliance with the requirements of Section 1823 and other environmental protection performance and reclamation standards for mining and reclamation of prime farmland of the regulatory program.

Section 1785.17(e)(5): The Department finds that the aggregate total prime farmland acreage has not been decreased from that which existed prior to mining. Water bodies, if any, are located within the post-reclamation non-prime farmland portions of the permit area and the consent of all affected property owners has been obtained.

Section 1785.20: The requirements of this section are not applicable to this application.

C. Compliance with 62 Ill. Adm. Code 1773.19

Section 1773.19(a)(1): The Department has based its decision to approve, as modified, the application, based on public participation as provided by Sections 1773.13 and 1773.14, compliance with all applicable provisions of Section 1785, and the processing and complete review of the application.

Section 1773.19(a)(3): The Department is providing written notification of its final permit decision to the following persons and entities:

a. The applicant, each person who filed comments or objections to the application, and each party to the public hearing;

b. The County Board of the counties in which the application is located; and,

c. The Office of Surface Mining.

All materials supporting these findings are a part of the public record and are hereby incorporated by reference.

IV. PERMIT CONDITIONS

A. The permittee shall conduct surface coal mining and reclamation operations only on those lands specifically designated as the permit area on the maps submitted with the application and authorized for the term of the permit and that are subject to the performance bond or other equivalent guarantee in effect pursuant to 62 Ill. Adm. Code 1800.

B. The permittee shall conduct all surface coal mining and reclamation operations as described in the approved application, except to the extent that the Department otherwise directs in the permit.

C. The permittee shall comply with the terms and conditions of the permit, all applicable performance standards of the Federal and State Acts, and the requirements of the regulatory program.

D. Without advance notice, delay, or a search warrant, upon presentation of appropriate credentials, the permittee shall allow the authorized representatives of the Department and Secretary of the United States Department of the Interior to:

1. Have the right of entry provided for in 62 Ill. Adm. Code 1840.12; and,

2. Be accompanied by private persons for the purpose of conducting an inspection in accordance with 62 Ill. Adm. Code 1840, when the inspection is in response to an alleged violation reported to the Department by the private person.

E. The permittee shall take all possible steps to minimize any adverse impacts to the environment or public health and safety resulting from noncompliance with any term or condition of this permit, including, but not limited to:

1. Accelerated or additional monitoring necessary to determine the nature and extent of noncompliance and the results of the noncompliance;

2. Immediate implementation of measures necessary to comply; and,

3. Warning, as soon as possible after learning of such noncompliance, any person whose health and safety is in imminent danger due to the noncompliance.

F. As applicable, the permittee shall comply with 62 Ill. Adm. Code 1700.11(d) for compliance, modification, or abandonment of existing structures.

G. The permittee shall pay all reclamation fees required by 30 CFR 870 for coal produced under this permit for sale, transfer, or use.

H. Within thirty (30) days after a cessation order is issued under 62 Ill. Adm. Code 1843.11, for operations conducted under the permit, except where a stay of the cessation order is granted and remains in effect the permittee shall either submit to the Department the following information, current to the date the cessation order was issued, or notify the Department in writing that there has been no change since the immediately preceding submittal of such information:

1. Any new information needed to correct or update the information previously submitted to the Department by the permittee under 62 Ill. Adm. Code 1778.13(c); or

2. If not previously submitted, the information required from a permit application by 62 Ill. Adm. Code 1778.13(c).

I. Species Protection:

1. Issuance of this permit under the Surface Coal Mining Land Conservation and Reclamation Act does not in any way authorize any take of any listed species in violation of the Illinois Endangered Species Protection Act, 520 ILCS 10/1 *et seq*. With respect to the Indiana bat, an Incidental Take authorization has been approved as part of this permitting action consistent with and in compliance with the Endangered Species Act of 1973, 16 USC 1531 *et seq*. The Department has determined that this project may affect the northern long-eared bat, but that any resulting Incidental Take is not prohibited by the Final 4(d) rule and is consistent with the U.S. Fish and Wildlife Service Jan 2016 Programmatic Biological Opinion on the Final 4(d) rule. The Department and the applicant are in compliance with

Section 7 of the Endangered Species Act of 1973, as amended. If any other "take" as defined by these Acts is anticipated to result from permitted activities, it is recommended that the permittee apply for an Incidental Take permit from the Illinois Department of Natural Resources, Office of Resource Conservation for state listed species.

2. Issuance of this permit under the Surface Coal Mining Land Conservation and Reclamation Act does not in any way authorize any take of a bald or golden eagle, including nests or eggs, in violation of the Bald Eagle Protection Act (16 U.S.C. 668 *et seq.*). If "take" as defined by the Bald Eagle Protection Act is anticipated to result from permitted activities, it is recommended that the permittee should apply for an Incidental Take (non-purposeful take) permit from the U.S. Fish and Wildlife Service. The Department and the U.S. Fish and Wildlife Service shall be notified if a bald or golden eagle nest is observed in the permit area or in the vicinity of the permit area.

3. If any onsite stream and/or wetland mitigation is required based on upon U.S. Army Corps of Engineers requirements, then the Department shall be notified to establish appropriate permitting actions under SMCRA.

J. If the permit is conditionally issued under 62 Ill. Adm. Code Section 1773.15(b)(2) on the basis of **(1)** a presumption supported by certification under 62 Ill. Adm. Code Section 1778.14 that the violation is in the process of being corrected; **(2)** proof submitted under 62 Ill. Adm. Code Section 1773.15(b)(1)(A) that the violation is in the process of being corrected; or **(3)** pending the outcome of an appeal described in 62 Ill. Adm. Code Section 1773.15(b)(1)(B), issuance is conditioned as follows:

1. If subsequent to permit issuance applicant is issued a failure-to-abate cessation order, the permit shall be suspended and/or rescinded in accordance with the procedures for 62 Ill. Adm. Code Section 1773.20(c) Improvidently Issued Permits within 30 days of the issuance of the failure-to-abate cessation order.

2. If subsequent to permit issuance the Department is notified by the agency that has jurisdiction over the violation that the violation is no longer in the process of being corrected to the satisfaction of said agency, the permit shall be suspended and/or rescinded in accordance with the procedures for 62 Ill. Adm. Code Section 1773.20(c) Improvidently Issued Permits within 30 days of such notification.

3. If subsequent to permit issuance the circuit or district court reviewing the violation either denies a stay applied for in the appeal or affirms the violation, then the applicant shall submit the proof required under 62 Ill. Adm. Code Sections 1773.15(b)(1)(A) within 30 days after the court's decision or the permit shall be suspended and/or rescinded in accordance with the procedures for 62 Ill. Adm. Code Section 1773.20(c) Improvidently Issued Permits within 30 days of such failure to submit required proof.

K. Pursuant to Section 1778.15, the permittee shall possess all necessary legal rights to enter and conduct surface coal mining and reclamation operations within the permit area until final bond release is obtained.

The permittee has indicated valid permits shall be obtained from the Illinois Department of Transportation and private rail lines. Pursuant to 1778.15(a), and as committed in Attachment I.2.A, the permittee shall provide the Department with valid right of entry agreements with the (1) Illinois Department of Transportation and (2) private railways prior to the commencement of operations in regard to areas controlled by the Illinois Department of Transportation and the private railway lines.

L. The permittee shall commence all groundwater and surface water monitoring approved by this permit upon initial disturbance of lands within the permit area. Monitoring shall be in accordance with the approved permit and/or as outlined in Appendix C of this finding document.

M. The substitute topsoil material referenced in the response to Part II(13) (D and F) of the application shall be limited to the Rend, Bluford, Hickory-Kell, Okaw, Belknap and Orthent soil series where the subsoil texture is a silt loam. In addition, the pH, phosphorus, and potassium of the borrow materials shall be fertilized with rates to achieve a pH of 6.5, and phosphorus and potassium levels of 50 ponds/acre and 260 pounds/acre, respectively.

N. The approved operations plan includes the installation of a pipeline within a defined permit corridor and a diffuser site in the Big Muddy River. As required by 62 Ill. Adm. Code 1784.23 and 1784.30, the permittee shall submit an as-built certification of the pipeline and discharge structure within 30 days of completion of installation of the pipeline. The as-built shall be sealed by a qualified registered professional engineer and at a minimum include the following information:

1. Verification that the pipeline was installed within the permitted corridor at the minimum depths indicated in the Illinois Department of Agriculture's Pipeline Construction Standards and Policies for Agricultural Impact Mitigation (Attachment IV.2.B.3) and in the Typical Stream Crossing Drawing (Attachment IV.7.I) included in the permit application.

2. Location of all monitoring stations on a Surface Operations Map.

3. List of the monitoring equipment installed at each station.

4. Actual diameter of the installed pipeline and/or diameter of sections of the pipeline if different diameters were used.

5. Cross section of the discharge structure/diffuser site if any changes to the approved plan were made to these structures during installation.

O. The approved operations plan includes plans for monthly visual and physical monitoring of the pipeline, as well as an annual testing of the monitoring equipment. To ensure compliance with 62 Ill. Adm. Code 1784.11(b)(6) and 1817.45(a), the applicant shall:

1. Submit to the Department the results of the pressure testing performed prior to putting the pipeline in service. The initial testing results shall be included in the as-built document required by condition N.

2. Submit to the Department the results of the annual pipeline testing of the monitoring system with a clear description of any identified deficiencies and the steps that would be taken to maintain safe pipeline performance. The results of the annual testing of the pipeline monitoring system shall be submitted to the Department within 30 days of completion.

V. CONCLUSIONS

Based upon the information contained in the application, information otherwise available and made available to the applicant, the comments of State Agencies, the foregoing analysis of the probable impact of the proposed operations, all findings and information contained herein and conditions set forth in Part IV, the Department finds that there is a reasonable basis on which to issue a permit for the application, as modified.

Enter on behalf of the Illinois Department of Natural Resources, Office of Mines and Minerals, Land Reclamation Division as Regulatory Authority.

Illinois Department of Natural Resources

Donald Stewart, Director
Office of Mines and Minerals

Dated: December 5, 2019

APPROVED FOR EXECUTION
Date: 12/4/19
Legal Counsel:

12030906.docx

APPENDIX A

REQUIRED MODIFICATIONS

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Illinois Department of Natural Resources

One Natural Resources Way Springfield, Illinois 62702-1271
www.dnr.illinois.gov

Bruce Rauner, Governor
Wayne A. Rosenthal, Director

December 20, 2018

Carson Pollastro
Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951

Via Certified Mail 7017 1000 0001 0939 4488

Re: Modification to Permit Application No. 456
Pond Creek Mine

The Department, after reviewing the information contained in the permit application and information otherwise available to the applicant, and after considering all comments received, has determined that modification of Permit Application No. 456 is necessary. The modifications to the application shall comply with the requirements of 62 Ill. Adm. Code 1777.11. The modifications required by the Department are enclosed here. If the applicant does not desire to modify the permit application as described below, it may, by filing a written statement with the Department, deem the permit application denied, and such denial shall constitute final action.

Pursuant to 62 Ill. Adm. Code 1773.15(a)(1)(B)(i), modifications required by the Department shall be received within one year from the date of this letter. Absent the modifications required by the Department, the application does not demonstrate compliance with the requirements of the Illinois Surface Coal Mining Land Conservation and Reclamation Act, Regulations and Regulatory Program and the Department will issue a written finding denying the application.

The period for administrative review (62 Ill. Adm. Code 1847.3) shall commence upon:

- receipt by the applicant of a written decision from the Department, approving the application as modified, or
- if the applicant's modifications are insufficient, or if the applicant fails to submit the required modifications in accordance with 62 Ill Adm. Code 1773.15(a)(1)(B)(i), receipt by the applicant of a written decision from the Department denying the permit application, or
- receipt by the Department of the applicant's denial statement.

The modifications required by the Department are as follows:

1. Pursuant to 62 Ill. Adm. Code 1779.25(b), 1780.14(c), and 1780.25(a), and as required by Part 1.6 of the application, the Department is requiring the applicant to modify the application by submitting engineering certifications where the modifications result in changes to maps, plans, or cross sections submitted under the original application.

2. Pursuant to 62 Ill. Adm. Code 1777.11(c), and as required by Part I.1 of the application, the Department is requiring the submittal of a verification by a responsible official of the applicant for the information being submitted as a result of this modification letter.

3. Pursuant to 62 Ill. Adm. Code 1778.15 and Operator Memorandum 2011-01, the applicant is required to provide a signed notarized waiver from landowners for properties not owned or controlled by the permittee. Information provided in Attachment I.2.A reveals property not under control by the applicant and shall require a landowner waiver.

4. Pursuant to 62 Ill. Adm. Code 1778.13(c), the applicant shall provide information for each person who owns or controls the applicant under the definition of "owned or controlled" and "owns or controls" in 62 Ill. Adm. Code 1773.5. Review of the information provided and available to the Department, the applicant failed to provide ownership and control information for an owner/controller of the applicant, specifically Foresight Energy Services, LLC and Foresight Reserves LP as part owner/controller of Foresight Energy GP, LLC. The applicant shall provide current, updated ownership and control information for Williamson Energy, LLC including the necessary information for Foresight Energy Services, LLC or end date and complete ownership and control for Foresight Reserves LP or update ownership for Foresight Energy GP, LLC removing as part owner.

   Further review of the information provided in the ownership and control should be made by the applicant for other omissions or inaccuracies. The Department finds discrepancies with begin dates for some of the officers listed in the organizations ownership and control information.

5. Pursuant to 62 Ill. Adm. Code 1773.15(b)(1)(A), the applicant shall submit to the Department proof that current violations have been or are in the process of being corrected to the satisfaction of the issuing agency. Specifically, the Department finds two violations listed in Attachment I.9, CO 171025 and CO 171028, that will require additional information regarding the progress of abatement.

   The applicant shall provide proof from the PA Department of Environmental Protection of the progress of these violations. Review shall be made by the applicant to ensure all documents are included for all outstanding violations required to be reported.

6. Pursuant to 62 Ill. Adm. Code 1778.18, an application shall contain a certificate of liability insurance in compliance with 62 Ill. Adm. Code 1800.60. The Department finds the

certificate provided is not with an "authorized" insurer and shall require a revised certificate that is in compliance with the required regulations.

7. The response to Part V.1.B of the application is incomplete. Pursuant to 62 Ill. Adm. Code 1800.14, the applicant shall include the following:

   a. Information on the costs associated with removing the diffuser and all associated items from the Big Muddy River. Include all potential costs (such as possible coffer dam to divert water from the work site, divers to work in the Big Muddy River if needed, etc.)

   b. Information on possible removal costs associated with the pipeline such as air relief valves and other pipeline structure that cannot remain permanently post reclamation.

8. Pursuant to 62 Ill. Adm. Code 1783.21, Part II.13.D of the application, page II-8, must be modified to provide for a minimum topsoil removal thickness of 6 inches or greater where present.

9. Pursuant to 62 Ill. Adm. Code 1783.21, Part IV.2.B.3 of the application, page IV-2, must be modified to identify the qualifications of the person referenced in the soil handling procedure. In addition, the response must clarify it uses the most current version of the IDOA pipeline guidelines during construction.

10. Attachment IV.1 "Figure 2 Water Flow Diagram Proposed System" shows an Outfall 010 referred to as the "Pond Creek Stormwater Mixing Zone." This outfall and mixing zone are also referenced in the Attachment IV.1 narrative. Pursuant to 62 Ill. Adm. Code 1784.14(i) the applicant shall clarify if Outfall 010, "Pond Creek Stormwater Mixing Zone" is proposed as part of Permit Application No. 456.

11. According to Attachment IV.1, the applicant states that the holding cell will hold mine infiltration water as well as decant water from the slurry cell. Pursuant to 62 Ill. Adm. Code 1784.14(i), the applicant shall clarify whether the IEPA mixing zone permit has considered potential constituents contained within the clarified decant water.

12. The following concerns the response to Part III.2.D.1.a. Considering the response to Modification Question 11 and pursuant to 62 Ill. Adm. Code 1784.14(b)(1), the applicant shall provide representative water quality data from the water holding cell and clarify whether the chloride and sulfate data represent only the infiltrating groundwater or a mix of infiltrating groundwater and process water (if applicable).

13. In response to Part III.2.D.1.a, the applicant states an anticipated maximum flow rate of infiltration water from the mine is 3,500,000 gallons per day. Pursuant to 62 Ill. Adm. Code

1784.14(b)(2), the applicant shall clarify what this value represents in relation to the amount of water the company intends to discharge from the facility.

14. The Department is in receipt of a letter addressed to the applicant dated August 30, 2018 from the Illinois EPA (IEPA) requesting changes or clarification. Pursuant to 62 Ill. Adm. Code 1784.14, the applicant shall provide responses to the questions in the IEPA letter. If any response to the IEPA letter results in changes to the permit application, the applicant shall clearly indicate which application part and/or map is being revised.

15. In response to Part IV.1, the applicant references Attachment IV.1 for operations plan information. Page 3 of Attachment IV.1 indicates the preparation plant requires 2,300,000 gpd. In contrast, the water flow diagram proposed system depicts the preparation plant supply to be of 2,880,000 gpd. Pursuant to 62 Ill. Adm. Code 1777.11, clarify the apparent discrepancy in preparation plant volumes.

16. In response to Part IV.5.C.2, the applicant references Attachment IV.5.C.2 for additional information concerning the water management pipeline. Pursuant to 62 Ill. Adm. Code 1817.41(a), the applicant shall provide the following information and update all appropriate responses as necessary:

    a. Locate on the Operations Map automatic and manual shut off valves and pressure gauges.

    b. Provide additional detail on the process to pressure test pipeline integrity after it has been constructed and prior to being placed into operation.

    c. Provide additional detail on the operational monitoring of the pipeline to detect leaks and the actions taken to shut down the pipeline should monitoring indicate a potential leak is occurring.

    d. Provide additional detail on procedures and actions to be taken should a spill occur.

17. In response to Part IV.7.I, the applicant requests a stream buffer variance to multiple streams for the temporary construction practices involved in placing the transport pipeline. Pursuant to 62 Ill. Adm. Code 1817.57, the following additional information shall be provided concerning disturbances in the buffer zone and channel of the Big Muddy River.

    a. The response discusses adequately sized riprap to be keyed into the toe of the embankment. The applicant shall provide minimum sizing design based on expected stream flow velocities to assure a stable bank is maintained.

    b. The applicant shall expand the narrative to address construction steps of the diffuser port within the Big Muddy River channel. Detail on the anticipated extent of the

disturbance during installation and specific steps to control and contain off-site impacts shall be provided.

c. The area not to be disturbed shall be designated a buffer and marked as specified in Section 1817.11.

18. In response to Part IV.7.B, it appears the applicant answered the questions referring to handling of drainage after the pipeline has been put in place and covered by soil material. To ensure compliance with 62 Ill. Adm. Code 1817.45(a), the applicant shall expand the discussion in this response to explain which erosion and sediment control measures will be used to handle drainage from unaffected areas during the construction of the waterline.

19. In Attachment IV.1, the applicant states that monitoring of the water pipeline will include a monthly visual inspection of each road and highway crossing, the Pond Creek crossing and the Big Muddy discharge site. It will also include a physical inspection of the monitoring equipment. Pursuant to 62 Ill. Adm. Code 1817.41(a), the applicant shall provide:

a. A list of all inspection sites and a map defining the inspection site locations.

b. Additional information describing how the entire pipeline corridor will be maintained for access by both the Department's staff to inspect and for company personnel to maintain and make necessary repairs in a timely manner.

c. Specifically what monitoring equipment is intended to be physically inspected.

d. Further information addressing the need to physically inspect air release valve locations and other similar critical junctions in the pipeline system as part of the monthly inspection.

20. Pursuant to 62 Ill. Adm. Code 1780.23 and 1784.15, the applicant shall provide the acreage and capability of each land use within the proposed permit area, employing only land use categories of 62 Ill. Adm. Code 1701.5. Further, the "fish and wildlife" land use category must be subdivided as required by Operator Memorandum 2015-01. Use **only these land uses for completing the land use maps.**

a. The individual land use acreages provided in the Pre-mining Land Use Table in Part II.4 of the application do not calculate to the Total Permit Acreage provided within this table. The applicant shall clarify this discrepancy.

b. The applicant shall revise all Tables, Maps and Figures to reflect **only** the "fish and wildlife" land use categories outlined within Operator Memorandum 2015-01.

21. Pursuant to 62 Ill. Adm. Code 1777.11(a)(3) and as required by Part V.2.A of the application, the applicant shall provide acreage figures for each post-mining land use proposed and designate the post-mining land uses on the Post-Mining Land Use Maps.

    a. The applicant shall revise all Tables, Maps and Figures to reflect **only** the "fish and wildlife" land use categories outlined within Operator Memorandum 2015-01.

    b. The individual land use acreages provided in the Post-Mining Land Use Table in Part V.2.A of the application do not calculate to the Total Permit Acreage provided within this table. The applicant shall clarify this discrepancy.

    c. Acreage for post-mining land uses provided by the applicant in the Post-Mining Land Use Table in Part V.2.A of the application are not the same as that provided in the Pre-mining Land Use Table in Part II.4. The applicant states in multiple locations of the application that post-mining land uses are the same as pre-mining land use. The acreage provided within the tables contradicts this statement and the applicant shall clarify this discrepancy.

22. Pursuant to 62 Ill. Adm. Code 1817.97(f) and required by Part V.B.3, the applicant is required to provide a statement explaining how impact control measures, management techniques, and monitoring methods will be utilized to protect or enhance habitats of unusually high value for fish and wildlife such as wetlands and riparian areas to be affected by the proposed mining and reclamation operations. The applicant shall address the following pertaining to the proposed water management pipeline construction corridor.

    a. In response to Part V.B.3, the applicant states that "no habitats of unusually high value have been observed within the project area". The applicant has provided a Stream and Wetland delineation report as Attachment II.9 to Part II of the application identifying streams and wetlands located within the proposed permit area. The applicant shall provide a statement in Part V.B.3 explaining how impact control measures, management techniques, and monitoring methods will be utilized to protect or enhance these areas.

    b. The applicant has provided a Stream and Wetland delineation report as Attachment II.9 to Part II of the application. Wetland A and Wetland B are not part of this proposed permit and shall be removed from all applicable parts of the application.

    c. As required by Part V.3.B.1, the applicant shall provide information on whether or not ponds on site will contain hazardous concentrations of toxic-forming materials and if so, then describe how control measures, management techniques, and monitoring methods will be used to ensure how wildlife protected under the

Endangered Species Act, Migratory Bird Treaty Act, and the Bald Eagle Protection Act are excluded from these areas or justify why this information is not provided.

23. Pursuant to 62 Ill. Adm. Code 1817.111, 1817.114, and as required by in Part V.1.D.3, the applicant is required to describe methods to be used in planting and seeding.

    a. In response to Part V.1.D.3, the applicant refers to planting of the proposed refuse disposal area. No refuse disposal area is proposed as part of this application. The applicant shall clarify this discrepancy.

    b. In response to Part V.1.D.3, the applicant provides a list of considerations and recommendations to prepare the site for planting. The applicant is required by Part V.6.D.3 to provide the actual methods to be used in planting and seeding rather than considerations and recommendations. The applicant shall revise this response in the application to include the actual methods to be implemented.

24. Pursuant to 62 Ill. Adm. Code 1784.21(a)(2)(A) and 1817.97(b), the applicant is required to provide site specific resource information for threatened and endangered species including but not limited to the Indiana bat *(Myotis sodalis)* (INB) and northern long-eared bat *(Myotis septentrionalis)* (NLEB). This information has been provided in Attachment II.8 and Part V.3.B.4; however, the following information/updates are required:

    a. Attachment II.8 refers to Permit 434 within the title on Page 1. This shall be revised to reflect the correct permit number.

    b. Attachment II.8 and Part V.3.B.4 of the application states that NLEB were not identified within the project area and therefore, in accordance with current USFWS protocol, are not present within the project area. The applicant did not survey the entire project alignment, thus probable absence cannot be assumed within the portions of the project that were not surveyed. The applicant shall update Attachment II.8 and Part V.3.B.4 of the application, including the discussion of whether the project is consistent with the northern long-eared bat *(Myotis septentrionalis)* Final 4(d) Rule published in the Federal Register in January 2016.

    c. The applicant has identified 3.9 acres of forested acres to be disturbed within known INB habitat based on the survey information provided. It is required that at least 70 percent of the total INB habitat that will be lost should be replaced or mitigated off-site as described in the 2013 Indiana bat Protection and Enhancement Guidelines published by the USFWS. The applicant shall update the Long-Term Habitat Replacement section of the INB PEP.

d. Tree Clearing restrictions within the INB PEP state that tree clearing operations will only occur from November 15 to March 31, unless otherwise authorized. These dates are not consistent with those described in the 2013 Indiana bat Protection and Enhancement Guidelines published by the USFWS. The applicant shall clarify this inconsistency.

e. The applicant has stated within the summary of the INB PEP that forested acres cleared during construction operations will be supplemented in the short-term by erecting bat boxes. The applicant shall update the Short-term Habitat Replacement section of the PEP to reflect this statement and provided further details as to the timing and number of bat boxes to be erected.

If you have any questions, please contact this office at (217) 782-4970, or our Southern office in Benton at (618) 439-9111.

Sincerely,

Nick San Diego, Supervisor
Office of Mines and Minerals

NSD:JSc

cc: W. Gillespie
Williamson County Clerk 7017 1000 0001 0939 4495
Franklin County Clerk 7017 1000 0001 0939 4501

APPENDIX B

CONSIDERATION OF COMMENTS AND OBJECTIONS

62 Ill. Adm. Code 1773.13(b) allows submission of written comments on applications. The following are comments received from the State Agencies, County Board and other members of the public and the Department's response to those comments.

Illinois Department of Agriculture

Comment: The Illinois Department of Agriculture (IDOA) has reviewed the above referenced permit application. The application is for a 12.5-mile long 18 and 24-inch water mains to pump water from the underground mine to the Big Muddy River. All water from the mine will go through holding cells before being discharged to the pipeline. The pipeline will follow the railroad right-of-way (ROW), both active and abandoned, a gas pipeline and road ROW. Construction affects 12.67 acres of cropland. The pipeline will be in place for 10-years then removed. The mine has indicated they will follow the IDOA's Pipeline Construction Standards and Policies. The IDOA requests that the revision shown on the agricultural website be used. See: *https://www2.illinois.gov/sites/agr/Resources/LandWater/Documents/pipelinestandardspo/icies.pdf.*

Response: The Department required modification of the application (Appendix A, Modification Question No. 9) to ensure the most current version of the IDOA Pipeline Constructions Standards and Policies were included in the permit.

Illinois Environmental Protection Agency

Comment:

1. To ensure compliance with 62 Ill. Adm. Code 1817.42 as it pertains to mine discharge quality, the Schedule A contained in Part III of the application should be revised as follows:

    a. Iron concentrations are indicated to be within the range of 3.0 - 6.0 mg/1. The applicant should revise this indication to provide an "estimate" of basin discharge Iron concentrations rather than the acceptable range from the Subtitle D regulations.
    b. Total Suspended Solids concentrations are indicated to be within the range of 35.0 - 70.0 mg/1. The Applicant should revise this indication to provide an "estimate" of basin discharge Total Suspended Solids concentrations rather than the acceptable range from the Subtitle D regulations.

2. The pipeline corridor area should be included in the annual stormwater monitoring plan.

Response: Please see the response to Appendix A, Modification Question No. 14.

U.S. Department of Agriculture, Natural Resource Conservation Service

Comment: Any bare soil exposed following surface coal mining should be seeded, limed, fertilized and mulched to minimize soil erosion. Please refrain from using tall fescue or reed canary grass in seeding mixtures and only plant native trees and shrubs for wildlife areas. Following pipeline installation, drainage should be provided where necessary to return the affected areas to their former land use. Wetlands should be returned to historic hydrologic conditions. Prime Farmland acreage should be reclaimed to standards established by the Illinois Surface Coal Mining Land Conservation and Reclamation Act.

Response: This comment has been noted and forwarded to the applicant.

U.S. Department of the Interior, Fish and Wildlife Service

Comment: To facilitate compliance with Section 7(c) of the Endangered Species Act of 1973, as amended, Federal agencies are required to obtain from the Fish and Wildlife Service (Service) information concerning any species, listed or proposed to be listed, that have ranges which include the project area. As the State of Illinois has been delegated the responsibility of issuing mining permits by the Office of Surface Mining, we are providing the following list of threatened and endangered species to assist in your evaluation of the proposed permit. The list for the proposed permit area includes the endangered Indiana bat (Myotis sodalis), endangered piping plover (Charadrius melodus), and threatened northern long-eared bat (Myotis septentrionalis). There is no designated critical habitat in the project area at this time.

Response: Comment noted and forwarded to the applicant.

Comment: Applicants should be directed to our Information, Planning, and Conservation System (IPaC) at the link below to determine whether any federally threatened and endangered species, designated critical habitat, or other natural resources of concern may be affected by a proposed project and to obtain a preliminary or official U.S. Fish and Wildlife species list. For projects that require FWS review, request an official species list from the Regulatory Documents page. https://ecos.fws.gov/ipac/

Response: This comment has been forwarded to the applicant. In addition, the Department has supplied the Service's website to future applicants as an encouraged and available resource.

Comment: Based on the location of the proposed permit area, the Service concurs that the proposed project is not likely to adversely affect the piping plover.

Response: Comment noted and forwarded to the applicant.

Comment: Information in the permit application indicates that 3.9 acres of known Indiana bat habitat will be impacted by the proposed mining activity. Presence of the Indiana bat was documented in a mist net survey conducted in 2017, thus a Protection and Enhancement Plan (PEP) was developed for the proposed mine area that lies within the 2.5 mile buffer of the documented maternity roost tree in accordance with the 2009 Range-wide Indiana Bat PEP Guidelines, as revised in 2013. The PEP includes a number of protection and enhancement measures including avoidance of the majority of wooded habitat within the permit area, winter tree clearing from November 15 to March 31, tree girdling and bat box installation to provide temporary habitat, riparian buffer zone protection, and maintenance of watering areas. The applicant is not proposing to replant the forested habitat acres to be disturbed.

The PEP guidelines state that at least 70 percent of the total Indiana bat forest habitat that will be lost should be replaced or mitigated off-site. The applicant should develop a replacement plan or off-site mitigation measures. Information in the permit application indicates that the post mining acres for fish and wildlife woody will increase and may account for the replacement. The PEP should be reconciled with the post-mining land use in the reclamation plan.

The applicant did not survey the entire project alignment, thus probable absence for the northern long-eared bat cannot be assumed within the portions of the project that were not surveyed. The applicant should include the northern long-eared bat in the PEP or rely upon the finding of the programmatic biological opinion for the northern long-eared bat final 4(d) rule and utilize the streamlined section 7 consultation framework to fulfill their project-specific section 7 responsibilities for the northern long-eared bat. If the applicant utilizes the streamlined consultation framework, then the streamlined consultation form should be completed.

See https://www.fws.gov/midwest/endangered/mammals/nleb/s7.html

Based on the lack of information in the permit application, the Service is not able to provide concurrence for listed bat species at this time. The Service requests the additional information be provided for review and concurrence.

Response: The Department would like to take this opportunity to outline protection an enhancement measures that have changed from the original submittal based on modification requirements.

The Indiana bat (*M. sodalis*) and northern long-eared bat (*M. septentrionalis*) Protection and Enhancement Plan (PEP) located in Attachment II.8 has been updated to address long term habitat replacement requirements. The applicant has

proposed to reforest 2.73 acres, restoring 70% of the known habitat proposed to be removed by this project and therefore complying with the 2013 Guidelines.

Additionally, tree clearing restrictions within the PEP have been modified to state that tree clearing operations will only occur from October 15 to March 31. These dates appropriately reflect those outlined for winter tree clearing in the 2103 guidelines.

The applicant has also modified the PEP to state "the probable absence of the NLEB cannot be assumed". The applicant has included a discussion utilizing the key to the northern long-eared bat 4(d) rule for federal actions to conclude that the proposed actions are not prohibited and therefore a PEP for this species is not required. However, the applicant has chosen to include this species within the PEP found in Attachment II.8 of the application. The applied protection and enhancement measures will potentially be beneficial to the northern long-eared bat.

Based on information provided by the applicant and appropriate agency consultations, the Department has determined that this project may affect the northern long-eared bat, but that any resulting Incidental Take is not prohibited by the Final 4(d) rule and is consistent with the U.S. Fish and Wildlife Service Jan 2016 Programmatic Biological Opinion on the Final 4(d) rule. The Department has completed the IPAC Determination Key: Northern Long-Eared Bat (NLEB) Consultation and 4(d) Rule Consistency, which was submitted to the Service via IPAC on July 31, 2019.

Comment: [Per the follow-up USFWS correspondence dated October 2, 2019] - Based on the lack of information in the permit application, the Service was not able to provide concurrence for listed bat species. We requested additional information be provided for our review and concurrence. Information in your response indicates that the Protection and Enhancement Plan (PEP) was updated to address long-term habitat replacement requirements for the Indiana bat. Based on this information, the Service has determined that the take of 3.9 acres of known habitat is not likely to jeopardize the continued existence of the Indiana bat.

Information in your letter indicates that consultation for the northern long-eared bat was addressed by using our northern long-eared bat determination key within our Information for Planning and Consultation (IPaC) system. Based upon the IPaC submission, the action is consistent with activities analyzed in the Programmatic Biological Opinion on the Final 4(d) Rule for the northern long-eared bat and issuance of the verification letter concludes consultation for the northern long-eared bat. This information sufficiently addresses our comments regarding the northern long-eared bat.

Response: Comment noted and forwarded to the applicant.

Comment: Although the bald eagle has been removed from the threatened and endangered species list, it continues to be protected under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act (BGEPA). The Service developed the National Bald Eagle Management Guidelines to provide landowners, land managers, and others with information and recommendations regarding how to minimize potential project impacts to bald eagles, particularly where such impacts may constitute "disturbance," which is prohibited by the BGEPA. A copy of the guidelines is available at:

http://www.fws.gov/midwest/eagle/pdf/NationalBaldEagleManagementGuidelines.pdf

The Service is unaware of any bald eagle nests in the permit area; however, if a bald eagle nest is found in the permit area or vicinity of the permit area then our office should be contacted and the guidelines implemented.

Response: The applicant has provided a statement outlining that the applicant is unaware of any bald or golden eagle nests within one mile of the project. The applicant includes a discussion committing to contacting the U.S. Fish and Wildlife Service for the development of a protection and enhancement plan if a nest is encountered. See Part V.2.B.2 of the application.

Comment: [Per the follow-up USFWS correspondence dated October 2, 2019] - The Service indicated that it is unaware of any bald eagle nests in the permit area; however, if a bald eagle nest is found in the permit area or vicinity of the permit area then our office should be contacted. The applicant provided a statement that no eagle nests are known within the project area or vicinity. This information sufficiently addresses our comments.

Response: Comment noted and forwarded to the applicant.

Comment: The permit area includes 23.0 acres of cropland, 16.8 acres of fish and wildlife herbaceous, 18.6 acres of fish and wildlife woody, 0.4 acres of fish and wildlife water, 3.7 acres of fish and wildlife wetland, 0.1 acres residential, and 8.2 acres industrial/commercial.

Response: The Department would like to take this opportunity to clarify that information in the modified permit application indicates that the permit area will includes 16.4 acres of cropland, 20.7 acres of fish and wildlife herbaceous, 21.1 acres of fish and wildlife woody, 0.4 acres of fish and wildlife water, 3.6 acres of fish and wildlife wetland, 0.2 acres developed water resources, 0.1 acres residential, and 8.2 acres industrial/commercial.

Comment: [Per the follow-up USFWS correspondence dated October 2, 2019] - Thank you for your letter dated August 6, 2019, providing response to our comments on permit

application No. 456 by Williamson Energy, LCC (Pond Creek Mine), for surface coal mining and reclamation operations in Franklin and Williamson Counties, Illinois. The permit area is 70.7 acres and the proposed mining activity will impact a total of 70.7 acres. The permit area includes 16.4 acres of cropland, 20.7 acres of fish and wildlife herbaceous, 21.1 acres of fish and wildlife woody, 0.4 acres of fish and wildlife water, 3.6 acres of fish and wildlife wetland, 0.2 acres of developed water resources, 0.1 acres residential, and 8.2 acres industrial/commercial. These comments are provided under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.); the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.) and, the National Environmental Policy Act (83 Stat. 852, as amended P.L. 91-190, 42 U.S.C. 4321 et seq.).

Response: Comment noted and forwarded to the applicant.

Comment: Information in the permit application indicates that proposed activities will impact a total of 3.7 acres of wetlands including 0.4 acres of unconsolidated bottom wetlands. The proposed post mining land use plan includes 3.7 acres of wetlands.

The Service has no objection to the proposed wetland mitigation.

The Service recommends that the seed mix for emergent wetland restoration include native forbs, which will provide greater benefits to native pollinators and the monarch butterfly.

Response: The Department would like to take this opportunity to clarify that information in the modified permit application indicates that the proposed activities will impact a total of 3.6 acres of fish and wildlife wetland and proposed post mining land use plan includes 3.6 acres of wetlands. The recommendation by the Service to incorporate native forbs into the seeding mix for emergent wetland restoration has been forwarded to the applicant.

Comment: Information in the permit application indicates that the reclaimed area will include 22.1 acres of woody fish and wildlife habitat and 21.0 acres of herbaceous fish and wildlife habitat.

The Service recommends that the planting of any non-native, exotic, and invasive species be avoided.

The Service also recommends the incorporation of native forbs in the seeding mix which will provide greater benefits to native pollinators.

The Service recommends that the applicant include an invasive species control plan in the reclamation plan.

Response: The Department would like to take this opportunity to clarify that information in the modified permit application indicates that the reclaimed area will include 21.1 acres of woody fish and wildlife habitat and 20.7 acres of herbaceous fish and wildlife habitat.

The applicant has proposed native and non-native species for Fish and Wildlife post-mining land uses (PMLUs). See Attachment V.1.D.2.b. of the application that contains species lists and justification for the use of some non-native species. The regulations found at Section 1816.111(a)(2) and (c) allow non-native species if they are necessary to achieve the desired post-mining land use or are necessary for erosion control. In addition, the 2013 Indiana bat guidelines provides the same flexibility in Section 2.4.2.2 item no. 3 for the use of non-native woody area herbaceous ground cover if the applicant demonstrates the proposed species are slow growing and beneficial for wildlife. The applicant has proposed non-native species for temporary/cover crop vegetation. The Department does not have the regulatory authority to require native species for temporary seed mixes. The recommendation by the Service to incorporate native forbs in the herbaceous seeding mix was noted and has been forwarded to the applicant.

Pursuant to Section 1816.116(b)(1) and 1784.15(b)(1), the Department required the applicant to achieve the approved species and/or PMLU vegetation success standards during the applicable period of liability. Undesirable invasive species control will be part of the remedial action plan if deemed necessary by the applicant or the Department.

Comment: [Per the follow-up USFWS correspondence dated October 2, 2019] - The Service recommended that the planting of any non-native, exotic, and invasive species be avoided and that the applicant include an invasive species control plan in the reclamation plan. The Service also recommended the incorporation of native forbs into the seeding mix. Information included in the response sufficiently addresses our comments.

Response: Comment noted and forwarded to the applicant.

Public Comments

The Department has considered and evaluated all comments concerning the effects of mining within the proposed permit areas and adjacent areas. The issues raised that are deemed pertinent to the permit application are addressed below.

Comment 1: Commenters asked if their questions were going to be answered at the hearing, expressed dismay that questions were not answered and requested clarification as to how they will obtain those answers to their questions.

Response: The regulations at 62 Ill. Adm. Code 1773.14(d)(2) states that "The hearing officer shall allow the county board, the applicant, and any interested persons to present data, views, or arguments." The purpose of the hearing is not to inform the public but to allow the public to "present data, views, or arguments" concerning the application to the Department. Comments pertinent to the application are then taken into consideration by the Department, with each specialist in their individual scientific area reviewing the application and addressing those comments in the permit decision document.

Comment 2: Commenters expressed concern over the impact of the project on the quality of the Big Muddy River.

Response: The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the Illinois Environmental Protection Agency's (IEPA). Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 3: A commenter asked what is currently being done with the water generated at the mine.

Response: It is assumed the commenter, by using the term "generated," is referring to mine infiltration water removed from the underground workings. According to the currently approved NPDES Permit IL0077666, the mine infiltration water that is pumped from the underground works is routed to Pond 006. This water is used at the wash plant or stored on the permitted surface area in existing impoundments and ponds.

Comment 4: A commenter asked about details of the water to be discharged and the concentration of pollutants in the water.

Response: Please see the response to Appendix A, Modification Question Nos. 11 and 12.

Comment 5: A commenter asked if the pipeline work had begun and when a decision on the application would be made.

Response: At the time of this comment, the Permit No. 456 application for the pipeline was still under review. Any work related to the pipeline as it relates to the proposed surface coal mining and reclamation operations detailed for this application cannot lawfully begin until the Department approves the application and issues the permit decision. Here, after completion of review, it was determined that modifications of the application were required and the applicant had one year to provide appropriate

responses to the request for modifications. Those responses have since been submitted and approved. This permit findings document memorializes the Department's decision to issue the permit.

Comment 6: Commenters questioned the impact to the water level of the Big Muddy River, including during low flow conditions as a result of the proposed discharge.

Response: Based on information provided in the application, the volume of mine water to be discharged in the Big Muddy River will be dependent on the flow of the river upstream of the point of discharge. Thus, the discharge will be intermittent and will be adjusted accordingly. The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 7: Commenters asked how the concentrations of chlorides and sulfates in the discharge water would impact the receiving stream, adjacent waterways and water courses further downstream, including the anticipated effects on local biota and the public.

Response: The IEPA is the regulatory agency that determines the concentrations of chlorides and sulfates that can be discharged into a water body through its NPDES permitting process. The potential impacts to the receiving stream, adjacent waterways and water courses further downstream, including the anticipated effects on local biota and the public, is an issue for the IEPA to address through that process. Potential impacts resulting from another agency's permitting responsibility is beyond the purview of the Department.

Comment 8: Commenters indicated the hydrologic balance investigation for the application should include the areas included within the longwall panels and that the analysis was an attempt to obscure the effects on the local water table. One of these commenters asked what the actual cone of depression created by the mine pumpage.

Response: This permit application is for the construction and operation of a pipeline to transport underground mine infiltration water to a diffuser system at the Big Muddy River. This permit application does not cover the shadow area encompassed by the longwall mining panels. Nevertheless, the Department does not believe there is a cone of depression as this water is leaking into the mine from cracks in the overlying unit above the coal seam. The water is then physically pumped out of the mine, not the overlying unit.

Comment 9: Commenters were concerned there are, or may be, adverse impacts accruing from the rate of water pumping and area groundwater drawdown, as well as the long-term impacts to local water quantity that may be needed in the future.

Response: There have been no reported issues from surrounding citizens regarding the company pumping out infiltrating groundwater out of the mine. According to data presented in the application, this groundwater is naturally high in chlorides and sulfates, making it unfavorable as a source of potable groundwater. The Department is unaware of any plans or proposals to utilize this water bearing sandstone as a source of potable water.

Comment 10: A commenter indicated Permit No. 375 incorrectly reflected the depth of the coal seam and that the shallower depth of mining negatively impacted his ponds and well. Further, the commenter indicated the Department needed to monitor his well to understand the hydraulic balance of the area.

Response: The issues raised relate to underground mining and subsidence and are not pertinent to the activities proposed in Permit No. 456. Potential subsidence impacts to a well will not provide relevant information on the hydrologic balance of the proposed permit area in this application.

Comment 11: Commenters expressed concerns that the public wasn't given adequate or appropriate notice of the permit application or the public hearing and sufficient time to prepare for the hearing. One stated that "I own a significant amount of land I do not live here full time, but I would have thought that there might be a better communication system to land owners regarding important items such as this. The meeting was quickly called and not very publicized. Your written comment deadline is also too short given that many people have only barely heard of the Big Muddy River pollution by Williamson Energy, LLC, and Pond Creek Mine, and they have not had time to read the application and gather their research and comments on the permit proposal."

Response: The purpose of the public hearing, as stated at 62 Ill. Adm. Code 1773.14(d)(2), is to "allow the county board, the applicant, and any interested persons to present data, views, or arguments." The application has been on file with the Williamson and Franklin Counties Clerk Offices since July 18, 2018. In addition, the application was posted to the Department's website on July 20, 2018. Notice of the application was published by the applicant in the Marion Republican four (4) times, with the first publication on July 18, 2018, and the last on August 8, 2018. The application was available for public review for more than three (3) months prior to the close of the comment period. It is the Department's opinion the public has been provided all the opportunities prescribed by the regulations to review the application and the additional ten (10)-day period afforded after the public hearing provided adequate time for interested parties to review the application and submit written comments.

The regulations at 62 Ill. Adm. Code 1773.14(b) require that "The Department shall publish notice of the hearing in a newspaper of general circulation within the county. Such notice shall be published by the Department at least two (2) weeks prior to the scheduled hearing date."

The notice published for the public hearing explained what application was to be covered by the hearing, and the time, place and location of the hearing. It also provided the Department's contact information. That notice was published October 2, 2018 in the Southern Illinoian.

The Department's requirements for public notification of the public hearing were met.

Comment 12: Commenters indicated that insufficient research had been done to insure irreparable damage to water systems will not occur. Those concerns addressed effects to endangered species that may come to the area (gray wolf, black bear and mountain lion), the redheaded woodpecker, hellbenders, the alligator snapping turtle and other reptiles and amphibians living in and around the waterways which would receive the discharge. Commenters also expressed concern regarding these effects on the LaRue-Pine Hills area and its diverse biota.

Response: The IEPA is the regulatory agency that determines the effluent concentrations that can be discharged into a water body through its NPDES permitting process. The potential impacts to the receiving stream, adjacent waterways and water courses further downstream, including the anticipated effects on endangered species and other local biota, is an issue for the IEPA to address through that process. Potential impacts resulting from another agency's permitting responsibility is beyond the purview of the Department.

Comment 13: A commenter indicated the bond paid for reclamation was insufficient and needed to take into account the value of fishing, boating and the ecosystem impacted by the proposed action.

Response: The regulations at 62 Ill. Adm. Code 1800.14(b) require that "[t]he amount of the bond shall be sufficient to assure the completion of the reclamation plan if the work has to be performed by the Department in the event of forfeiture..." The amount of bond calculated by the Department is in regard to the pipeline installation requested in the proposed permit. Therefore, the topics noted in the comment are beyond the purview of "completion of the reclamation plan." Any determination of the effect of the water on the ecosystem and recreational sports would be outside the scope of the Department's regulatory jurisdiction.

Comment 14: Commenters indicated an on-site water treatment system, or other solutions should be considered by the applicant in lieu of the pipeline. In addition, a commenter indicated the IDNR should require evidence of such assessments. Commenters also

asked what the mine has done to fully review other options to treat the groundwater on-site and suggested that IDNR should request that the mine show serious assessments or other ways of dealing with this water, as there were no clear examples in the permit application of other options that were considered to treat the high chloride and sulfate levels at the mine.

Response: The Department does not have the regulatory authority to require the type of assessments addressed in the comment.

Comment 15: The Douglas School is an old school turned into artists' studio spaces. A commenter expressed concerns that the Old Historic Douglas School could be negatively impacted by high water and water quality during periods of flooding.

Response: The Department does not have the regulatory authority to evaluate the potential downstream effects related to the proposed mixing zone. The authority for such an evaluation is under the regulatory jurisdiction of the IEPA.

Comment 16: The Big Muddy River is indicated as Public Waters by IDNR. Impacts of this added discharge do not appear to have been adequately evaluated and essential information for this application appears to be lacking. There is no information on what the added 2,700,000 to 3,500,000 gallons per day will mean to erosion impacts, river water levels, public use of the river for recreation or other public uses. This river is already prone to flooding and has documented low flows which clearly could mean different impacts from the proposed discharges that have not been adequately assessed. The amount of water that would flow into the Big Muddy River on a daily basis would overwhelm the levy structures in place on the Big Muddy River.

Response: Based on information provided in the application, the volume of mine water to be discharged in the Big Muddy River will be controlled by a diffuser and be metered at any given time based on the actual flow volume in the river as well as the water quality of the discharge and receiving stream.

The IEPA is the regulatory agency that determines the discharge flow volumes and concentrations of monitored parameters that can be discharged into a water body through its NPDES permitting process.

Several measures are proposed to reduce erosion impacts from the discharge flow. The design of the diffuser includes 5 ports that will be submerged to maximize dispersion and minimize effects on the receiving water. The diffuser ports will be mounted on a steel structure that will be supported by piles. A 50-inch-thick revetment with a D50 riprap size of 25 inches has been proposed to be used on the river bank where the diffuser will be located. Other temporary sediment control measures to be used during construction of the diffuser site include: silt fences, silt socks, straw/hay bales and removal and storage of subsoil and topsoil. The

Department will monitor the performance of the erosion control measures and take appropriate action should erosion become an issue.

Comment 17: A commenter suggested the mining operations should be converted from longwall mining to room and pillar mining and potentially avoid the mine water generation to begin with.

Response: The concern expressed would be better directed to the applicant. The Department is not involved in business decisions made by private entities.

Comment 18: Commenters questioned if the applicant intentionally located the pipeline diffuser below the closest gauging station and if the Department had given consideration to the volume of water proposed to be discharged and its effect on the public's right to use the river. These comments also suggested that by putting the outlet downstream of the Plumfield gauging station the Corps of Engineers would not have a true reading of the of the water level and may release more water at Rend Lake, causing more flooding downstream.

Response: Based on information provided in the application, the volume of mine water to be discharged in the Big Muddy River will be dependent on the flow of the river upstream of the point of discharge. Thus, the discharge will be intermittent and will be adjusted accordingly. The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 19: A commenter asked what the current levels of chlorides and sulfates are in the Big Muddy River.

Response: This is outside the scope of the Department's regulatory purview. The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 20: A commenter asked if full consultation with other divisions within IDNR had been conducted.

Response: The Land Reclamation Division of IDNR (LRD), upon receipt of a complete application, notifies various offices within the IDNR, as well as other State, local and Federal agencies, allowing each to submit comments to be taken in to consideration during the application review process. Here, LRD forwarded

notification to the other offices within IDNR on July 20, 2018. All agency comments have been considered in LRD's review of the application and are addressed in the Part III Summary of the Department's Findings.

Comment 21: A commenter asked why IDNR or EPA would ever allow water with elevated chlorides or sulfates to further pollute the Big Muddy River.

Response: The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 22: Commenters expressed opinions about the poor quality of old mines and asked if IDNR or EPA had been successful in cleaning up pollution caused by old mines.

Response: LRD is involved in the regulation of active coal mining operations. The reclamation of "old" mines, or lands impacted by mining prior to the permanent program rules and regulations is under the jurisdiction of the Department's Abandoned Mine Lands Division. Questions related to IEPA's involvement with "cleaning up pollution caused by old mines" should be directed to that agency.

Comment 23: Commenters asked about how climate change would impact the need for water in the future and how this proposal would affect the local water supply.

Response: The concern expressed related to climate change is outside the regulatory purview of the Department.

Comment 24: A commenter indicated the mining industry caused public health issues and this proposal would exacerbate that issue.

Response: The concern expressed is outside the regulatory purview of the Department. This comment has been forwarded to the applicant.

Comment 25: A commenter indicated that the sulfate and chloride concentrations presented throughout the application were inconsistent, and the final discharge concentration was well in excess of those concentrations expressed elsewhere in the application.

Response: Please see the responses to Appendix A, Modification Questions Nos. 11 and 12.

Comment 26: A commenter asked if the applicant is pumping to a tributary of Pine Creek (as the permit indicates) is working why do they need this application.

Response: The Department is unaware of a "Pine Creek" in the vicinity of the Pond Creek Mine, and therefore assumes that the commenter is referring to Pond Creek. The

Pond Creek Mine does not pump water directly into a tributary of Pond Creek. However, water from the mine's sediment ponds (Outfalls 001, 002, 003, 004, 005, 006, 007, and 008) can discharge into an unnamed tributary of Pond Creek. Please refer to the Department's response to Comment 3 above for a description of the mine's current handling of infiltration water from the underground works. According to the application, Williamson Energy, LLC has a finite capacity to store water and expects to encounter an increase in groundwater infiltration as mining progresses.

Comment 27: One commenter questioned why the mine is attempting to pump high sulfate and high chloride water to the Big Muddy when an earlier request for a mixing zone was rejected years ago.

Response: The IEPA is the regulatory entity that approves mixing zones. The Department permits any actual conveyance system that would be necessary for such a mixing zone. The Department received a permit application (No. 455) for such a conveyance system January 30, 2017 which the applicant subsequently withdrew on March 2, 2017. This application was withdrawn by the applicant prior to review and not denied as the commenter alludes. Any other actions taken by the IEPA on Permit No. 455 are best addressed by that agency.

Comment 28: Commenters stated that the Big Muddy River is already listed as impaired on the 2018 Illinois EPA 303(d) list and is given a medium rating. Their concern is that the river is already at risk from pollutants and there does not appear to be adequate consideration of a full range of mine alternatives to the discharges requested in this permit application or other best practices the mine could utilize are not provided in any significant variety or detail.

Response: The Department does not have the regulatory authority to require the type assessment addressed in the comment. The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 29: Commenters questioned what will the proposed daily discharge of high levels of chlorides and sulfates do to existing fish and aquatic life in the Big Muddy River and to other downstream uses? Those commenters indicated that additional pollution loading of this river, particularly at times of low flow, are a concern to us in addition to the known problems high levels of chlorides cause for fish and other aquatic life. Chlorides are stated in some sources to be accumulative. There is nothing in the application that was found to assess what the daily and long-term biological and water quality impacts of the high levels of chlorides and sulfates will do.

Response: The IEPA is the regulatory agency that determines the concentrations of chlorides and sulfates that can be discharged into a water body through its NPDES permitting process. The potential impacts the receiving stream, adjacent waterways and water courses further downstream, including the anticipated effects on local biota, such as fish and other aquatic life, is an issue for the IEPA to address through that process. Potential impacts resulting from another agency's permitting responsibility is beyond the regulatory purview of the Department.

Comment 30: Commenters had questions regarding what fish and aquatic species are currently utilizing the proposed discharge section of the Big Muddy River and are there any locations downstream that have mussel populations? What are the biological and environmental impacts of the high chloride levels? The Big Muddy River is also listed as having varieties of mussels and information on any mussel beds and what impacts the discharges could mean is lacking.

Response: The IEPA is the regulatory agency that determines the concentrations of chlorides and sulfates that can be discharged into a water body through its NPDES permitting process. The potential impacts the receiving stream, adjacent waterways and water courses further downstream, including the anticipated effects on local biota, such as fish and other aquatic species, is an issue for the IEPA to address through that process. Potential impacts resulting from another agency's permitting responsibility is beyond the regulatory purview of the Department.

Comment 31: A commenter asked what different mining practices could be done to reduce the amount of groundwater infiltrating the mine?

Response: The scope of the commenter's question falls beyond the regulatory purview of the Department. The comment has been forwarded to the applicant.

Comment 32: Commenters indicated the diffuser is located on a cut bank of the river, which could potentially experience expedited erosion and bank stability problems risking infrastructural damages.

Response: Engineering practices at the river bank will be utilized to reduce significant erosion impacts and enhance aquatic habitat. The diffuser ports will be mounted on a steel structure that will be supported by piles. Stream bank stabilization proposed for the bank of the Big Muddy River consist of a 50-inch-thick revetment using median riprap size of 25 inches. The riprap will be keyed into the toe of the slope with native plantings on the banks above. This bank stabilization will help prevent further erosion due to the stream channel and protect the water management facilities and infrastructure. The Department will monitor the performance of the erosion control measures and take appropriate action should erosion become an issue.

Comment 33: Commenters indicated it is unclear what heavy metals or other possible contaminants such as arsenic or radioactive materials and what the cumulative effect of additional pollutants will be. The application is also unclear about whether there is a chance of this water mixing with acid mine drainage.

Response: Please consult with the IEPA regarding what other parameters were reviewed for this mixing zone. The Department finds that the chance of acid mine drainage mixing with the water destined for the mixing zone is low to negligible.

Comment 34: A commenter indicated the Stream Protection Rule was created to clarify vague and problematic components of SMCRA, but even though it was rescinded it should be used to mitigate the damage caused by Foresight Energy.

Response: The Department cannot enforce regulations that have not been promulgated or are not in force.

Comment 35: A commenter asked how will the low water quality with its high sulfates and chlorides effect timber along the river and who would be responsible for the monetary loss to land owners?

Response: The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenter's concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Monetary loss to landowners based on water quality issues resulting from another agency's permitting responsibility is beyond the regulatory purview of the Department.

Comment 36: A commenter asked if they drain water into the Big Muddy, will it be via Pond Creek? If so, who will be responsible for cleaning up the creek due to the number of log jams on it.

Response: The application proposes a pipeline to pump mine water from underground into the Big Muddy River. The concerns expressed regarding the log jams are beyond the regulatory purview of the Department.

Comment 37: Commenters indicated the average concentrations listed for Chloride (2237 mg/l) and Sulfate (1940 mg/l) in the effluent, coupled with the discharge rate equal approximately 22,700 kg/d Cl2- and 19,400 kg/d SO42- were significant quantities when considering the hydrological characteristics of the Big Muddy River at this point in its watershed.

Response: The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 38: A commenter indicated the negative charges of Chloride and express a high affinity to remobilize any positively charged cations in channel sediments of the Big Muddy River. This becomes an important concern when considering metals like Manganese, Magnesium, Iron, Cadmium, Arsenic, Lead, etc. can be present in riverbed sediments. The negative charges extract these positive charged cations, causing elements that would otherwise be immobile, to be brought back into solution and transported downstream. This topic is not discussed anywhere in the application, yet is a real concern considering the quantity, concentration, and duration the mine anticipates the point source effluent to be active.

Response: The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenters' concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 39: A full Environmental Impact Statement should be conducted to determine the full effects of this proposed pipeline.

Response: An environmental impact statement is not required under 62 Ill. Adm. Code Parts 1700-1850 for this proposed surface coal mining and reclamation operation.

Comment 40: Drinking water pollutant levels are more restrictive than river water; the proposed discharges fail to meet drinking water standards, which mean public uses of Big Muddy River water could incur additional treatment costs in the years ahead.

Response: The concern expressed is beyond the regulatory purview of the Department. The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenter's concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

Comment 41: Commenters indicated that we share concerns about the lack of regulatory enforcement that most mines in Illinois have not been inspected in 12 years.

Response: The regulations at 62 Ill. Adm. Code 1800.11(a-b) require that "(a) The Department shall conduct an average of at least one partial inspection per month of each active surface coal mining and reclamation operation under its jurisdiction and shall

conduct partial inspections of each inactive surface coal mining and reclamation operation under its jurisdiction to ensure enforcement of the approved State program... (b) The Department shall conduct an average of at least one complete inspection per calendar quarter of each active or inactive surface coal mining and reclamation operation under its jurisdiction..."

The Department continues to meet its inspection mandate.

Comment 42: A commenter questioned how much affect would this have on tourism which is another major resource of southern Illinois?

Response: The effects on tourism are outside scope of the Department's regulatory purview.

Comment 43: Commenters asked if the pipeline be granted eminent domain or will the mine owner purchase easements from landowners?

Response: Eminent domain is not applicable to the proposed pipeline. It is the applicant's responsibility to obtain the necessary right of entry for the project.

Comment 44: Commenters questioned that since the pipeline crosses over the county line, if the pipeline breaks in one county does the other county have to pay for the cleanup and what recourse will farmers have when the pipeline breaks and damages their field?

Response: Operators of such pipelines are responsible for cleanup of any spillage as well as damages.

Comment 45: A commenter asked what will happen to their property when the Big Muddy River floods again with the extra salt and sulfides and dead wildlife washing in? The river will flood again without the extra 2.5 million gallons of water from the Pond Creek Mine.

Response: The Department's review of the application is conducted pursuant to 62 Ill. Adm. Code Parts 1700 – 1850. The commenter's concerns relate to the discharge of water into rivers and streams, which is an activity regulated by the IEPA. Please consult with IEPA to address issues related to maximum discharge quantities, river loading capacities, proposed mixing zones, and other related matters.

APPENDIX C

Williamson Energy, LLC, Pond Creek Mine

Application for Permit No. 456

And Permit Nos. 375 & 417
And Revisions No. 1, 2, 3, 5, 6, 7, 9, 10, and 11 to Permit No. 375
Assessment and Findings of Probable Cumulative Hydrologic Impacts

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APPENDIX C

Williamson Energy, LLC, Pond Creek Mine
Application for Permit No. 456
And Permit Nos. 375 & 417
And Revisions No. 1, 2, 3, 5, 6, 9, 10, and 11 to Permit No. 375
Assessment and Findings of Probable Cumulative Hydrologic Impacts

Williamson Energy, LLC (hereinafter referred to as "permittee" or "applicant" as applicable) was required to submit a determination of probable hydrologic consequences of the proposed mining and reclamation operations, both on and off the permit area, pursuant to 62 Ill. Adm. Code 1784.14(e) for underground mines.

Pursuant to 62 Ill. Adm. Code 1773.15(c)(5), the Department must make an assessment of the probable cumulative impacts of all anticipated coal mining on the hydrologic balance in the cumulative impact area, in accordance with 62 Ill. Adm. Code 1784.14(f), and find in writing that the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area.

The following assessment and findings are intended to fulfill the above requirements.

I. GENERAL INFORMATION

A. Historical Coal Mines (ISGS)

Several coal mines have operated in the vicinity of the Pond Creek Mine. Former coal mines were present to the west, south and east of the Pond Creek Mine.

Both surface and underground mines operated in the area, with operations dating back to 1944.

1. Ziegler No. 4 Mine (1944-1980)

To the south and west of the Permit No. 375 area is the former Ziegler No. 4 underground mine. This mine encompasses approximately 4,726 acres and operated as a room and pillar mine.

2. Orient No. 4 Mine (1952-1987)

Also to the south of the Permit No. 375 area, the former Orient No. 4 underground mine operated. This mine was approximately 6,530 acres in size and operated as a room and pillar mine from 1952 to 1987.

3. Malone No. 1 Mine (1976-1979)

This former surface mine is located to the east of the permit area. The Malone mine operated as a small surface mine from 1976 to 1979 and was approximately 82 acres in size.

4. Phoenix No. 1 Mine (1988-1993)

To the east, occupying the same general location as the form Malone No. 1 surface mine, the Phoenix No. 1 Mine was present. Two permits were issued by the Department. Permit No. 200 was issued in 1988 and Permit No. 270 was issued in 1992. The mine ceased operations in 1993 and in 2008, the Department placed the permit areas into forfeiture status.

B. Active Coal Mines

Pond Creek Mine (2005-current)

1. Permit No. 375 (issued 2005)

The original Pond Creek Mine permit was issued for an underground coal mining operation. Permit No. 375 was originally for approximately 540 acres to be used as surface support facilities for an underground coal mining operation. The surface support facilities include a coal preparation plant, parking lots, access roads, drainage control structures, office buildings, changing rooms, assembly rooms, warehousing facilities, storage facilities, ventilation facilities, refuse disposal areas, power distribution facilities, power lines, water lines, stockpile areas and other associated facilities. Williamson Energy extracts the Herrin No. 6 Coal Seam, at a depth ranging from 450 to 600 vertical feet from the surface, utilizing room and pillar and longwall mining within the originally permitted 4,631 (approximately) acre shadow area. The room and pillar mining is designed to prevent subsidence and/or to be areas of unplanned subsidence, while the longwall mine area is planned subsidence.

2. Permit No. 375, Significant Revision Nos. 1, 3, 5, 6, 7, and 9 (issued 2007, 2010, 2011, 2012, 2013, and 2014, Respectively)

Revision Nos. 1, 3, 5, 6, 7 and 9 to Permit No. 375 approved additional shadow area to allow for both room and pillar developmental and longwall mining operations. The additional shadow area totals approximately 10,588 acres.

3. Permit No. 375, Significant Revision No. 2 (issued 2009)

Revision No. 2 to Permit No. 375 converted previously approved permit area to Refuse Disposal Area No. 2 for the mine.

4. Permit No. 375, Significant Revision No. 4 (Withdrawn)

This proposed revision was withdrawn by the applicant and not issued.

5. Permit No. 375, Significant Revision No. 8 (Withdrawn)

Revision No. 8 to Permit No. 375 is a proposal to inject coal slurry into the former underground works of the Pond Creek Mine. This application has been withdrawn.

6. Permit No. 417 and Significant Revision No. 10 to Permit No. 375 (issued 2015)

Permit No. 417 and Significant Revision No. 10 to Permit No. 375 added approximately 230 acres for an additional refuse disposal area, to be known as Refuse Disposal Area No. 3.

7. Permit No. 375, Significant Revision No. 11 (issued 2018)

Significant Revision No. 11 to Permit No. 375 added 10,913.7 acres of shadow area to the existing mining operations. To date, 57 Insignificant Permit Revisions (IPRs), 84 Incidental Boundary Revisions (IBRs), and 14 minor field decisions have been issued by the Department since the original permit was issued. The IPRs were issued for a variety of reasons, including, but not limited to: surface drainage modifications; pond design changes; rail loop load-out modifications; underground boreholes for rockdust, power supplies and ventilation; installation/replacement of groundwater monitoring wells; changes to the existing refuse disposal areas.

The IBRs were also issued for a variety of reasons, including but not limited to: refuse disposal area changes; borehole installation; soil stockpile changes; addition of diversion ditches, and other surface water drainage; mine ventilation changes and shadow area expansions of 20 acres or less. Through IBRs, Williamson Energy has added approximately 229.3 acres to the original surface facilities permit area and approximately 592 acres of shadow area.

The total surface facilities permit area is now approximately 1,070 acres, whereas, the total shadow area is approximately 25,715 acres.

8. Application for Permit No. 456

The Application for Permit No. 456 proposes to add a 12.5-mile pipeline from the currently approved water holding cells on the western boundary of the mine site to the Big Muddy River. According to the application, the pipe size will be a minimum of 18 inches throughout its total length. The permittee also has an application pending with the Illinois Environmental Protection Agency (IEPA) for a mixing zone. According to the application, the mixing zone is being requested due to the inability to dispose of water infiltrating into the mine. This water has naturally elevated chloride and sulfate concentrations. The amount of water that can be discharged into the Big Muddy River at any given moment is dependent on the chloride concentration of the mine effluent,

the chloride concentration in the receiving stream, and the flow of the receiving stream. However, the maximum pumping rate for this facility will be limited to 5,000 gallons per minute according to the draft NPDES permit and the Application for Permit No. 456 documentation.

II. PROBABLE CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT (CHIA) OF APPLICATION FOR PERMIT NO. 456

A. Cumulative Impact Area (CIA) Evaluation

For purposes of a Cumulative Hydrologic Impact Assessment (CHIA), the Cumulative Impact Area (CIA) is defined as follows:

> The area, including the permit area, within which impacts resulting from the proposed operation may interact with the impacts of all anticipated mining on surface and groundwater systems. Anticipated mining shall include, at a minimum, the entire projected lives through bond release of:
>
> the proposed operation;
>
> all existing operations;
>
> any operation for which a permit application has been submitted to the Department.

This is based upon baseline geologic and hydrologic information. See 62 Ill. Adm. Code Sections 1701.Appendix A and 1784.14.

1. Office of Surface Mining Guidance

The Federal Office of Surface Mining Mid-Continent Region (OSM-MCR) developed a document in June 2007 entitled *Hydrologic Considerations for Permitting and Liability Release, a Technical Reference for the Mid-Continent Region*. In determining whether a CHIA is required, OSM-MCR states that "the operative word in the CHIA concept is *cumulative* which seemingly necessitates the potential interaction of two or more anticipated mining operations." (p. 17) Further OSM-MCR states, "While it may be possible that for a single hydrologically isolated mine the probable hydrologic consequences determination made by the operator would be adopted by the regulatory authority as the CHIA, nevertheless such a conclusion must be reached by the regulatory authority on a case-by-case basis." (p.17)

2. CIA Determination for Application for Permit No. 456

Please see the CHIA for Significant Revision No. 2 to Permit No. 375 for baseline information regarding the original permit and shadow areas and for the Department's determination of the CIA for Permit No. 375. The proposed 12.5 – mile pipeline encompasses a total of 70.51 acres that will terminate at a mixing zone in the Big Muddy River. The proposed pipeline route will cross the

following HUC-12 watersheds, West Frankfort - Pond Creek, Lake Creek, Chittyville - Pond Creek, and Cambon Lake - Big Muddy River. Although the pipeline crosses these four watersheds the assessment area was only expanded to the permit boundaries of the proposed Application for Permit No. 456 area.

According to the Water Management Operations section in the application, the infiltrating groundwater is from an overlying sandstone which has naturally elevated concentrations of chlorides and sulfates. Part III of the application states, chloride concentration generally varies between 1,699 mg/L and 2,799 mg/L, whereas the sulfate values range between 820 mg/L and 2,120 mg/L. As mentioned previously, this water cannot be discharged through the existing sediment ponds on site without exceeding the NPDES permit limits. Therefore, the mine is seeking to discharge this water into the Big Muddy River via a pipeline and a mixing zone (pending IEPA approval).

According to the application and the draft NPDES permit, the volume of mine effluent that can be discharged to the Big Muddy River will be dependent on the flow of the Big Muddy River, chloride concentration of the Big Muddy River, and chloride concentration of the mine discharge water. The maximum pumping rate from the facility has been limited to 5,000 gallons per minute. The application states, the proposed pipeline will be an 18-inch high-density polyethylene (HDPE) pipe that will be buried and capable of handling 125 psi of pressure. The pipeline will be installed using both open trench and boring techniques. The applicant has committed to installing a secondary containment pipe outside of the transport pipe within the 100-foot stream buffer zone of Pond Creek. The applicant has additionally committed to minimize impacts to agricultural lands according to the Standards and Policies for Agricultural Mitigation.

The applicant states the pipeline will be monitored for leaks or potential problems using ultrasonic or similar technology flow meters. These flow meters will be clamped to the pipe and hooked into a telemetry or fiber optic network that can relay real-time information back to the mine. This system will also be tied to an alarm system that activates if a specific difference in flow rate is exceeded. The system will utilize pressure gauges and air release valves to release any potentially trapped air in the pipeline. In the event excessive pressure is measured, the pumps will be shut off, according to the application. The applicant has additionally committed to monthly inspections of the pipeline at road boring sites, the Pond Creek boring site, the Big Muddy River discharge site, and the monitoring stations housing the flow meters, air valves, and pressure gauges.

As mentioned previously, the proposed pipeline route will cross four watersheds. In determining a CIA area, the Department first evaluated the area encompassed by these four watersheds. However, given the construction parameters of the pipeline, the monitoring constraints, and the applicant's commitment to monthly inspections and/or maintenance, the Department does not expect there to be any negative impacts to the hydrologic balance from the proposed operations. The construction activities as proposed in the application will only temporarily affect the area encompassed by the proposed permit. The Department does not expect the surface water and groundwater will be negatively impacted by the temporary construction activities proposed for the installation of the pipeline. As such, the Department is expanding the CIA for the Application for

Permit No. 456 by 70.51 acres, which is the acreage of the proposed pipeline. The Department has determined that as long as the applicant properly operates the pipeline per the commitments given in the application, there should be minimal to no impact to the surface water or groundwater within the CIA area. Further, the Department expects no impacts outside the CIA area.

The CIA acreage has also been expanded to encompass surface IBRs previously not included in the assessment area. These surface IBRs include additional area for vertical turbine pumps, pipelines, boreholes, man/material shafts, and ventilation shafts. The original surface water and groundwater assessment areas were within the Town of West Frankfort – Pond Creek HUC-12 watershed. The additional surface IBRs spread the facility into the following watersheds: Tilley Creek – Ewing Creek, Prairie Creek – Middle Fork Saline River, Gassaway Branch – Middle Fork Saline River, Brushy Creek, and Buckley Creek – Crab Orchard Creek. The Department evaluated the above listed watersheds to account for the mine expansion and to possibly extend the assessment area. However, the Department determined that expanding the assessment area beyond the permit areas in the watersheds would make the CIA too large for the relatively minor facilities approved by the aforementioned IBRs. These IBRs were approved for facilities and the Department assumes they will not fail. Thus, the CIA has been expanded to only include the additional permitted acreage.

The new CIA acreage is 4,245 acres and depicted on Map 1. This includes the original Permit No. 375 area, Permit No. 417 area, all the surface IBRs previously not included, and the proposed Application for Permit No. 456 area.

B. Assessment of the Probable Hydrologic Consequences (PHC)

1. Permit Area and the Shadow Area

Previously, the Department conducted the required hydrologic assessment on the original Permit No. 375 permit area, shadow area, and their respective adjacent areas, as well as Significant Revision No. 11 to Permit No. 375, which added additional shadow area. Application for Permit No. 456 does not propose any additional shadow area, therefore, the Department is not revising the assessment at this time.

Per 62 Ill. Adm. Code Section 1701.Appendix A, the following terms are defined:

The "permit area" is defined as:

> [T]he area of land and water within the boundaries of the permit which are designated on the permit application maps, as approved by the Department. This area shall include all areas which are or will be affected by the surface coal mining and reclamation operations during the term of the permit indicated on the approved map which the operator submitted with the operator's application and which is required to be bonded under 62 Ill. Adm. Code 1800 and where the operator proposes to conduct surface coal mining and reclamation operations under the permit, including all disturbed areas; provided, that areas adequately

> bonded under another valid permit may be excluded from a permit area. The permit area excludes the area defined in this Part as the shadow area.

The "shadow area" is defined as:

> [A]ny area beyond the limits of the permit area in which underground mine workings are located. This area includes all resources above and below the coal that are protected by the State Act that may be adversely impacted by underground mining operations including impacts of subsidence.

The "adjacent area" is defined as:

> [T]he area located outside the permit area, or shadow area, where a resource or resources, determined according to the context in which adjacent area is used, are or reasonably could be expected to be adversely impacted by proposed mining operations.

As described in Section I.B.8 above, the proposed permit area for the Application for Permit No. 456 consists of 70.51 acres. The permittee provided information obtained from the Illinois State Geological Survey on domestic groundwater wells within ½ mile of the proposed permit area. As mentioned previously in Section II.A.2, the CIA was also expanded to encompass the acreage approved by the surface IBRs previously not included in the assessment area. Given the minimal disturbance expected from the proposed operations and the facilities approved by the aforementioned IBRs, for the purposes of this CHIA, the Department has determined there is no adjacent area as no impacts are expected outside of the proposed permit area or the IBR areas being added to the assessment area.

a. Regional Hydrologic Area

The existing permit and shadow areas, as well as the proposed permit area are located in the glaciated upland area of northern Williamson County. It is situated at the headwaters of the major drainage systems of the region. Unnamed tributaries of Pond Creek, named and unnamed tributaries of Middle Fork Saline River, as well as unnamed tributaries of the Big Muddy River pass near and through the existing and proposed permit and the existing shadow area.

b. Permit Area Surface Waters Assessment Area

The Permit Area Surface Water Assessment Area was evaluated in the CHIA for Permit No. 375 Revision No. 10 and Permit No. 417 but has been revisited by the Department for Application for Permit No. 456. The Permit Area Surface Water Assessment Area has been defined as the approximately 4,245 acres which includes the existing Permit No. 375 area, Permit No. 417 area, the surface IBR areas previously not included in the assessment area, and the Application for Permit No. 456 area (Map 1). An explanation of the delineation of the original surface water assessment area in the Pond Creek Watershed can be found in the CHIA for Permit No. 417 and Revision No. 10 to Permit No. 375. As mentioned in Section II.A.2, the Department extended the

assessment area to include the permit areas encompassed by the surface IBRs east of Permit No. 417 and the Application for Permit No. 456 area. Since all these areas are for facilities related to the mining operation (pipeline, borehole, shafts, etc.), the Department is assuming these operations will not fail and will not negatively impact the hydrologic balance.

c. Permit Area Groundwater Assessment Area

Based upon the assumption that shallow groundwater mimics the topography in the area, the Permit Area Groundwater Assessment Area is the same as has been described in II.B.1.b above and as depicted in Map 1.

d. Shadow Area Surface Waters Assessment Area

The Shadow Area Surface Waters Assessment Areas were evaluated in the CHIAs for Significant Revision Nos. 9 and 11 to Permit No. 375. The Shadow Area Surface Waters Assessment Area, associated with Significant Revision No. 11 to Permit No. 375, is approximately 17,625 acres. The Shadow Area Surface Waters Assessment Area associated with Significant Revision No. 9 to Permit No. 375 is approximately 22,441 acres. This application does not propose to modify any of the previously approved shadow area permits. Please refer to the CHIAs for Significant Revision Nos. 9 and 11 to Permit No. 375 for discussion of the Shadow Area Surface Waters Assessment Areas.

e. Shadow Area Groundwater Assessment Area

The Shadow Area Groundwater Assessment Areas are the same as the Shadow Area Surface Water Assessment Areas. The Shadow Area Groundwater Assessment Areas were evaluated in the CHIA's for Significant Revision Nos. 9 and 11 to Permit No. 375. The Shadow Area Groundwater Assessment Area, associated with Significant Revision No. 11 to Permit No. 375, is approximately 17,625 acres. The Shadow Area Groundwater Assessment Area associated with Significant Revision No. 9 to Permit No. 375 is approximately 22,441 acres. This application does not propose to modify any of the previously approved shadow area permits. Therefore, they will no longer be discussed in this CHIA. Please refer to the CHIAs for Significant Revision Nos. 9 and 11 to Permit No. 375 for discussion of the Shadow Area Groundwater Assessment Areas.

2. Geologic Information Required by 62 Ill. Adm. Code 1784.22

a. Baseline Information

Application for Permit No. 456 provides similar information on the regional bedrock geology of the area as the original Permit Application for Permit No. 375 did. The geology of the area consists of typical Pennsylvanian system formations, where approximately sixty percent of the Pennsylvanian strata is classified as sandstones and the remaining forty percent is classified as siltstones and shales. Of this forty percent, coal and/or limestones make up approximately one

percent of this material. The Cottage Grove Fault System is located in the region but is not within the existing or proposed permit areas.

Unconsolidated deposits within the proposed permit area are Pleistocene in age and range from 4 to 33 feet thick. These deposits consist mainly of clay, silt and till materials, but known, limited areas of sand can be found. Surface topography in the proposed permit area is relatively flat-lying, with the southern portion of the area topographically higher than the northern portion of the area.

Site-specific geology, was provided in the boring and corehole logs submitted with the original permit application, as well as the Applications for Permit No. 417 and Significant Revision No. 10 to Permit No. 375. The Herrin No. 6 Coal seam is overlain by alternating layers of shale and limestone.

As stated in the Application for Permit No. 456, the infiltrating groundwater is from a saline zone within the Anvil Rock or Gimlet Sandstone units. The interburden between the Herrin No. 6 coal seam and the base of the Anvil Rock varies between 10 feet and 60 feet. The applicant believes the sandstone units are mostly discontinuous and the caved zone above the mined longwall panels extends into these sandstone units which leads to the water infiltrating into the mine.

b. Geologic Information Findings

The applicant presented no acid base accounting data with this application since the applicant is not proposing any changes in the coal refuse management. The applicant has committed to constructing the pipeline using the best management construction techniques that follow the provisions of Standards and Policies for Agricultural Mitigation.

The applicant also presented information on the sandstone units overlying the Herrin No. 6 coal seam that is the source of the infiltrating groundwater. To protect the miners underground, the operator must pump this water out of the mine. Since the water is naturally high in chlorides and sulfates the applicant is requesting a mixing zone from the IEPA. Otherwise, this water could not be discharged from the existing NPDES outfalls on site without exceeding compliance limits. The Department finds as long as the pipeline is properly constructed, maintained, operated, and the limits of the NPDES permit are adhered to, any impacts to the hydrologic balance should be minimized.

3. Hydrologic Information Required by 62 Illinois Adm. Code 1784.14

a. Baseline Information

i. Surface Water Quantity Baseline Information

No baseline surface water quantity information from stream monitoring points in the vicinity of the proposed permit area was presented in this application. The applicant did provide data for the existing stream monitoring points in the vicinity of the main surface facilities. Surface water

quantity information was previously discussed in the CHIAs for the original permit application and Permit No. 417. The applicant is expecting minimal impacts to the surface water quantity in the vicinity of the proposed permit area during the construction of the pipeline and little to no impacts when the pipeline is operational. According to Attachment IV.1 of the application, the applicant will monitor the pipeline for leaks using a network of flow meters. Additionally, the plan has provisions to double wall the pipeline within the Pond Creek stream buffer zone. Attachment IV.1 of the application also states the mine can discharge as much as 5,000 gallons per minute into the Big Muddy River via a diffuser system based on the flow of the river and other conditions specified in the NPDES permit.

ii. Surface Water Quality Baseline Information

No baseline surface water quality information from stream monitoring points in the vicinity of the proposed permit area was presented with this application. The applicant did provide data for the existing stream monitoring points in the vicinity of the main surface facilities. The applicant is expecting minimal impacts to the surface water quality in the vicinity of the proposed permit area during the construction of the pipeline and little to no impacts when the pipeline is operational given the provisions discussed in the previous section.

The applicant did provide the water quality expected out of the water holding cell prior to entering the pipeline. Table III.2.D.1.a in the application displays representative data obtained from the water holding cell which could contain a mixture of mine infiltration water, process water from the preparation plant, and decant water from the slurry cells. The chloride concentration varied between 1,699 mg/L and 2,799 mg/L, whereas the sulfate concentration varied between 820 mg/L and 2,120 mg/L. According to Attachment IV.1 of the application, the water that will be discharged will be process water and mine infiltration water. The document goes on to say an Anti-Degradation document was submitted to IEPA on November 18, 2016 and the clarified decant water from the slurry cell was considered in the analysis. Surface water quality for the main surface facilities was previously discussed in the CHIAs for the original permit application and Permit No. 417 and will not be changed due to this application.

iii. Groundwater Quantity Baseline Information

The applicant installed no groundwater monitoring wells for this permit application. The applicant felt the minimal disturbance from the construction activities should not affect the shallow groundwater quantity in the vicinity of the proposed permit area. The applicant surveyed the Illinois State Geological Survey (ISGS) public water well records to identify users who may be utilizing the groundwater. In Attachment III.2.B.1 and the Hydrologic Maps of the Application for Permit No. 456, the applicant identified eight private water wells and their respective users within ½ mile of the proposed permit boundary. One of the wells is noted to be plugged according to the information the applicant obtained from the ISGS records. The applicant did not conduct a door – to – door survey given the minimally invasive construction methods and protections that will be employed to install the pipeline. As such, the applicant does not expect any listed well owner to experience groundwater quantity issues as a result of this operation.

In Attachment IV.1 of the application, the applicant states the daily quantity of mine infiltration water required to be pumped out amounts to 2,700,000 gallons per day. The applicant anticipates the maximum flow of mine infiltration water to be 3,500,000 gallons per day. The application notes the applicant is not aware of any groundwater users using the water from the Anvil Rock or Gimlet Sandstone units. Most private groundwater well users are utilizing the shallow groundwater from the unconsolidated layer. The applicant noted one user who has a well drilled down to these sandstones, however it appears it was drilled deep for additional storage capacity in the well according to the application.

iv. Groundwater Quality Baseline Information

As mentioned in the previous section, the applicant notes the construction methods to install the pipeline should be minimally invasive. As such, the applicant does not believe the shallow groundwater quality will be affected by the proposed operations. The application states the infiltrating groundwater has elevated chloride and sulfate levels that would not otherwise be allowed to discharge through the outfalls currently approved in the NPDES permit. Table III.2.D.1.a in the application displays representative data obtained from the water holding cell which could contain a mixture of mine infiltration water, process water from the preparation plant, and decant water from the slurry cells according to Attachment IV.1 of the application. The chloride concentration varied between 1,699 mg/L and 2,799 mg/L, whereas the sulfate concentration varied between 820 mg/L and 2,120 mg/L according to the application.

The applicant is assuming the primary driver for the elevated chloride and sulfate concentration is the infiltrating groundwater. Since this water has naturally elevated chlorides and sulfates, the applicant notes there are no known private users of this groundwater. As mentioned in the previous section, the applicant notes one user who has a well that is drilled into this interval, but the applicant asserts this was done for additional storage capacity in the well rather than utilization of the unit for water.

b. Findings

i. Surface Water Quantity Findings

Previous surface water assessments can be found in the CHIAs for Permit Nos. 375 and 417. The applicant presented information in the application to indicate the construction of this pipeline will be minimally invasive. Additionally, the applicant has committed to provisions in the pipeline construction and operation to prevent leaks and ensure reliable operation. Therefore, the Department finds the construction of this pipeline will cause little to no impact to the surface water quantity in the vicinity of the proposed permit area. This conclusion also applies to the previously approved surface IBRs now being included in the assessment area.

The application states up to 5,000 gallons per minute can be discharged into the Big Muddy River depending on the flow of the river and other conditions specified in the draft NPDES

permit for this mine. The mixing zone is currently pending approval by IEPA, however the draft NPDES permit suggests their analysis found the additional volume of water would not negatively affect the Big Muddy River. Therefore, the Department will not comment any further on the volume of water going to the Big Muddy River.

Shadow Area

Application for Permit No. 456 will have no impact on the surface water quantity that may be present within the existing shadow areas.

ii. Surface Water Quality Findings

Given the relatively non-invasive construction, maintenance commitment, and operational provisions of the pipeline to prevent leaks, the Department finds the surface water quality will be minimally affected or not affected at all by the proposed operations. This conclusion also applies to the previously approved surface IBRs now being included in the assessment area.

Table III.2.D.1.a in the application gave representative water quality data for the holding cell and showed elevated chloride and sulfate values. Attachment IV.1 of the application stated the water holding cell could contain a mixture of mine infiltration water, process water from the preparation plant, and decant water from the slurry cells. The applicant also stated this was considered in the Anti-Degradation Analysis conducted by IEPA for the mixing zone into the Big Muddy River. According to the draft NPDES permit, the IEPA determined the mixing zone will not negatively affect the Big Muddy River, as such, the Department will not comment further on their analysis. Therefore, the Department finds as long as the applicant follows and meets the provisions laid out in the NPDES permit, the surface water quality should not be negatively affected.

Shadow Area

Application for Permit No. 456 will have no impact on the surface water quality that may be present within the existing shadow areas.

iii. Groundwater Quantity Findings

It is not anticipated the shallow groundwater quantity will be significantly impacted by the proposed operations. Attachment III.2.B.1 and the Hydrologic Maps of the Application for Permit No. 456 identified eight private water wells and their respective users within ½ mile of the proposed permit boundary. One of the wells is noted to be plugged according to the information the applicant obtained from the ISGS records. The Department does not expect the groundwater quantity of the private well users to be impacted by the proposed operations. Given the relatively non-invasive construction, maintenance commitment, and operational provisions of the pipeline to prevent leaks, the Department finds the groundwater quantity will be minimally affected or not affected at all by the proposed operations. This conclusion also applies to the previously approved surface IBRs now being included in the assessment area.

As stated in previous CHIAs for this mine, the groundwater infiltrating in the mine works originates in sandstone aquifers that are currently (and historically) not in use by local residents for two reasons. The first is the cemented nature of the sandstone creates low aquifer yield and the second is the documented poor quality of this water. Local residents tend to obtain their drinking water from surface sources due to the highly mineralized water that is present in this sandstone unit.

Therefore, the effect of the pumping of this groundwater that infiltrates the mine workings is not anticipated to have a negative impact on any current drinking, domestic, or usable aquifer quantity.

Shadow Area

Application for Permit No. 456 will have no impact on the groundwater quantity that may be present within the existing shadow areas.

iv. Groundwater Quality Findings

Similar to the Groundwater Quantity Findings, it is not anticipated the shallow groundwater quality will be significantly impacted by the proposed operations. Attachment III.2.B.1 and the Hydrologic Maps of the Application for Permit No. 456 identified eight private water wells and their respective users within ½ mile of the proposed permit boundary. One of the wells is noted to be plugged according to the information the applicant obtained from the ISGS records. The Department does not expect the groundwater quality of the private wells users to be impacted by the proposed operations. Given the relatively non-invasive construction, maintenance commitment, and operational provisions of the pipeline to prevent leaks, the Department finds the groundwater quality will be minimally affected or not affected at all by the proposed operations. This conclusion also applies to the previously approved surface IBRs now being included in the assessment area.

As mentioned in the previous section, the groundwater infiltrating in the mine works originates in sandstone aquifers that are currently (and historically) not in use by local residents due to low aquifer yield and poor quality. Local residents tend to obtain their drinking water from surface sources due to the highly mineralized water that is present in this sandstone unit. Therefore, the effect of the pumping of this groundwater that infiltrates the mine workings is not anticipated to have a negative impact on any current drinking, domestic, or usable aquifer quality.

Shadow Area

Application for Permit No. 456 will have no impact on the groundwater quality that may be present within the existing shadow areas.

III. CONCLUSION

The surface water and groundwater monitoring programs have been designed to provide sufficient lead time for notification of any potential impacts, as well as to provide ample time for investigation and mitigation of any impacts prior to reaching off-site. Both the groundwater and surface water monitoring programs are dynamic and as such, the Department reserves the right to add monitoring parameters or monitoring locations should the need arise. The applicant/permittee is required to monitor the surface water and groundwater throughout the life of the mine, up to and including the time of final bond release.

The Department has now conducted a hydrogeologic assessment on the proposed additional acreage described in the Application for Permit No. 456 and the previously approved surface IBRs now being included in the assessment area. As noted in the discussions throughout this document, the Department has concluded that the additional proposed surface facilities permit area will not have a negative impact on either the surface water or groundwater regimes.

Neither the surface water nor groundwater within the assessment areas will be materially damaged unless the quantity and/or quality of water is degraded on a long-term or permanent basis, beyond the applicable standards or a long-term or permanent loss of use is reported. Material damage occurs when the impact is immitigable. Neither the applicant/permittee, nor the Department anticipates that this will occur.

Therefore, the cumulative hydrologic impact assessment finds that the proposed operations have been designed to prevent material damage to the hydrologic balance beyond the permitted areas.

In summary, the assessment and findings of the probable cumulative impact of all anticipated mining in the area on the hydrologic balance finds that this operation has been designed to prevent material damage to the hydrologic balance outside the permit areas.

IV. REFERENCES AND ATTACHMENTS

REFERENCES

Booth, C.J., and E.D. Spande, 1991, *Changes in hydraulic properties of strata over active longwall mining, Illinois, USA*: Proceedings, Fourth International Mine Water Congress, Portschach, Austria/Lubljana, Slovenia, September, p.12.

Cartwright, K., and C.S. Hunt, 1981, *Hydrogeologic aspects of coal mining in Illinois: An Overview.* Illinois State Geological Survey, Environmental Geology Notes #90.

Hoving, S.J. and W.C. Hood, 1984, *The Effects of Different Thicknesses of Limestone and Soil Over Pyrite Materials on Leachate Quality.* In 1984 Symposium of Surface Mining, Hydrology, Sedimentology, and Reclamation, University of Kentucky, Lexington, KY, December 2-7, p 251-257.

Infanger, M.K., and W.C. Hood, 1980, *Positioning acid-producing overburden for minimal pollution.* Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation. Univ. of Kentucky, Dec. 1-3.

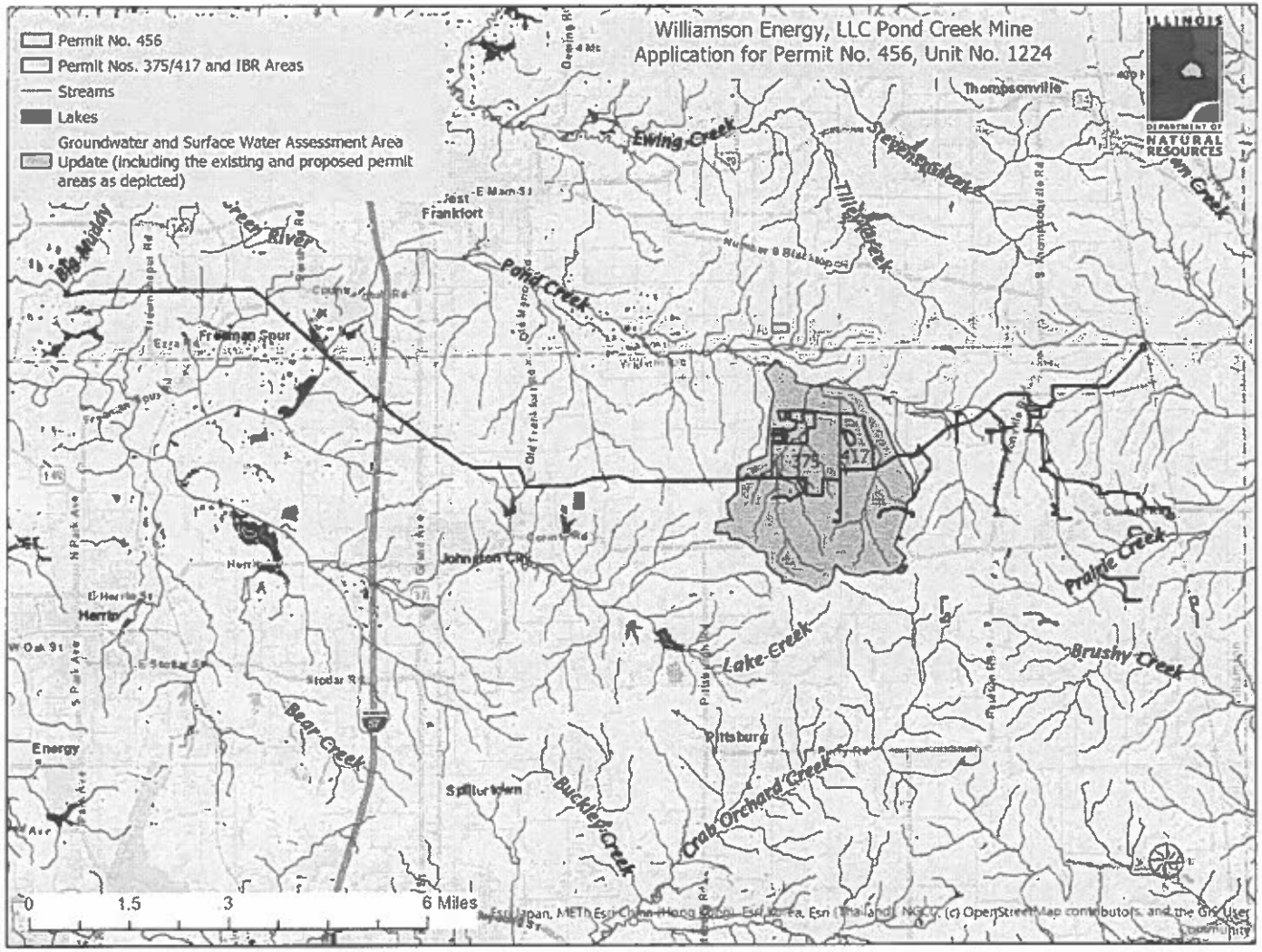
Illinois State Geologic Survey, *Coal Mines and Industrial Mineral Mines Franklin County,* August 2017.

Owili-Eger, A.A.C., 1983, Geohydrologic and hydrogeochemical impact of longwall coal mining on local aquifers. Society of Mining Engineers AIME Pre-print No. 83-376, p.16.

Pryor, W.A., 1956, *Groundwater geology in southern Illinois: A preliminary report.* Illinois State Geological Survey, Circular #212.

United States Department of the Interior, Office of Surface Mining, *Technical Reference for the Mid-Continent Region: Hydrologic Considerations for Permitting and Liability Release,* June 2007.

Zuehls, E.E., et al., 1981, *Hydrology of Area 35, Eastern Region, Interior Coal Province, Illinois and Kentucky.* United States Geologic Survey, Water Resources Investigations Open-File Report 81-403.



Map 1 – Current CIA and Assessment Map

R05643

APPENDIX D

DECISION ON PROPOSED POST-MINING LAND USE OF PERMIT AREA

The pre-mining and post-mining land use acreage of the permitted area is as follows*:

	Pre-mining	Post-mining
Cropland	16.4	16.4
Water Resources	0.2	0.2
Residential	0.1	0.1
Industrial/Commercial	8.2	8.2
Fish & Wildlife Habitat**	45.8	45.8
Total	70.7	70.7

*The Department notes that other agencies with environmental and land use authority may use land use definitions other than 62 Ill. Adm. Code 1701.5. Reports for those agencies which may be included in the application will classify and tabulate land uses based on their definitions. As a result, those land use tabulations may not directly correlate with the above tables.

** To facilitate the assessment of the revegetation success performance standards, the post-mining land use of Fish and Wildlife Habitat is broken out as follows:

Wildlife-Herbaceous	Wildlife-Woody	Wildlife-Wetland	Wildlife-Water
20.7	21.1	3.6	0.4

The Department thus finds the areas affected by surface coal mining operations will be restored in a timely manner to conditions that are capable of supporting the use which they were capable of supporting before mining or to higher or better use achievable under the criteria and procedures of 62 Ill. Adm. Code 1817.133, or as noted above. The plan of restoration submitted by the applicant does not present any actual or probable hazard to public health or safety nor does it pose any actual threat of water diminution or pollution as indicated in Appendix C, and the proposed land uses following mining are not impractical or unreasonable as all the post-mining land uses existed prior to mining and are compatible with the surrounding areas. The land uses are consistent with applicable land use policy and plans known to the Department and no objections were received from any governmental agency with such authority. The plan does not involve unreasonable delay

in implementation and is not in violation of any other applicable law known to the Department. Federal court decisions, commonly known and the "Flannery decisions" and current regulations provide for the distinct difference between surface and underground mining. In this permit the operations will involve the trenching and burying of a pipeline through the permit area. Reclamation by soil replacement and revegetation will occur shortly afterward as part of the operation with the exception of any surface access areas. There are no land use or land capability changes requested by the permitee. These disturbances are considered minor in comparison to surface mining and the removal of overburen and coal.

APPENDIX E

DOCUMENTATION PROVIDED BY APPLICANT TO COMPLY WITH
62 Ill. Adm. Code 1773.15(b)(1)(A)

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

September 13, 2017

Mr. Charles Shestak
Canterbury Coal Company
46226 National Road
St. Clairsville, OH 43950

Re: David/Dianne Mine
Permit No.03841302
Compliance Order Nos. 171025 and 171028
Kiskiminetas Township
Armstrong County

Dear Mr. Shestak:

We have enclosed an executed Consent Assessment of Civil Penalty for the above referenced compliance orders.

We appreciate your cooperation in resolving this matter. If you have any questions, please contact me at 724-925-5500.

Sincerely,

Jeffrey V. Parr
Compliance Specialist
District Mining Operations

cc: Permit File

Enclosure

New Stanton District Office
131 Broadview Road | New Stanton, PA 15672 | 724.925.5500 | F 724.925.5557
www.dep.pa.gov

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division
(Rev 06/19/17)

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

In The Matter Of:

Canterbury Coal Company 46226 National Road Saint Clairsville, OH 43950	: : : :	Compliance Order No. 171028 Permit No. 03841302 - License No. 5006 Kiskiminetas Township Armstrong County

CONSENT ASSESSMENT OF CIVIL PENALTY

This Consent Assessment of Civil Penalty ("CACP") is entered into this 23 day of August 2017, by and between the Commonwealth of Pennsylvania, Department of Environmental Protection ("Department") and Canterbury Coal Company ("Canterbury Coal").

The Department has found and determined the following:

A. The Department is the agency with authority to administer and enforce [The Clean Streams Law, Act of June 22, 1937, P.L. 1987, *as amended*, 35 P.S. §§ 691.1--691.1001]; [the Surface Mining Conservation and Reclamation Act, Act of May 31, 1945, P.L. 1198, *as amended*, 52 P.S. §§ 1396.1--1396.19a ("Surface Mining Act")]; [the Coal Refuse Disposal Control Act, Act of September 24, 1968, P.L. 1040, *as amended*, 52 P.S. §§ 30.51--30.66 ("Coal Refuse Act")]; [the Noncoal Surface Mining Conservation and Reclamation Act, Act of December 19, 1984, P.L. 1093, *as amended*, 52 P.S. §§ 3301 -- 3326 ("Noncoal Act")]; [the Bituminous Mine Subsidence and Land Conservation Act, Act of April 27, 1966, P.L. 31, *as amended*, 52 P.S. §§ 1406.1--1406.21 ("Bituminous Subsidence Act)]; Section 1917-A of the Administrative Code of 1929, Act of April 9, 1929, P.L. 177, *as amended*, 71 P.S. § 510-17, and the rules and regulations promulgated thereunder.

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October 21, 2019
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Land Reclamation Division

H. On May 5, 2017 as evidenced by Sample No. 4137-091, Canterbury Coal caused or allowed a discharge of water at the David/Dianne Mine, from outfall 001, with an aluminum concentration of 1.524 mg/L which exceeds the permit limit of 0.75 mg/L.

I. Canterbury Coal's conduct set forth above constitutes a violation of Sections 301, 307, 315, and 611 of the Clean Streams Law, 35 P.S. §§ 691.301, 691.307, 691.315, 691.611 and Section 86.13 of the Rules and Regulations, 25 Pa. Code § 86.13.

J. The violations described in Paragraph(s) F through I above constitute unlawful conduct under Section 611 of the Clean Streams Law, 35 P.S. § 691.611 and Section 17a of the Bituminous Subsidence Act, 52 P.S. § 1406.17a and subject Canterbury Coal to a claim for civil penalty liability under Section 605 of the Clean Streams Law, 35 P.S. § 691.605 and Section 17 of the Bituminous Subsidence Act, 52 P.S. § 1406.17.

After full and complete negotiation of all matters set forth in this CACP and upon mutual exchange of the covenants herein, the parties desiring to avoid litigation and intending to be legally bound, it is hereby ASSESSED by the Department and AGREED to by Canterbury Coal as follows:

1. Assessment. In resolution of the Department's claim for civil penalties, which the Department is authorized to pursue under Section 605 of the Clean Streams Law, 35 P.S. § 691.605, and Section 17f of the Mine Subsidence Act, 52 P.S. § 1406.17(f). The Department hereby assesses a civil penalty of TWO THOUSAND FIVE HUNDRED SEVENTY-TWO DOLLARS ($2,572), which Canterbury Coal hereby agrees to pay.

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October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

2. Civil Penalty Settlement. Canterbury Coal consents to the assessment of the civil penalty assessed in Paragraph 1, which shall be paid in full upon signing this CACP. This payment is in settlement of the Department's claim for civil penalties for the violations set forth in the paragraphs above for the date[s] set forth therein. The payment shall be by corporate check or the like, made payable to the Commonwealth of Pennsylvania and sent to Compliance Specialist, PA DEP – New Stanton District Office, 131 Broadview Road, New Stanton, PA 15672.

3. Findings.

a. Canterbury Coal agrees that the findings in Paragraphs A through J are true and correct and, in any matter or proceeding involving Canterbury Coal and the Department, Canterbury Coal shall not challenge the accuracy or validity of these findings.

b. The parties do not authorize any other persons to use the findings in this CACP in any matter or proceeding.

4. Reservation of Rights. The Department reserves all other rights with respect to any matter addressed by this CACP, including the right to require abatement of any conditions resulting from the events described in the Findings. Canterbury Coal reserves the right to challenge any action which the Department may take, but waives the right to challenge the content or validity of this CACP.

IN WITNESS WHEREOF, the parties have caused this CACP to be executed by their duly authorized representatives. The undersigned representatives of Canterbury Coal certify, under penalty of law, as provided by 18 Pa. C. S. § 4904, that they are authorized to execute this CACP on behalf of Canterbury Coal, that Canterbury Coal consents to the entry of this CACP as

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Land Reclamation Division

an ASSESSMENT of the Department; that Canterbury Coal hereby knowingly waives any right to a hearing under the statutes referenced in this CACP; and that Canterbury Coal knowingly waives its right to appeal this CACP, which rights may be available under Section 4 of the Environmental Hearing Board Act, Act of July 13, 1988, P.L. 530, 35 P.S. § 7514; the Administrative Agency Law, 2 Pa. C.S. § 103(a) and Chapters 5A and 7A; or any other provision of law. [Signature by Canterbury Coal's attorney certifies only that the agreement has been signed after consulting with counsel.]

FOR Canterbury Coal Company:

Name Robert D. Moore
Title President + Treasurer

Name
Title Michael O. McKown
Secretary

waived
[Name
Attorney for [Operator]]

FOR THE COMMONWEALTH OF PENNSYLVANIA, DEPARTMENT OF ENVIRONMENTAL PROTECTION:

Name: Joseph F. Leone
Title: District Mining Manager

Barbara Grabowski
Name: Barbara Grabowski
Assistant Regional Counsel

COMMENT: If the Operator is a corporation, this document must be signed by both (1) the President or Vice President *and* (2) the Secretary or Treasurer, unless a resolution from the Board of Directors is attached that authorizes the signatory to sign on behalf of the corporation.

AUG 24 2017

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

James Plumley

From: Thomas, Ryan L <Ryan.L.Thomas@wv.gov>
Sent: Thursday, October 17, 2019 1:06 PM
To: Hunter, Hodge
Subject: Re: [External] S-6020-89 NOV #63 Extension

CAUTION: This email originated from outside of Murray Energy. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Yes, I will be extending this violation up to 11-14-19. I will do the paperwork as soon as I get back in the office.

Ryan Thomas
Environmental Inspector
Division of Mining and Reclamation
1159 Nick Rahall Greenway
Fayetteville, WV 25840
Office: 304-574-4465
Email: Ryan.L.Thomas@wv.gov

On Oct 17, 2019, at 1:59 PM, Hunter, Hodge <hodgehunter@coalsource.com> wrote:

> CAUTION: External email. Do not click links or open attachments unless you verify sender.
>
> Mr. Thomas,
>
> Could we get an extension for NOV #63 on permit S-6020-89?
>
> Thank you,
> Hodge Hunter
>
> Hodge Hunter | Environmental Engineer
> Murray Maple Eagle Coal, LLC | hodgehunter@coalsource.com
> 1345 Elkridge Road | Powellton, WV 25161
> Office: 304-981-4922 | Cell: 870-260-2848
>
> <image001.jpg>

MR-6
ERIS

West Virginia Department of Environmental Protection
MR-6 MINE INSPECTION REPORT

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

PERMIT NUMBER	INSPECTION DATE	INSPECTION TIME	INSPECTION REASON	INSPECTION TYPE	MINE STATUS	PHOTOS	BLASTING Last 30 Days?	BLASTING Ins. Req'd?
O102392	11/16/2018	10 00	IN	P	AM	No	No	No

PERMITTEE NAME: THE MARSHALL COUNTY COAL COMPANY MSHA #: 4601437
OPERATOR NAME: MR-19 DATE:
NPDES #: WV0020834 NPDES EXPR DATE: 08/07/2019 PERMIT EXPR DATE: 02/28/2021
PERMIT ACRES: 1,160.68 TOTAL DISTBD: 900.00 RECLMD: 75.00 ANCIL-LARY: 0 UNRECLMD: 825
DATES: PH I: PH II: LAST AUG SEED: MR-8:
LAST INSP DATE: 10/30/2018 TYPE: P BOND INC: 1 INC BONDED ACRES: 1,160.68 CUR IBR#: 28 CUR REV#: 16
EXPR DATES: INACT: EMER RESP PLAN: INS: 06/01/2019 BLAST AD:
TIME USED (HRS)==> PERMIT REVIEW: 0.25 INSPECT: 0.25 TRAVEL: 0.25 REPORT: 0.25

INSPECTION COMMENTS

NOV 31 Follow-up. NOV 31 is now being enforced under the Consent Order dated May 14, 2018. The violation is terminated.

ENFORCEMENT STANDARD		EVALUATION	VIO#	ENFORCEMENT STANDARD		EVALUATION	VIO#
0100	Distance Prohibited			0200	Exceeding Limits		
0300	Signs and Markers			0400	Sediment Control		
0500	Design Certification			0600	Effluent Limits		
0700	Surface Water			0800	Ground Water		
0900	Blasting Procedures			1000	Haul Roads		
1100	Refuse Impoundments			1200	Topsoil Handling		
1300	Backfill / Grading			1400	Reclamation Schedule		
1500	Revegetation Requirements			1600	Disposal of Excess Spoil		
1700	Highwall Elimination			1800	Downslope Spoil Disposal		
1900	Postmining Land Use			2000	Ceased Mining Temporarily		
2100	Acid bearing /Toxic Material			2200	Method of Operations		
2300	Change of Operator			2400	Permit Conditions		
2500	Diversions and Drainage Control			2600	Fugitive Dust Control		
2700	Subsidence Plan			2800	Insurance Current		
2900	Bonding Current			3000	Other Conditions	FC	

WATER QUALITY TESTS

Structure ID	Outfall	pH	Fe	Mn	Al	No Flow	Not Const.	Treatment

AUTH. COMPANY REPRESENTATIVE: Joe Williams
DELIVERY METHOD / DATE TIME: Mail 11/21/2018 10:00:00
CERTIFIED MAIL NUMBER:
ADDRESS: 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950
WV DEP REP.: Andrew M Coleman

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 · (217) 782-3397
JB PRITZKER, GOVERNOR
JOHN J. KIM, DIRECTOR

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

217-782-9861

July 23, 2019

CERTIFIED MAIL # 7015 0640 0002 6956 7712
RETURN RECEIPT REQUESTED

Sugar Camp Energy, LLC
Attn: Mr. Mark G. Schuerger
11525 North Thompsonville Road
Macedonia, Illinois, 62860

Re: Notice of Non-Issuance of Compliance Commitment Agreement
Violation Notice: W-2019-50002
Sugar Camp Energy
W0558010004

Dear Mr. Schuerger:

The Illinois Environmental Protection Agency ("Illinois EPA") has reviewed the proposed Compliance Commitment Agreement ("CCA") terms submitted by **Sugar Camp Energy** in a letter dated **June 26, 2019**, in response to the Violation Notice dated **March 25, 2019**, and has decided not to issue a proposed CCA for these violations. Due to the nature and seriousness of the violations, the Illinois EPA has determined that these violations may not be able to be resolved without the involvement of the Office of the Attorney General or the State's Attorney.

Because the violations remain the subject of disagreement between the Illinois EPA and **Sugar Camp Energy**, this matter will be considered for referral to the above-referenced prosecutorial authorities for formal enforcement action and the imposition of penalties.

Questions regarding this matter should be directed to Greg Spencer at 217/782-9871. Written communications should be directed to:

Illinois EPA – Division of Water Pollution Control
Attn: Greg Spencer/CAS #19
P.O. Box 19276
Springfield, IL 62794-9276

Sincerely,

Roger Callaway
Compliance Assurance Section
Division of Water Pollution Control
Bureau of Water

4302 N. Main St., Rockford, IL 61103 (815) 987-7760
595 S. State, Elgin, IL 60123 (847) 608-3131
2125 S. First St., Champaign, IL 61820 (217) 278-5800
2009 Mall St., Collinsville, IL 62234 (618) 346-5120
9511 Harrison St., Des Plaines, IL 60016 (847) 294-4000
412 SW Washington St., Suite D, Peoria, IL 61602 (309) 671-3022
2309 W. Main St., Suite 116, Marion, IL 62959 (618) 993-7200
100 W. Randolph, Suite 10-300, Chicago, IL 60601 (312) 814-6026

PLEASE PRINT ON RECYCLED PAPER

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October 21, 2019
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MR-6
ERIS

West Virginia Department of Environmental Protection
MR-6 MINE INSPECTION REPORT

PERMIT NUMBER	INSPECTION DATE	INSPECTION TIME	INSPECTION REASON	INSPECTION TYPE	MINE STATUS	PHOTOS	BLASTING Last 30 Days?	BLASTING Ins. Req'd?
U200707	10/04/2019	12:00	IN	P	AM	No	Yes	Yes

PERMITTEE NAME: THE MARSHALL COUNTY COAL COMPANY MSHA #: 46-01437
OPERATOR NAME: MR-19 DATE:
NPDES #: WV0020834 NPDES EXPR DATE: 11/07/2019 PERMIT EXPR DATE: 11/18/2023
PERMIT ACRES: 158.13 TOTAL DISTBD: 110.00 RECLMD: 0.00 ANCIL-LARY: 0 UNRECLMD: 110
DATES: PH I: PH II: LAST AUG SEED: MR-8:
LAST INSP DATE: 09/20/2019 TYPE: P BOND INC: 1 INC BONDED ACRES: 158.13 CUR IBR#: 15 CUR REV#: 1
EXPR DATES: INACT: EMER RESP PLAN: INS: 06/01/2020 BLAST AD:
TIME USED (HRS)==> PERMIT REVIEW: 0.25 INSPECT: 0.25 TRAVEL: 0.00 REPORT: 0.25

INSPECTION COMMENTS

Marshall County Coal Co: 6S #1 - NOV 6 extension request beyond 90 days has been received from to company. Progress to abate the NOV has been outlined in the attached report. An additional 30 days extension is being granted to allow for completion of the access road and all drainage control. New abatement date is 11/1/2019.

ENFORCEMENT STANDARD		EVALUATION	VIO#	ENFORCEMENT STANDARD		EVALUATION	VIO#
0100	Distance Prohibited			0200	Exceeding Limits		
0300	Signs and Markers			0400	Sediment Control		
0500	Design Certification			0600	Effluent Limits		
0700	Surface Water			0800	Ground Water		
0900	Blasting Procedures			1000	Haul Roads		
1100	Refuse Impoundments			1200	Topsoil Handling		
1300	Backfill / Grading			1400	Reclamation Schedule		
1500	Revegetation Requirements			1600	Disposal of Excess Spoil		
1700	Highwall Elimination			1800	Downslope Spoil Disposal		
1900	Postmining Land Use			2000	Ceased Mining Temporarily		
2100	Acid bearing /Toxic Material			2200	Method of Operations		
2300	Change of Operator			2400	Permit Conditions		
2500	Diversions and Drainage Control	COM		2600	Fugitive Dust Control		
2700	Subsidence Plan			2800	Insurance Current		
2900	Bonding Current			3000	Other Conditions		

WATER QUALITY TESTS

Structure ID	Outfall	pH	Fe	Mn	Al	No Flow	Not Const.	Treatment

AUTH. COMPANY REPRESENTATIVE: Joe Williams
DELIVERY METHOD / DATE TIME: Certified 10/7/2019 12:00:00
CERTIFIED MAIL NUMBER: 7017 2400 0000 3494 3808
ADDRESS: 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950
WV DEP REP.: James T. Harvey

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

MR-16
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West Virginia Department Of Environmental Protection

MR-16 VIOLATION FOLLOW-UP INSPECTION REPORT

PERMIT NUMBER	ORIGINAL INSPECTION AND VIOLATION DATA						NEW VIOLATION ACTIVITY	
	DATE	TIME	FORM #	FACILITY #	ENF STD	ORIGINAL VIOL#	DATE	TIME
U200707	07/08/2019	09:30	6		2500	6	10/04/2019	12:00

PERMITTEE NAME THE MARSHALL COUNTY COAL COMPANY

Violation is hereby: ☐ Terminated ☐ Withdrawn ☐ Remains in force as written ☐ Show Cause submitted

☑ Extended to 11/01/2019 at 12:00 ☐ NOV modified to CO # ____ ☐ CO modified to NOV # ____

Action taken to abate:

The company continues to work on completion of the access road and drainage control structures. An extension request beyond 90 days has been submitted by the company with a detailed report of activities taken thus far to abate the violation. An additional 30 days extension is being granted to a new abatement date of 11/1/2019.

INSPECTOR'S CIVIL PENALTY ASSESSMENT RECOMMENDATION (check)

Seriousness: 1☐ 2☐ 3☐ 4☐ 5☑ 6☐ 7☐ 8☐ 9☐ 10☐ Negligence: 0☐ 1☐ 2☐ 3☐ 4☑ 5☐ 6☐ 7☐ 8☐

Good Faith: 0☐ 1☐ 2☐ 3☑ 4☐ 5☐ 6☐ 7☐ 8☐ Consent Agreement in effect? ☐ Yes ☑ No

Comments:

AUTH. COMPANY REPRESENTATIVE Joe Williams

DELIVERY METHOD / DATE TIME Certified 10/7/2019 12:00:00

CERTIFIED MAIL NUMBER 7017 2400 0000 3494 3808

ADDRESS 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950

WV DEP REP. James T. Harvey

Austin Caperton
[Secretary, Department of Environmental Protection]

James T. Harvey
[WV DEP Representative]

10/7/19
Date

Names of individuals at informal Conference:

Results: CO was:	☐ Upheld	☐ Modified	☐ Terminated	☐ Withdrawn

Comments:

SUPERVISOR: _____ DATE: _____ TIME: _____

COMPANY REPRESENTATIVE: _____ DATE: _____

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Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

The Marshall County Coal Company
46226 National Road
St. Clairsville, Ohio 43950
Phone: 740-338-3100
Fax: 740-338-3405

October 4, 2019

James Harvey
Inspector Specialist
WV Department of Environmental Protection
Division of Mining and Reclamation
47 School Street, 301
Philippi, WV 26416

RE: The Marshall County Coal Company
6 South 1 Airshaft
U200707 NOV 6

Mr. Harvey,

This letter is in response to the remedial measures stated in NOV 6 for The Marshall County Coal Company's 6 South #1 Airshaft, WVDEP Permit U200707.

As you are aware, the completion of the site has taken longer than planned. This is largely due to the amount of unsuitable material encountered during construction. Another significant factor has been the performance of the on-site contractor. This contractor has since been removed from the project and a replacement contractor has resumed construction. The new contractor has since installed five additional culverts and removed the Trans Canada gas line that was intersecting the access road.

Currently the development of the drainage control system continues. Much of the pad and access road is at final grade and a number of culverts have been installed. Enclosed is a status report of the drainage components proposed in the design. At this time The Marshall County Coal Company requests a thirty day extension of the October 4th abatement date in order to complete the installation of the remaining ditches and culverts.

Regards,

Joe Williams
Environmental Engineer

CC: Cory Barack
Jim Turner
Guy Shelledy
Jim Mazzocca
Paul McGee
Christian Warfield
File

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Land Reclamation Division

6 South #1 Site - Drainage Structures Status Report - 2019 10 03

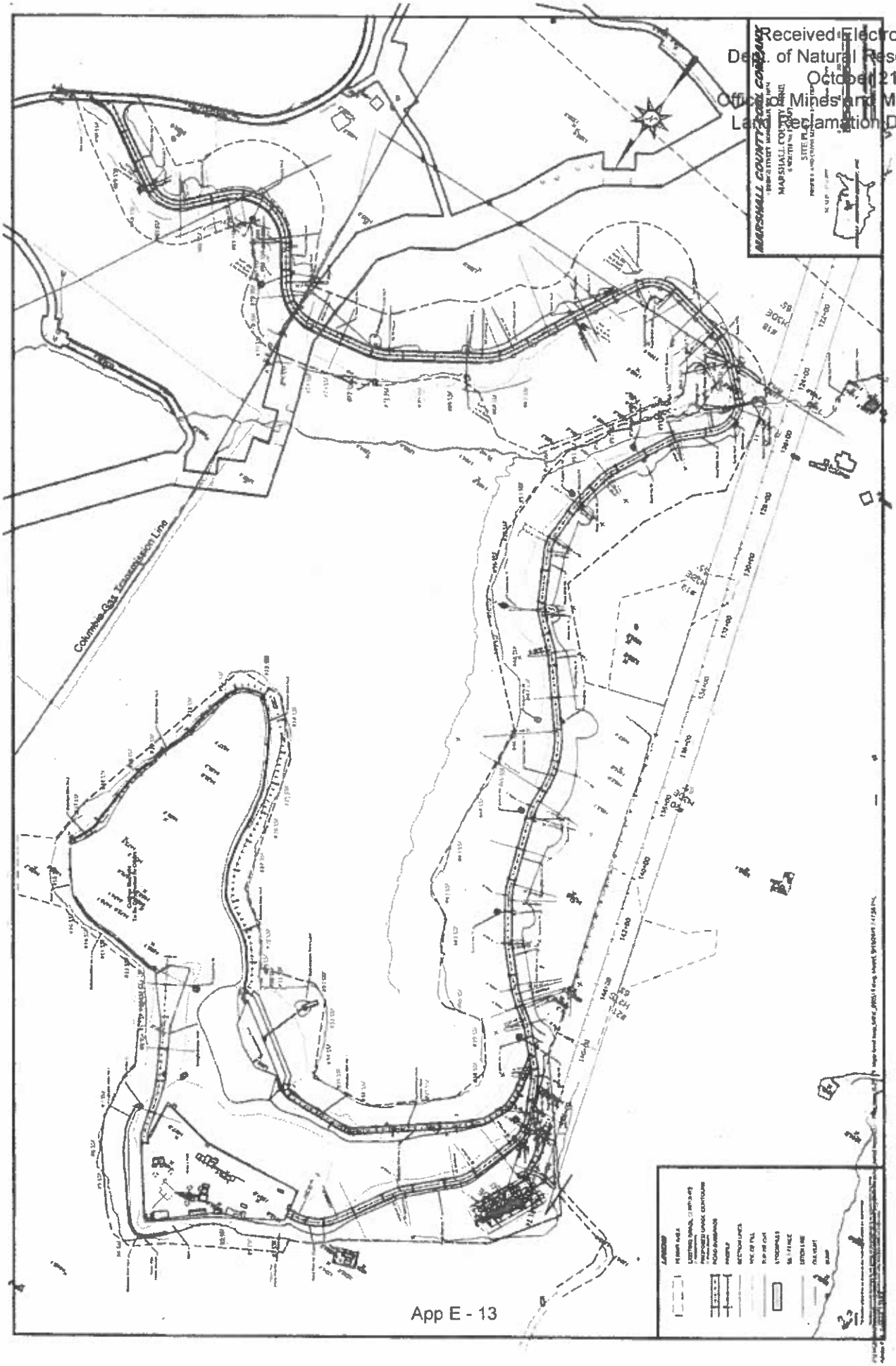
Road Ditch and Culvert Information from Rt. 250 to the Stream Crossing								
Road Ditch No.	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Start Plus	0+20	2+80	6+60	9+20	13+15	16+10	19+65	22+10
End Plus	2+80	6+60	9+20	13+15	16+10	19+65	22+10	27+20
Length (ft)	260	380	260	395	295	355	245	510
Road to Grade	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
Ditch to Grade	Complete	Complete	Complete	Incomplete	Complete	Complete	Complete	Complete
Ditch Fabric	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete
Culvert Sump	Complete	Incomplete	Incomplete	Complete	Complete	Complete	Complete	Complete
Culvert	Complete	Incomplete	Incomplete	Complete	Complete	Complete	Complete	Complete
Culvert Apron	Complete	Incomplete	Incomplete	Complete	Incomplete	Incomplete	Complete	Complete

Road Ditch and Culvert Information from the Shaft Pad to the Stream Crossing									
Road Ditch No.	No. 17	No. 16	No. 15	No. 14	No. 13	No. 12	No. 11	No. 10	No. 9
Start Plus	62+16	53+80	51+20	47+00	43+90	40+70	37+25	33+60	31+20
End Plus	53+80	51+20	47+00	43+90	40+70	37+25	33+60	31+20	27+20
Length (ft)	836	260	420	310	320	345	365	240	400
Road to Grade	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
Ditch to Grade	Complete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete
Ditch Fabric	Complete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete
Culvert Sump	Complete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete
Culvert	Complete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete
Culvert Apron	Complete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete

All Ditches that Drain to the Sediment Pond				
Ditch No.	C.D. #1	C.D. #2	C.D. #3	C.D. #4
Start Plus	0+00	18+09	14+55	0+00
End Plus	9+38	0+00	0+00	14+67
Length (ft)	938	1,809	1,455	1,467
Road to Grade	Complete	N/A	N/A	N/A
Ditch to Grade	Complete	Complete	Incomplete	Complete
Ditch Fabric	Complete	Complete	Incomplete	Complete
Culvert Sump	Complete	Complete	Incomplete	Complete
Culvert	Complete	Complete	Incomplete	Complete
Culvert Apron	Complete	Complete	Incomplete	Complete

Drainage Project Totals and % Complete			
	Total	Complete	% Complete
Road to Grade	7,134	7,134	100%
Ditch to Grade	11,865	7,355	62%
Ditch Fabric	11,865	5,050	43%
Culvert Sump	19	9	47%
Culvert	19	9	47%
Culvert Apron	19	7	37%

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MR-6
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West Virginia Department of Environmental Protection
MR-6 MINE INSPECTION REPORT

PERMIT NUMBER	INSPECTION DATE	TIME	REASON	TYPE	MINE STATUS	PHOTOS	BLASTING Last 30 Days?	BLASTING Ins. Req'd?
U200707	03/29/2019	12:00	IN	F	AM	No	No	No

PERMITTEE NAME THE MARSHALL COUNTY COAL COMPANY MSHA # 46-01437

OPERATOR NAME MR-19 DATE

NPDES # WV0020834 NPDES EXPR DATE 08/07/2019 PERMIT EXPR DATE 11/18/2025

PERMIT ACRES 153.14 TOTAL DISTBD 65.00 RECLMD 0.00 ANCIL-LARY 0 UNRECLMD 60

DATES: PH I PH II LAST AUG SEED MR-5

LAST INSP DATE 03/18/2019 TYPE C BOND INC 1 INC BONDED ACRES 153.14 CUR IBR# 14 CUR REV# 0

EXPR DATES: INACT EMER RESP PLAN INS 06/01/2019 BLAST AD

TIME USED (HRS)===> PERMIT REVIEW 0.25 INSPECT 0.50 TRAVEL 0.25 REPORT 0.50

INSPECTION COMMENTS

NOV Follow-up. The permittee has provided a letter detailing the amount of soil removed from the 5N #3 site. It is estimated 20 cubic yards of topsoil and 486 cubic yards of subsoil were removed and taken to the ball field. They also provided plant nutrient testing results of the soil. A potential site has been identified to find replacement soil. The NOV will be extended to complete the required work.

ENFORCEMENT STANDARD		EVALUATION	VIO#	ENFORCEMENT STANDARD		EVALUATION	VIO#
0100	Distance Prohibited			0200	Exceeding Limits		
0300	Signs and Markers			0400	Sediment Control		
0500	Design Certification			0600	Effluent Limits		
0700	Surface Water			0800	Ground Water		
0900	Blasting Procedures			1000	Haul Roads		
1100	Refuse Impoundments			1200	Topsoil Handling	COM	
1300	Backfill / Grading			1400	Reclamation Schedule		
1500	Revegetation Requirements			1600	Disposal of Excess Spoil		
1700	Highwall Elimination			1800	Downslope Spoil Disposal		
1900	Postmining Land Use			2000	Ceased Mining Temporarily		
2100	Acid bearing /Toxic Material			2200	Method of Operations		
2300	Change of Operator			2400	Permit Conditions		
2500	Diversions and Drainage Control			2600	Fugitive Dust Control		
2700	Subsidence Plan			2800	Insurance Current		
2900	Bonding Current			3000	Other Conditions		

WATER QUALITY TESTS

Structure ID	Outfall	pH	Fe	Mn	Al	No Flow	Not Const.	Treatment

AUTH. COMPANY REPRESENTATIVE Joe Williams

DELIVERY METHOD / DATE TIME Mail 4/10/2019 10:00:00

CERTIFIED MAIL NUMBER

ADDRESS 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950

WV DEP REP. Andrew M Coleman App E-14

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Land Reclamation Division

MR-16

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West Virginia Department Of Environmental Protection

MR-16 VIOLATION FOLLOW-UP INSPECTION REPORT

PERMIT NUMBER	ORIGINAL INSPECTION AND VIOLATION DATA						NEW VIOLATION ACTIVITY	
	DATE	TIME	FORM #	FACILITY #	ENF STD	ORIGINAL VIOL#	DATE	TIME
U200707	03/19/2019	08:30	8		1200	4	03/29/2019	12:00

PERMITTEE NAME THE MARSHALL COUNTY COAL COMPANY

Violation is hereby: ☐ Terminated ☐ Withdrawn ☐ Remains in force as written ☐ Show Cause submitted

☑ Extended to 04/30/2019 at 12:00 ☐ NOV modified to CO # ____ ☐ CO modified to NOV # ____

Action taken to abate:

The permittee has provided a letter detailing the amount of soil removed from the 5N #3 site. It is estimated 20 cubic yards of topsoil and 485 cubic yards of subsoil were removed and taken to the ball field. They also provided plant nutrient testing results of the soil. A potential site has been identified to find replacement soil. The NOV will be extended to complete the required work.

INSPECTOR'S CIVIL PENALTY ASSESSMENT RECOMMENDATION (check)

Seriousness: 1☐ 2☐ 3☑ 4☐ 5☐ 6☐ 7☐ 8☐ 9☐ 10☐ Negligence: 0☐ 1☐ 2☐ 3☐ 4☑ 5☐ 6☐ 7☐ 8☐

Good Faith: 0☐ 1☐ 2☐ 3☐ 4☐ 5☐ 6☑ 7☐ 8☐ Consent Agreement in effect? ☐ Yes ☑ No

Comments:

AUTH. COMPANY REPRESENTATIVE Joe Williams

DELIVERY METHOD / DATE TIME Mail 4/10/2019 10:00:00

CERTIFIED MAIL NUMBER ____

ADDRESS 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950

WV DEP REP. Andrew M Coleman

Austin Caperton
[Secretary, Department of Environmental Protection]

[WV DEP Representative] 3/29/19 Date

Names of individuals at informal Conference:

Results: CO was:	☐ Upheld	☐ Modified	☐ Terminated	☐ Withdrawn

Comments:

SUPERVISOR: ____ DATE: ____ TIME: ____

COMPANY REPRESENTATIVE: ____ DATE: ____

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October 21, 2019
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Land Reclamation Division

MATTHEW G. BEVIN
GOVERNOR

CHARLES G. SNAVELY
SECRETARY

ANTHONY R. HATTON
COMMISSIONER

ENERGY AND ENVIRONMENT CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION

300 SOWER BOULEVARD
FRANKFORT, KENTUCKY 40601

June 14, 2019

CERTIFIED MAIL No. 7017 0530 0000 2491 5064

The Muhlenberg County Coal Co LLC
46226 National Rd
Saint Clairsville, OH 43950

Re: Notice of Violation
AI ID: 124971
AI Name: The Muhlenberg County Coal Co LLC
Activity ID: ENV20190001
KPDES Permit #: KYGW40062
DNR Permit #: multiple

Dear The Muhlenberg County Coal Co LLC:

The Kentucky Department for Environmental Protection (DEP) has issued the enclosed Notice of Violation for violations discovered at your facility for the 2018 monitoring period attached (see 2nd page). Please review the Notice of Violation carefully to ensure that all remedial measures are completed by the specified deadlines.

Your cooperation and attention to this matter is appreciated. If you have any questions, please contact me at 502-782-6852 or linda.metts@ky.gov.

Sincerely,

Linda Metts

Linda Metts
Environmental Enforcement Specialist
Division of Enforcement

Enclosure

Kentucky UNBRIDLED SPIRIT

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October 21, 2019
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Land Reclamation Division

PERMITS REVIEWED BY THE DIVISION OF ENFORCEMENT

REVIEW PERIOD: Specified below				
LINE #	KPDES PERMIT NUMBER	DNR PERMIT NUMBER	NOV ISSUED YES	NOV ISSUED NO
1	KYGW40062 (Oct 2018-Dec 2018)	889-5020, 889-7012, 889-5021	X	
2	KYGW40011 (Sept 2018-Dec 2018)			X
3				
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35				

*The above permits were reviewed for The Muhlenberg County Coal Co LLC.
** If other permits for this company existed for the above monitoring period, that were omitted from this review, please contact Linda Metts at 502-782-6852 or linda.metts@ky.gov.

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Land Reclamation Division

COMMONWEALTH OF KENTUCKY
ENERGY and ENVIRONMENT CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION
Division of Enforcement

NOTICE OF VIOLATION

To: The Muhlenberg County Coal Co LLC
46226 National Rd
Saint Clairsville, OH 43950

AI Name: The Muhlenberg County Coal Co LLC **AI ID:** 124971 **Activity ID:** ENV20190001
County: Muhlenberg
KPDES Permit: KYGW40062
DNR Permit: 889-5020, 889-7012, 889-9007
Date(s) Violation(s) Observed: 06/12/2019

This is to advise that you are in violation of the provisions cited below:

1 Violation Description for Subject Item AIOO0000124971():
No person shall, directly or indirectly, throw, drain, run or otherwise discharge into any of the waters of the Commonwealth, or cause, permit or suffer to be thrown, drained, run or otherwise discharged into such waters any pollutant, or any substance that shall cause or contribute to the pollution of the waters of the Commonwealth in contravention of the standards adopted by the cabinet or in contravention of any of the rules, regulations, permits, or orders of the cabinet or in contravention of any of the provisions of this chapter. [KRS 224.70-110]

Description of Non Compliance:
Failing to comply with 401 KAR 5:065, Section 2(1), which cites to 40 CFR 122.41(a), by failing to comply with the KPDES permit limits for **Total Recoverable Iron (TRFe)**, for permit KYGW40062. The permitted limits for TRFe are a monthly average of 3.0 mg/l and a daily maximum of 4.0 mg/l. The reported results are as follows:

Outfall 001: a monthly average of 5.509 mg/l and a daily maximum of 10.7 mg/l for December of 2018.

The remedial measure(s), and date(s) to be completed by are as follows:
The Muhlenberg Co Coal Co LLC shall comply with the terms and conditions of the current KPDES permit of the facility, KYGW40062. [KRS 224.70-110]

Violations of the above cited statute(s) and/or regulation(s) are subject to a civil penalty per day per violation. Violations carry civil penalties of up to $25,000 per day per violation depending on the statutes/regulations violated. In addition, violations may be concurrently enjoined. Compliance with remedial measures and their

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Office of Mines and Minerals
Land Reclamation Division

deadlines does not provide exemption from liability for violations during the period of remediation, nor prevent additional remedial measures from being required.

If you have questions or need further information, write or call the undersigned:

Department for Environmental Protection
Division of Enforcement
300 Sower Blvd
Frankfort, KY 40601
502-782-6852 (7:30 AM –3:30 PM)
Ms. Linda Metts, Enforcement Specialist

Issued By: Linda Metts

Ms. Linda Metts
Environmental Enforcement Specialist
Compliance and Operations Branch
Date: June 14, 2019

Issued By: Lori E. Conway

Ms. Lori E. Conway
Environmental Enforcement Specialist
Compliance and Operations Branch
Date: June 14, 2019

How Delivered: Certified Mail Certified/Registered #7017 0530 0000 2491 5064

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October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

MURRAY MAPLE EAGLE COAL, LLC

46226 NATIONAL ROAD
ST. CLAIRSVILLE, OHIO 43950

PHONE: (740) 338-3100
FAX: (740) 338-3405

November 11, 2019

Ryan Thomas
Environmental Inspector
WV Department of Environmental Protection
Division of Mining and Reclamation
1159 Nick Rahall Greenway
Fayetteville, WV 25840

RE: Murray Maple Eagle Coal, LLC
Permit Renewal
S-6020-89 NOV 63

Mr. Thomas,

This letter is in response to the remedial measures stated in NOV 63 for Murray Maple Eagle Coal, LLC's permit renewal on WVDEP Permit S-6020-89. At this time, Murray Maple Eagle Coal, LLC has submitted an application for permit renewal, and is currently working on replying to the corrections sent by the DEP.

Murray Maple Eagle Coal, LLC requests a 30 day extension of the abatement date in order to finish the corrections.

I recommend approval up to 12-12-19.

11-12-19

11 14 19

Regards,

Hodge Hunter
Environmental Engineer
Murray Maple Eagle Coal, LLC

CC: Murray Maple Eagle – S-6020-89 file

From: Williams, Joseph <JosephWilliams@coalsource.com>
Sent: Monday, December 02, 2019 12:51 PM
To: Nagel, Jon
Subject: Fwd: [External] NOV 6

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

Sent via the Samsung Galaxy S& 6, an AT&T 4G LTE smartphone

-------- Original message --------
From: "Harvey, James T" <James.T.Harvey@wv.gov>
Date: 12/2/19 12:48 PM (GMT-05:00)
To: "Williams, Joseph" <JosephWilliams@coalsource.com>
Subject: RE: [External] NOV 6

CAUTION: This email originated from outside of Murray Energy. Do not click links or open attachments unless you recognize the sender and know the content is safe.

New abatement date is 12/27. I'll get the paperwork to you this week, hopefully. Thanks and have a good one.

- Jim H.

From: Williams, Joseph <JosephWilliams@coalsource.com>
Sent: Wednesday, November 27, 2019 1:33 PM
To: Harvey, James T <James.T.Harvey@wv.gov>
Subject: [External] NOV 6

CAUTION: External email. Do not click links or open attachments unless you verify sender.

Jim,

Attached is a status report and an extension request for NOV 6.

Thanks,

Joe Williams
Environmental Engineer
Murray American Energy
6126 Energy Road
Moundsville, WV 26041
(304) 709-2133

MR-6
ERIS

West Virginia Department of Environmental Protection
MR-6 MINE INSPECTION REPORT

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

PERMIT NUMBER	INSPECTION DATE	TIME	REASON	TYPE	MINE STATUS	PHOTOS	Last 30 Days?	Ins. Req'd?
U200707	11/01/2019	12:00	IN	P	AM	No	No	No

PERMITTEE NAME: THE MARSHALL COUNTY COAL COMPANY — MSHA #: 46-01437
OPERATOR NAME: — MR-19 DATE:
NPDES #: WV0020834 — NPDES EXPR DATE: 12/07/2019 — PERMIT EXPR DATE: 11/18/2023
PERMIT ACRES: 158.13 — TOTAL DISTBD: 110.00 — RECLMD: 0.00 — ANCIL-LARY: 0 — UNRECLMD: 110
DATES: PH I: — PH II: — LAST AUG SEED: — MR-8:
LAST INSP DATE: 10/24/2019 — TYPE: A — BOND INC: 1 — INC BONDED ACRES: 158.13 — CUR IBR#: 15 — CUR REV#: 1
EXPR DATES: INACT: — EMER RESP PLAN: — INS: 06/01/2020 — BLAST AD:
TIME USED (HRS)==> PERMIT REVIEW: 0.25 — INSPECT: 0.25 — TRAVEL: 0.00 — REPORT: 0.25

INSPECTION COMMENTS

Marshall County Coal Company - 6S #1. Company has requested an additional 30-day extension of NOV 6 to allow completion of abatement requirements. Aerial overflight inspection on 10/24 showed significant progress on the road and ditches. An additional 30 days is being granted putting the new abatement date at 11/29/2019.

ENFORCEMENT STANDARD		EVALUATION	VIO#	ENFORCEMENT STANDARD		EVALUATION	VIO#
0100	Distance Prohibited			0200	Exceeding Limits		
0300	Signs and Markers			0400	Sediment Control	COM	
0500	Design Certification			0600	Effluent Limits		
0700	Surface Water			0800	Ground Water		
0900	Blasting Procedures			1000	Haul Roads		
1100	Refuse Impoundments			1200	Topsoil Handling		
1300	Backfill / Grading			1400	Reclamation Schedule		
1500	Revegetation Requirements			1600	Disposal of Excess Spoil		
1700	Highwall Elimination			1800	Downslope Spoil Disposal		
1900	Postmining Land Use			2000	Ceased Mining Temporarily		
2100	Acid bearing /Toxic Material			2200	Method of Operations		
2300	Change of Operator			2400	Permit Conditions		
2500	Diversions and Drainage Control	COM		2600	Fugitive Dust Control		
2700	Subsidence Plan			2800	Insurance Current		
2900	Bonding Current			3000	Other Conditions		

WATER QUALITY TESTS

Structure ID	Outfall	pH	Fe	Mn	Al	No Flow	Not Const.	Treatment

AUTH. COMPANY REPRESENTATIVE: Joe Williams
DELIVERY METHOD / DATE TIME: Hand 11/4/19 0930
CERTIFIED MAIL NUMBER:
ADDRESS: 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950
WV DEP REP.: James T. Harvey — J. T. Harvey

MR-16

ERIS

West Virginia Department Of Environmental Protection

MR-16 VIOLATION FOLLOW-UP INSPECTION REPORT

Received Electronically
Dept. of Natural Resources
October 21, 2019
Office of Mines and Minerals
Land Reclamation Division

PERMIT NUMBER	ORIGINAL INSPECTION AND VIOLATION DATA						NEW VIOLATION ACTIVITY	
	DATE	TIME	FORM #	FACILITY #	ENF STD	ORIGINAL VIOL#	DATE	TIME
U200707	07/08/2019	09:30	6		2500	6	11/01/2019	12:00

PERMITTEE NAME THE MARSHALL COUNTY COAL COMPANY

Violation is hereby: ☐ Terminated ☐ Withdrawn ☐ Remains in force as written ☐ Show Cause submitted

☑ Extended to 11/29/2019 at 12:00 ☐ NOV modified to CO # ____ ☐ CO modified to NOV # ____

Action taken to abate:

Aerial overflight on 10/24 showed significant progress toward completion of the road and drainage control structures. Company has submitted written request for a 30 day extension which is being granted. New abatement date is 11/29/2019.

INSPECTOR'S CIVIL PENALTY ASSESSMENT RECOMMENDATION (check)

Seriousness: 1☐ 2☐ 3☐ 4☐ 5☑ 6☐ 7☐ 8☐ 9☐ 10☐ Negligence: 0☐ 1☐ 2☐ 3☐ 4☑ 5☐ 6☐ 7☐ 8☐

Good Faith: 0☐ 1☐ 2☐ 3☑ 4☐ 5☐ 6☐ 7☐ 8☐ Consent Agreement in effect? ☐ Yes ☑ No

Comments:

AUTH. COMPANY REPRESENTATIVE Joe Williams

DELIVERY METHOD / DATE TIME Hand 11/4/19 0930

CERTIFIED MAIL NUMBER ____

ADDRESS 46226 NATIONAL ROAD, SAINT CLAIRSVILLE, OH 43950

WV DEP REP. James T. Harvey

Austin Caperton
[Secretary, Department of Environmental Protection]

[WV DEP Representative]

11/4/19
Date

Names of individuals at informal Conference:

Results: CO was:	☐ Upheld	☐ Modified	☐ Terminated	☐ Withdrawn

Comments:

SUPERVISOR: ____ DATE: ____ TIME: ____

COMPANY REPRESENTATIVE: ____ DATE: ____

APPENDIX F

THREATENED AND ENDANGERED SPECIES
Endangered Species Act of 1973, 16 USC 1531, et seq.
62 Ill. Adm. Code 1773.15(c)(10)

The Department reviewed Permit Application No. 456 for potential effects of coal mining operations and reclamation activities on federally listed threatened and endangered species. The following factors were considered for all species that could potentially be adversely affected: status of species in the proposed permit area and adjacent area, site specific resource information, direct and indirect effects, and cumulative effects.

Five primary sources were utilized to identify federally listed threatened and endangered species that could potentially be affected by the proposed coal mining operations and reclamation activities. These sources include threatened and endangered species review information submitted by the applicant, public comments, the U.S. Fish and Wildlife Service (USFWS), the Illinois Department of Natural Resources/Division of Real Estate Services and Consultation/Office of Realty and Capital Planning (ORCP), and Department records.

Information Submitted by the Applicant

The threatened and endangered species review srubmitted by the applicant as a requirement of the Department's UCM-1 application addressed state listed species known to occur in Williamson County, Franklin County, and applicable adjacent areas using records obtained from the Illinois Natural Heritage Database. Records for fourteen state listed threatened or endangered species, the barn owl (*Tyto alba*), the bewick's wren (*Thryomanes bewickii*), the ornate box turtle (*Terrapene ornate*), the chuck-will's widow (*Caprimulgus carolinensis*), the least bittern (*Ixobrychus exilis*), the little blue heron (*Egretta caerulea*), the river cooter (*Pseudemys cancinna*), the river redhorse (*Moxostoma carinatum*), the yellow-crowned night heron (*Nyctanassa violacea*), climbing milkweed (*Matelea decipiens*), dull meadow beauty (*Rhexia mariana*), eryngo (*Eryngium prostratum*), false bugbane (*Cimicfuga racemose*), and green trillium (*Trillium viride*) were deemed by the applicant as possible to occur on the proposed project area. The applicant provided Site Specific Resource Information and Protection and Enhancement Plan for each of these species. None of these species are currently listed as federally threatened or endangered.

Information in the permit application indicates that 3.9 acres of known Indiana bat habitat will be impacted by the proposed mining activity. Presence of the Indiana bat was documented in a mist net survey conducted in 2017, thus a Protection and Enhancement Plan (PEP) was developed for the proposed permit area that lies within the 2.5-mile buffer of the documented maternity roost tree in accordance with the USFWS revised 2013 edition of the "2009 Range-wide Indiana Bat Protection and Enhancement Plan Guidelines" (Guidelines).

Information in the permit application indicates that probable absence of the northern long-eared bat cannot be assumed. The project will not impact known northern long-eared bat hibernacula or disturb known northern long-eared bat maternity roost trees or trees within a quarter mile of a known maternity roost tree. Therefore, the project is consistent with the northern long-eared bat Final 4(d) rule (Federal Register, January 2016) and subsequent "no critical habitat" determination (Federal Register, April 2016) issued by the USFWS. Although the project is consistent with the 4(d) rule, the applicant chose to include the northern long-eared bat in the PEP because the species will also benefit from the outlined protection and enhancement measures.

Public Comments

Public comments were recorded from the requested Public Hearing held on October 23, 2018 and written comments submitted to the Department relevant to this application. Comments supplied by the public were focused on the effects of allowable discharge into adjacent waterways, which is not an approvable action by the Department. The Illinois Environmental Protection Agency (IEPA) is the regulatory agency that determines the effluent concentrations that are allowed to be discharged into a water body through its NPDES permitting process. The potential impacts the receiving stream, adjacent waterways and water courses further downstream is an issue for the IEPA to address through that process. Effects and potential impacts resulting from another agency's permitting responsibility is beyond the purview of the Department. Comments received by the public are further addressed within Appendix B of this findings document.

U.S. Fish and Wildlife Service

The USFWS provided comments on this application in a letter dated September 4, 2018 and follow up comments and concurrence in a letter dated October 2, 2019. The USFWS identified three federally listed species for the proposed permit area, the endangered Indiana bat, the endangered piping plover, and the threatened northern long-eared bat. The USFWS concluded that there is "no designated critical habitat in the project area at this time."

The USFWS stated that "based on the location of the permit area, the Service concurs that the proposed project is not likely to adversely affect the piping plover."

Based on confirmed presence of the Indiana bat, as documented in a mist net survey conducted in 2017, an Indiana bat PEP was developed for the proposed permit area that lies within the 2.5-mile buffer of the documented maternity roost tree. This includes 3.9 acres of known Indiana bat habitat. The USFWS stated that "The PEP includes a number of protection and enhancement measures including avoidance of the majority of wooded habitat within the permit area, winter tree clearing from November 15 to March 31, tree girdling and bat box installation to provide temporary habitat, riparian buffer zone protection, and maintenance of watering areas. The applicant is not proposing to replant the forested habitat acres to be disturbed." Upon on permit modifications supplied by the applicant as required by the Department the USFWS stated that "that the Protection and Enhancement Plan (PEP) was updated to address long-term habitat replacement requirements for the Indiana bat." Based on this information the USFWS indicated that "the Service has determined

that the take of 3.9 acres of known habitat is not likely to jeopardize the continued existence of the Indiana bat."

The Department completed the USFWS's Information Planning and Consultation (IPaC) Determination Key: Northern Long-Eared Bat (NLEB) Consultation and 4(d) Rule Consistency, which was submitted to the Service via IPaC on July 31, 2019. The USFWS stated that "Based upon the IPaC submission, the action is consistent with activities analyzed in the Programmatic Biological Opinion on the Final 4(d) Rule for the northern long-eared bat and issuance of the verification letter concludes consultation for the northern long-cared bat. This information sufficiently addresses our comments regarding the northern long-eared bat."

Illinois Office of Realty and Capital Planning

Pursuant 17 Ill. Adm. Code Section 1075 the Department consulted with ORCP (previously the Office of Realty and Environmental Planning) via the online EcoCAT (Ecological Compliance Assessment Tool) system regarding state listed species within the permit boundary and adjacent area. The initial consultation was conducted on December 5, 2018, and a termination letter was provided on December 17, 2018, which concluded that adverse effects to the protected resources identified are unlikely. Taking into account the consultation termination issued by ORCP, the Department concurs that the operations as approved are unlikely to adversely affect any species protected under the Illinois Endangered Species Protection Act (520 ILCS 10/1 *et seq.*).

Department Records and Determination

The Department utilized the Illinois Department of Natural Resources DIRT (Detailed Impact Review Tool) mapping system to review whether or not the project lies within the buffer zone of documented occurrences of any state or federally listed threatened or endangered species.

The applicant submitted the required information to the Department regarding the Indiana bat and the northern long-eared bat including summer survey data documenting the presence of the Indiana bat, suitable habitat determination, and an Indiana bat PEP. The Department has determined that the applicant correctly and diligently followed the protocol specified in the Guidelines (USFWS, 2013); by following these guidelines the applicant is in compliance with the USFWS and Office of Surface Mining Reclamation and Enforcement (OSMRE) 1996 Biological Opinion on the implementation of the Surface Mining Control and Reclamation Act of 1977 (PL 98-87) with regard to assuring compliance with the Endangered Species Act. The Department determined that a PEP was necessary for the known Indiana bat habitat within the proposed permit area that lies within the 2.5-mile buffer of the documented maternity roost tree. The applicant documented presence of the Indiana bat and followed the Guidelines (USFWS, 2013) to develop the PEP. The Department utilized the key to the northern long-eared bat 4(d) rule for federal actions to conclude that proposed actions are not prohibited, therefore a PEP for this species was not required, however the applicant chose to include the northern long-eared bat in the PEP.

The Department considered site specific resource information, information provided by the applicant, concurrence by the USFWS that adverse effects to federally listed species are not likely, termination of the ORCP Section 1075 consultation, and Department records. The Department has determined the proposed mining operations and reclamation activities will not affect the continued existence of threatened or endangered species or result in destruction or adverse modification of their critical habitats, as determined under the Endangered Species Act of 1973 (16 USC 1531 *et seq.*).

Status of Potentially Adversely Affected Species

Indiana bat

The Guidelines (USFWS, 2013) specify the necessity to consider whether known or suitable winter habitat (hibernacula) and/or suitable summer habitat (maternity roosting/feeding) and/or swarming habitat (mating behavior/assessment of hibernacula suitability (Van Schaik, 2015)) of the endangered Indiana bat are located within the proposed permit area. Winter hibernation habitat for the species includes caves, abandoned underground mine workings, and railroad tunnels. Summer maternity roosting habitat includes trees or snags greater than or equal to 5 inches diameter at breast height (dbh) with exfoliating bark (USFWS, 2013) under which female bats, usually numbering less than 100 individuals, roost (Menzel, et al 2001). Suitable swarming habitat consists of forested areas with the described trees that are located within a 10 mile radius of any potential hibernacula (USFWS, 2013).

A major cause of the decline of the Indiana bat is associated with impediments to functioning hibernacula including blocked cave entrances, improper bat gate designs which may impede bat flight into caves or impede proper air flow through caves (USFWS, 1999 and Federal Register, 2007). Arousal following human disturbance to hibernating bats can lead to premature emergence from hibernacula, decreased body condition, and decreased survival (Menzel, et al 2001). Additional causes of decline in the species can be attributed to disturbances or removal of active maternity roost trees and loss of critical habitat. More recently, White Nose Syndrome (WNS) has been identified as having a negative effect on Indiana bat populations.

The range of the Indiana bat covers most of the eastern half of the United States with the majority of roosting colonies in Indiana, Kentucky, and Missouri (USFWS, 2014). For the Indiana bat, recent population data comparing 1997 estimates with historic levels indicate that the range wide population is less than half of historical levels. Indiana bats have declined significantly in some states including Kentucky and Missouri, but have increased in some states, most notably Indiana. Population estimates show an increase of about 30% in Illinois from historical levels to the present (Clawson 2002, Clawson 2004). In 2012 the Service reported an increase in Indiana bats in Illinois from 21,677 in 2001 to 55,956 in 2011.

Northern long-eared bat

Suitable winter habitat for this species includes caves and underground mines with high humidity, no air currents, and a constant temperature range (USFWS, 2015). The USFWS indicated in the *Federal Register* (April 2016) that a critical habitat designation is not necessary for this species, however Appendix H (USFWS, 2014) does define suitable summer roosting habitat as any forested area or isolated live tree or snag that is "≥ 3 inches dbh with exfoliating bark, cracks, crevices, and/or cavities". Suitable swarming habitat is typically within 5 miles of a known or potential hibernaculum and can include linear features such as fence rows, riparian buffers, or other travel corridors (USFWS, 2014).

The USFWS indicates that because the above described roosting habitat for the northern long-eared bat is not limited, habitat loss is not a significant threat to the species. The Final 4(d) Rule (Federal Register, January 2016) prevents "take" during sensitive life stages and prohibits incidental take where WNS occurs under these circumstances: if the take occurs within a hibernaculum, if the take occurs from tree removal within 0.25 miles of a known hibernaculum, or if the take occurs from the removal of a known/occupied maternity roost tree or tree within 150 foot radius of the maternity tree between June 1st and July 31st.

The range of the northern long-eared bat in the United States extends across 37 states in the eastern and north-central areas of the country, including Illinois (Federal Register, 2015 and USFWS, 2015). A contributing factor to the overall decline of the species is WNS, a fungal disease affecting hibernating bats with widespread mortality (USGS, 2015). First observed in New York in 2006, WNS has rapidly spread throughout the Northeast and Midwest; northern long-eared bat populations have been reduced by 99% in parts of its range (USFWS, 2015). The first documented observance of WNS in Illinois affecting a northern long-eared bat occurred in LaSalle County in 2013; WNS has since been documented in at least ten additional Illinois counties (IDNR, 2015). The Federal Register Final Rule (2015) listing the species as federally threatened indicates that "overall, summer surveys from Illinois have not documented a decline due to WNS to date".

Site Specific Resource Information

A survey was conducted to assess the presence or absence of the Indiana bat and northern long-eared bat within the proposed permit area. The survey was conducted by a qualified wildlife biologist from May 18, 2017 through May 25, 2017 with tracking persisting through July 1, 2017. The survey was conducted in accordance with the USFWS's 2107 Range-Wide Indiana Bat Summer Survey Guidelines (USFWS 2017). During this survey, one pregnant/female Indiana bat was captured and tracked to a roost north of the proposed permit area, thus identifying a 2.5-mile protective buffer around the documented maternity roost tree in accordance with the USFWS Guidelines. The Department determined that a PEP was necessary for the 3.9 acres of known Indiana bat habitat within the proposed permit area that lies within the 2.5-mile buffer. The survey confirmed that the Indiana bat is present in the proposed permit area and will be adversely affected and possibly "taken" as defined in the Endangered Species Act; federal guidelines requires the applicant to obtain Incidental Take authorization for the 3.9 acres of known Indiana bat habitat within the proposed permit.

Information in the permit application indicates that no northern long-eared bats were captured during this survey, but probable absence of the northern long-eared bat cannot be assumed. Furthermore, no known caves or underground openings where northern long-eared bats hibernate or could potentially hibernate exist within the permit area. No known/occupied maternity roost tree data is known near the project area for the northern long-eared bat. The Department utilized the key to the northern long-eared bat 4(d) rule for federal actions to conclude that proposed actions are not prohibited.

Direct and Indirect Effects

Take of an Indiana bat and/or a northern long-eared bat is a possible consequence of the proposed mining operations and associated activities. Take could result from killing or injuring bats if roost trees were knocked down while occupied by vulnerable females and/or young; in areas identified as known habitat the applicant has committed to honor a "no cut" period during the time of year bats could be present in trees to minimize the likelihood of such take. Removal of feeding habitat, even if done when the bats are not present, could have indirect effects on the species until this feeding habitat can be restored. The applicant has proposed to replace the required 70% of pre-mining known habitat that is removed during the course of proposed mining operation and associated activities. Emphasis will be placed on planting tree species that are recommended in the Guidelines (USFWS, 2013) for the benefits they provide to threatened and endangered bat species. Habitat modifications resulting from clearing trees in general could also be interpreted as take under the Endangered Species Act (Romanik, 2010); the applicant has requested an Incidental Take authorization to account for this broader definition of take. Incidental Take authorization for the Indiana bat is hereby granted under the authority of the 1996 Biological Opinion issued by the USFWS to OSMRE (USFWS 1996). In addition, the Department has determined that this project may affect the northern long-eared bat, but that any resulting Incidental Take is not prohibited by the Final 4(d) rule. Therefore this project is consistent with the USFWS January 2016 Programmatic Biological Opinion on the Final 4(d) rule. The Department and the applicant are in compliance with Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

The applicant has committed to the following measures to be implemented within the identified known habitat which should serve to minimize disturbances and adverse impacts to Indiana bats and northern long-eared bats:

1. The applicant will limit tree clearing to October 15 through March 31 of any calendar year to avoid take of a female and/ or young Indiana bat or northern long-eared bat.

2. The applicant will provide short-term roosting habitat by girdling 24 trees adjacent to the project area as described in the Indiana bat and northern long-eared bat PEP.

3. The applicant will provide long term habitat replacement by restoring 70% of the known habitat with woody species known to be beneficial to threatened and endangered bat species as described in the reclamation plan and northern long-eared bat PEP.

4. The applicant will utilize herbaceous ground cover species as described in the Indiana bat PEP that will provide cover and resources for wildlife, reduce competition for tree seedlings/saplings, and provide soil stability and erosion control.

Cumulative Effects

Cumulative effects under the Endangered Species Act are defined at 50 CFR Section 402.02 which states "Cumulative effects are those effects of future state, or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation." In the case of a mining permit being issued by the State of Illinois to a private company to develop a privately owned coal reserve, there is no federal action subject to consultation. Therefore, there are no cumulative effects to consider as that term is defined under Section 402.02. The Department nevertheless has considered other future state, county, township and private activities that are reasonably certain to occur within the adjacent land area. Adjacent and nearby land consists of active coal mining operations, agricultural crop land, scattered residential areas, county roads, small lakes, streams, and forested areas. Most of the adjacent acreage is owned and managed by private entities other than the active underground mining operations which are currently owned by permittee. In regards to adjacent and nearby land holdings, the Department has no reason to believe that detrimental cumulative effects to any threatened or endangered bat species would result from state, county, township, and/or private land management practices or activities. If the applicant chooses to submit a new application to the Department for surface effects on nearby lands that contain streams or forested acres, then new threatened and endangered species reviews and PEPs will be required. The Department is not aware of any state, county, township or private activities that would reasonably be certain to occur in the area adjacent or close to the proposed permit area that would adversely affect any threatened or endangered bat species.

Summary

The Department considered the status of the federally endangered Indiana bat and the federally threatened northern long-eared bat, both with the potential to be adversely impacted by the proposed mining operations and associated activities. Although overall populations continue to decline, the Indiana bat population in Illinois is stable or increasing (Clawson, 2004 and USFWS, 2011). Northern long-eared bat population data in the Midwest is limited, however estimates indicate possibly as many as four million northern long-eared bats in 6 states of the Midwest; 21 hibernacula have been documented in Illinois, mostly from the southern region (Federal Register, 2015).

The Department has considered site specific resource information; a survey confirmed that the Indiana bat is present in the proposed permit area and will be adversely affected and possibly "taken" as defined in the Endangered Species Act; federal guidelines requires the applicant to obtain Incidental Take authorization for the 3.9 acres of known Indiana bat habitat within the proposed permit. The USFWS determined that the take of 3.9 acres of known habitat is not likely to jeopardize the continued existence of the Indiana bat. No northern long-eared bats were captured

during survey efforts, but probable absence of the northern long-eared bat could not be assumed. The Department utilized the key to the northern long-eared bat 4(d) rule for federal actions to conclude that proposed actions are not prohibited.

The Department considered direct and indirect effects of proposed operations on the Indiana bat and northern long-eared bat; the most significant threat to these species from mining operations and associated activities is take due to disturbance of an occupied maternity roost tree. The applicant has committed to honor a "no-cut" restriction period within the areas identified as known habitat to prevent the possibility of this type of take. Removal of trees may also affect feeding habitat; the best technology currently available for replacement of feeding habitat includes planting trees during reclamation. The applicant has committed to this post-mining reclamation activity along with other provision set forth in the Indiana bat PEP.

The Department has considered cumulative effects as defined under 50 CFR 402.02 and has considered future state and private activities reasonably certain to occur in the adjacent area and is not aware of any such activities which could adversely affect the Indiana bat or the northern long-eared bat.

Conclusion

Pursuant to Section 1817.97(a), the applicant has proposed to minimize disturbances and adverse impacts to the Indiana bat and the northern long-eared bat by implementing measures described above, while using the best technology currently available. Following these measures will minimize and appropriately mitigate adverse impacts to the Indiana bat and northern long-eared bat. Incidental Take for the Indiana bat is authorized by the Department via this permitting action and the Department has determined that any Incidental Take of the northern long-eared bat is not prohibited by the Final 4(d) Rule.

The Incidental Take as authorized is a take provided for by the Endangered Species Act of 1973 (16 USC 1531 *et seq.*) and is not a violation of this Act. Except as specifically authorized, no other take of a federally listed species is allowed; the applicant remains subject to the prohibitions found at Section 1817.97(d) of taking a federally listed species protected under the Endangered Species Act. Unauthorized take is a violation of Section 1817.97(d); in addition, failure of the applicant to implement the measures specified in the approved plan as part of this permit will subject the applicant to enforcement measures under Sections 1773.17(b), 1817.97(a), and in the case of a take in violation of the Endangered Species Act, Section 1817.97(d).

After having considered the status of the Indiana bat and northern long-eared bat, site specific resource information, direct and indirect effects, and cumulative effects, and in the context of the applicant's commitments for measures to minimize and mitigate disturbances and adverse impacts to the Indiana bat and northern long-eared bat and conditions imposed by the Department, the Department finds that the operation will not affect the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitats, as determined under the Endangered Species Act of 1973 (16 USC 1531 *et seq.*).

Literature Cited

Clawson, Richard L. (2002). Trends in population size and current status. Pp. 7-13 *In* The Indiana bat: biology and conservation of an endangered species. Missouri Dept. of Conservation, Columbia, Missouri.

Clawson, R. (2004). National status of the Indiana bat. pp. 1-6. *In* Vories, K.C. and A. Harrington. (eds.). 2004. Proceedings of Indiana Bat and Coal Mining: A Technical Interactive Forum. November 16-18, 2004. Louisville, KY. USDOI Office of Surface Mining and Coal Research Center, Southern Illinois University at Carbondale Illinois.

Federal Register. (2007). 50 CFR Part 17 – Endangered and Threatened Wildlife and Plants; 90 Day and 12 Month Findings on a Petition to Revise Critical Habitat for the Indiana Bat. FR/Vol. 72, No.43/Tuesday, March 6, 2007/Proposed Rules. Pp. 9913-9917.

Federal Register. (2015). 50 CFR Part 17 – Endangered and threatened wildlife and plants; Threatened species status for the Northern long-eared bat with 4(d) rule. FR/Vol. 80, No. 63/Thursday April 2, 2015/Rules and Regulations. Pp. 17974- 18033.

Federal Register. (January 2016). 50 CFR Part 17 – Endangered and threatened wildlife and plants; 4(d) rule for the Northern long-eared bat. FR/Vol. 81, No. 9/Thursday January 14, 2016/Rules and Regulations. Pp. 1900-1922.

Federal Register. (April 2016). 50 CFR Part 17 – Endangered and threatened wildlife and plants; Determination that designation of critical habitat is not prudent for the Northern long-eared bat. FR/Vol. 81, No. 81/Wednesday April 27, 2016/Rules and Regulations. Pp. 24707-24714

Illinois Department of Natural Resources. (2015). Press release: White-nose syndrome found in three additional Illinois counties. http://www.dnr.illinois.gov/news/Pages/White-NoseSyndromeFoundinThreeAdditionalIllinoisCounties.aspx. Accessed October 13, 2015.

Menzel, M. A., Menzel, J. M., Carter, T. C., Ford, W. M., & Edwards, J. W. (2001). Review of the forest habitat relationships of the Indiana bat (*Myotis sodalis*) (Vol. 284). US Department of Agriculture, Forest Service, Northeastern Research Station.

Romanik, P. (2010). Everything you wanted to know about "take" in the Endangered Species Act. *pp 45-48. In* Vories, K.C., A.H. Caswell, and T.M. Price (eds.) 2010. Proceedings of Protecting Threatened Bats at Coal Mines: A Technical Interactive Forum *August 31 – September 3, 2010 Charleston, WV.*

Van Schaik, J., Janssen, R., Bosch, T., Haarsma, A.-J., Dekker, J. J. A., & Kranstauber, B. (2015). Bats Swarm Where They Hibernate: Compositional Similarity between Autumn Swarming

and Winter Hibernation Assemblages at Five Underground Sites. *PLoS ONE*, *10*(7), e0130850. http://doi.org/10.1371/journal.pone.0130850

U.S. Fish and Wildlife Service. (1996). Endangered Species Act – Section 7 Consultation Biological Opinion and Conference Report, U.S. Dept. Interior, Office of Surface Mining Reclamation and Enforcement (OSM); Surface Coal Mining Regulatory Programs Under the Surface Mining Control and Reclamation Act of 1977, PL 95-87 issued Sept 24, 1996. 15 pp.

U.S. Fish and Wildlife Service. (1999). Agency draft. Indiana bat revised recovery plan. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota. 53 pp.

U.S. Fish and Wildlife Service. (2011). (2009 revised) Rangewide population Estimate for the Indiana Bat (*Myotis sodalis)* by Recovery Unit (http://www.fws.gov/midwest/Endangered/mammals/inba/pdf/2009inbaRangewidePopJuly2011.pdf revised 7-14-2011). 5 pp.

U.S. Fish and Wildlife Service. (2013). (2009 revised) Range-wide Indiana bat protection and enhancement plan guidelines.

U.S. Fish and Wildlife Service. (2014). Agency directive, USFWS Regions 2, 3, 4, 5 & 6. Northern Long-Eared Bat Interim Conference and Planning Guidance. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota. 67 pp.

U. S. Fish and Wildlife Service. (2015). Northern long-eared bat (*Myotis septentrionalis*) fact sheet.http://www.fws.gov/midwest/endangered/mammals/nleb/pdf/NLEBFactSheet01April2015.pdf

U. S. Fish and Wildlife Service. (2016). Northern long-cared bat (*Myotis septentrionalis*) status: Threatened with 4(d) Rule. https://www.fws.gov/Midwest/endangered/mammals/nleb/index.html

U.S. Fish and Wildlife Service. (2016). Programmatic biological opinion on the final 4(d) rule for the northern long-eared bat and activities excepted from take prohibitions, USFWS Regions 2, 3, 4, 5 & 6. Midwest Regional Office, Bloomington Minnesota. 109 pp.

U.S. Fish and Wildlife Service. (2017). 2017 Range-Wide Indiana Bat Summer Survey Guidelines.

U. S. Geological Survey. (2015). National wildlife health center: White – nose syndrome (WNS). http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/.Accessed October 13, 2015.

APPENDIX G

FINDINGS ON THE OPERATOR'S TECHNOLOGICAL CAPABILITY TO RESTORE PRIME FARMLAND

The original permit application and subsequent modification of the application addressed the requirements of Section 1785.17. Pursuant to Section 1785.17(c), the applicant submitted detailed plans for the mining and restoration of the prime farmlands affected by surface mining activities.

1785.17(c)(1): The applicant has submitted a soil survey of the permit area which meets the standards of the National Cooperative Soil Survey. Itemized prime farmland soil map units and soil descriptions can be obtained from the Custom Soil Survey Report provided in the application. Additional reference documents include the NRCS Web Soil Survey and the University of Illinois Agricultural Experiment Station - Bulletin 811, which were used as references to evaluate the pre-mining data.

1785.17(c)(2): The proposed method and type of equipment to be used for removal, storage, and replacement of the soils were described pursuant to Sections 1823.12 and 1823.14. The A, B and C horizons will be removed by conventional equipment used for pipeline installation. Replacement will be with the same equipment.

1785.17(c)(2): Soil will be temporarily stockpiled adjacent to the excavation; plans for identifying the prime soils and plans for soil stabilization before redistribution were submitted in conformance with 1823.13. Stockpile stabilization will occur by establishment of a vegetative cover and mulch, if necessary; these measures will minimize erosion.

1785.17(c)(3): Documents were reviewed supporting the use of B/C horizon mixtures in place of the original B horizon. This information supports the belief that the proposed methods of reclamation will achieve, within a reasonable time, equivalent or higher levels of yield than those of non-mined prime farmland in the surrounding area.

McCormack, Donald, 1974 "Soil Reconstruction: For the Best Results After Mining" Proc. Second Res. and Appl. Tech. Symp. on Mined Land Recl., NCA, Louisville, KY, October 22-24, 1974.

Snarski, R. R., J. B. Fehrenbacher, I. Jansen, 1981, "Physical and Chemical Characteristics of Pre-mine Soils and Post-mine Soil Mixtures in Illinois", SSSA Jour., V45:806-812.

McSweeny, I. Jansen and W. S. Dancer, 1981, "Subsurface Horizon Blending: An Alternative Strategy to B Horizon Replacement for Construction of Post-Mine Soils", SSSA, Jour., V45:784-799.

Jansen, Ivan, 1981. "Reconstruction Soils After Surface Mining of Prime Agricultural Land", Mining Eng., March SME Rpt.78-F-375.

McSweeny, I. Jansen, 1984. "Soil Structure and Associated Rooting Behavior in Minesoils", SSSA Jour 48:607-612.

Christ, Richard, 1980, "The Effect of Soil from B and C Horizons on Yield Potential of Soybeans", Unpublished Thesis, Dept. of Plant and Soil Sci., Southern Ill. Univ. Carbondale, Il.

Spindler, D. and J. Bauer, 1986 Prime Farmland Restoration Plans - Planning and Information Needs" Proc. Nat. Assoc. State Land Recl., Sept 1986, Columbia, S.C.

In addition to relying on the above data, the Department has relied on the expertise of its Land Reclamation Division and the fact that thousands of acres of prime farmland and high capability land have met the cropland productivity performance standards using a B/C soil horizon mix. Pipeline and drainage tile installation type activities have a minimum impact on farmland due to the small area of disturbance. The applicant will be following the Illinois Department of Agriculture guidelines for pipeline installation. Based on this evidence, the Department considers it quite probable that the applicant will meet bond release requirements on the prime farmland areas which will be mined and reclaimed.

1785.17(c)(4): Due to the narrow size of the individual fields, yield data was not available for the fields within the permit area. The operator will be required to lime and fertilize the reclaimed prime farmland and cropland fields as needed to bring them to levels required under an optimum level of management. In addition, to satisfy the requirements of Section 1785.17(c)(4), the Department consulted the productivity indexes for each of the soil types on the permit area in "Optimum Crop Productivity Ratings for Illinois Soil", University of Illinois, Bulletin 811.

The Department has determined the soil productivity after mining will be returned to equivalent levels of yield as non-mined prime farmlands of the same soil type in the surrounding area under equivalent management practices, as discussed hereafter.

The Federal Act specifically requires in Section 5l0(d)(1) that two findings be made by the Regulatory Authority in granting a permit to mine on prime farmland; the Department regulations at Section 1785.17 also require a prime farmland finding. Section 510(d)(1) states:

> "In addition to finding the application in compliance with subsection (6) of this section, if the area proposed to be mined contains prime farmland pursuant to Section 507(b)(16), the Regulatory Authority shall, after consultation with the Secretary of Agriculture, and pursuant to regulations issued hereunder by the Secretary of Interior with the concurrence of the Secretary of Agriculture, grant a permit to mine on prime farmland if the Regulatory Authority finds in writing that the operator has the technological capability to restore such mined area, within a reasonable time, to equivalent or higher levels of yield as non-mined

> prime farmland in the surrounding area under equivalent levels of management and can meet the soil reconstruction standards in Section 515(b)(7). Except for compliance with subsection (b), requirements of this paragraph (1) shall apply to all permits issued after the date of enactment of this Act."

The first requirement concerns the operator's technological capability to restore the mined area, within a reasonable time, to equivalent or higher levels of yield as non-mined farmland in the surrounding area under equivalent levels of management. The Department, or the Regulatory Authority has reviewed other data not submitted by the operator which supports the Regulatory Authority's finding:

> Dancer, W. S. and I. Jansen. 1981 "Greenhouse evaluation of solum and substratum materials in the southern Illinois coal field: I Forage crops", Jour. Environ. Qual. 10:396-400.
>
> Powell, J., et al., 1985, "Reclamation of Prime Farmland in Kentucky", Pres Nat. Mtg. of Am. Soc. Surf. Min. and Recl. Oct, Denver, Co.
>
> Spindler, Dean, 1981, "Three Case Studies on Rowcrop Production on Mined Land" prepared for the Symposium on Surface Mining Hydrology, Sedimentation and Reclamation, University of Kentucky, Lexington, KY, December 7-11.

The Regulatory Authority has also reviewed the information from its testing program that thousands of acres of prime farmland and high capability land have met the cropland productivity performance standards. These documents are available for inspection at the Land Reclamation Division Office in Springfield.

The second requirement of Section 510(d)(1) concerns soil reconstruction standards in Section 515(b)(7). The Regulatory Authority has reviewed the application concerning the operator's plan to comply with these requirements and find it complies with Section 515(b)(7) of the Federal Act and Sections 1785.17 and 1823 of the Department's regulations. In addition, the Regulatory Authority has considered the method and equipment to be utilized and has found that the planned method is appropriate to successfully comply with the requirements of 510(d)(1) and Section 1823 of the Department's regulations.

1785.17(d): The Regulatory Authority has consulted with the USDA, Natural Resource Conservation Service (NRCS), designated representative of the Secretary of Agriculture. The Department's consideration of the NRCS comments are addressed in Appendix B.

1785.17(e)(1): The approved post-mine land use of the reclaimed prime farmlands will be cropland.

1785.17(e)(2): The Department has considered the comments of the representative of the U.S. Secretary of Agriculture (NRCS).

1785.17(e)(3): As previously discussed, the Department believes the applicant has the technological capability to restore prime farmland, within a reasonable time, to equivalent or higher levels of yields as non-mined prime farmland.

1785.17(e)(4): The special requirements for prime farmland restoration of Section 1823 have been addressed below in accordance with Section 1785.17(e)(4). Some of the subsections in Section 1823 have been previously addressed by Section 1785.17 discussions. Only those items not previously discussed will be below.

1823.14(a)(1): The minimum depth of the reconstructed prime farmland soil will be 60 inches.

1823.14(a)(2): This section is applicable to the Ava series. The proposed B/C mix for root media will meet or exceed high capability standards.

1823.14(b): Topsoil will be replaced to its premining thickness after the root medium replacement and the area is returned to final grade.

1823.14(c): Compaction will be minimized by handling the soil during dry weather and/or the Department will require a compaction alleviation plan if it is determined that excessive compaction is causing low yields.

1823.14 (d): The permittee will be excavating the B and C horizons immediately underneath the B horizons as part of the pipeline trenching. Pipeline and drainage tile installation type activities have a minimum impact on farmland due to the small area of disturbance. The applicant will be following the Illinois Department of Agriculture guidelines for pipeline installation. The subsoil will be returned to its required thickness.

1823.14 (e): The original A horizon will be replaced. The operator has proposed multiple soil series sources of supplemental topsoil material in the proposed permit area. The department has limited that substitute material to the Rend, Bluford, Hickory-Kell, Okaw, Belknap and Orthent soil series where the subsoil texture is a silt loam. In addition, the pH, phosphorus, and potassium of the borrow materials shall be fertilized with rates to achieve a pH of 6.5, and phosphorus and potassium levels of 50 ponds/acre and 260 pounds/acre, respectively. Please see Part IV Condition No. M. Topsoil will be returned to the required thickness and suitably protected from erosion.

1823.14(f): The applicant has made a commitment for fertilization based on soil tests.

1823.15: The applicant will comply with the seeding and mulching requirements pursuant to Sections 1823.15, 1816.113 and 1816.114.

In making this finding, the Regulatory Authority has relied on available data and opinions of experts, as found relevant to this application. In addition, the Regulatory Authority has relied on the expert technical opinion of its staff. Such reliance was intended by Congress as is apparent in

the legislative history of the Federal Act. At page 105 of the House Conference Report No. 95-493, the Conferees state:

> "It is the intention of the Conferees that the written finding that the regulatory authority is required to make before a permit is granted to mine on prime farmland can be based in part on the expert opinion of the regulatory authority, the operator has the technological capability to perform the soil reconstruction standards of Section 515(b)(7) and the performance of those standards will result in the restoration of the mined area to equivalent or higher levels of agricultural yield as non-mined prime farmland in the surrounding area under equivalent levels of management. This does not mean that mining and restoration must have taken place in the surrounding area, but simply that the operator can show by agricultural school studies, or other data for comparable areas that equivalent yields can be obtained after mining."

This finding is based on significant and substantial evidence and is in keeping with the standards for prime farmland review approved by the Office of Surface Mining. (See letter from Acting Director Reeves to Illinois Director Evilsizer, dated April 7, 1980, which is incorporated by reference.)

This finding is based solely upon characteristics peculiar to this particular operator and the prime farmland soil types involved.

All materials supporting this finding are a part of the public record and are hereby incorporated by reference.

Based upon the foregoing analysis of the probable impact of the proposed operations and a review of the application and Interagency and public comments thereon, the Department finds that there is a reasonable basis on which to issue the permit as requested by the applicant.

Enter on behalf of the Illinois Department of Natural Resources, Office of Mines and Minerals, Land Reclamation Division, as the Regulatory Authority.

Section 1: 8-K (8-K)

UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
WASHINGTON, DC 20549

FORM 8-K

CURRENT REPORT

Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934

Date of Report (date of earliest event reported): December 19, 2019

FORESIGHT ENERGY LP

(Exact Name of Registrant as Specified in Charter)

Delaware	001-36503	80-0778894
(State or Other Jurisdiction of Incorporation)	(Commission File Number)	(IRS Employer Identification No.)
211 North Broadway, Suite 2600 Saint Louis, MO (Address of Principal Executive Offices)		63102 (Zip Code)

(Registrant's telephone number, including area code): (314) 932-6160

(Former Name or Former Address, if Changed Since Last Report)

Check the appropriate box below if the Form 8-K filing is intended to simultaneously satisfy the filing obligation of the registrant under any of the following provisions (*see* General Instruction A.2. below):

☐ Written communications pursuant to Rule 425 under the Securities Act (17 CFR 230.425)

☐ Soliciting material pursuant to Rule 14a-12 under the Exchange Act (17 CFR 240.14a-12)

☐ Pre-commencement communications pursuant to Rule 14d-2(b) under the Exchange Act (17 CFR 240.14d-2(b))

☐ Pre-commencement communications pursuant to Rule 13e-4(c) under the Exchange Act (17 CFR 240.13e-4(c))

Securities registered pursuant to Section 12(b) of the Act:

Title of each class	Trading Symbol(s)	Name of each exchange on which registered
Common units representing limited partner interest	*	*

*On November 25, 2019, a Form 25 relating to the delisting and deregistration under Section 12(b) of the Registrant's common units representing limited partner interests was filed by the New York Stock Exchange LLC. The common units currently trade on the OTCQX® Best Market under the symbol "FELPU."

Indicate by check mark whether the registrant is an emerging growth company as defined in Rule 405 of the Securities Act of 1933 (§ 230.405 of this chapter) or Rule 12b-2 of the Securities Exchange Act of 1934 (§ 240.12b-2 of this chapter).

Emerging growth company ☐

If an emerging growth company, indicate by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act. ☐

Item 1.01 Entry into a Material Definitive Agreement.

As previously disclosed, on December 13, 2019, Foresight Energy LLC and Foresight Energy Finance Corporation (wholly owned subsidiaries of Foresight Energy LP (the "**Partnership**")) (together, the "**Issuers**") solicited the consent of the holders (the "**Holders**") (such solicitation, the "**Consent Solicitation**") of the Issuers' 11.50% Second Lien Senior Secured Notes due 2023 (the "**Notes**") to amend (such amendments, the "**Amendments**") the indenture governing the Notes (as amended, supplemented or otherwise modified from time to time, the "**Indenture**"), as more fully described below. The Consent Solicitation expired at 5:00 p.m., New York City time, on December 19, 2019 (the "**Expiration Time**").

As of the Expiration Time, the Issuers had received consents to the Amendments from Holders of at least a majority in aggregate principal amount of the outstanding Notes not owned by the Issuers or their affiliates. As a result, on December 19, 2019, the Issuers, the guarantors party thereto and Wilmington Trust, National Association, the trustee (the "**Trustee**") for the Notes, entered into a second supplemental indenture (the "**Second Supplemental Indenture**") providing for the Amendments to the Indenture.

The Amendments (i) amend Section 6.01(b) of the Indenture to extend the grace period for payment of interest due on the Notes from 90 days to 150 days and (ii) amend Section 4.03 of the Indenture to eliminate the requirement that the Issuers periodically hold a publicly accessible conference call to discuss the Issuers' financial information for the relevant fiscal period.
The Partnership continues to engage in discussions with its creditor constituencies and explore potential restructuring alternatives.

The foregoing descriptions of the Amendments, the Second Supplemental Indenture and the Indenture are qualified in their entirety by reference to the full text of the Second Supplemental Indenture, the First Supplemental Indenture dated as of October 30, 2019 and the Indenture, each of which is incorporated herein by reference to **Exhibit 4.1**, **Exhibit 4.2** and **Exhibit 4.3** to this Current Report on Form 8-K, respectively.

Item 3.03 Material Modification to Rights of Security Holders.

The disclosure set forth in Item 1.01 of this Current Report on Form 8-K is incorporated into this item by reference.

CAUTIONARY STATEMENT REGARDING FORWARD-LOOKING STATEMENTS

Certain statements and information in this Current Report on Form 8-K and certain oral statements made by our representatives from time to time may constitute "forward-looking statements." The words "propose," "believe," "expect," "anticipate," "plan," "intend," "foresee," "outlook," "estimate," "potential," "continues," "may," "will," "seek," "approximately," "predict," "anticipate," "should," "would," "could" or other similar expressions are intended to identify forward-looking statements, which are generally not historical in nature. Forward-looking statements also include statements about our liquidity, our capital structure and expected results of operations. These forward-looking statements are based on the Partnership's current expectations and beliefs concerning future developments and their potential effect on us. While management believes that these forward-looking statements are reasonable as and when made, there can be no assurance that the future developments affecting us will be those that we anticipate.

We continue to experience substantial financial, business, operational and reputational risks that threaten our ability to continue as a going concern and could materially affect our present expectations and projections. For additional information regarding known material factors that could cause our actual results to differ from those contained in or implied by forward-looking statements, please see the section entitled "Risk Factors" in the Partnership's Annual Report on Form 10-K for the year ended December 31, 2018, filed with the Securities and Exchange Commission on February 27, 2019 and subsequent Quarterly Reports on Form 10-Q.

You are cautioned not to place undue reliance on forward-looking statements, which are made only as of the date hereof. We undertake no obligation to publicly update or revise any forward-looking statements after the date they are made, whether as a result of new information, future events or otherwise, except as required by law.

Item 9.01 Financial Statements and Exhibits.

(d) Exhibits

Exhibit No.	Exhibit Description
4.1	Second Supplemental Indenture, dated as of December 19, 2019 (to the Indenture dated as of March 28, 2017), by and among Foresight Energy LLC, Foresight Energy Finance Corporation, the guarantors party thereto and Wilmington Trust, National Association, as trustee.
4.2	First Supplemental Indenture, dated as of October 30, 2019 (to the Indenture dated as of March 28, 2017), by and among Foresight Energy LLC, Foresight Energy Finance Corporation, the guarantors party thereto and Wilmington Trust, National Association, as trustee (incorporated herein by reference to Exhibit 4.1 to FELP's Current Report on Form 8-K, filed with the SEC on October 31, 2019).
4.3	Indenture, dated as of March 28, 2017, by and among Foresight Energy LLC, Foresight Energy Finance Corporation, the guarantors party thereto and Wilmington Trust, National Association, as trustee (incorporated herein by reference to Exhibit 4.1 to FELP's Current Report on Form 8-K, filed with the SEC on April 3, 2017).

SIGNATURES

Pursuant to the requirements of the Securities Exchange Act of 1934, the registrant has duly caused this report to be signed on its behalf by the undersigned, hereunto duly authorized.

Foresight Energy LP

By: Foresight Energy GP LLC
its general partner

By: /s/ Robert D. Moore
Robert D. Moore
Chairman of the Board, President and Chief Executive Officer

Date: December 20, 2019

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Section 2: EX-4.1 (EX-4.1)

EXHIBIT 4.1

SECOND SUPPLEMENTAL INDENTURE

SECOND SUPPLEMENTAL INDENTURE to the Indenture (as defined below) (the "*Supplemental Indenture*"), dated as of December 19, 2019, is made by and among Foresight Energy LLC, a Delaware limited liability company (the "*Company*"), Foresight Energy Finance Corporation, a Delaware corporation ("*Co-Issuer*, and together with the Company, the "*Issuers*"), the guarantors party hereto (the "*Guarantors*") and Wilmington Trust, National Association, as trustee (in such capacity, the "*Trustee*"), and amends the Indenture, dated as of March 28, 2017, among the Issuers, the Guarantors and the Trustee, as amended by the First Supplemental Indenture, dated as of October 30, 2019 (as further amended and supplemented from time to time, the "*Indenture*").

RECITALS:

WHEREAS, pursuant to the Indenture, the Issuers have issued $425,000,000 in aggregate principal amount of 11.50% Second Lien Senior Secured Notes due 2023 (the "*Notes*");

WHEREAS, the Issuers have requested consents of the Holders of the Notes to amend the terms of the Indenture as set forth in Article I herein (the "*Proposed Amendments*");

WHEREAS, pursuant to Section 9.02 of the Indenture, the written consent of Holders of at least a majority in aggregate principal amount of the outstanding Notes (the "*Requisite Consents*") is sufficient to adopt the Proposed Amendments set forth in Article I;

WHEREAS, the holders of at least a majority in aggregate principal amount of the Notes outstanding (which excludes any Notes owned by the Issuers or their affiliates) have validly tendered consents and not validly withdrawn their consents to the adoption of the Proposed Amendments effected by this Supplemental Indenture in accordance with the provisions of the Indenture;

WHEREAS, having received the Requisite Consents for all of the Proposed Amendments, the Issuers and the Guarantors desire to amend the Indenture as provided herein;

WHEREAS, the Issuers have delivered to the Trustee, pursuant to Section 9.02 of the Indenture, an Officer's Certificate stating that the Issuers have received the Requisite Consents, and have provided certification of such receipt to the Trustee;

WHEREAS, the Issuers have also delivered to the Trustee, pursuant to Sections 7.02(b), 9.02 and 9.05 of the Indenture, (i) a resolution of the Board of Directors of the Company authorizing the execution of this Supplemental Indenture, and (ii) an Officer's Certificate and an Opinion of Counsel, each stating that the execution of this Supplemental Indenture is authorized or permitted by the Indenture and that all conditions precedent to the execution and delivery of this Supplemental Indenture have been satisfied; and

WHEREAS, all other conditions and requirements necessary to make this Supplemental Indenture a valid, binding and legal instrument enforceable in accordance with its terms have been performed and fulfilled by the parties hereto, and the execution and delivery thereof have been in all respects duly authorized by the parties hereto.

NOW, THEREFORE, in consideration of the foregoing and for other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, the parties mutually covenant and agree for the equal and ratable benefit of the Holders of the Notes as follows:

ARTICLE I
AMENDMENTS

Section 1.01. Amendments to Indenture.

(i) Section 6.01(b) of the Indenture is hereby amended and restated in its entirety to read as follows:

"(b) the Issuers default in the payment of interest on any Note when the same becomes due and payable, and the default continues for a period of 150 days;"

(ii) Section 4.03(d) of the Indenture is hereby deleted and amended and restated to read in its entirety as set forth below:
"(d) [Intentionally omitted]."

(iii) Section 4.03(e) of the Indenture is hereby amended to delete the reference to ", and a publicly accessible quarterly conference call of such Parent".

(iv) The first sentence of Section 4.03(f) of the Indenture is hereby amended to (i) add the word "and" immediately before the word "furnishes", (ii) delete the reference to ", and holds a publicly accessible quarterly conference call" and (iii) replace the reference to "Sections 4.03(a) and (d)" with "Section 4.03(a)".

ARTICLE II
MISCELLANEOUS

Section 2.01. Effectiveness. This Supplemental Indenture shall become effective upon the execution and delivery of the Supplemental Indenture by the parties hereto.

Section 2.02. Confirmation. Except as expressly amended hereby, the Indenture is in all respects ratified and confirmed and all the terms, conditions and provisions thereof shall remain in full force and effect. For the avoidance of doubt, this Supplemental Indenture shall not impair or affect the contractual right of any Holder of a Note or Notes to receive any principal payment or interest payment on such Holder's Note or Notes, on or after the Stated Maturity thereof, or to institute suit for the enforcement of any such payment. Upon the execution and

delivery of this Supplemental Indenture by the Issuers, the Guarantors and the Trustee, this Supplemental Indenture shall form a part of the Indenture for all purposes, and every Holder of Notes heretofore or hereafter authenticated and delivered shall be bound hereby. Any and all references to the Indenture, whether within the Indenture or in any notice, certificate or other instrument or document, shall be deemed to include a reference to this Supplemental Indenture (whether or not made), unless the context shall otherwise require.

Section 2.03. Counterparts. The parties may sign any number of copies of this Supplemental Indenture. Each signed copy shall be an original, but all of them together represent the same agreement. The exchange of copies of this Supplemental Indenture and of signature pages by facsimile, .pdf transmission or other electronic means shall constitute effective execution and delivery of this Supplemental Indenture for all purposes. Signatures of the parties hereto transmitted by facsimile or .pdf transmission or other electronic means shall be deemed to be their original signatures for all purposes.

Section 2.04. Capitalized Terms. Capitalized terms used herein without definition shall have the meanings assigned to them in the Indenture.

Section 2.05. GOVERNING LAW. THIS SUPPLEMENTAL INDENTURE SHALL BE GOVERNED BY AND CONSTRUED IN ACCORDANCE WITH THE LAWS OF THE STATE OF NEW YORK.

Section 2.06. Effect of Headings. The section headings herein are for convenience only and shall not affect the construction hereof.

Section 2.07. Acceptance by the Trustee. The Trustee accepts the amendments to the Indenture effected by this Supplemental Indenture and agrees to execute the trusts created by the Indenture as hereby amended, but only upon the terms and conditions set forth in the Indenture; *provided, however*, that to the extent the Requisite Consents of Holders of Notes to any amendment effected by or delivered in connection with this Supplemental Indenture are determined by a court of competent jurisdiction to have not been validly obtained in accordance with the Indenture or applicable laws, such amendment shall not be deemed to have occurred.

Section 2.08. Trustee Disclaimer. The recitals contained herein and the statements made in any Officer's Certificate shall be taken as the statements of the Issuers, and the Trustee assumes no responsibility for their correctness, and none of the recitals contained herein or the statements made in any Officer's Certificate are intended to or shall be construed as statements made or agreed to by the Trustee. The Trustee makes no representations as to the validity or sufficiency of this Supplemental Indenture or the consequences of any amendment provided herein.

IN WITNESS WHEREOF, the parties hereto have caused this Supplemental Indenture to be duly executed and attested, all as of the date first above written.

ISSUERS:

FORESIGHT ENERGY LLC, as Issuer

By:/s/ Robert D. Moore
Name: Robert D. Moore
Title: President and Chief Executive Officer

FORESIGHT ENERGY FINANCE CORPORATION, as Co-Issuer

By:/s/ Robert D. Moore
Name: Robert D. Moore
Title: President and Chief Executive Officer

GUARANTORS:

ADENA RESOURCES, LLC
AKIN ENERGY LLC
AMERICAN CENTURY MINERAL LLC
AMERICAN CENTURY TRANSPORT LLC
COAL FIELD CONSTRUCTION COMPANY LLC
COAL FIELD REPAIR SERVICES LLC
FORESIGHT COAL SALES LLC
FORESIGHT ENERGY EMPLOYEE SERVICES CORPORATION
FORESIGHT ENERGY LABOR LLC
FORESIGHT ENERGY SERVICES LLC
HILLSBORO TRANSPORT LLC
LD LABOR COMPANY LLC
LOGAN MINING LLC
M-CLASS MINING, LLC
MACH MINING, LLC
MACOUPIN ENERGY LLC
MARYAN MINING LLC
OENEUS LLC D/B/A SAVATRAN LLC
SENECA REBUILD LLC
SITRAN LLC
SUGAR CAMP ENERGY, LLC
TANNER ENERGY LLC
VIKING MINING LLC
WILLIAMSON ENERGY, LLC

By:/s/ Robert D. Moore
Name: Robert D. Moore
Title: President and Chief Executive Officer

TRUSTEE:

WILMINGTON TRUST, NATIONAL ASSOCIATION

By:/s/ Nedine P. Sutton
Name: Nedine P. Sutton
Title: Vice President

[Signature Page – Second Supplemental Indenture]

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Coal analysts say bankruptcy filing is 'increasingly likely' for Illinois Basin's Foresight Energy

November 25, 2019

S&P Global Market Intelligence ($):

One of the few major U.S. coal companies to dodge the bankruptcy court may soon need to file for Chapter 11 restructuring if the current market and economic forces working against the coal industry persist, according to recent securities filings.

Over the past few weeks, Foresight Energy LP exercised an option to delay a $24.4 million interest payment and negotiated the right to skip a publicly accessible quarterly call to discuss its third-quarter finances. As management of the Illinois Basin coal miner management works to restructure its balance sheet, the New York Stock Exchange delisted its stock and Foresight affiliate Murray Energy Corp. filed for a bankruptcy reorganization.

"With a significant debt load and a near-term pricing recovery increasingly unlikely, a Chapter 11 bankruptcy filing appears increasingly likely," B. Riley FBR analyst Lucas Pipes wrote in a Nov. 14 note.

While some coal companies struggled to sell assets even through bankruptcy auctions, Pipes noted that Foresight still owns some attractive mining assets, with its longwall mines capable of producing coal at a lower cost than its peers. However, the company has about $1.25 billion in gross debt on its balance sheet.

"The partnership continues to engage in discussions with its creditor constituencies and is exploring potential restructuring alternatives," Foresight wrote in a Nov. 12 securities filing. "As a result of these discussions and potential restructuring efforts, it may be necessary for us to file a voluntary petition for relief under Chapter 11 of the United States Bankruptcy Code in order to implement a restructuring, or our creditors, under certain circumstances, could force us into an involuntary bankruptcy or liquidation."

Illinois Basin producers turned to a recent boom in export markets to make up for a decline in domestic demand, but that demand is retrenching. In the third quarter of 2018, Foresight captured $140.8 million in international coal sales. In the third quarter of 2019, it reported $34.8 million from export markets, a 75.3% decline. Domestic sales fell from $151.2 million to $146.7 million in the same period.

Source: https://ieefa.org/coal-analysts-say-bankruptcy-filing-is-increasingly-likely-for-illinois-basins-foresight-energy/

RECEIVED
DEPT. OF NATURAL RESOURCES
SPRINGFIELD

JUL 18 2018

OFFICE OF MINES & MINERALS
LAND RECLAMATION DIVISION

State of Illinois
Department of Natural Resources
Office of Mines and Minerals; Land Reclamation Division
One Natural Way
Springfield, IL 62702

PERMIT APPLICATION 456
WATER MANAGEMENT PIPELINE

VOLUME I OF II: PARTS I – V

POND CREEK MINE NO. 1
WILLIAMSON COUNTY, IL

Prepared for
WILLIAMSON ENERGY, LLC
JOHNSTON CITY, IL

ALLIANCE PROJECT NO. B17-222-1413
MAY 2017
Re-Submitted July 2018

RECEIVED
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OFFICE OF MINES & MINERALS
LAND RECLAMATION DIVISION

Alliance Consulting, Inc.
Engineers · Constructors · Scientists

June 21, 2018

Project No. B17-222-1413

Mr. Nick San Diego, Supervisor
Illinois Department of
Natural Resources
Land Reclamation Division
One Natural Resources Way
Springfield, IL 62702-1271

Responses to Incomplete Comments
Permit Application 456
Williamson Energy, LLC
Williamson County, Illinois

Dear Mr. San Diego:

On behalf of our client, Williamson Energy LLC, Alliance Consulting, Inc. is submitting a copy with original signatures and one duplicate copy to address the Incomplete Comments dated May 18, 2018 (attached).

Response to Comment 1 - Attachment I.2.A. has been revised. Acreage has been added to the table.

Response to Comment 2 - Parcel 11-32-100-003 has been added to Attachment I.2.A.

Response to Comment 3 - Boring operations will be conducted outside of the 100 feet road right-of-way for all road crossings. All references to trenching through roads have been removed from the Hydrology-Mining Operation Maps (Drawing Nos. B17-222-M13 – M16) and Part I.12.B.4 has been revised to indicate no roads will be closed.

Response to Comment 4 - Boring operations will be conducted outside of the 100 feet road right-of-way for all road crossings. No agreements will be needed from the county highway department.

Response to Comment 5 - The public notice has been revised per the comment.

Response to Comment 6 - The narrative for Part I.12.C.4 has been revised. All references to trenching across the roads have been removed. Boring operations will be conducted outside the 100 feet road buffer zones. A

124 Philpott Lane ▯ Raleigh County Airport Industrial Park ▯ Beaver, WV 25813-9502 ▯ TELE (304) 255-0491 ▯ FAX (304) 255-4232

	variance is requested for construction/installation operations for areas adjacent to the public roads.
Response to Comment 7 -	Typical cross sections have been included in Attachment IV.7.I.
Response to Comment 8 -	All references to "preliminary designs" have been removed.
Response to Comment 9 -	Part IV.7.I has been revised to address ephemeral streams.
Response to Comment 10.a. -	Refer to the revised Attachment II.8 for the requested information.
Response to Comment 10.b. -	Part V.3.B.4 has been revised to include the requested information.
Response to Comment 10.c. -	Refer to the revised Attachment II.8 for the requested information.
Response to Comment 11 -	Attachment V.1.D.2.b has been revised to include a permanent wetland vegetation species list and reclamation plan.

If you have any questions, or require additional information, please contact us.

Sincerely,

ALLIANCE CONSULTING, INC.

Stephen M. Sutphin
Senior Project Manager

SMS:sms
Enclosures

FILE: 17222-03

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Illinois Department of
Natural Resources

One Natural Resources Way Springfield, Illinois 62702-1271
www.dnr.illinois.gov

Bruce Rauner, Governor
Wayne A. Rosenthal, Director

May 18, 2018

Carson Pollastro
Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951

Re: Application No. 456
Response Dated April 2018

Dear Mr. Pollastro:

This letter will serve as notice that the permit application for Pond Creek Mine, submitted in response to the Department's incomplete letter dated November 6, 2017, under the Surface Coal Mining Land Conservation and Reclamation Act and the promulgated rules and regulations, is **not** administratively complete for review.

The following points must be addressed by the applicant for the Department to continue its review process:

1. Response to Part I.2 and I.3, property owners and locations, appears to be incomplete. Attachment I.2.B indicates many property owners have Easements with the applicant and others do not. The applicant is required to provide land owner waiver documents from surface property owners for areas the applicant does not control, for inclusion in the application for an application to be deemed administratively complete. Additionally, the applicant did not provide acreage figures to determine percentage of controlled/uncontrolled property.

2. One parcel ID No. 11-32-100-003, indicated on Identification of Interest Map 4, shows a portion of the proposed boundary from the NW before crossing under Lake Creek Road. This property is not listed in Attachment I.2.B. The applicant shall verify whether this is a mapping error or revise/update Attachment I.2.B.

   Additionally, if this parcel is to be included, the applicant shall provide the required information indicating right of entry or landowner waiver for inclusion in the application.

3. The applicant has provided agreements with the local road authorities for operations within the road right of ways. The agreements indicate all crossings to be bored under. The applicant indicates road crossings will be bored under and trenched through. Road agreements provided from Williamson and Franklin County Highway Departments indicate operations shall be within the right of way of the roads and do not allow trenching. The Hydrology - Mining Operations Maps indicate some areas to be trenched and roads closed. This information conflicts with the road authority agreements and shall require attention.

   Further, Part I.12.B.4 indicates roads will be closed. Review of the road agreements does not indicate the applicant has the authority to close roads. If the applicant is to close roads, the public notice must be revised to indicate an approximate time and duration of the closure for each road to be closed.

4. Review of the Ownership Identification Map Drawings M1, M2, M3 and M4 indicates public roads not discussed in the Franklin County Highway Department agreement. The applicant needs to clarify the crossings and locations of Horseshoe Road, Deason Road, Sandburg Road, Gossage Road Lake Creek Road and Cheatman Road. The Applicant needs to verify whether operations for crossing these roads are within each road's right of way or within 100 feet of the outside right of way.

5. The Department found discrepancies in the locations of the following roads:

   The public notice indicates Deason Road is in the NE/4 T7S, R2E, Section 28 and SW/4 Sec 27. Review of the map indicates Deason Road runs N/S at the corners; Sec28, SE; Sec 27, SW; Sec 34, NW; Sec 33 NE. The applicant will need to revise the notice.

   Similarly, Lake Creek Road is along the north border of Sections 32, 31 and 30; and south borders of Sections 29 and 30. The public notice states the road is in the NE/4 of Section 30.

6. The applicant requests a variance for operations within 100 feet of the right of way of a road, in response to Part I.12.C.4. The operations proposed do not allow for a variance.

7. The applicant failed to provide a cross section depicting stream crossings, as requested per Comment 21 of the Incomplete Letter sent by the Department on November 6, 2017. Pursuant to 62 Ill. Adm. Code 1784.23(b)(6), the applicant shall provide design cross sections of the stream crossings proposed for the perennial stream Pond Creek and the 8 intermittent and the ephemeral streams' crossings. All stream crossings' cross sections shall include details, including but not limited to: the depth at which the waterline will be buried under the streambed, the watershed area that the stream is draining at the point of

construction, and any protection measures to be used on stream crossings to prevent water pollution and damage to public and private property.

8. The applicant provided preliminary engineering design in response to Part IV.5.C.2 and stated that specifics of the waterline hydraulic design such as pipe sizes and location of fittings will be provided before the installation of the pipeline. To ensure compliance with 62 Ill. Adm. Code 1784.30, the applicant shall provide detailed engineering design before the application can be deemed approved after technical review. The applicant shall provide a schedule with the dates when any detailed design plans for the waterline that are not submitted with the general plan will be submitted to the Department. The Department shall have approved, in writing, the detailed design plan for the water pipeline before construction of the structure begins.

9. The applicant has supplied a Wetland and Stream Delineation Report as Attachment II.9 in Part II of the application. The report identified 9 streams categorized as ephemeral to be disturbed. The applicant has failed to provide a justification for any stream characterized as ephemeral based on Department regulations as requested in Comment 10 (b.) of the Incomplete Letter sent by the Department on November 6, 2017. Please refer to Operator Memorandum No. 2017-06 for further explanation regarding ephemeral stream justifications. The names and qualifications of the person(s) making the determination shall be supplied. Should any of the streams not meet the criteria of an ephemeral stream based on Department regulations, a request to be exempt from the 100 ft. buffer requirements should be included.

10. The application indicates a total of 20.1 acres of Wildlife Woody pre-mining land use and the description of this habitat supplied in Part II(9) of the application includes woody species that are suitable summer Indiana bat and northern long-eared bat habitat. The applicant shall supply the following information in **Part V(3)(B)(4)** of the application:

    a. The applicant has included the bat survey results as Attachment V.3.B.4., but has failed to update the response to **Part V(3)(B)(4)** that states the proposed permit area is scheduled to be surveyed for threatened and endangered bat species beginning May 17, 2017.

    b. The applicant has provided an Indiana Bat Protection and Enhancement Plan in Part II of the application but failed to include an Incidental Take authorization request for the Indiana bat meeting the specifications of the "Range-wide Indiana Bat Protection and Enhancement Plan Guidelines" (revised 2013) developed by the U.S. Fish and Wildlife Service and the Office of Surface Mining, or justify why an incidental take authorization request is not required under those guidelines. If needed, the incidental take table provided in the 2013 Guidelines should be included with the PEP.

c. The applicant failed to update Part V(3)(B)(4) discussing whether or not the project is consistent with the northern long-eared bat Final 4(d) Rule (January 2016).

11. The applicant has failed to supply a Wildlife Wetland species list or wetland reclamation plan, as requested in Comment 12 of the Incomplete Letter sent by the Department on November 6, 2017. The applicant has supplied a Wetland and Stream Delineation Report as Attachment II.9 in Part II of the application. The report delineated 31 wetlands totaling approximately 6.73 acres to be disturbed. Upon review, Attachment V.1.D.2.b does not include a Wildlife Wetland species list or reclamation plan. The applicant shall provide measures to comply with 62 Ill. Adm. Code 1816.97(f) and include a permanent wetland vegetation species list and reclamation plan that is compatible with the Corp of Engineers Wetland Delineation Manual.

Upon submission of a new application, complete with the above listed information included, the Department will again review the permit application to determine if it is administratively complete.

Should you have any questions, please contact this office.

Sincerely,

Nick San Diego, Supervisor
Land Reclamation Division

NSD:JSc

cc: W. Gillespie

Alliance Consulting, Inc.
Engineers · Constructors · Scientists

April 3, 2018

Project No. B17-222-1413

Mr. Nick San Diego, Supervisor
Illinois Department of
Natural Resources
Land Reclamation Division
One Natural Resources Way
Springfield, IL 62702-1271

Responses to Incomplete Comments
Permit Application 456
Williamson Energy, LLC
Williamson County, Illinois

Dear Mr. San Diego:

On behalf of our client, Williamson Energy LLC, Alliance Consulting, Inc. is submitting a copy with original signatures and one duplicate copy to address the Incomplete Comments dated November 6, 2017 (attached).

Response to Comment 1 - Document information has been added to Attachment I.2.A.

Response to Comment 2 - The Identification of Interests Maps (Drawing Nos. B17-222-E1 through E4) and Attachments I.2.A & B have been revised per Williamson and Franklin Counties GIS property database.

Response to Comment 3 - Refer to the revised Ownership and Control information being submitted.

Response to Comment 4 - The public notice has been revised to address mining activities within 100 feet the right of way of roads.

Response to Comment 5 - The public notice refers to activities around "Horseshoe Road along the northeast quarter of Township 7 South, Range 2 East, Section 34 and the southwest quarter of Township 7 South, Range 2 East, Section 34". The public notice has been revised to reference activities around "Horseshoe Road along the northeast quarter of Township 7 South, Range 2 East, Section 34 and the ***northwest*** quarter of Township 7 South, Range 2 East, Section 34". No reference was found for activities around Horseshoe Road and southwest quarter of Section *28* and 34.

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Response to Comment 6 - Refer to Attachment I.12.B.4 – Illinois Department of Transportation for additional information concerning the road utility permits.

Response to Comment 7 - Part I.12.C.1 has been revised. The reference to 1761.14(d) has been corrected and the narrative now refers to Section 1761.14(b).

Response to Comment 8 - Refer to the revised narrative in Part III.2.A.1. for the clarification.

Response to Comment 9 - Part II.13.D has been revised per the comment.

Response to Comment 10.a. – f. - Refer to the revised Attachment II.8 for the requested information.

Response to Comment 11.a. – c. - Refer to the revised Attachment V.3.B.4 for the requested information.

Response to Comment 12 - Attachment V.1.D.2.b has been revised to include a permanent wetland vegetation species list and reclamation plan.

Response to Comment 13.a - The map legend has been corrected.

Response to Comment 13.b - The Cumulative Impact Area drainage area has been added to the CIA map (Drawing No. B17-222-E2). A drainage area for the pipeline installation was not delineated because of the short-term disturbance associated with the pipeline installation. The map legend has been corrected.

Response to Comment 14 - The six stream monitoring points, which are existing, are utilized for the existing cumulative impact area (mine area) and not for the proposed Water Management Pipeline. Per a conference call on July 15, 2017 with the IDNR hydrologist, it was discussed and agreed that the pipeline would not affect the currently approved CIA because the pipeline would not impact the surface and groundwater systems. Part III.2.D.1.a. states that the pipeline will not change the surface water and groundwater systems, drainage patterns and storm water runoff characteristics. This statement has been added to the narrative located under the Cumulative Hydrologic Impact Area section of Part III.2.D.1.a. – Water Management. The narrative in Part III.2.D.1.a. – Surface Water Sampling Points has been revised to indicate that Sites PC-1 and



PC-2 will be the only surface water sites associated with the Water Management Pipeline.

Response to Comment 15 - Per the comment, Part I.1.G has been revised to indicate the pipeline is a Support Facility and Part IV.5.B. have been revised to indicate the pipeline is a Mine Support Area.

Response to Comment 16 - A signed Engineering Certification has been included.

Response to Comment 17 - Copies of the Franklin County road agreements are included.

Response to Comment 18 - Part II.1 has been revised per the comment.

Response to Comment 19.a - Refer to the revised Attachment IV.1, which addresses installation of the pipeline crossing railroads

Response to Comment 19.b - Refer to Attachment IV.1 for information concerning the location of the gas line.

Response to Comment 20.a - A small soil storage area has been shown on the Hydrologic/Mining Operations Map – Sheet 4 (Drawing No. B17-222-M16). Refer to Attachment IV.1 under the narrative for the Big Muddy River for additional information.

Response to Comment 20.b - A proposed power line will be located within the permit boundary and will run from the intersection of Lake Creek Road to the proposed maintenance building/pump house. The power line has been added to the Hydrologic/Mining Operations Map – Sheet 4 (Drawing No. B17-222-M16). Refer to Attachment IV.1 under the narrative for the Big Muddy River for additional information.

Response to Comment 21 - Refer to Part IV.7.I for information on measures to be taken to prevent erosion, water pollution and stream channel stability.

Response to Comment 22 - Part IV.7.K.2 has been revised and contact will be made with IDNR-OWR for the Pond Creek crossing.

Response to Comment 23.a - Refer to Part IV.5.C.2 for additional information concerning the installation Water Control Structure at the Diffuser site

Response to Comment 23.b - Refer to the revised Part IV.5.C.2 narrative for additional information. Use word "wyes" has been removed and replaced with the word "elbows". At this time no wyes are proposed.



Refer to Attachment IV.5.C.2 for a description of the design for the pipeline and diffuser site.

If you have any questions, or require additional information, please contact us.

Sincerely,

ALLIANCE CONSULTING, INC.

Stephen M. Sutphin
Senior Project Manager

SMS:sms
Enclosures

cc: Will Gillespie

FILE: 17222-02

F

Illinois Department of
Natural Resources
One Natural Resources Way Springfield, Illinois 62702-1271
www.dnr.illinois.gov

Bruce Rauner, Governor
Wayne A. Rosenthal, Director

November 6, 2017

Carson Pollastro
Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951

Re: Application No. 456, Incomplete

Dear Mr. Pollastro:

This letter will serve as notice that the permit application for Pond Creek Mine, submitted under the Surface Coal Mining Land Conservation and Reclamation Act and the promulgated rules and regulations, is **not** administratively complete for review.

The following points must be addressed by the applicant in order for the Department to continue its review process:

1. The applicant, in its response to Part I.2.A, Property Ownership within the proposed boundary, did not provide the acreage for each of the surface owners, type of document conveying right of entry or landowner waiver to have the property included in the application. The applicant shall update Attachment I.2.A to include each property owner's acreage in the proposed area, the date of, and type of document that allows the applicant to enter and operate as proposed, and if no agreement has been reached with a property owner, a waiver allowing the applicant to include the property in the application.

2. Upon review of the Ownership Identification Map Drawings in conjunction with Attachment I.2.A, the reviewer finds several parcels listed on the maps that are not included in the list. Conversely, review indicates listings in Attachment I.2.A that cannot be located on the maps; one parcel located on Map 4 is listed as two different property owners. The list and maps must be updated to reflect correct information for location and property ownership.

3. The applicant, in response to Part I.9 has provided lists of violations for companies owned/controlled by the applicant and owners/controllers of the applicant. Review of the lists indicates several violations that are not marked "terminated" or "abated" and have no documentation whether the violations are being corrected in good faith with the issuing agency. The applicant shall, for all active violations listed (those not indicated as

"terminated" or "abated") provide current documentation to indicate the company is working with the issuing agency to resolve the issue.

During completeness review the Department finds a cessation order issued to Maple Creek Mining, Inc. which has links with the ownership of the applicant. Although this violation occurred after the submittal of your application, the Department is notifying you this violation will be included in technical review if it has not been abated.

4. The applicant indicates roads may be temporarily closed, in response to Part I.12.B.4. Upon review of the Hydrology – Mining Operations Map and public notice submitted, the reviewer finds the public notice inadequate as it does not indicate specific operations within 100 feet of the outside right of way of each road.

Further, the public notice provided indicates activities around Horseshoe Road in the SW/4 of Sec 28 and 34, T7S, R2E. Hydrology – Mining Operations Map does not indicate the proposed area in this location.

Public notice will be reviewed for compliance upon receipt of all changes outlined in this letter.

6. The applicant indicates copies of road agreements shall be provided upon execution with the road authorities. Agreements were received from the Williamson County Highway Department and Illinois Department of Transportation. Agreements with the Illinois Department of Transportation indicate operations shall be completed within 180 days of approval or agreements are null and void. Agreements were signed February of 2017.

7. The applicant, in response to Part I.12.C.1 indicates, "Variance of Section 1761.14(d) is requested." This is not a valid regulation and shall be corrected.

8. Pursuant to 62 Ill. Adm. Code 1783.12, Attachment II.10.A must be modified to reflect any updates to the status of the Cultural and historical survey.

9. Pursuant to 62 Ill. Adm. Code 1783.21, Part II.13.D, page II-7 must be modified to agree with the topsoil removal thickness handling procedure outlined in Part IV.2.B.3, page IV-2.

10. The response to Part II.8 of the application references Attachment II.8. The applicant is required to provide information on site specific resources such as threatened and endangered species, other protected species, and potential habitats of high value. An EcoCAT Consultation has been provided as part of this application in Attachment II.8. This document only provides locality data for recorded occurrences. The applicant is required to update Part II.8 of the application with, at minimum, the following information:

a. For Wildlife Wetland Pre-Mining Land Use located within the proposed permit area, discuss how these areas will be avoided or replaced, and enhanced where applicable and provide general information on the steps taken to comply with the Section 404 of the Clean Water Act (1784.13(b)(9)). In addition, any wetland assessments conducted should be included in the application.
b. Based on aerial maps, the proposed pipeline appears to cross several streams/surface water bodies. The applicant shall characterize each of these streams using the definitions of ephemeral, intermittent, and perennial streams found in Appendix A Section 1701 of the Department regulations. Further, for any stream characterized as ephemeral a justification must be supplied for this determination based on Department regulations. The names and qualifications of the person(s) making the determination shall be supplied. If an ephemeral stream justification is applicable, please refer to Operator Memorandum No. 2017-06 for further explanation.
c. Should any of the streams meet the criteria of intermittent or perennial all applicable parts of the application shall be completed. This includes, but is but not limited to, adherence to or request to be exempt from the 100 ft. buffer requirements and Part 6 of the application regarding stream diversions/relocations.
d. Provide a complete threatened and endangered species list for both state and federally listed species that are known to occur within the county(ies) of the proposed permit area and each adjacent county. This information may have been submitted as part of previous approved permit applications. Referencing this material is acceptable, however the materials must be provided for Department review and evaluation per Operator Memorandum No. 90-08. The following resource is also suggested; https://www.dnr.illinois.gov/ESPB/Documents/ET_by_County.pdf
e. For each threatened and endangered species listed provide a determination based on species habitat requirements regarding the likelihood that the species may occur within the proposed permit and adjacent half mile area. In addition, provide the rationale justifying the determination. The names and qualifications of the person(s) making the determination shall be supplied.
f. For any state or federally listed threatened or endangered species deemed likely to occur in the permit or adjacent area provide a Protection and Enhancement Plan or justify why one is not necessary (not including the Indiana bat and northern-long eared bat as these species are handled in Part V of the application).

11. The application indicates a total of 20.1 acres of Wildlife Woody pre-mining land use and the description of this habitat supplied in Part II.9 of the application includes woody species that are suitable summer Indiana bat and northern long-eared bat habitat. The applicant shall supply the following information in Part V.3.B.4 of the application:

a. The response to Part V.3.B.4 states that the proposed permit area is scheduled to be surveyed for threatened and endangered bat species beginning May 17, 2017. The applicant shall update this response to include any results from these surveys.
b. Provide a Protection and Enhancement Plan and an Incidental Take authorization request for the Indiana bat meeting the specifications of the "Range-wide Indiana Bat

Protection and Enhancement Plan Guidelines" (revised 2013) developed by the U.S. Fish and Wildlife Service and the Office of Surface Mining, or justify why a Protection and Enhancement Plan and Incidental Take authorization request are not required under those guidelines.

c. Discuss whether or not the project is consistent with the northern long-eared bat Final 4(d) Rule (January 2016), and if not then provide a Protection and Enhancement Plan and Incidental Take authorization request that is consistent with the 2013 Indiana bat guidelines referenced above.

12. Attachment V.1.D.2.b does not include a Wildlife Wetland species list or reclamation plan. Should the applicant plan to disturb wetland habitat, a permanent wetland vegetation species list and reclamation plan that is compatible with the Corp of Engineers Wetland Delineation Manual shall be supplied.

13. The following concern the response to Part III.2.D.1.a:

a. On page 6, the applicant labeled Permit 417 as "Area No. 4", however, on the Cumulative Impacts Area Map, the area is labeled as "Area No. 3". Pursuant to 62 Ill. Adm. Code 1783.25 the applicant shall correct this discrepancy.
b. The applicant describes the cumulative impact area as the currently permitted area, the proposed pipeline, and the upstream drainage area of the unnamed tributary to Pond Creek as well as the downstream watershed areas leading to stream monitoring point PC-2. The cumulative impact area map only shows the currently permitted area and the pipeline as the cumulative impact area. Pursuant to 62 Ill. Adm. Code 1784.14(c) the applicant shall address this discrepancy.

14. The applicant has proposed to utilize six stream monitoring points in the vicinity of Permit No. 375. Pursuant to 62 Ill. Adm. Code 1784.14(i)(2) the applicant shall discuss how these stream monitoring points will be used to determine the impacts of the proposed pipeline.

15. In response to Part I.1.G, the applicant indicated the type of disturbance proposed is "other" and associated acreage for this type of disturbance to be 70.7 acres. Also, in response to Part IV.5.B, the applicant indicates that the type of support facility of the proposed waterline is "other". Pursuant 62 Ill. Adm. Code 1761.16(b)(1)(D), the applicant shall revise the response in Part I.1.G to define the proposed acreage to be affected by the installation of a water pipeline as a "Support Facility" type of disturbance. The applicant shall also revise response in Part IV.5.B to described proposed operations as construction of a "Mine Support Area".

16. Pursuant 62 Ill. Adm. Code 1783.25(b), the engineering certification shall include the signature and seal of a qualified registered professional engineer.

17. The applicant has provided road and highway authority agreements for operations within 100 feet of the ROW of Interstate 57, State Route 37 and Williamson County roads. However, an agreement with the Franklin County Road Authority was not included. Pursuant 62 Ill. Adm. Code 1761.14(b)(2), the applicant shall provide an agreement with the Franklin County Road Authority for operations within 100 feet of the ROW of Horseshoe Road, County Highway 6, Deason Road, Sandburg Road, Freeman Spur road, Gossage Road Lake Creek Road and Cheatman Road.

18. Pursuant 62 Ill. Adm. Code 1817.11, response in Part II.1 shall be revised to explain how the permit area perimeter will be marked and how perimeter markers will be set along it.

19. To ensure compliance with 62 Ill. Adm. Code 1817.180, the applicant shall address the following items:

    a. The Hydrology/Mining Operations maps show that the proposed water pipeline will cross two railroad tracks, one about 500 feet north of the Johnston City limits, and another railroad track about 770 feet west of Deason Rd, northwest of Freeman Spur. The applicant shall expand the narrative in response to Part IV.1 to provide details on how the waterline will pass through the railroads and what provisions will be taken to minimize damage or destruction to the railroad tracks and to minimize or prevent disruption of the railroad services.
    b. The Hydrology/Mining Operations maps also show a gas line that seems to be right next to, or in some sections, overlapping with the proposed water pipeline at different locations. Describe measures that will be taken to minimize damage or destruction to the gas line, prevent disruption of the gas line service and protect the public and the environment from any gas line rupture.

20. Drawing M16 shows a plan view of the 'Diffuser Site'. The applicant shall address the following items:

    a. The applicant has failed to provide a narrative in response to Part IV.2.B on how topsoil and subsoil from the area of the Diffuser Site will be removed and stored. To ensure compliance with 62 Ill. Adm. Code 1784.13(b)(4), the applicant shall explain how it will handle the soil material on the Diffuser Site and show location of topsoil and subsoil stockpiles on the plan view of the area.
    b. Power lines and power poles are depicted on the plan view of the 'Diffuser Site'. The power lines and power poles seem to continue along the water pipeline from the Diffuser Site to the east. The applicant shall clarify if power lines and power poles will be installed along the entire extent of the water line in response to Part IV.1. If power lines and power poles will be installed, this construction operation needs to be described and, power line and power poles along the water pipeline shall be depicted on the Mining Operations maps.

21. Response in Part IV.7.I states the water pipeline will be bored under Pond Creek and that there will be other crossings of ephemeral streams. Pursuant 62 Ill. Adm. Code 1784.30, the applicant shall provide details on how the water pipeline will cross Pond Creek and all the other ephemeral streams that are anticipated to be crossed. Details should be provided in the narrative in response to Part IV.1 about measures that will be taken to prevent erosion, water pollution and stream channel stability when boring under the streams. Appropriate cross sections of the stream crossings shall also be provided.

22. The point at which the applicant is proposing to cross Pond Creek serves an area of approximately 36 square miles. The applicant shall revise the response in Part IV.7.K.2 to answer positively. The applicant shall also contact the Office of Water Resources to discuss the need of obtaining a permit for the proposed construction activities under Pond Creek.

23. Pursuant 62 Ill. Adm. Code 1784.11(b)(6), the applicant shall provide more specifications on the operation of the proposed water pipeline. Details shall be provided on:

    a. Water control structure that are necessary for the operations of the Water Management Pipeline as mentioned on Page 3 of Attachment IV.1 and that will be installed at the Diffuser Site.
    b. Engineering design of pumping and piping system including location and design of anticipated provisions stated by the application in response to Part IV.5.C.2 such as air valves, joints, thrust blocks and wyes.

Upon submission of a new application complete with the above listed information included, the Department will again review the permit application to determine if it is administratively complete.

Should you have any questions, please contact this office.

Sincerely,

Scott K. Fowler, Supervisor
Land Reclamation Division

SKF:JSc

cc: W. Gillespie

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020 Fax: 618-983-3017

Mr. Nick San Diego, Supervisor
Illinois Department of
Natural Resources
One Natural Resources Way
Springfield, IL 62702-1271

Re: Williamson Energy, LLC - Permit Application 456 for Water Management Pipeline

Dear Mr. San Diego:

This letter authorizes Alliance Consulting, Inc. (Alliance), and its representatives, permission to perform work on, receive comments and submit corrections on the above referenced permit application. Please send copies of any comments to Alliance Consulting, Inc. at 124 Philpott Lane, Beaver, WV 25813, as well as Williamson Energy, LLC at the above address.

Thank you for your cooperation.

Sincerely,

WILLIAMSON ENERGY, LLC

Mark Schuerger
Authorized Agent

PART I

State of Illinois
Department of Natural Resources
Office of Mines and Minerals
Land Reclamation Division
One Natural Resources Way
Springfield, IL 62702-1271

APPLICATIOPN FOR SURFACE COAL MINING AND RECLAMATION OPERATIONS
PERMIT – UNDERGROUND OPERATIONS
UCM-1

PART I

(Application to be submitted 120 days (180 days for NPDES) prior to the desired effective date of the permit)

DATE: **7-13-18**

NOTICE
This state agency is requesting disclosure of information that is necessary to accomplish the statutory purpose as outlined under Ill. Rev. Stat. 1989, ch. 96 1/2, par. 7901 et seq. Disclosure of this information is voluntary, however failure to comply may result in this form not being processed. This form has been approved by the Forms Management Center.

1) A) General Information

(~~I~~) (~~We~~) (The) **Williamson Energy, LLC**
(Name of Company, Corporation, Partnership or Individual)
P. O. Box 99, Johnson City, IL 62951 **(618) 983-3020**
(Address) (Telephone Number)

hereby submit application # 456 for a permit to mine during a permit term of 5 years.

Type of Application:

[X] Underground Mining
[ ] Revision No. _____ to Permit No. _____
[ ] Shadow Area Addition
[ ] Renewal No._____ to Permit No. _____
[ ] Transfer of Permit No. _____
[ ] Acres to be added under renewal

Applicant's Social Security No. _____ (Voluntary) and/or Federal Employer Identification No. **20-0888529**.

Name of Mine **Pond Creek 1 (Mach #1 Mine)**.

MSHA ID No. **11-03141(Mine);**
IL08-03141-02 (Refuse Facility No. 2) & IL08-03141-03 (Refuse Facility No. 3).
List the Mine Safety and Health Administration (MSHA) number(s) for all mine associated structures that require MSHA approval.

I, **Mark Schuerger** _____ **Authorized Person**
Name Signature Title

under penalties of perjury declare that I have examined this application, including accompanying statements and documents and to the best of my knowledge it is true, and correct. (Signee must be at least a vice president or duly authorized representative for NPDES 35 Ill. Adm. Code 309.103(e))

This application is also to be used to apply for a:

IEPA Subtitle D (State) Permit Yes _____ No X NPDES Yes _____ No X

New _____
Renewal No. _____ Date: _____
Renewal No. _____ Date: _____
Modification No. _____ Date: _____
Modification No. _____ Date: _____

If this is an application for a NPDES permit, the Consolidated Permits Program - Application Form 2C (renewal), Form 2D (new), or Form 2E (sanitary) must be completed.

B) I _____
(vice president or his duly authorized representative)

hereby waive my right of the 90-day permit issuance deadline as required by the Illinois Environmental Protection Act, Section 39(a)(4) and the Illinois Pollution Control Board Rules and Regulations, 35 Ill. Adm. Code 309.225(c).

C) Who will be the operator of the permit site?
Name **Mach Mining, LLC**

Pursuant to 62 Ill. Adm. Code 1701.5 an operator is any person engaged in coal mining who removes or intends to remove more than 250 tons of coal.

If the operator is different from the applicant, provide the following information.

1) Operator's address **P. O. Box 300**
Johnston City, IL 62951

2) Operator's telephone No. **(618) 983-3020**

3) Operator's Social Security No.
(voluntary) and/or Federal Employer Identification No. **73-1734826**.

D) Who will extract coal under this permit?
Name **Mach Mining, LLC**

If different from applicant or operator provide the following:

1) Address **N/A**

2) Telephone No. _____
3) Social Security No. (Voluntary) and/or federal employer Identification No. _____

E) Who will pay abandoned mine land reclamation fees?
Name **Williamson Energy, LLC**

If the person paying the abandoned mine land reclamation fee is different from the applicant, provide the following information.

1) Address _____

2) Telephone No. _____

3) Payee's Social Security No. _____
(voluntary) and/or Federal Employer Identification No. _____

F) The permittee requests a permit on the following area as shown on the permit map.

				Location		
Mine Address	Pit No. or Name	Acres to be Permitted	Sec.	Twp.	Range	County
16468 Liberty School Road, Marion, IL 62959	**Water Management Pipeline**	**4.5**	**1**	**T8S**	**R2E**	**Williamson**
		4.7	**2**	**T8S**	**R2E**	
		3.0	**12**	**T8S**	**R2E**	
		6.4	**7**	**T8S**	**R3E**	
		3.4	**8**	**T8S**	**R3E**	
		4.9	**9**	**T8S**	**R3E**	
		2.1	**11**	**T8S**	**R3E**	
		4.1	**14**	**T8S**	**R3E**	
		6.3	**15**	**T8S**	**R3E**	
		0.9	**16**	**T8S**	**R3E**	
		4.0	**17**	**T8S**	**R3E**	
		1.9	**27**	**T7S**	**R2E**	**Franklin**
		6.2	**28**	**T7S**	**R2E**	
		3.7	**29**	**T7S**	**R2E**	
		0.1	**30**	**T7S**	**R2E**	
		4.9	**31**	**T7S**	**R2E**	
		0.4	**32**	**T7S**	**R2E**	
		5.6	**34**	**T7S**	**R2E**	
		3.6	**35**	**T7S**	**R2E**	

Total Acres **70.7**

G. Indicate the type of disturbance and associated acreage.

Acres		Type of Disturbance
0.0		Deep Mine Entries, Ventilation, Air Shafts
0.0		Mine Waste Areas
70.7		Processing Areas & Support Facilities
0.0		Access, Haul Roads, & Transport Facilities
0.0		Soil Storage Areas
0.0		Diversions
0.0		Other
0.0		Not to be Disturbed

H) For each phase (permit) of the proposed surface coal mining and reclamation operation over the life of the mine provide the anticipated or actual starting and termination date and the anticipated number of acres to

be affected. Designate the boundaries of each phase on the pre-mining land use map or other designated map.

Phases (Permits)	Starting Date	Termination Date	Acres to be Affected
Water Management Pipeline	**06/18**	**End of Mining**	**70.7**

2) A) Provide name and address of every legal or equitable owner of record of the permit area, and the mineral property to be mined.

RESPONSE: **Refer to Attachment I.2.A. for a list of surface owners. No mineral will be removed and no mineral owners are listed.**

B) Provide name and address of the owner of record for all surface and subsurface areas contiguous to any part of the proposed permit area.

RESPONSE: **Refer to Attachment I.2.B. for a list of contiguous surface owners. No mineral will be removed and no mineral owners are listed.**

C) Show location of owners of record of those lands, both surface and subsurface, included in or contiguous to the permit area on premining land use map or another map, if necessary.

RESPONSE: **Refer to the Ownership Identification map (Drawing Nos. B17-222-M1, M2, M3 and M4).**

3) A) Provide name and address of any holder of record of leasehold interest for the permit area, and the mineral property to be mined.

RESPONSE: **Mineral property will not be disturbed. This application addresses the surface facilities associated with the adjacent Permit 375 site.**

B) Provide a statement of all lands, interest in lands, options or pending bids on interest held or made by the applicant for lands, which are contiguous to the permit area.

RESPONSE: **N/A**

4) Provide name and address of any purchaser of record under a real estate contract of the property for the permit area.

RESPONSE: **N/A.**

5) A) The applicant is: _____**X**_____ corporation, _____ partnership, _____ single proprietorship, _____ association or other business entity.

B) For the resident agent who will accept service of process for the applicant provide the following information.

1) Name of resident agent **Illinois Corporation Service Company**.

2) Address **801 Adlai Stevenson Drive, Springfield, IL 62703**

3) Telephone No. **(800) 877-2556**

4) Social Security No. _____ (voluntary) and/or Federal Employer Identification No. **81-0669143**.

6) OWNERSHIP AND CONTROL INFORMATION

Ownership and control is evidenced by being the permittee of a surface coal mining operation, or by being the owner of record of 50 percent or more of an entity controlling a surface coal mining operation or by having any relationship, which gives direct or indirect authority over an entity controlling a surface coal mining operation.

Ownership and control is presumed if an entity is an officer or director; is an operator of a surface coal mining operation; has the authority to commit the financial or real property assets or working resources of an entity; is the owner of record of ten (10) through fifty (50) percent of an entity; is a general partner of a partnership; owns or controls coal to be mined by another entity and has the right to receive that coal after mining; or has the authority to determine how the surface coal mining operations will be conducted.

For an entity to refute a presumed ownership and control relationship, the entity must demonstrate to the satisfaction of the Department that the entity subject to the presumption does not have the authority directly or indirectly to determine the manner in which the relevant surface coal mining operation is conducted.

A) For each entity who owns or controls the applicant provide the following information.

1) Name of entity _____.

2) Address _____
_____

3) Social Security No. _____ (voluntary) and/or Federal Employer Identification No._____.

4) The entity's specific ownership and control relationship with the applicant _____

If more than one ownership and control relationship exists, list each relationship separately under this part providing all information requested.

a) Percentage of ownership if any _____.

b) Location in organizational structure _____
_____.

c) Position title _____.

i) Date position was assumed _____.

ii) Date of departure from position _____.

RESPONSE: **Refer to Attachment Part I; Item 6.A. for the ownership and control information.**

B) For each surface coal mining and reclamation operation in the United States either presently owned or controlled or owned or controlled within the five (5) years preceding the date of the application by the entity listed in (A) above provide the following information.

RESPONSE: **Refer to Attachment Part I; Item 6.A. for the list of coal mining and reclamation operations owned and/or controlled within the last 5 years.**

1) Name _____.

2) Address _____.

3) Name of regulatory authority _____.

4) Identification number.

a) Social security No. _____ (voluntary) and/or federal employer identification No. _____.

b) Federal permit No. _____.

c) State permit No. _____.

d) MSHA No. _____ and date of issuance _____.

7) For each surface coal mining operation in the United States owned or controlled by the applicant provide the following information.

RESPONSE: **Refer to Attachment Part I; Item 6.A. for the list of coal mining operations owned or controlled by the applicant.**

a) Name of Operation _____.

b) Address of Operation _____.
_____.

c) Name of regulatory authority _____.

d) Identification number:
i) Social Security No. _____ (voluntary)
and/or Federal Employer Identification No. _____.

ii) Federal permit No. _____.

iii) State Permit No. _____.

iv) MSHA No. _____ and date of issuance _____.

8) A) Has the applicant, any subsidiary, affiliate or entity controlled by or under common control with the applicant had:

1) A State or Federal coal mining permit suspended or revoked in the five (5) years prior to the date of submission of the application?
Yes _____ No X

2) A forfeiture of a performance bond under a coal mining permit?
Yes _____ No X

B) If the response to A)1) or 2) was yes, provide the following information:

1) Provide the identification number of the permit.

2) Provide the date of permit issuance.

3) Provide the date of permit suspension or revocation and/or the date of bond forfeiture.

4) Provide the name of regulatory authority who suspended or revoked the permit and/or forfeited the bond.

5) Provide a statement of the reason for the suspension, revocation and/or forfeiture action.

6) Provide the current status of the permit and/or bond.

7) For any administrative or judicial proceedings initiated concerning the suspension, revocation, and/or forfeiture provide the following:

a) Date of proceeding,

b) Location of proceeding, and

c) Current status of proceedings.

C) If the response to A)2) was yes, provide information on the applicant's present financial condition to provide assurances satisfactory to the Department that forfeiture will not again be necessary.

9) Violation history

A) For the three (3) year period preceding the date of submission of the application, provide a listing of Notices of Violation received for any provision of the Federal Act or any Federal State law, rule, or regulation pertaining to air or water environmental protection incurred in connection with any surface coal mining operations. The listing shall include the following:

1) Notice of violation number or other identifier.

2) Date of NOV issuance.

3) Permit identification number.

4) MSHA number.

5) Name of entity to whom NOV was written.

6) Name of regulatory authority or agency which issued the NOV.

7) A brief description of the alleged violation.

8) For any administrative or judicial proceedings initiated concerning the violation, provide the following:

a) Type of proceedings.

b) Date of proceedings

c) Location of proceedings.

d) Current status of proceedings.

9) Actions, if any, to abate the alleged violation.

RESPONSE: **Refer to Attachment Part I; Item 6.A. for the 3-year violation history.**

B) For any unabated cessation orders or unabated air and water quality violation notices received prior to the date of submission of the application for any surface coal mining and reclamation operation owned or controlled by the applicant or by any entity which owns or controls the applicant, provide a listing of the unabated cessation orders or violation notices which include the following:

1) Cessation order or notice of violation number or other identifier.

2) Date of CO or NOV issuance.

3) Permit identification number.

4) MSHA number

5) Name of entity to whom CO or NOV was written

6) Name of regulatory authority or agency which issued the CO or NOV.

7) A brief description of the alleged cessation order or violation.

8) For any administrative or judicial proceedings initiated concerning the cessation order or violation, provide the following:

a) Type of proceedings.

b) Date of proceedings

c) Location of proceedings

d) Current status of proceedings.

9) Actions, if any, to abate the alleged cessation order or violation.

RESPONSE: **N/A. There have been no unabated cessation orders or unabated air and water quality violation notices.**

10) Affidavits, Certifications, Insurance Certificate

A) Complete affidavit regarding applicant's legal right to enter and begin surface coal mining and reclamation operations in the permit area and whether that right is the subject of pending litigation. Identify the documents upon which affidavit is based by type and date of execution and identify specific lands to which each document pertains and explain the legal rights claimed by the applicant (Section 1778.15(a)). If the private mineral estate to be mined has been severed from the private surface estate, provide copies of the documents required under Section 1778.15(B)(1)-(3). On the permit map or other designated map show the boundaries of land within the permit area upon which the applicant has the legal right to enter and begin mining activities.

RESPONSE: **Refer to Attachment Part I.10.A**

B) Complete certification for engineering aspects of the application. In addition to the general certification, three specific certifications are included which are applicable only if the box in front of each is marked. The first two cover special permit requirements and should be marked only when they occur for the proposed permit. The third certification covers the Illinois Environmental Protection Agency permit requirements. In most cases, an Illinois registered engineer will be required to certify I.E.P.A. permit requirements. Except a otherwise provided all maps, plans and cross-sections included in the permit application shall be prepared by, or under the direction of, and sealed by a qualified registered professional

engineer licensed under the Illinois Professional Engineering Act, a qualified registered structural engineer licensed under the Illinois Structural Engineering Act or if authorized by state law, a qualified registered professional land surveyor licensed under the Illinois Land Surveyors Act with assistance from experts in related fields.

RESPONSE: Refer to Attachment Part I.10.B

C) A certificate of liability insurance or evidence that the applicant is self-insured is required prior to permit issuance. The certificate may be submitted with the application or when fee and bond are submitted. Minimum insurance coverage required is for bodily injury $300,000 for each occurrence, and $500,000 aggregate and for property damage $300,000 each occurrence, and $500,000 aggregate.

RESPONSE: Refer to Attachment Part I.10.C

11) Provide a draft copy of proposed newspaper notice, and the name of local newspaper of general circulation in which advertisement of the application will be published. Certificate of publication is to be submitted not later than four weeks after the last date of publication.

RESPONSE: Refer to Attachment Part I.11

12) Areas Designated Unsuitable for Mining

A) Does proposed permit area include and/or shadow area include --

Areas designated unsuitable for surface coal mining and reclamation operations, or under study for designation in an administrative proceeding as unsuitable for surface coal mining and reclamation operations? (Sections 1762 and 1764)

Yes _____ No __X__

B) Does proposed permit area include and/or shadow area include --

1) Lands within boundaries of the National Park System, National Wildlife Refuge System, the National System of Trails, the National Wilderness Preservation System, the Wild and Scenic Rivers System, and National Recreation Areas, etc. (Section 1761.11(a))?

Yes _____ No __X__

2) National Forest land?
Yes _____ No __X__

3) Any land which will adversely affect any publicly-owned park or places included in the National Register of Historic Places, etc. (per Sections 1761.11(c))?

Yes _____ No __X__

If yes, complete Part II, Section 10, B) and C).

4) Any public roads, which are to be removed, relocated or temporarily closed?

Yes _____ No __X__

Indicate on the pre-mining land use map or other designated map the location of the public roads and attach a copy of the written agreement from the appropriate authority authorizing the

relocation, removal or temporary closure. Describe the measures to be used to insure that the interest of the public and land owners affected will be protected.

RESPONSE: **The locations of the crossings are shown on the Hydrology - Mining Operations Map (Drawing No. B17-222-M13 through M16). Indicated on this map are proposed locations where the waterline will be bored under the roads. Prior to any construction for boring beneath State Route 37 and Interstate 57, valid IDOT permits will be renewed and copies will be submitted to the Department. Installation and construction activities will be within 100 feet of public roads, but will be completed over a short period of time. Beginning and ending boring operations will be conducted outside of the public road right of way. Once completed, there will be no further construction activities. During construction/ installation activities, no equipment will be allowed to endanger the public or the landowner. Traffic control signage will be used when work is in progress, as needed.**

C) Within the proposed permit area will Surface Coal Mining and Reclamation operations be located --

1) Within 100 feet of the right-of-way line of any public road?

Yes ___X___ No _____

If yes, explain proposed procedures for complying with regulation Section 1761.14(b), including request for variance, if relevant. Provide location of public roads on pre-mining land use map or other designated map. Describe the measures to be used to insure that the interest of the public and land owners affected will be protected.

RESPONSE: **Disturbance for the installation of the Water Management Pipeline is proposed within 100 feet of several public roads as shown on the Hydrology - Mining Operations Map (Drawing No's B17-222-M13 and B17-222-M16). Disturbance within 100 feet of the right of way of all public roads will be associated with the boring under each road for the installation of the proposed waterline. A variance of Section 1761.14(b) is requested for being within 100 feet of a public road right of way. Construction activities will be within 100 feet of the road right of way, however, beginning and ending boring operations will be conducted outside of the public road right of way. Installation and construction activities will be completed over a short period of time. Once completed, there will be no further construction activities. During construction and installation activities, no equipment will be allowed to endanger the public or the landowner. Traffic control signage will be used when work is in progress, as needed.**

The public notice will provide for a public hearing in accordance with Section 1761.14. Refer to Attachment I.11 for the public notice.

2) Within 300 feet measured horizontally from any occupied dwelling?
Yes ___X___ No _____

If so, is waiver provided meeting requirements of Section 1761.15(d)?

RESPONSE: **The proposed permit boundary will be within 300 feet of occupied dwellings. The 300 foot buffer zones are shown on the Hydrology - Mining Operations Map (Drawing No. B17-222-M13 through M16). Refer to Attachment I.12.C.2 for a list of the waivers.**

3) Within 300 feet measured horizontally of any public building, school, church, community or institutional building or public park?
Yes _____ No ___X_____

4) Within 100 feet measured horizontally of a cemetery?
Yes _____ No ___X_____

D) Are valid existing rights claimed for any part of the permit area?
Yes _____ No _____X_____

If yes, provide documentation to substantiate claim.

PART I ATTACHMENT I.2.A
SURFACE OWNERSHIP

WILLIAMSON ENERGY, LLC - WATER MANAGEMENT FACILITY
ATTACHMENT I.2.A - SURFACE LAND OWNER INFORMATION

PIN (MAP #)	SURFACE OWNER	MAILING ADDRESS	CITY	STATE	ZIP CODE	RIGHT OF ENTRY DOCUMENT	DATE EXECUTED	ACRES
03-11-400-008	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	1.4
03-11-400-007	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	0.8
03-14-200-006	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	0.9
03-14-100-005	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	1.5
03-14-100-001	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	1.5
03-15-200-001	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	3.2
03-15-100-001	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	3.1
03-16-200-007	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	0.4
03-09-400-006	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	1.1
03-09-400-004	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	1.4
03-09-300-015	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	1.4
03-09-300-013	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	1.1
03-16-100-011	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	0.4
03-17-200-023	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	3.2
03-17-100-016	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	0.9
03-08-327-003	COBB, JACK L & SHIRLEY	16699 OLD FRANKFORT ROAD	JOHNSTON CITY	IL	62951	EASEMENT	01/13/2017	0.4
03-08-327-004	COBB, JACK L	16699 OLD FRANKFORT ROAD	JOHNSTON CITY	IL	62951	EASEMENT	01/13/2017	0.4
03-08-326-009	COBB, JACK L	16699 OLD FRANKFORT ROAD	JOHNSTON CITY	IL	62951	EASEMENT	01/13/2017	0.8
03-08-300-022	COBB, JACKIE L & SHIRLEY J	16699 OLD FRANKFORT ROAD	JOHNSTON CITY	IL	62951	EASEMENT	01/13/2017	0.1
03-08-300-008	BISHOP, BENJAMIN T II & BROWN, L. B	13801 GERMAN CHURCH ROAD	WEST FRANKFORT	IL	62896	EASEMENT	02/07/2017	0.2
03-08-300-024	RICHARD, WINIFRED J ETAL	13715 GERMAN CHURCH ROAD	WEST FRANKFORT	IL	62896	EASEMENT	01/13/2017	0.6
03-08-300-003	RICHARD, WINIFRED J ETAL	13715 GERMAN CHURCH ROAD	WEST FRANKFORT	IL	62896	EASEMENT	01/13/2017	0.4
03-08-300-035	GRANT, LINDELL D JR & PAMELA	13503 GERMAN CHURCH ROAD	WEST FRANKFORT	IL	62896	EASEMENT	01/17/2017	0.4
03-07-400-026	GRANT, LINDELL D JR & PAMELA	13503 GERMAN CHURCH ROAD	WEST FRANKFORT	IL	62896	EASEMENT	01/17/2017	0.8
03-07-400-027	TROUT REVOCABLE TRUSTS	302 INDIAN DR.	JOHNSTON CITY	IL	62951	SURFACE USE AGREEMENT	11/14/2016	2.4
03-07-326-006	BYERS, FLOSSIE & PAYNE, LEAH	16783 DUNCAN ROAD	JOHNSTON CITY	IL	62951	EASEMENT	11/28/2016	0.1
03-07-500-004	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	0.2
03-07-326-011	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	1.3

NOTE: Railroad construction permits will be executed 30 days prior to construtions.

WILLIAMSON ENERGY, LLC - WATER MANAGEMENT FACILITY
ATTACHMENT I.2.A - SURFACE LAND OWNER INFORMATION

PIN (MAP #)	SURFACE OWNER	MAILING ADDRESS	CITY	STATE	ZIP CODE	RIGHT OF ENTRY DOCUMENT	DATE EXECUTED	ACRES
03-07-100-010	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	1.4
03-07-100-011	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410	EASEMENT	01/17/2017	0.2
03-07-505-002	UNION PACIFIC RAILROAD	1400 DOUGLAS ST.	OMAHA	NE	68179	EASEMENT	see note	0.1
02-12-505-001	UNION PACIFIC RAILROAD	1400 DOUGLAS ST.	OMAHA	NE	68179	EASEMENT	see note	0.1
02-12-200-038	HIGHWAY 37 NORTH WATER DIST.	PO BOX 268	JOHNSTON CITY	IL	62951	EASEMENT	03/08/2017	0.6
02-12-200-032	THREE ANGELS BROADCASTING, INC.	PO BOX 220	WEST FRANKFORT	IL	62896	EASEMENT	01/26/2017	1.1
02-12-200-027	DUNSTON, JAMES R TRUST 1/2 INT DUNSTON, JUDITH LYNN TRUST 1/2 INT	106 E OAK STREET	WEST FRANKFORT	IL	62896	EASEMENT	01/23/2017	1.3
02-01-300-009	DUNSTON, JAMES R TRUST 1/2 INT DUNSTON, JUDITH LYNN TRUST 1/2 INT	106 E OAK STREET	WEST FRANKFORT	IL	62896	EASEMENT	01/23/2017	2.9
02-01-300-002	DUNSTON, JAMES R TRUST 1/2 INT DUNSTON, JUDITH LYNN TRUST 1/2 INT	106 E OAK STREET	WEST FRANKFORT	IL	62896	EASEMENT	11/17/2016	0.3
02-01-300-011	LIVINGSTON, STEVE C	18094 COLLINS RD	WEST FRANKFORT	IL	62896	EASEMENT	01/09/2017	1.2
02-02-200-006	GRIZZELL, DALLAS D., MILDRED	18097 COLLINS RD	WEST FRANKFORT	IL	62896	EASEMENT	01/12/2017	4.8
11-35-300-002	SCHRODER, HOWARD	PO BOX 393	HERRIN	IL	62948	EASEMENT	02/03/2017	3.5
11-34-400-011 (was 11-34-400-007)	MCDANIEL, KEVIN & COLLEEN	112 FOX CREEK RD	BELLEVILLE	IL	62223	EASEMENT	02/03/2017	2.0
11-34-200-010	PARKER, CLYDE A	10579 HORSESHOE ROAD	WEST FRANKFORT	IL	62896	EASEMENT	07/20/2016	2.1
11-34-100-009	JACKANICZ, ANDREW	2391 JACKANICZ ROAD	WEST FRANKFORT	IL	62896	EASEMENT	06/14/2017	1.5
11-27-300-011	JACKANICZ, ANDREW & MARY JANE	2391 JACKANICZ ROAD	WEST FRANKFORT	IL	62896	EASEMENT	06/14/2017	0.4
11-27-300-002	JACKANICZ FAMILY TRUST	2257 JACKANICZ ROAD	WEST FRANKFORT	IL	62896	EASEMENT	06/14/2017	1.5
11-28-400-008	JACKANICZ FAMILY TRUST	2257 JACKANICZ ROAD	WEST FRANKFORT	IL	62896	EASEMENT	06/14/2017	0.8
11-28-501-002	BNSF RAILWAY COMPANY	2650 LOU MENK DRIVE	FORT WORTH	TX	76131	EASEMENT	see note	0.1
11-28-400-007	JACKANICZ, CHARLEY W	8715 ST HWY 149	WEST FRANKFORT	IL	62896	EASEMENT	10/17/2016	0.1
11-33-200-001	JACKANICZ, CHARLEY W	8715 ST HWY 149	WEST FRANKFORT	IL	62896	EASEMENT	10/17/2016	2.2
11-33-100-012	JACKANICZ, CHARLEY W	8715 ST HWY 149	WEST FRANKFORT	IL	62896	EASEMENT	10/17/2016	0.2
11-33-100-013	FITCH, LARRY & LINDA	7029 LAKE CREEK ROAD	WEST FRANKFORT	IL	62896	EASEMENT	06/07/2016	1.4
11-33-100-009	HUMERICKHOUSE, CYNTHIA & MICHAEL	953 SANDBURG ROAD	WEST FRANKFORT	IL	62896	EASEMENT	06/10/2016	0.8
11-33-100-001	MITCHELL, BRADLEY & RAINEE	511 SANDBURG ROAD	WEST FRANKFORT	IL	62896	EASEMENT	05/18/2016	0.8

NOTE: Railroad construction permits will be executed 30 days prior to construtions.

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WILLIAMSON ENERGY, LLC - WATER MANAGEMENT FACILITY
ATTACHMENT I.2.A - SURFACE LAND OWNER INFORMATION

PIN (MAP #)	SURFACE OWNER	MAILING ADDRESS	CITY	STATE	ZIP CODE	RIGHT OF ENTRY DOCUMENT	DATE EXECUTED	ACRES
11-32-200-011 (was 11-32-200-009)	RIDGEWAY, LINDA	701 W. CRAFT	ROBINSON	IL	62454	EASEMENT	05/24/2016	1.1
11-32-200-012 (was 11-32-200-009)	KYLE MARTIN & STACEY MICHELLE FODOR	306 CANDY CANE LANE	WEST FRANKFORT	IL	62896	EASEMENT	05/24/2016	0.4
11-32-200-001	GAYER, BILL T.	7802 PARRISH CIRCLE	WEST FRANKFORT	IL	62896	EASEMENT	07/11/2016	0.9
11-32-100-009	RICH, MAHLON L. & SANDRA	7550 LAKE CREEK ROAD	WEST FRANKFORT	IL	62896	EASEMENT	05/18/2016	0.3
11-29-300-007	LASWELL, JOSEPH, L.	7635 LAKE CREEK ROAD	WEST FRANKFORT	IL	62896	EASEMENT	08/29/2016	0.6
11-29-300-003	FITCH, WARREN D.	7357 LAKE CREEK ROAD	WEST FRANKFORT	IL	62896	EASEMENT	06/07/2016	0.3
11-29-300-009	FITCH, WARREN D. & PEGGY	7357 LAKE CREEK ROAD	WEST FRANKFORT	IL	62896	EASEMENT	06/07/2016	0.1
11-32-100-003	FITCH, JAMES	7232 LAKE CREEK RD	WEST FRANKFORT	IL	62896	SURFACE WAIVER & CONSENT	08/16/2016	0.01
11-32-100-001	CHEATHAM, WILLIE R.	7149 LAKE CREEK ROAD	WEST FRANKFORT	IL	62896	EASEMENT	06/07/2016	0.4
11-31-200-002	JACKANICZ FAMILY TRUST	2257 JACKANICZ ROAD	WEST FRANKFORT	IL	62896	EASEMENT	06/14/2017	0.8
11-31-200-001	JACKANICZ FAMILY TRUST	2257 JACKANICZ ROAD	WEST FRANKFORT	IL	62896	SURFACE USE AGREEMENT	06/14/2017	4.0

TOTAL ACRES 70.7

NOTE: Railroad construction permits will be executed 30 days prior to construtions.

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PART I ATTACHMENT I.2.B
CONTIGUOUS OWNERS

WILLIAMSON ENERGY, LLC - WATER MANAGEMENT FACILITY
ATTACHMENT I.2.B - CONTIGUOUS SURFACE LAND OWNER INFORMATION

PIN (MAP #)	SURFACE OWNER	MAILING ADDRESS	CITY	STATE	ZIP CODE
03-12-300-004	WILLIAMSON ENERGY, LLC	PO BOX 99	JOHNSTON CITY	IL	62951
03-11-400-011	ANDERSON, PHILIP S & KAREN TRS	16234 WILLIAMS PRAIRIE RD.	JOHNSTON CITY	IL	62951
03-14-200-002	ANDERSON, CARL L & MERILEE TRS	302 CIRCLE DR	SALEM	IL	62881
03-11-400-005	ANDERSON, CARL L & MERILEE TRS	302 CIRCLE DR	SALEM	IL	62881
03-14-200-001	ANDERSON, CARL L & MERILEE TRS	302 CIRCLE DR	SALEM	IL	62881
03-11-300-006	ANDERSON, CARL L & MERILEE TRS	302 CIRCLE DR	SALEM	IL	62881
03-14-100-002	ANDERSON, PHILIP S & KAREN TRS	16234 WILLIAMS PRAIRIE RD.	JOHNSTON CITY	IL	62951
03-14-100-003	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410
03-10-400-001	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410
03-15-200-002	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410
03-10-400-002	ANDERSON, CARL L & MERILEE TRS	302 CIRCLE DR	SALEM	IL	62881
03-10-300-004	ANDERSON, CARL L & MERILEE TRS	302 CIRCLE DR	SALEM	IL	62881
03-15-100-002	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410
03-09-400-008	MID-CONTINENTAL FUELS, INC.	16070 MID-CONTINENTAL FUELS RD	JOHNSTON CITY	IL	62951
03-09-400-009	FLEENER, JOHN K & SARAH J	P. O. BOX 102	JOHNSTON CITY	IL	62951
03-16-200-010	FLEENER, JOHN K & SARAH J	P. O. BOX 102	JOHNSTON CITY	IL	62951
03-09-400-001	RAINEY, DONALD M TRUSTEE	15247 GERMAN CHURCH ROAD	JOHNSTON CITY	IL	62951
03-09-400-005	MID-CONTINENTAL FUELS, INC.	16070 MID-CONTINENTAL FUELS RD	JOHNSTON CITY	IL	62951
03-09-300-016	MID-CONTINENTAL FUELS, INC.	16070 MID-CONTINENTAL FUELS RD	JOHNSTON CITY	IL	62951
03-16-100-002	MID-CONTINENTAL FUELS, INC.	16070 MID-CONTINENTAL FUELS RD	JOHNSTON CITY	IL	62951
03-16-100-010	MID-CONTINENTAL FUELS, INC.	16070 MID-CONTINENTAL FUELS RD	JOHNSTON CITY	IL	62951
03-09-300-014	MID-CONTINENTAL FUELS, INC.	16070 MID-CONTINENTAL FUELS RD	JOHNSTON CITY	IL	62951
03-08-400-008	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410
03-17-200-010	MID-CONTINENTAL FUELS, INC.	16070 MID-CONTINENTAL FUELS RD	JOHNSTON CITY	IL	62951
03-17-200-028	MID-CONTINENTAL FUELS, INC.	16070 MID-CONTINENTAL FUELS RD	JOHNSTON CITY	IL	62951
03-17-100-020	DAVIX, WILLIAM D & JULIE L SHAW, WILLIAM TYLER	312 S. ODLE STREET	WEST FRANKFORT	IL	62896
03-08-400-009	BARWICK, DEAN E	635 E CRISAFULLI RD	MERRITT ISLAND	FL	32953
03-17-200-030	MID-CONTINENTAL FUELS, INC.	16070 MID-CONTINENTAL FUELS RD	JOHNSTON CITY	IL	62951
03-08-400-006	BARWICK, MARK A.	16545 OLD BEN ROAD	JOHNSTON CITY	IL	62951
03-08-328-003	BLADES, SHIRLEY A	16442 OLD FRANKFORT RD	JOHNSTON CITY	IL	62951
03-17-100-016	NEW RIVER ROYALTY, LLC	3801 PGA BLVD., SUITE 903	PALM BEACH GARDENS	FL	33410
03-08-326-004	LAYNE, STEVEN L & RHONDA S	13872 EBERHARDT RD	JOHNSTON CITY	IL	62951

WILLIAMSON ENERGY, LLC - WATER MANAGEMENT FACILITY
ATTACHMENT I.2.B - CONTIGUOUS SURFACE LAND OWNER INFORMATION

PIN (MAP #)	SURFACE OWNER	MAILING ADDRESS	CITY	STATE	ZIP CODE
03-08-300-029	EBERHARDT, EARL RAY & MERLINA	13193 EBERHARDT RD	JOHNSTON CITY	IL	62951
03-07-400-023	EBERHARDT, EARL RAY & MERLINA	13193 EBERHARDT RD	JOHNSTON CITY	IL	62951
03-07-401-003	TROUT REVOCABLE TRUSTS	302 INDIAN DR.	JOHNSTON CITY	IL	62951
03-07-326-013	DAVIS, CHRISTOPHER & DARLA	16746 MONROE ROAD	WEST FRANKFORT	IL	62896
03-07-326-012	ELLIS, DONNA LYNN	12933 GERMAN CHURCH ROAD	JOHNSTON CITY	IL	62951
03-07-326-002	BALL, PAULA JEAN	16830 MONROE RD	WEST FRANKFORT	IL	62896
03-07-326-003	RICHISON, RONALD	16786 MONROE ROAD	WEST FRANKFORT	IL	62896
03-07-300-022	MARRS, PATSY ETAL	16875 MONROE RD	WEST FRANKFORT	IL	62896
03-07-300-023	MARRS, RYAN D & CELESTIA N	16843 MONROE ROAD	JOHNSTON CITY	IL	62951
03-07-100-003	MARGELLI, ALBERT C	17317 MONROE RD	JOHNSTON CITY	IL	62951
02-12-200-046	REDEMPTION CHURCH JOHNSTON CITY	17466 NORTH RT 37	JOHNSTON CITY	IL	62951
02-12-200-044	SULLIVAN, ROSS W	14263 FOWLER SCHOOL ROAD	MARION	IL	62959
02-12-200-031	THREE ANGELS BROADCASTING, INC.	PO BOX 220	WEST FRANKFORT	IL	62896
02-12-200-009	KEYROCK ENERGY LLC	207 E. MAIN STREET	JOHNSON CITY	TN	37605
02-12-200-011	MEUTH, STEVEN E & JANE ANN	17026 ROUTE 37	JOHNSTON CITY	IL	62951
02-12-200-008	MENCKOWSKI, RICKY F & SAYLOR, BRITTANI A	17060 ROUTE 37	JOHNSTON CITY	IL	62951
02-12-200-007	WIEGAND, ERIC & KATHERINE	1613 E ST LOUIS ST	WEST FRANKFORT	IL	62896
02-12-200-005	MC VEY, TERRY L	17529 RT 37 NORTH	JOHNSTON CITY	IL	62951
02-12-200-004	MC VEY, TERRY L	17529 RT 37 NORTH	JOHNSTON CITY	IL	62951
02-12-200-037	MENCKOWSKI, RICKY F & SAYLOR, BRITTANI A	17060 ROUTE 37	JOHNSTON CITY	IL	62951
02-12-200-034	CROWN BATTERY MANUF. COMPANY	1445 MAJESTIC DR.	FREMONT	OH	43420
02-12-200-033	KEMP, CHARLES & BEULAH TRS	11972 STIRITZ RD	WEST FRANKFORT	IL	62896
02-12-200-002	MURPHY, JUDITH ANN	STATE ROUTE 37	JOHNSTON CITY	IL	62951
02-12-200-035	KEMP, CHARLES & BEULAH TRS	11972 STIRITZ RD	WEST FRANKFORT	IL	62896
02-01-300-013	KEYROCK ENERGY LLC	207 E. MAIN STREET	JOHNSON CITY	TN	37605
02-01-400-029	BUNDY, PATRICK & ALLEGRA	17445 ROUTE 37	JOHNSTON CITY	IL	62951
02-01-400-032	WOODHALL, DEBBIE & ETAL	17375 ROUTE 37	JOHNSTON CITY	IL	62951
02-01-300-012	KEMP, CHARLES & BEULAH TRS	11972 STIRITZ RD	WEST FRANKFORT	IL	62896
02-01-300-001	RICHMOND, KENNETH	613 S. LOCUST	WEST FRANKFORT	IL	62896
02-01-300-006	LIVINGSTON, STEVE C	18094 COLLINS RD	WEST FRANKFORT	IL	62896
02-01-100-004	ABBA, ANGELO TONY & ET AL	14165 ALLEN RD.	CARTERVILLE	IL	62918
02-02-400-002	JOHNSON, PAUL & MELISSA J	14936 GERMAN CHURCH RD.	JOHNSTON CITY	IL	62951
02-02-200-005	GRIZZELL, GARY G & ALFREDA L	3390 STATE RT 13 & 127	PICKNEYVILLE	IL	62274

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WILLIAMSON ENERGY, LLC - WATER MANAGEMENT FACILITY
ATTACHMENT I.2.B - CONTIGUOUS SURFACE LAND OWNER INFORMATION

PIN (MAP #)	SURFACE OWNER	MAILING ADDRESS	CITY	STATE	ZIP CODE
02-02-200-004	GRIZZELL, DALLAS DEAN & MILDRED	18097 COLLINS RD	WEST FRANKFORT	IL	62896
02-02-100-002	GRIZZELL, DALLAS DEAN & MILDRED	18097 COLLINS RD	WEST FRANKFORT	IL	62896
02-02-100-003	JAJ LTD PARTNERSHIP & BASS VENTURES, LLC	5885 N. STATE RT 159	EDWARDSVILLE	IL	62025
11-35-300-003	SCHRODER, HOWARD	PO BOX 393	HERRIN	IL	62948
11-35-300-007	SCHWARTZ, WILLIAM	7030 N STATE RT 159	MORO	IL	62067
11-35-300-005	BASS VENTURES LLC	5885 N. STATE RT 159	EDWARDSVILLE	IL	62025
11-35-300-006	BASS VENTURES LLC	5885 N. STATE RT 159	EDWARDSVILLE	IL	62025
	JAJ LIMITED PARTNERSHIP	7030 N STATE RT 159	MORO	IL	62067
11-35-300-008	KEYROCK ENERGY LLC	207 E. MAIN STREET	JOHNSON CITY	TN	37605
11-34-400-002	SCHRODER, HOWARD	PO BOX 393	HERRIN	IL	62948
11-34-200-008	GLODICH, MIKE	209 W MAIN	WEST FRANKFORT	IL	62896
11-34-200-006	HAMPTON, SUZANNE	10477 HORSESHOE RD	WEST FRANKFORT	IL	62896
11-34-200-005	PARKER, CLYDE A	10579 HORSESHOE ROAD	WEST FRANKFORT	IL	62896
11-34-200-002	BARTONI, CHARLES	9806 FREEMAN SPUR BLKTOP	WEST FRANKFORT	IL	62896
11-34-100-011	RIDINGS, ROBERT	2055 STATE HWY 14	MULKEYTOWN	IL	62865
11-34-100-001	JACKANICZ FAMILY TRUST	2257 JACKANICZ ROAD	WEST FRANKFORT	IL	62896
11-33-200-002	JACKANICZ FAMILY TRUST	2257 JACKANICZ ROAD	WEST FRANKFORT	IL	62896
11-28-400-003	JACKANICZ, CHARLEY W	8715 ST HWY 149	WEST FRANKFORT	IL	62896
11-28-300-002	JACKANICZ, CHARLEY W	8715 ST HWY 149	WEST FRANKFORT	IL	62896
11-28-300-021	FITCH, LARRY & LINDA	7029 LAKE CREEK ROAD	WEST FRANKFORT	IL	62896
11-28-300-014	SABRE INVESTMENTS LLC	PO BOX 3074	CARBONDALE	IL	62902
11-29-400-012	TACKETT, VERLIN	PO BOX 1809	MARION	IL	62959
11-29-400-004	SURGALSKI, VIRGINIA	PO BOX 103	FREEMAN SPUR	IL	62841
11-29-400-005	SURGALSKI, KENDRA	7727 LAKE CREEK RD	WEST FRANKFORT	IL	62896
11-32-100-008	COLYER, PEARL	7528 LAKE CREEK RD	WEST FRANKFORT	IL	62896
11-32-100-007	CLARK, KENNETH	7434 LAKE CREEK RD	WEST FRANKFORT	IL	62896
11-32-100-006	CLARK, KENNETH	7434 LAKE CREEK RD	WEST FRANKFORT	IL	62896
11-32-100-005	CLARK, KENNETH	7434 LAKE CREEK RD	WEST FRANKFORT	IL	62896
11-32-100-004	SUMMERS, KEVIN	7414 LAKE CREEK RD	WEST FRANKFORT	IL	62896
11-32-100-003	FITCH, JAMES	7322 LAKE CREEK RD	WEST FRANKFORT	IL	62896
11-29-300-014	SMITH, JOSHUA	7145 LAKE CREEK RD	WEST FRANKFORT	IL	62896
11-30-400-004	BEARDEN, BRIAN	7059 LAKE CREEK RD	WEST FRANKFORT	IL	62896
11-30-400-006	FITCH, LINDELL	6931 LAKE CREEK RD	WEST FRANKFORT	IL	62896
11-31-100-001	KIRCHNER FARMS LLC	1411 SWITCH BACK RD	MULKEYTOWN	IL	62865
11-30-300-001	KIRCHNER FARMS LLC	1411 SWITCH BACK RD	MULKEYTOWN	IL	62865
11-30-400-001	KIRCHNER FARMS LLC	1411 SWITCH BACK RD	MULKEYTOWN	IL	62865

PART I ATTACHMENT I.6. ADDRESSES THE FOLLOWING:

PART I ATTACHMENT I.6.A & B
OWNERSHIP & CONTROL INFORMATION,

PART I ATTACHMENT I.7
OWNED OR CONTROLLED MINING OPERATIONS,

AND

PART I ATTACHMENT I.9.A
VIOLATION HISTORY

TABLE 1.4.1 - Williamson Energy, LLC
Owners and Controllers of the Applicant

Name	Address	SSN (voluntary)/EIN	Ownership or Control Relationship to the Applicant/ Position- Title	Ownership Percentage	Location in Organizational Structure	Date Position Assumed	Termination Date
Foresight Energy LLC	211 N. Broadway, Suite 2600, St. Louis, MO 63102	27-3135321	Member	100%	-	8/12/2010	-
Robert D. Moore	46226 National Road, St. Clairsville, Ohio 43950	-	Chief Executive Officer	-	-	5/31/2015	-
Robert D. Moore	46226 National Road, St. Clairsville, Ohio 43950	-	President	-	-	5/31/2015	-
Rashda M. Buttar	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Senior Vice President	-	-	9/12/2011	7/23/2017
Rashda M. Buttar	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	General Counsel	-	-	9/12/2011	7/23/2017
Rashda M. Buttar	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Secretary	-	-	9/12/2011	7/23/2017
James T. Murphy	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Vice President	-	-	9/1/2015	9/30/2017
Cody E. Nett	46226 National Road, St. Clairsville, Ohio 43950	-	Corporate Secretary	-	-	7/21/2017	-
Jeremy J. Harrison	46226 National Road, St. Clairsville, Ohio 43950	-	Chief Accounting Officer	-	-	9/30/2017	-
Jeremy J. Harrison	46226 National Road, St. Clairsville, Ohio 43950	-	Principal Accounting Officer	-	-	9/30/2017	-

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TABLE 1.4.1 - Foresight Energy, LLC
Owners and Controllers of the Applicant

Name	Address	SSN (voluntary)/EIN	Ownership or Control Relationship to the Applicant/ Position- Title	Ownership Percentage	Location in Organizational Structure	Date Position Assumed	Termination Date
Foresight Energy LP	211 N. Broadway, Suite 2600, St. Louis, MO 63102	80-0778894	Member	100%	-	6/10/2014	-
Robert D. Moore	46226 National Road, St. Clairsville, Ohio 43950	-	Chief Executive Officer	-	-	5/31/2015	-
Robert D. Moore	46226 National Road, St. Clairsville, Ohio 43950	-	President	-	-	5/31/2015	-
Rashda M. Buttar	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Senior Vice President	-	-	10/31/2012	7/23/2017
Rashda M. Buttar	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	General Counsel	-	-	9/12/2011	7/23/2017
Rashda M. Buttar	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Secretary	-	-	10/31/2012	7/23/2017
Cody E. Nett	46226 National Road, St. Clairsville, Ohio 43950	-	Corporate Secretary	-	-	7/21/2017	-
Jeremy J. Harrison	46226 National Road, St. Clairsville, Ohio 43950	-	Chief Accounting Officer	-	-	9/30/2017	-
Jeremy J. Harrison	46226 National Road, St. Clairsville, Ohio 43950	-	Principal Accounting Officer	-	-	9/30/2017	-

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TABLE 1.4.1 - Foresight Energy, LP
Owners and Controllers of the Applicant

Name	Address	SSN (voluntary)/EIN	Ownership or Control Relationship to the Applicant/ Position- Title	Ownership Percentage	Location in Organizational Structure	Date Position Assumed	Termination Date
Murray Energy Corporation	46226 National Road, St. Clairsville, Ohio 43950	31-1956752	Shareholder	53%	-	3/28/2017	-
Foresight Energy GP LLC	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	General Partner	-	-	-	-
Robert D. Moore	46226 National Road, St. Clairsville, Ohio 43950	-	Chief Executive Officer	-	-	5/31/2015	-
Robert D. Moore	46226 National Road, St. Clairsville, Ohio 43950	-	President	-	-	5/31/2015	-
Rashda M. Buttar	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Senior Vice President	-	-	11/5/2015	7/23/2017
Rashda M. Buttar	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	General Counsel	-	-	11/5/2015	7/23/2017
Rashda M. Buttar	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Secretary	-	-	11/5/2015	7/23/2017
Jeremy J. Harrison	46226 National Road, St. Clairsville, Ohio 43950	-	Chief Accounting Officer			9/30/2017	-
Jeremy J. Harrison	46226 National Road, St. Clairsville, Ohio 43950	-	Principal Accounting Officer	-	-	9/30/2017	-
Cody Nett	46226 National Road, St. Clairsville, Ohio 43950	-	Corporate Secretary			7/21/2017	-
John F Dickinson	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Director	-	-		12/31/2015
E Hunter Harrison	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Director	-	-		9/10/2015
E Bartow Jones	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Director	-	-		1/30/2015
Chris Cline	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Chairman of the Board	-	-		3/28/2017
Chris Cline	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Corporate Officer	-	-		3/28/2017

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TABLE 1.4.1 - Foresight Energy GP, LLC
Owners and Controllers of the Applicant

Name	Address	SSN (voluntary)/EIN	Ownership or Control Relationship to the Applicant/ Position- Title	Ownership Percentage	Location in Organizational Structure	Date Position Assumed	Termination Date
Murray Energy Corporation	46226 National Road, St Clairsville, Ohio 43950	31-1956752	Shareholder	80%	-	4/16/2015	-
Foresight Reserves LP	211 N. Broadway, Suite 2600, St Louis, MO 63102		Shareholder	20%	-	4/16/2015	-
Robert D Moore	46226 National Road, St. Clairsville, Ohio 43950	-	Director	-	-	5/31/2015	-
Robert D Moore	46226 National Road, St. Clairsville, Ohio 43950	-	Chief Executive Officer	-	-	5/31/2015	-
Robert D Moore	46226 National Road, St Clairsville, Ohio 43950	-	President	-	-	5/31/2015	-
Robert D Moore	46226 National Road, St. Clairsville, Ohio 43950	-	Chairman	-	-	3/28/2017	-
Daniel Hermann	211 N Broadway, Suite 2600, St Louis, MO 63102	-	Director	-	-	9/15/2014	-
Paul Vining	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Director	-	-	1/1/2016	-
Brian Sullivan	211 N Broadway, Suite 2600, St Louis, MO 63102	-	Director	-	-	8/10/2016	-
Rashad Buttar	211 N. Broadway, Suite 2600, St. Louis, MO 63102	-	Senior Vice President	-	-	6/17/2014	7/23/2017
Rashad Buttar	211 N Broadway, Suite 2600, St. Louis, MO 63102	-	General Counsel	-	-	6/17/2014	7/23/2017
Rashad Buttar	211 N Broadway, Suite 2600, St. Louis, MO 63102	-	Secretary	-	-	6/17/2014	7/23/2017
G Casey	211 N Broadway, Suite 2600, St. Louis, MO 63102	-	Director	-	-	9/10/2015	-
James Murphy	211 N Broadway, Suite 2600, St. Louis, MO 63102	-	Corporate Officer	-	-	6/10/2015	9/30/2017
Robert Edward Murray	46226 National Road, St Clairsville, Ohio 43950	-	Director	-	-	3/28/2017	-
Cody E Nett	46226 National Road, St Clairsville, Ohio 43950	-	Corporate Secretary	-	-	7/21/2017	-
Jeremy J Harrison	46226 National Road, St Clairsville, Ohio 43950	-	Chief Accounting Officer	-	-	9/30/2017	-
Jeremy J Harrison	46226 National Road, St Clairsville, Ohio 43950	-	Principal Financial Officer	-	-	9/30/2017	-

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TABLE 1.4.1 - Murray Energy Corporation
Owners and Controllers of the Applicant

Name	Address	SSN (voluntary)/EIN	Ownership or Control Relationship to the Applicant/ Position- Title	Ownership Percentage	Location in Organizational Structure	Date Position Assumed	Termination Date
Murray Energy Holdings Company	46226 National Road, St Clairsville, Ohio 43950	20-0100463	Owner	100%	-	10/21/2003	-
Robert Eugene Murray	46226 National Road, St Clairsville, Ohio 43950	-	Director	-	-	2/23/2001	-
Henry W. Fayne	46226 National Road, St. Clairsville, Ohio 43950	-	Director	-	-	1/28/2005	-
Robert D Moore	46226 National Road, St. Clairsville, Ohio 43950	-	Director	-	-	4/23/2007	-
Richard L. Lawson	46226 National Road, St Clairsville, Ohio 43950	-	Director	-	-	1/28/2005	-
Robert Eugene Murray	46226 National Road, St Clairsville, Ohio 43950	-	Chief Executive Officer	-	-	2/23/2001	-
Robert D. Moore	46226 National Road, St. Clairsville, Ohio 43950	-	Executive V.P	-	-	8/15/2012	-
Robert D. Moore	46226 National Road, St. Clairsville, Ohio 43950	-	Chief Financial Officer	-	-	8/15/2012	-
Robert Eugene Murray	46226 National Road, St Clairsville, Ohio 43950	-	Chairman of the Board	-	-	2/23/2001	-
Robert Eugene Murray	46226 National Road, St Clairsville, Ohio 43950	-	President	-	-	2/23/2001	-
Michael O McKown	46226 National Road, St. Clairsville, Ohio 43950	-	Secretary	-	-	2/24/2001	-
Michael D Loiacono	46226 National Road, St. Clairsville, Ohio 43950	-	Treasurer	-	-	2/23/2001	-
B J Cornelius	46226 National Road, St Clairsville, Ohio 43950	-	Sr VP – Marketing & Sales	-	-	8/15/2012	-
Roy A Heidelbach	46226 National Road, St Clairsville, Ohio 43950	-	Asst Vice President-Operations	-	-	9/11/2007	-
Ryan Michael Murray	46226 National Road, St. Clairsville, Ohio 43950	-	Vice President-Operateions	-	-	9/11/2007	-
Michael O Mckown	46226 National Road, St. Clairsville, Ohio 43950	-	Senior VP – Law & Admin	-	-	8/15/2012	-
Robert D. Moore	46226 National Road, St. Clairsville, Ohio 43950	-	Chief Operating Officer	-	-	8/15/2012	-
Michael T.W Carey	46226 National Road, St. Clairsville, Ohio 43950	-	VP – Govt Relations	-	-	6/1/2012	-
Robert Edward Murray	46226 National Road, St. Clairsville, Ohio 43950	-	Executive VP - Marketing and Sales	-	-	1/30/2015	-
Jason D. Witt	46226 National Road, St. Clairsville, Ohio 43950	-	Assistant Secretary	-	-	4/30/2013	-
Paul B Piccolini	46226 National Road, St. Clairsville, Ohio 43950	-	VP - H.R. & Employee Relations	-	-	1/4/2014	-
Anthony C Vcelka, II	46226 National Road, St. Clairsville, Ohio 43950	-	Assistant Treasurer	-	-	7/29/2014	-
James R. Turner, Jr	46226 National Road, St. Clairsville, Ohio 43950	-	Senior Vice President	-	-	8/14/2015	-
Eric S. Grimm	46226 National Road, St. Clairsville, Ohio 43950	-	Assistant VP of Operations	-	-	5/21/2017	-
John R. Forrelli	46226 National Road, St. Clairsville, Ohio 43950	-	Senior Vice President	-	-	11/1/2010	4/1/2016
Robert Edward Murray	46226 National Road, St. Clairsville, Ohio 43950	-	VP – External Affairs	-	-	8/15/2012	7/29/2014
Robert Edward Murray	46226 National Road, St. Clairsville, Ohio 43950	-	VP – Marketing & Sales	-	-	8/15/2012	9/29/2014

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TABLE 1.4.1 - Murray Energy Holdings Company
Owners and Controllers of the Applicant

Name	Address	SSN (voluntary)/EIN	Ownership or Control Relationship to the Applicant/ Position- Title	Ownership Percentage	Location in Organizational Structure	Date Position Assumed	Termination Date
Robert Eugene Murray	46226 National Road, St. Clairsville, Ohio 43950	-	Director	-	-	10/21/2003	-
Robert D. Moore	46226 National Road, St. Clairsville, Ohio 43950	-	Director	-	-	2/23/2001	-
Michael O. McKown	46226 National Road, St. Clairsville, Ohio 43950	-	Director	-	-	6/30/2003	-
Michael D Loiacono	46226 National Road, St. Clairsville, Ohio 43950	-	Treasurer	-	-	4/23/2007	-
Michael O. McKown	46226 National Road, St. Clairsville, Ohio 43950	-	Secretary	-	-	1/28/2005	-
Robert Eugene Murray	46226 National Road, St. Clairsville, Ohio 43950	-	President	-	-	2/23/2001	-
Robert Eugene Murray	46226 National Road, St. Clairsville, Ohio 43950	-	Chief Executive Officer &Chair	-	-	8/15/2012	-
Robert D. Moore	46226 National Road, St. Clairsville, Ohio 43950	-	Chief Financial Officer	-	-	8/15/2012	-
Murray, Robert Eugene Trustee, (REM Family Trust)	46226 National Road, St. Clairsville, Ohio 43950	-	Shareholder - 20% Class B Non-Voting Stock	-	-	5/10/2010	-
Robert Edward Murray	46226 National Road, St. Clairsville, Ohio 43950	-	Shareholder - 20% Class B Non-Voting Stock	-	-	6/30/2003	-
Ryan Michael Murray	46226 National Road, St. Clairsville, Ohio 43950	-	Shareholder - 20% Class B Non-Voting Stock	-	-	6/30/2003	-
Fifth Third Bank of NE Ohio - Trustee (Murray 2003 Trust)	46226 National Road, St. Clairsville, Ohio 43950	-	Shareholder - 20% Class B Non-Voting Stock	-	-	10/13/2003	-
Jonathan Robert Murray	46226 National Road, St. Clairsville, Ohio 43950	-	Shareholder - 20% Class B Non-Voting Stock	-	-	6/30/2003	-
Murray, Robert Eugene Trustee, (REM Family Trust)	46226 National Road, St. Clairsville, Ohio 43950	-	Shareholder	100% Class A Voting Stock	-	2/23/2001	-

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TABLE I.4.1 - Mach Mining LLC (Operator)
Owners and Controllers of the Applicant

Name	Address	SSN (voluntary)/EIN	Ownership or Control Relationship to the Applicant/ Position- Title	Ownership Percentage	Location in Organizational Structure	Date Position Assumed	Termination Date
Robert D. Moore	46226 National Road, St. Clairsville, Ohio 43950	-	Chief Executive Officer	-	-	5/31/2015	-
Robert D. Moore	46226 National Road, St. Clairsville, Ohio 43950	-	President	-	-	5/31/2015	-
Cody E. Nett	46226 National Road, St. Clairsville, Ohio 43950	-	Corporate Secretary	-	-	7/21/2017	-
Jeremy J. Harrison	46226 National Road, St. Clairsville, Ohio 43950	-	Chief Accounting Officer	-	-	9/30/2017	-
Jeremy J. Harrison	46226 National Road, St. Clairsville, Ohio 43950	-	Principal Accounting Officer	-	-	9/30/2017	-

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TABLE 1.4.2
Ownership and Control Information for Other Permitted U.S. Surface Coal Mining and Reclamation Operations

Owner/Entity from Table 1.4.1	Permittee/Company Name of Operation in U.S. Individual has been Associated with for the Previous 5 Years.	Position Title to Company	Company EIN	Federal or State Permit Number	State	Name of Regulatory Authority	MSHA Number with Date of Issuance
Foresight Energy LLC	Hillsoboro Energy LLC	Member	20-5231639	399, 424	IL	IDNR	IL08-1211: 1/30/12; IL08-03216-03: 1/15/14
Foresight Energy LLC	Macoupin Energy LLC	Member	26-2809005	56, 209, 265, 291, 302, 419	IL	IDNR	IL08-00726: 2/26/90
Foresight Energy LLC	Sugar Camp Energy LLC	Member	41-2178049	382, 434	IL	IDNR	IL08-03189-03: 1/6/12
Foresight Energy LLC	Williamson Energy LLC	Member	81-0669143	375, 417	IL	IDNR	IL08-03141-01: 6/26/07; IL-08-03141-02: 12/3/10
Cody E. Nett	Energy Resources, Inc.	Assistant Secretary	31-1044044	17930120, 24880103	PA	PADEP	3602695: 5/25/1988
Cody E. Nett	Energy Resources, Inc.	Vice President	31-1044044	17930120, 24880103	PA	PADEP	3602695: 5/25/1988
James T. Murphy	Hillsoboro Energy LLC	Vice President	20-5231639	399, 424	IL	IDNR	IL08-1211: 1/30/12; IL08-03216-03: 1/15/14
James T. Murphy	Macoupin Energy LLC	Vice President	26-2809005	56, 209, 265, 291, 302, 419	IL	IDNR	IL08-00726: 2/26/90
James T. Murphy	Sugar Camp Energy LLC	Vice President	41-2178049	382, 434	IL	IDNR	IL08-03189-03: 1/6/12
James T. Murphy	Williamson Energy LLC	Vice President	81-0669143	375, 417	IL	IDNR	IL08-03141-01: 6/26/07; IL-08-03141-02: 12/3/10
Rashda M. Buttar	Hillsoboro Energy LLC	General Counsel	20-5231639	399, 424	IL	IDNR	IL08-1211: 1/30/12; IL08-03216-03: 1/15/14
Rashda M. Buttar	Hillsoboro Energy LLC	Secretary	20-5231639	399, 424	IL	IDNR	IL08-1211: 1/30/12; IL08-03216-03: 1/15/14
Rashda M. Buttar	Hillsoboro Energy LLC	Senior Vice President	20-5231639	399, 424	IL	IDNR	IL08-1211: 1/30/12; IL08-03216-03: 1/15/14
Rashda M. Buttar	Macoupin Energy LLC	Secretary	26-2809005	56, 209, 265, 291, 302, 419	IL	IDNR	IL08-00726: 2/26/90
Rashda M. Buttar	Macoupin Energy LLC	Senior Vice President	26-2809005	56, 209, 265, 291, 302, 419	IL	IDNR	IL08-00726: 2/26/90
Rashda M. Buttar	Sugar Camp Energy LLC	General Counsel	41-2178049	382, 434	IL	IDNR	IL08-03189-03: 1/6/12
Rashda M. Buttar	Sugar Camp Energy LLC	Secretary	41-2178049	382, 434	IL	IDNR	IL08-03189-03: 1/6/12
Rashda M. Buttar	Sugar Camp Energy LLC	Senior Vice President	41-2178049	382, 434	IL	IDNR	IL08-03189-03: 1/6/12

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TABLE 1.4.2
Ownership and Control Information for Other Permitted U.S. Surface Coal Mining and Reclamation Operations

Owner/Entity from Table 1.4.1	Permittee/Company Name of Operation in U.S. Individual has been Associated with for the Previous 5 Years.	Position Title to Company	Company EIN	Federal or State Permit Number	State	Name of Regulatory Authority	MSHA Number with Date of Issuance
Rashda M. Buttar	Williamson Energy LLC	General Counsel	81-0669143	375, 417	IL	IDNR	IL08-03141-01: 6/26/07; IL-08-03141-02: 12/3/10
Rashda M. Buttar	Williamson Energy LLC	Secretary	81-0669143	375, 417	IL	IDNR	IL08-03141-01: 6/26/07; IL-08-03141-02: 12/3/10
Rashda M. Buttar	Williamson Energy LLC	Senior Vice President	81-0669143	375, 417	IL	IDNR	IL08-03141-01: 6/26/07; IL-08-03141-02: 12/3/10
Robert D. Moore	American Energy Corp	Assistant Secretary	31-1550443	D-0425, D-1159	OH	ODNR	3301070: 11/6/2000; 3302122: Unk
Robert D. Moore	Andalex Resources Inc	Treasurer	61-0931325	C0070019, C0070033	UT	UT-DOGM	4202233: 8/9/2006; 4201864: 6/20/2011
Robert D. Moore	Canterbury Coal Co	President	25-1127473	3950701, 3900115, 3743701, 3841302	PA	PADEP	3608544: 2/1/1996
Robert D. Moore	Canterbury Coal Co	Treasurer	25-1127473	3950701, 3900115, 3743701, 3841302	PA	PADEP	3608544: 2/1/1996
Robert D. Moore	Eighty Four Mining Co	Vice President	25-1695903	63743702, 63831302	PA	PADEP	3600958: 9/30/1998
Robert D. Moore	Energy Resources Inc	Director	31-1044044	17930120, 24880103	PA	PADEP	3602695: 5/25/1988
Robert D. Moore	Genwal Resource Inc	Treasurer	87-0533099	C015032	UT	UT-DOGM	4202356-4201715: 1/1/1981
Robert D. Moore	Hillsoboro Energy LLC	Chief Executive Officer	20-5231639	399, 424	IL	IDNR	IL08-1211: 1/30/12; IL08-03216-03: 1/15/14
Robert D. Moore	Hillsoboro Energy LLC	President	20-5231639	399, 424	IL	IDNR	IL08-1211: 1/30/12; IL08-03216-03: 1/15/14
Robert D. Moore	KenAmerican Resources Inc	Assistant Treasurer	61-1264385	8895009, 8895011, 8899044, 8890147	KY	DSMRE	
Robert D. Moore	Macoupin Energy LLC	Chief Executive Officer	26-2809005	56, 209, 265, 291, 302, 419	IL	IDNR	IL08-00726: 2/26/90

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TABLE 1.4.2
Ownership and Control Information for Other Permitted U.S. Surface Coal Mining and Reclamation Operations

Owner/Entity from Table 1.4.1	Permittee/Company Name of Operation in U.S. Individual has been Associated with for the Previous 5 Years.	Position Title to Company	Company EIN	Federal or State Permit Number	State	Name of Regulatory Authority	MSHA Number with Date of Issuance
Robert D. Moore	Macoupin Energy LLC	President	26-2809005	56, 209, 265, 291, 302, 419	IL	IDNR	IL08-00726: 2/26/90
Robert D. Moore	Murray American Energy Inc	President	46-4091556	U010083, U007083, U043100, U019183, U004584, U005383, U008683; 30841319, 30743702	WV;PA	WVDEP;PADEP	
Robert D. Moore	Murray Keystone Processing Inc	Vice President	46-4068709	3951601	PA	PADEP	3608540: 9/22/1998
Robert D. Moore	OhioAmerican Energy Inc	President	20-3044610	D-2180, D-2291, D-2304, D-2312, D-2362, D-2382, D-2411	OH	ODNR	
Robert D. Moore	Sugar Camp Energy LLC	Chief Executive Officer	41-2178049	382, 434	IL	IDNR	IL08-03189-03: 1/6/12
Robert D. Moore	Sugar Camp Energy LLC	President	41-2178049	382, 434	IL	IDNR	IL08-03189-03: 1/6/12
Robert D. Moore	The American Coal Company	Treasurer	73-1543124	2, 255, 257, 306, 352, 344, 401	IL	IDNR	1102752: 11/7/1983; 1103232: 9/23/2010
Robert D. Moore	The Franklin County Coal Company	Vice President	46-4797001	202, 274, 43, 281	IL	IDNR	1100601: 11/14/1986
Robert D. Moore	The Harrison County Coal Company	Vice President	46-4067631	U010483, U102592	WV	WVDEP	4601318: Unk
Robert D. Moore	The Marion County Coal Company	Vice President	46-4067755	U007883, O104491	WV	WVDEP	4601433: Unk
Robert D. Moore	The Marshall County Coal Company	Vice President	46-4064123	U102692, O102392, U003383, U200707, O200211	WV	WVDEP	4601437: Unk
Robert D. Moore	The Monongalia County Coal Company	Vice President	46-4067864	U004684, O101193; 30841312, 30950701	WV;PA	WVDEP;PADEP	4601968: unk

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TABLE 1.4.2
Ownership and Control Information for Other Permitted U.S. Surface Coal Mining and Reclamation Operations

Owner/Entity from Table 1.4.1	Permittee/Company Name of Operation in U.S. Individual has been Associated with for the Previous 5 Years.	Position Title to Company	Company EIN	Federal or State Permit Number	State	Name of Regulatory Authority	MSHA Number with Date of Issuance
Robert D. Moore	The Ohio County Coal Company	Vice President	46-4054000	U102591, U104591, U200306, O100100, O200706, O201806; 63981301	WV;PA	WVDEP;PADEP	4601436: Unk
Robert D. Moore	UtahAmerican Energy Inc	Treasurer	34-1874726	ACT007013	UT	UT-DOGM	4202241: 2/24/1999
Robert D. Moore	West Ridge Resources Inc	Treasurer	87-0585129	C007041	UT	UT-DOGM	4202233: 8/9/2006
Robert D. Moore	Williamson Energy LLC	Chief Executive Officer	81-0669143	375, 417	IL	IDNR	IL08-03141-01: 6/26/07; IL-08-03141-02: 12/3/10
Robert D. Moore	Williamson Energy LLC	President	81-0669143	375, 417	IL	IDNR	IL08-03141-01: 6/26/07; IL-08-03141-02: 12/3/10

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TABLE 1.4.3
Pending Permit Applications Associated with a Table 1.4.2 Operations of Owners and Controllers

Name of Owner/Controller from Table 1.4.2	Name of Applicant Company	Position Title	State	Name of Regulatory Authority	Permit Application Number or other Identifier	Date of Permit Application
Williamson Energy, LLC	Williamson Energy	N/A	IL	IDNR	456	5/25/2017

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TABLE 1.4.4
Surface Coal Mining Operations Owned or Controlled by the Applicant

Name of Surface Coal Mining Operation (Company)	Address	EIN	Applicant's Relationship to Company (Including Percentage of Ownership and Location in Organizational Structure)	State	Name of Regulatory Authority	Federal or Sate Permit Number	MSHA Number and Date of Issuance
Williamson Energy, LLC	211 N. Broadway, Suite 2600, St. Louis, MO 63102	81-0669143		IL	IDNR	375, 417	IL08-03141-01: 6/26/07; IL-08-03141-02: 12/3/10

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TABLE 1.5
Revocation/Suspension and Forfeiture History

Enforcement				Permit Information					Appeal Information			
Entity /Permittee	Suspension, Revocation, or Bond Forfeiture	Date of Enforcement	Reason of Enforcement	Permit No.	State and Regulatory Authority	Permit Issue Date	Bond Amount (Forfeiture)	Current Status of Permit, Bond, or Similar Security Involved	Type of Appeal (Administrative, Judicial)	Date	Location of Proceeding	Status

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TABLE 1.5.3
List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
IDNR	IL0061727	NOV 58-04-15	6/29/2015	TACC	Failure to meet effluent limits at Outfall 002 with pH of 4.97 (below 6.0 minimum) and chlorides of 5834 1 mg/L (above 2000 maximum).		Abated	Treatment ongoing at Pond 002
DOGM	ACT007041	NOV #21156	9/10/2015	UEI	Permittee failed to follow the required monitoring plan during the mining of longwall panels #18, #20, and #21. Immediately implement monitoring.		Abated	
IDNR	257	NOV 58-01-16	2/18/2016	TACC	Slurry uncontrollably deposited to unauthorized areas within and outside of the permitted area.		Abated	
IDNR	43	NOV 67-3-16	3/30/2016	Consolidation CC	Items from the 2015 reclamation schedule were not completed on time. NOV 67-3-16 issued for not meeting the March 1, 2016 deadline.		Abated	A plan with reasonable deadlines set in 2015, 2016, 2017, 2018, and 2019 has been established to complete the reclamation requirements associated with NOV 67-3-16.
IEPA	A-2016-00017	A-2016-00017	4/4/2016	TACC	CAAPP permit requirements were not met and a complete updated CAAPP permit application to include a railcar loadout operation must be submitted.		Abated	
DOGM	ACT015032	NOV #21175	4/19/2016	UEI	Failure to submit and receive approval from UDOGM for the installation of a metal/chain-link fence around the warehouse (as well as update MRP).		Abated	Abated with submittal and approval by UDOGM
IDNR	IL0036021	CO 01-16	7/6/2016	Consolidation CC	Failure to abate NOV 67-3-16 within extension time granted. CO 01-16 abatement actions are required by August 8, 2016.		Abated	De-watering requirement began. A plan with reasonable deadlines was established to complete the reclamation requirements associated with NOV 67-3-16. CO 01-16 abated.
IDNR	255, 257, 352	NOV 58-02-16	10/4/2016	TACC	Failure to submit the renewal applications in a timely manner. The notification system that IDNR uses to alert permit holders of their permit expiration dates failed to send the "180 day letters" to us		Abated	This NOV will be vacated as soon as the signed and sealed copies from the Saline County courthouse reach the IDNR office. NOV abated 10/21/16
IDNR	2	58-1-17	2/21/2017	TACC	Failure to include flow from Sediment Basin 002E from the quarterly reports for October, November, and November.		Abated	Discharge monitoring reports for the basin must be submitted by March 21, 2017.

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TABLE 1.5.3
List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
IDNR	399	38-01-17	3/3/2017	Hillsboro	Failure to report flow from Sediment Basin 002 (NPDES Outfall 002) for the month of November 2016 in the quarterly discharge monitoring reports. (The Department documented flow during the Nov. 10, 2016 inspection.) Failure to report flow from Smith Reservoir (NPDES Outfall 007) for the month of November 2016 in the quarterly discharge monitoring reports. (The Department documented flow during the Nov. 7, 2016 inspection.)		Abated	
IDNR	56	72-1-17	3/7/2017	Macoupin			Abated	
IDNR	202	67-1-17	5/8/2017	Consolidation CC	Failue to complete final grading, seeding, and mulching required on former Pond 005		Abated	Final grade, seeding, and mulching must occur by June 1, 2017
IDNR	401	58-2-17	5/8/2017	TACC	Coal waste was deposited in unauthorized area in an uncontrolled manner impacting an adjacent ephemeral stream diversion and receiving stream		Abated	Remove all coal refuse from diversion ditch, remove material downstream, provide a summary of events that contributed to the receiving of NOV,and provide a plan to the department detailing the construction practicesto ensure downstream slopes will be maintained by June 1, 2017. Regreade and shape the downstream slope of the bunkhouse according to the plan by July 1, 2017
IDNR	401	58-3-17	6/8/2017	TACC	permit renewal application for IDNR permit 401 was not submitted 180 days before expiration		Abated	
KDMRE	875-0030		1/30/2015	MCLEAN	An unpermitted haul road was used to haul in topsoil for reclamation purposes. Extended to allow time to obtain permit revision for affected area.		Abated	Obtaining permit revision to permit the affected area
KDMRE	889-9004		3/17/2015	KRI	Data for CYP-8 and CYP-9 sites were not submitted in surface and groundwater monitoring reports. NNC 13-0942 issued for failure to report		Abated	Abated
KDMRE	889-9004		3/17/2015	KRI	Sediment basin #2 discharging water at pH 2.88 NNC 13-0943 issued for failure to maintain effluent limits.		Abated	Abated as discharged was stopped

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TABLE 1.5.3
List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
KDMRE	889-9004		4/21/2015	KRI	1st Quarter 2015 Gob Pile Certification received late (was due 4/14, received 4/15). NNC #13-0945 as KDMRE "non-correctable", but effectively is abated.		Abated	Report was submitted, but one day late. KDMRE files missing deadlines as "non-correctable", but the report has been received, and is effectively "abated."
KDMRE	889-5009		5/6/2015	KRI	Sediment basin KY-M-269 was discharging at pH of 4.47 into receiving wetlands and there is therefore no up- or downstream measurments.		Abated	Discharge stopped, violation abated.
KDEP	KYG045591		6/1/2015	KRI	Various water quality exceedances and unheeded monitoring requirements noted.		Abated	Agency "non-remedial" is effectively abated with payment of penalty
KDEP	KY0105562		6/1/2015	KRI	Various water quality exceedances and unheeded monitoring requirements noted.		Abated	Agency "non-remedial" is effectively abated with payment of penalty
KDMRE	889-9004		7/13/2015	KRI	Failure to pass all surface drainage through sediment control structures with water escaping the permit area with iron greater than 10mg/L.		Abated	Discharge contained
KDMRE	889-5009		8/17/2015	KRI	Permittee has mined coal on 5 unpermitted cemetary tracts. NNC #13-0966 issued. Revise the permit to include the undermined cemetaries.		Abated	Extended with provisions to add areas to permit boundary. Permitting process is lengthly, extension granted. Abated on 8/22/2016
KDMRE	889-5009		8/24/2015	KRI	Failure to submit groundwater monitoring point data for 8003-1725 on 2nd quarter monitoring. Agency "Non-correctable" (effectively abated)		Abated	Corrected report sent. Agency "non-correctable" (effectively abated).
KDMRE	889-9004		8/24/2015	KRI	Failure to submit groundwater monitoring points 24 and 24A on 2nd quarter monitoring. Corrected report sent. Agency "non-correctable (effectively abated)		Abated	Corrected report sent. Agency "non-correctable" (effectively abated).
KDMRE	889-5011		8/24/2015	KRI	Failure to submit groundwater well data for 8003-1725 on 2nd quarter monitoring. Agency "Non-correctable" (effectively abated).		Abated	Corrected report sent. Agency "non-correctable" (effectively abated).
KDMRE	KY0105562		8/28/2015	KRI	Various water quality exceedances and unheeded monitoring requirements noted. Same issues as noted above with 2015001 violations issued June 1, 2015.		Abated	Agency "non-remedial" is effectively abated. Working to combine this violation with the previous violation 2015001 issued on June 1, 2015. May still require additional payment.
KDMRE	889-9004		11/12/2015	KRI	Water discharging from sediment basin SB-1 with a pH of 4.49		Abated	

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TABLE 1.5.3
List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
KDMRE	889-9004		11/12/2015	KRI	Drainage bypassing approved sediment control structure. Water leaving the soututhern edge of the permit with iron concentration greater than 10 mg/L.		Abated	
KDMRE	889-5009		11/16/2015	KRI	Well 8003-1725 reported dry for three (3) consecutive quarters Within 30 days, well must be rehabilitated or must submit an application to replace well.		Abated	
KDMRE	889-5011		11/16/2015	KRI	Well 8003-1725 reported dry for three (3) consecutive quarters. Within 30 days, well must be rehabilitated or must submit an application to replace well.		Abated	
KDMRE	889-9004		3/24/2016	KRI	Substandard water flowing off-permit from the southern dam of CFD-1. Also, Gullies were present on the southern face of the gob pile NNC 13-1434 issued.		Abated	Dozer work completed on the souther dam of CFD-1 and the seep is no longer flowing. Abatement of NNC 13-1434
KDMRE	889-0147		3/29/2016	KRI	Water discharging from sediment basin #2 with a pH of 9.6, and diversion ditches DD1 and DD3 have been eroded and no longer meet specifications.		Abated	Remedial work has been completed per KDMRE inspection report on 5/27 NNC 13-1435 abated
KDMRE	889-9004		6/1/2016	KRI	Failure to submit annual certifications of maintenance for slurry impoundments CFD-1 and CFD-2 Written as NNC 13-1437 on the insp. rpt. but is actually 13-1438		Abated	Paperwork submitted.
KDMRE	889-5011		10/26/2016	KRI	Permittee has failed to maintain sediment structure SB-5. The primary spillway has blown out		Abated	Principle spillway portion of dam was washed out and we have until 11/28/16 to repair it. Mike sent contractor to site 10/27/16
KDMRE	889-9004		11/9/2016	KRI	Permittee has failed to operate CFD-1 according to the plan approved in permit. Permitee overfilled south end of CFD-1 with slurry and placed a berm across the spillway which stoped the discharge.		Abated	Permitee must cease the pumping of slurry into the south end of CFD-1. Permitee must either remove the alteration to the spillway or obtain a permit revisionto approve alterations made.
KDMRE	889-5009		11/21/2016	KRI	Permittee has failed to submit surface and groundwater 3rd quarter reports, GW-4 reports, and AM-02 monitoring reports withing the required deadline.		Abated	Monitoring reports were submitted. See Violation sheet.

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TABLE 1.5.3
List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
KDMRE	889-9004		11/23/2016	KRI	Permittee has failed to begin seeding sites SB#2, the non-toxic material pile near CRD-1, the outslopes of CRD-1, and areas on CRD-1 where erosion was repaired within the 7 days given to do so.		Abated	Permittee must seed, mulch, and maintain around areas SB#2, the non-toxic material pile near CRD-1, the outslopes of CRD-1, and areas on CRD-1 where erosion was repaired. Permittee must then reseed in the spring of next year.
KDMRE	889-5009		2/2/2017	KRI	Permitee has allowed the accumulation of mud and coal dust to occurr in the right of way of hwy 181 and the associated road ditches		Abated	Permittee has 30 days to remove and dispose of all material from permit that has accumulated. KRI is continueing work. The agency extended till April 6, 2017.
ODNR	D-0360	NOV #29963	9/30/2015	TOVCC	Water flowing from coal stockpile down to area below SR 148 bridge. Required remedial action: clean up material, install sumps, reinstall silt fence / build dyke.		Abated	Abated with completion of remedial actions.
ODNR	2382	29435	4/5/2016	OAEI	Water discharging through the embankment beneath the principal spillway pipe of structure 005.		Abated	Abated with repairs.
ODNR	D-0360	29971	12/19/2016	TOVCC	pH of pond was 3.0 when it should be between 6.5-9.0.		Abated	Pond must be treated to a pH of 6.5-9.0 prior to discharge by 12/27/16. Water from pond must not be discharged until effluent limits are met
ODNR	D-0425	CO I-13083	6/14/2017	AEC	Drilling fluid was discharged beyond the permit limits and sediment was found in unnamed tributaryand Jakes Run stream on the Wharton and Bettinazzi property		Abated	Cease all mining activities beyond permit limits, including drilling activity causing off site discharges. Take all measures necessary to stop discharge of sediment into the stream.
PADEP	3841302	N/A	2/2/2015	Canterbury CC	Compliance Order: October DMRs self-report		Abated	
PADEP	30841312 / PA0013790	C.O 151023A	5/11/2015	Consolidation CC	Outlet 022 discharging with Aluminum concentration of 3.189 mg/L, exceeding the 1.1 mg/L limit. Compliance Order (C.O.) docket # 151023A issued. Amended to fix information on 5/22.		Abated	

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TABLE 1.5.3
List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
PADEP	30841312 / PA0013790	NOV 06/30/15	6/30/2015	Consolidation CC	Monthly average and instant maximum aluminum concentration at outfall 005 was exceeded on first quarter DMRs. NOV issued and lifted		Abated	Lifted immediately after issued
PADEP	30841312 / PA0013790	NOV 8/27/15	8/27/2015	Consolidation CC	DMRs showed a no-flow at Outfall 022 in April and at 005 in June, conflicting with inspector sampling data (sometimes finds it flowing when we do not)		Abated	NOV issued and lifted
PADEP	30841312 / PA0013790	NOV 10/27/15	10/27/2015	Consolidation CC			Abated	
PADEP	30841312 / PA0013790	NOV 4/29/16	4/29/2016	The Monongalia County Coal	Effluent characterization for special condition requirements of Part B of the NPDES permit, required 2 years after NPDES issuance, was not submitted		Abated	Required effluent characterization has been provided to PADEP.
PADEP	63743702 / PA0214248	NOV 4/29/16	4/29/2016	The Washington County Coal	Effluent characterization for special condition requirements of Part B of the NPDES permit, required 2 years after NPDES issuance, was not submitted.		Abated	Data had been previously submitted to the department. NOV abated (should probably technically have been withdrawn)
PADEP	03743701	NOV 5/5/16	5/5/2016	Canterbury CC	Operator has not begun desludging the sediment basins as noted in previous inspection reports. NOV issued to require desludging by 5/12.		Abated	Abated with the start of the desludging process.
PADEP	03951601	NOV 5/18/16	5/18/2016	MKPI	Impoundment certifications expired 5/4/16. NOV cited requiring the submission of the annual impoundment certifications by 6/17/16		Abated	Abated with the submission of the certifications
PADEP	03841302	NOV 6/28/16	6/28/2016	Canterbury CC	Sample collected on 6/2/16 showed a manganese concentration of 2.867 mg/L, over the limit of 2.5		Abated	Abated with manganese concentration returning to compliant levels
PADEP	03841302	NOV 8/3/16	8/3/2016	Canterbury CC	NOV issued for exceeding manganese limit at Outfall 001 on sample collected 6/15. Immediately lifted as compliant sample was taken 6/28.		Abated	Compliant sample collected 6//28 shows Manganese limits were being met. NOV lifted.
PADEP	30841312 / PA0013790	NOV 8/24/16	8/24/2016	The Monongalia County Coal	Effluent limits on outfall 023 were not reported when the HMR/DMR's were submitted for the second qtr 2016.		Abated	
PADEP	03951601	NOV 9/23/16	9/23/2016	MKPI	requires operator to submit a request for temporary cessation		Abated	submitted temporary cessation
PADEP	03841302	CO 12/20/16	12/20/2016	Canterbury CC	NOV issued for exceeding manganese limit at Outfall 001 on sample collected 12/20/16		Abated	Operator must provide proper treatmentto ensure discharges are meeting effluent standards.
PADEP	03841302	C O 161067	1/9/2017	Canterbury CC	Manganese concentraionat outfall 001 was recorded at 3.635 mg/L when the effluent limit is 2.5 mg/L		Abated	

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TABLE 1.5.3
List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
PADEP	30841312 / PA0013790	CO #171012	3/3/2017	The Monongalia County Coal	CO issued for reporting No Flow when the inspector found a flow		Abated	
PADEP	30841312 / PA0013790	CO #171013	3/3/2017	The Monongalia County Coal	Water exceeded effluent limits at outfall 022 with an aluminum concentration of 2.6 mg when, and an aluminum concentraition of 2.06 mg when the limit is 1.1mg. Water exceedded effluent limit at outfall 023 with an aluminum concentration of 5.9mg and 1.46mg when the limit is set at 1.3mg		Abated	
PADEP	03841302	C.O. 171025	6/6/2017	Canterbury CC	Outfall 001 was discharging water with an aluminum concentration of 1.449 mg/L which exceeds the limit of 0.78mg/L. Sample collected on 4/17/17		Satisfactory Progress	Operator must provide proper treatmentto ensure discharges are meeting effluent standards.
PADEP	03841302	C.O. 171028	6/20/2017	Canterbury CC	Outfall 001 discharging with an aluminum concentration of 1.524 mg/L which exceeds the limit of 0.75 mg/L.		Satisfactory Progress	Operator must provide proper treatmentto ensure discharges are meeting effluent standards.
PADEP	30841312 / PA0013790	C.O. 171029	6/26/2017	The Monongalia County Coal	Outfall 023 discharged water with an aluminum concentration of 3.758 mg?l when the effluent limit is 1.3 mg/L.		Abated	
PADEP	30841312 / PA0013791	CO #171029	6/26/2017	The Monongalia County Coal	Outfall 023 exceeded the aluminum concentration of 1.3 mg/L with a concentration of 3.758 mg/L.		Abated	
PADEP	63733706	CO #171030	7/11/2017	MCMI	Failure to have an approved reclamation plan.		Terminated	
PADEP	03951601	C.O. 171032	8/8/2017	MKPI	Discharged water from an area disturbed by mining did not meet effluent limits with a Iron concentration of 42.582 mg/L when the limit is 7.0 mg/L, and a Manganese concentration of 11.119 mg/L which exceeds the limit of 5.0 mg/L.		Abated	Operator must provide proper treatment to ensure discharges are meeting effluent standards.
WVDEP	U007883	U007883 (52)	1/12/2015	Consolidation CC	Black water / coal fines discharging into Paw Paw Creek, discoloring water, disturbing hydrologic balance		Abated	Coal fine discharge stopped, no longer causing hydrologic balance. Abatement period extended to allow for a written plan to minimize potential for a repeat event

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List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
WVDEP	U004684	U004684 (36)	1/22/2015	Consolidation CC	Outfall 002 pH 9.7 (limit is 9.0)		Withdrawn	Follow-up inspection 002 was not discharging. Operator submitted justification to DEP outlining how access to the pond had been restricted and pump malfunctioned. Resolved
WVDEP	P203514	P203514 (1)	1/26/2015	AMEI	Prospect permit Hole P-01 caused degredation of groundwater quality from a nearby landowner water well		Abated	Extended with permittee checking and purging the well, waiting for it to clear.
WVDEP	U007883	IHCO #53	2/10/2015	Consolidation CC	Contractor spill at 1-D borehole construction site. IHCO #53 issued for excessive contribution of suspended solids into tributary. Modified to NOV #55		Abated	Abated with stopped discharge from the site and no remaining water with high solids was located. "Slug" has dissipated. Abated
WVDEP	U007883	NOV #55	2/10/2015	Consolidation CC	Contractor spill at 1-D borehole construction site. IHCO #53 issued for excessive contribution of suspended solids into tributary. Modified to NOV #55		Abated	Abated with stopped discharge from the site and no remaining water with high solids was located. "Slug" has dissipated. Abated
WVDEP	U007883	NOV #54	2/10/2015	Consolidation CC	Contractor spill at 1-D borehole construction site. NOV #52 issued for failure to install proper temporary E&S controls		Abated	Abated with installation of adequate sediment control for the site
WVDEP	U043100	NOV #7	2/13/2015	Consolidation CC	RO break flowed off-permit allowing chlorides to enter an unnamed tributary of Campbell Run. NOV #7 issued for disturbance to hydrologic balance		Abated	Discharged to Campbell Run was stopped. Pipeline break was temporarily repaired. A more permanent repair will occur when weather permits
WVDEP	O102392	NOV #28	3/4/2015	Consolidation CC	Outlet 006 discharging at pH of 3.85 (below the minimum limit), and Iron at 5.0 (above maximum limit). NOV #28 issued for failure to maintain effluent limits		Abated	Outlet 006 was pumped down to stop discharge. NOV extended until lab results are received.
WVDEP	O100100	NOV #12	3/4/2015	Consolidation CC	Outlet 020 discharging iron at 3.5 mg/L. NOV#12 issued for exceeding effluent limit.		Abated	Outlet 020 was pumped down to stop discharge. Inspector sample lab data received, NOV terminated.
WVDEP	U102591	NOV #51	3/9/2015	Consolidation CC	Emergency Warning Plan for Brown's Run Slurry Impoundment expired 3/8/2015. NOV #51 issued for failure to submit and obtain approval for new plan		Abated	EWP was submitted but WVDEP requires a filing fee with submission, extended. Abated with fee submission and plan is now being reviewed by WVDEP
WVDEP	U010483	NOV #88	3/16/2015	Consolidation CC	Pipe burst released water & material into Robinson Run. NOV #88 issued for failure to minimize disturbance to hydrologic balance		Abated	Line was repaired. NOV terminated.

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TABLE 1.5.3
List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
WVDEP	U010483	NOV #89	3/25/2015	Consolidation CC	Outlet 032 discharging muddy water into and discoloring Sam's Run and the South Fork of Fish Creek NOV #89 issued.		Abated	Filtration system installed; extended Abated with filtration & floc treatment.
WVDEP	U007083	NOV #43	4/8/2015	Consolidation CC	Power to pmp was interrupted, sump overflowed, untreated mine water left permit area and stained ditch leading to UNT of Dent's Run NOV #43 issued.		Abated	When power was restored, our pump was unable to keep up with accumulated water, so we installed a bigger pump.
WVDEP	U004684	NOV #37	4/22/2015	Consolidation CC	Failure to stabilize refuse benches in that a large "erosion gully" (actually a temp. ditchline) developed above the new flume ditch. NOV #37 issued.		Abated	Repaired, abated
WVDEP	U004684	NOV #38	4/22/2015	Consolidation CC	Failure to spread and compact refuse material in layers not exceeding two feet (top of refuse not spread/compacted due to mine idle) NOV #38 issued		Withdrawn	Spread and compacted, abated.
WVDEP	U004684	NOV #39	4/22/2015	Consolidation CC	Unapproved materials (some combustible debris, some noncombustible) were disposed of in refuse pile. Needs removed. NOV #39 issued		Abated	Materials removed. Abated
WVDEP	U102591	NOV #52	6/13/2015	Consolidation CC	Pump failed and drainage sump discharged black water from outlet 015 into Ohio River NOV #52 issued		Withdrawn	Abated with cleanup and pump restoration NOV withdrawn as it is essentially the same as NOV 53
WVDEP	U102591	NOV #53	6/13/2015	Consolidation CC	Pump failure allowed black water discharge from outlet 015 into Ohio River NOV #53 issued for conditions not allowable in waters of the state		Abated	Abated with cleanup and pump restoration
WVDEP	U003383	NOV #72	7/22/2015	Consolidation CC	Outlet 005 discharging with TSS at 228.0 (above 70 maximum) and total aluminum at 2 20 mg/L (above 0.75 maximum) due to water line rupture disrupting treatment		Abated	The line has been replaced and the line will be inspected during pond cleanings to prevent non-compliant discharge.
WVDEP	U102692	NOV #6	8/12/2015	Consolidation CC	Outlet 030 discharge exceeding maximum aluminum concentration.		Abated	Laboratory report of subsequent sample shows compliance is being met. Violation abated.
WVDEP	U200707	NOV #1	8/24/2015	Consolidation CC	Air Blast exceeded maximum decibel level of 133 dB (at 134 4 dB)		Abated	Abated with reoccurance provention plan submittal and with subsequent air blasts shown to be within decibel limits. (Contractor responsibility)
WVDEP	O201806	NOV #5	9/4/2015	Consolidation CC	Filtration socks were removed by a storm drain, allowing sediment laden water during washdown procedure to drain into Boggs Run and discolor the stream		Abated	Sediment control socks reinstalled around the drain grates. Violation abated.

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TABLE 1.5.3
List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
WVDEP	O102591	NOV #54	12/1/2015	Consolidation CC	Outlet 015 and 023 discharges exceeding their respective aluminum concentration limits. NOV #54 issued		Abated	
WVDEP	U010483	NOV #90	12/7/2015	Consolidation CC	Water line break caused orange staining in the unnamed tributary of Quaker Fork. NOV issued for causing conditions not allowable in state waters		Abated	
WVDEP	U102692	NOV #7	12/8/2015	Consolidation CC	Outlet 415 discharge had an amonia/nitrogen level of 20 23 mg/L, exceeding the limit of 6 mg/L. NOV #7 issued.		Abated	
WVDEP	U003383	NOV #73	12/17/2015	Consolidation CC	Outlet 029 discharging with aluminum concentration of 1 27 mg/L, exceeding the limit of 0.75 mg/L. NOV #73 issued.		Abated	
WVDEP	O200706	NOV #1	12/21/2015	Consolidation CC	Contractor pushed coal fines into a perimeter ditch resulting in unallowable discharge to US waters. NOV #1 issued. Contractor to reimburse penalty.		Abated	
WVDEP	O102592	NOV #29	12/30/2015	Consolidation CC	Discharge at Outlet 419 B.O.D was 12 2 mg/L, exceeding the limit of 10 mg/L. NOV #29 issued		Abated	
WVDEP	U003383	NOV #74	1/26/2016	Consolidation CC	Pump failure caused Outlet 005 to discharge water with iron concentration greater than 5 00 mg/L. NOV #74 issued.		Abated	A new pump was installed and discharge from 005 ceased. NOV #74 abated
WVDEP	U010483	IHCO #91	3/23/2016	The Harrison County Coal Co	Freshwater contaminated with dust suppressant flowed into UNT of Bartholomew creek. Foam present Cease discharge Immediately		Abated	Discharge was ceased. New valve was installed on the end of the pipe preventing the occurrence of accidental discharges in the future.
WVDEP	AIR PERMIT	AIR QUALITY 4/7/16	4/7/2016	The Ohio County Coal Co	Failure to inspect facility for asbestos prior to demolition. Failure to notify the WVDEP Division of Air Quality at least ten days prior to demolition.		Abated	Letter has been sent to DAQ. Awaiting response/abatement. DAQ response email no further actions needed
WVDEP	WV0004201	NOV #1	5/3/2016	The Ohio County Coal Co.	Outlet 003 was sampled and lab analysis returned a chloride concentration of 607 mg/L, although the field testing kit showed much less		Withdrawn	Re-run of sample showed a level of 56.9 mg/L, well under permitted limit. It is likely there was a decimal placement error in the original laboratory analysis. Agency withdrawn.
WVDEP	U003383	NOV #75	7/12/2016	The Marshall County Coal Co	Failure to obtain approval to subside tract 3-16-2 prior to mining in excess of 60% extraction within 30° angle of draw of a cemetery		Abated	Abated with submission of legal right to subside tract 3-16-2 and obtained approval from WVDEP.

R05761

TABLE 1.5.3
List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
WVDEP	U010483	NOV #1	7/18/2016	The Harrison County Coal Co	AMD line break caused mine water to flow to an UNT of Quaker Fork Orange staining on ground and creek, some vegetation killed NOV #1 issued		Abated	Permittee has repaired the pipeline break, has regraded, seeded, and mulched the eroded area due to pipeline break. NOV #1 terminated
WVDEP	U003383 / WV0020834	NOV #2	7/22/2016	The Harrison County Coal Co	NOV #2 issued for conditions not allowable in state waters in that seeps from the impoundment were discharging black water into Cunningham Run		Abated	Abated as diversion and sump were installed to collect water and pump water back to the slurry cell. Slurry cell is being pumped down to elimate the source of black water.
WVDEP	O104491	IHCO #5 / NOV #6	7/26/2016	The Marion County Coal Co.	IHCO #5 issued for discharge from Outlet 002 resulting in fish kill in Sugar Run and Paw Paw Creek		Abated	Ponds pumped down to eliminate the source of discharge. IHCO #5 was converted to NOV #6, and NOV #6 was terminated.
WVDEP	WV0004201	NOV #2	8/4/2016	The Ohio County Coal Co.	Brown's run impoundment (Outlet 009) is discharging orange water, field tested to be greater than 10 mg/L. NOV #2 issued		Abated	Installed a control system to control discharging from outlet 009. NOV#2 was terminated
WVDEP	U004684	NOV #40	8/11/2016	The Monongalia County Coal	Failed to maintain sediment capacity in ponds one and two.		Abated	Ponds one and two were cleaned and brought back to sediment capacity.
WVDEP	O104491	NOV #2	9/2/2016	The Marion County Coal Co	NOV #2 issued for high conductivity and chloride seepage from 1st treatment pond at St. leo.		Abated	Fixed sump collection system at St Leo. Conductivity & Chlorides have decreased in the UNT of south fork. NOV #2 abated on 10/3/16
WVDEP	WV1017799	NOV #1	10/24/2016	The Ohio County Coal Co.	NOV 1 issued. Sediment found in Bogg's Run stream and on stream bottom		Abated	
WVDEP	WV0004201	11/01/55	11/1/2016	The Ohio County Coal Co.	Outlet 401 was out of compliance for BOD 5 day		Abated	NOV Abated 12/13/16
WVDEP	U0102392 / WV0020834	NOV #31	1/20/2017	Marshall County Coal Compa	IHCO modified to NOV. Black residue fond in ditch and delta of Fish Creek.		Extended	
WVDEP	U0102392 / WV0020834	NOV #32	1/24/2017	Marshall County Coal Compa	Failed to maintain effluent limitations from outfall 035 blackwater discharging		Abated	
WVDEP	U003383 / WV0020834	NOV 676	1/30/2017	Marshall County Coal Compa	Failed to maintain proper drainage of pond 4 (associated with outlet 017).		Abated	The pipe will be removed and an open channel spillway will be constructed
WVDEP	U007883	NOV #56	2/23/2017	Consolidation CC	Failed to minimize disturbance to prevailing hydrologic balance at mine site and associated off site areas. Harvey 1 impoundment was contributing tp grey black solid material in Harvey Run		Abated	Reduced suspended solids to be within effluent limit.

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TABLE 1.5.3
List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
WVDEP	O102392	NOV #34	3/2/2017	Marshall County Coal Compa	Failed to maintain effluent limit at Conner Run outlet 006		Abated	Stop discharging water non-compliant water out of outlet 006.
WVDEP	O102392	NOV #33	3/15/2017	Marshall County Coal Compa	Failed to maintain hydrologic balance in Conner Run with black water discharging into Conner Run from outlet 035		Abated	Remove black water and residue from Conner Run.
WVDEP	O102591	NOV #56	4/18/2017	The Ohio County Coal Co	Did not meet Effluent limits at outlet 017 TSS was 117mg the limit is 70mg.		Abated	
WVDEP	O102592	NOV# 57	4/18/2017	The Ohio County Coal Co	Did not meet Effluent limits at outlet 017 Total Aluminum was 0.82 mg the limit is 0.75mg.		Abated	
WVDEP	U003383	NOV #77	5/22/2017	Marshall County Coal Compa	A large slip formed below the shaft pad Material from the slip partially blocked the right hand sediment ditchfor 10 feet and completely blocked the ditch for another 10 feet		Abated	Ditch must be cleaned out and slip must be repaired
WVDEP	U003383	NOV #78	5/22/2017	Marshall County Coal Compa	NOV issued for not installing proper sediment control		Abated	
WVDEP	U003383	NOV #79	5/22/2017	Marshall County Coal Compa	NOV issued for not stabilizing slopes to prevent erosion		Abated	
WVDEP		NOV #35	5/23/2017	Marshall County Coal Compa	Sediment left the permitted area and entered a wetland area. 1/4 of the wetland has been impacted		Abated	
WVDEP	O200211	NOV #1	6/1/2017	Marshall County Coal Compa	Permittee failed to certify an approved drainage system, and construction of the sediment pond and drainage ditches prior to the commencement of mining operations		Abated	Submit and obtain approval for the certifications of the drainage and control structure for this permit
WVDEP	O200211	NOV #2	6/1/2017	Marshall County Coal Compa	Permittee failed to monitor the article 3 surface surface water monitoring point DGR. This point was not monitored for Acidity and alkalinity as required by section U-1 of the SMA premit.		Abated	
WVDEP	U004684	NOV #41	6/23/2017	The Monongalia County Coal	Unapproved material on course refuse pile		Abated	
WVDEP	U010483	NOV #92	7/11/2017	The Harrison County Coal Co	TSS score of disharge from sediment pond 001 did not meet the effluent lims.		Abated	
WVDEP	U010483	NOV #93	7/21/2017	The Harrison County Coal Co	Discharge at pond 001 did not meet effluent limits		Abated	
WVDEP	U0102392 / WV0020834	NOV #36	8/3/2017	Marshall County Coal Compa	Failed to maintain effluent limitations from outfall 035 blackwater discharging		Abated	Stop the discharge from outlet 035 and clean the spillway to prevent additional sediment from entering conners run
WVDEP	U007083 / WV0038288	NOV #44	8/3/2017	Arkwright	Failure to maintain hydrologic Balance in Little Indian Creek located north of pump #24		Abated	Pump must be repaired before operations can continue

R05763

TABLE 1.5.3
List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
WVDEP	U0102392 / WV0020834	NOV #36	8/22/2017	Marshall County Coal Compa	failed to submit a certification for the quarterly inspection of the ireland refuse area for the 2nd QTR of 2017		Terminated	
WVDEP	U004684	NOV #42	8/23/2017	The Monongalia County Coal	Coal slurry leaked into WV fork of Dunkard Creek from outlet 002. water with suspended solids overtopped the thickener tank and exited the permit via a storm drain and eventually discharged into the ohio river without passing through an approved sediment control system.		Terminated	
WVDEP	U003383 / WV0020834	NOV #80	8/30/2017	Marshall County Coal Compa			Terminated	Provide report detailing what parts of the system failed and repair all faulty parts.

R05764

TABLE 1.5.4
Violation History for Surface Coal Mining Operations Owned/Controlled by Applicant

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions

R05765

PART I ATTACHMENT I.10.A
AFFIDAVIT OF LEGAL RIGHT TO ENTER

Attachment I.10.A

(I) (~~We~~) Mark Schuerger under penalties of perjury declare on behalf of the applicant,
(Individual or Individuals)

Williamson Energy, LLC that said applicant has valid documents which bestow upon the applicant a legal right to enter and commence surface coal mining and reclamation operations upon lands contained in the proposed permit area, and such legal right is not in any way the subject of pending court litigation.

Dated this 13 day of July, 2018.

Signature

Authorized Person
Title

Sworn to and subscribed before me

this 13 day of July, 2018.

Notary Public

OFFICIAL SEAL
STACI R LOWRY
Notary Public - State of Illinois
My Commission Expires Jan 14, 2019

My commission expires: Jan 14, 2019

PART I ATTACHMENT I.10.B
ENGINEERING CERTIFICATION

ENGINEERING CERTIFICATION

I hereby certify the engineering design used in preparation of this application, attachments, and supplements were done by me or under my direct supervision.

I certify that I am familiar with all of the plans, specifications, reports, and maps submitted as part of this application and that said information is accurate.

I certify to the best of my knowledge all such design is in accordance with all applicable local, state and federal laws, rules and regulations.

I further certify that all applicable maps and/or drawings have been individually sealed in accordance with the Professional Engineering Act, 225 ILCS 325/15.

INDIVIDUAL P.E. CERTIFICATION

Claudio E. Yon	062-050632
Name	**Illinois Registration Number (Seal)**
Alliance Consulting, Inc.	
Firm	
124 Philpott Lane,	
Beaver, WV 25813	
Address	**Signature**
304-255-0491	6/21/18
Phone Number	**Date**

CLAUDIO ELI YON
062-050632
LICENSED
PROFESSIONAL
ENGINEER
STATE OF ILLINOIS

PROFESSIONAL DESIGN FIRM CERTIFICATION

Complete if applicable. If not, respond N/A.

☒ As an employee of a "professional design firm" as defined by the Illinois Department of Financial and Professional Regulation, I certify that the professional design firm is registered and in good standing with the Illinois Department of Financial and Professional Regulation.

Alliance Consulting of West Virginia, Inc.	184.006236
Professional Design Firm Name	**Professional Design Firm Number**

PART I ATTACHMENT I.10.C
CERTIFICATES OF LIABILITY INSURANCE

ACORD

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY): 05/31/2018

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must have ADDITIONAL INSURED provisions or be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER	CONTACT NAME: Karen Williams	
Reschini Agency, Inc. 922 Philadelphia Street P.O. Box 449 Indiana PA 15701	PHONE (A/C, No, Ext): (724)349-1300 FAX (A/C, No): (724)349-1446 E-MAIL ADDRESS: kwilliams@reschini.com	
	INSURER(S) AFFORDING COVERAGE	NAIC #
	INSURER A : Certain Underwriters at Lloyds (Apollo Liab Consortium)	AA-1120106
INSURED Foresight Energy, LLC; Williamson Energy, LLC Murray Energy Corporation 46226 National Road St. Clairsville OH 43950	INSURER B :	
	INSURER C :	
	INSURER D :	
	INSURER E :	
	INSURER F :	

COVERAGES CERTIFICATE NUMBER: 18 Foresight/Williamson REVISION NUMBER:

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSD	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
A	[X] COMMERCIAL GENERAL LIABILITY [ ] CLAIMS-MADE [X] OCCUR GEN'L AGGREGATE LIMIT APPLIES PER: [ ] POLICY [X] PRO-JECT [X] LOC [ ] OTHER:			PC304000M	06/01/2018	06/01/2019	EACH OCCURRENCE	$ 1,000,000
							DAMAGE TO RENTED PREMISES (Ea occurrence)	$ 1,000,000
							MED EXP (Any one person)	$ 10,000
							PERSONAL & ADV INJURY	$ 1,000,000
							GENERAL AGGREGATE	$ 2,000,000
							PRODUCTS - COMP/OP AGG	$ 2,000,000
								$
	AUTOMOBILE LIABILITY [ ] ANY AUTO [ ] OWNED AUTOS ONLY [ ] SCHEDULED AUTOS [ ] HIRED AUTOS ONLY [ ] NON-OWNED AUTOS ONLY						COMBINED SINGLE LIMIT (Ea accident)	$
							BODILY INJURY (Per person)	$
							BODILY INJURY (Per accident)	$
							PROPERTY DAMAGE (Per accident)	$
								$
	[ ] UMBRELLA LIAB [ ] OCCUR [ ] EXCESS LIAB [ ] CLAIMS-MADE [ ] DED [ ] RETENTION $						EACH OCCURRENCE	$
							AGGREGATE	$
								$
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? (Mandatory in NH) Y/N [ ] If yes, describe under DESCRIPTION OF OPERATIONS below	N/A						[ ] PER STATUTE [ ] OTH-ER	
							E.L. EACH ACCIDENT	$
							E.L. DISEASE - EA EMPLOYEE	$
							E.L. DISEASE - POLICY LIMIT	$

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)

Coverage for blasting subsidence is included in the above referenced policy.

CERTIFICATE HOLDER

IL Dept of Natural Resources Land Reclamation Div
Office of Mines & Minerals
One Natural Resources Way
Springfield IL 62702-1273

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE

Karen Williams

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PART I ATTACHMENT I.12.B.4
HIGHWAY AUTHORITY AGREEMENTS

Attachment I.12.B.4

The two attached utility permits from the Illinois Department of Transportation were granted to Adena Resources, LLC, which is a land/utility company for Foresight Energy, LLC.

Adena Resources, LLC and Williamson Energy, LLC are subsidiaries of Foresight Energy, LLC. Adena Resources provides support services to mining companies operating under Foresight Energy, such as Williamson Energy.

WILLIAMSON COUNTY HIGHWAY DEPARTMENT AGREEMENT

Williamson Energy, LLC
PO Box 99
Johnston City, Illinois 62959
Office: 618-983-3020 Fax: 618-983-3017

January 26, 2017

Gregory S. Smothers, County Engineering
County of Williamson, State of Illinois
1817 North Court Street
Marion, Illinois 62959

RE: County Highway Permit To Install Waterlines
Dated 18th day of January, 2017 ("Permit")
By and Between:
Williamson Energy LLC ("Williamson Energy"), and,
Williamson County Highway Department ("County Highway Department")
(collectively the "Parties")

Dear Mr. Smothers and County Officials:

Pursuant to the subject referenced Permit, Williamson Energy and the County Highway Department desire to reach further mutual understanding and agreement corresponding to certain matters set forth therein. Accordingly, and Parties desire to enter into this Letter Agreement to amend said Permit as follows.

For and in consideration of the mutual benefits to be derived herefrom, Williamson Energy and County Highway Department amend the Permit as follows:

1. Page 2, 1st Paragraph reads as follows:
"It is anticipated that these utilities will be operated for a period of up to 10 years from the date of this permit. Once these utilizes are no longer being used, it is anticipated that they will be removed from the roadway right of ways within the following year."

   The Parties hereby amend Page 2, 1st Paragraph to read as follows:
"The term of the Permit shall be in force and have effect for a period of 10 years from the date of this Permit, and as long thereafter as mining operations continue to be conducted by Williamson Energy, its successor and assigns, under IDNR Permit #375. Upon termination and abandonment of the utilities operated by Williamson Energy under the Permit; Williamson Energy shall either remove its utilities, or alternatively, transfers and assigns to the County Highway Department all rights, title and interest in and to the utilities to the County Highway Department corresponding to only those areas said County owns in and to its rights of ways under the Permit, as directed by the County Highway Department."

2. Page 3, Item No. 10. reads as follows:
"A performance bond in the amount of $150,000 will be kept on file with the Williamson County Highway Department throughout the life of the installation and operation activities of these permitted utilities. Once the utilities are abandoned and removed, the bond will be returned to Williamson Energy."

The Parties hereby amend Page 3, Item No. 10. to read as follows:
The Parties hereby state that the performance bond in the amount of $150,000.00 under that certain agreement titled, ***Agreement Between the County of Williamson, State of Illinois and Williamson Energy LLC Authorizing Subsidence of County Roads and Highways by Williamson Energy, LLC****, dated the 22nd day of January, 2008, shall be held by the County Highway Department for the life of the installation and operations activities of the Permit.*

Williamson Energy and the County Highway Department acknowledge that the Permit is currently in effect, and, except as amended herein, that the Permit shall remain in full force and effect according to its terms.

Williamson Energy greatly appreciates your continued cooperation with respects to all matters to satisfy this undertaking.

Thank you.

Very truly yours,
WILLIAMSON ENERGY, LLC

encl.

By: Lu M. Landon

Its: Authorized Person

Acknowledged and Agreed to by:

Gregory S. Smothers

Its: County Engineer, Williamson County Highway Department

GREGORY S. SMOTHERS
COUNTY ENGINEER

SCOTT BARGER
DESIGN ENGINEER

YVONNE RICHERT
OFFICE MANAGER

WILLIAMSON COUNTY
HIGHWAY DEPARTMENT
MARION, ILLINOIS 62959

1817 NORTH COURT ST.
MARION, ILLINOIS 62959

TELEPHONE 618-998-2145

COUNTY HIGHWAY PERMIT TO INSTALL WATERLINES

WHEREAS, **Williamson Energy**, has requested permission to construct/install and operate a new 18" - 24" water line across **Liberty School Road, (TR 548), Williams Prairie Road (TR 550), Harris School Road (TR 556), Old Ben Road (TR 340), Old Frankfort Road (TR 344), Eberhardt Road (TR 041), Duncan Road (TR 334), Monroe Road (TR 332) and Collins Road (TR 318)** in Williamson County which is subject to the jurisdiction and authority of said County and its officers.

WHEREAS, the proposed construction consists of installation of new 18" - 24" waterline to be placed along and/or under the following roadway under jurisdiction of the Williamson County Highway Department **Liberty School Rd, Williams Prairie Rd, Harris School Rd, Old Ben Rd, Old Frankfort Rd, Eberhardt Rd, Duncan Rd, Monroe Rd and Collins Rd in Williamson County**

The locations are as follows:

- **Site 1** – Liberty School Road in the SW¼ of the SW¼ of Section 12, T8S, R3E (Lake Creek Township) and the SE¼ of the SE¼ of Section 11, T8S, R3E (Lake Creek Township)
  - Proposed Road Bore
- **Site 2** – Williams Prairie Road in the NE¼ of the NW¼ of Section 14, T8S, R3E (Lake Creek Township)
  - Proposed Road Bore
- **Site 3** – Harris School Road in the NW¼ of the NW¼ of Section 15, T8S, R3E (Lake Creek Township) and the NE¼ of the NE¼ of Section 16, T8S, R3E (Lake Creek Township)
  - Proposed Road Bore
- **Site 4** – Old Ben Road in the NW¼ of the NE¼ of Section 17, T8S, R3E (Lake Creek Township)
  - Proposed Road Bore
- **Site 5** – Old Frankfurt Road in the NE¼ of the NW¼ of Section 17, T8S, R3E (Lake Creek Township)
  - Proposed Road Bore
- **Site 6** – Eberhardt Road in the SE¼ of the SW¼ of Section 8, T8S, R3E (Lake Creek Township)
  - Proposed Road Bore

- **Site 7** – Duncan Road in the NE¼ of the SW¼ of Section 7, T8S, R3E (Lake Creek Township)
    - Proposed Road Bore
- **Site 8** – Monroe Road in the NW¼ of the SW¼ of Section 7, T8S, R3E (Lake Creek Township)
    - Proposed Road Bore
- **Site 9** – Collins Road in the NW¼ of the SW¼ of Section 1, T8S, R2E (Herrin Township) and the NE¼ of the SE¼ of Section 2, T8S, R2E (Herrin Township)
    - Proposed Road Bore

It is anticipated that these utilities will be operated for a period of up to 10 years from the date of this permit. Once these utilizes are no longer being used, it is anticipated that they will be removed from the roadway right of ways within the following year.

THEREFORE, be it permitted and granted by the County Engineer of Williamson County, Illinois, that permission be granted to proceed with said construction and operations, subject to the following conditions:

1. That the petitioner shall furnish all materials, do all work and pay all costs of such work.

2. That one-way traffic be maintained during the period of construction and adequate protection for the safety of the public be provided. This includes all necessary signing, flagmen or other traffic control.

3. That the petitioner or his assigns shall assume all risks and liability for accidents and damages that may occur to persons or property on account of said work and utilities.

4. That this permit is effective insofar only as the County has jurisdiction and does not presume to release the petitioner from compliance with the provisions of any existing statute relative to the work involved.

5. That the said work shall be constructed to the satisfaction of the County Engineer.

6. That the work shall be performed so as not to permanently impair the existing road, and that any damage to the said road that might be done during the time of construction shall be repaired to the satisfaction of the County Engineer.

7. That the water line shall be a minimum of four (4) feet below the present grade of the road and four (4) feet below the existing ground line if located outside of the roadbed but within the R.O.W.

8. That the water line shall be relocated at no expense to the County if such a move is needed for future maintenance or construction work on the subject road.

9. Crossings under all nine of the roadway crossings must be made utilizing directional bore and the waterline must be encased in steel conduit.

10. A performance bond in the amount of **$150,000** will be kept on file with the Williamson County Highway Department throughout the life of the installation and operation activities of these permitted utilities. Once the utilities are abandoned and removed, the bond will be returned to Williamson Energy.

11. All trenching or open cuts made within county right of way must be repaired/restored to its prior condition or better. This includes but is not limited to restoring damage to any drainage ways, entrances, roads, signs, shoulders, slopes, culverts, silting, as well as seeding and mulching these disturbed areas to restore proper ground cover.

12. Care must be taken to prevent damage to drainage structures/pipes resulting from trenching or direct boring operations. Open cuts must be a narrow as possible (no greater than 2') to limit damages to surrounding features.

13. Any future damages to these roads resulting from the operation of these utilities on the right of ways will be the responsibility of Williamson Energy to repair to restore the roadway to its previous condition.

PERMIT REQUESTED BY: _____
Williamson Energy, LLC

IN WITNESS WHEREOF, I have hereunto set my hand and seal as the County Engineer of Williamson County, Illinois, this 18TH day of January, 2017

Gregory S. Smothers
County Engineer
Williamson County Highway Dept.

FRANKLIN COUNTY HIGHWAY DEPARTMENT AGREEMENT

PETITION

WHEREAS, Williamson Energy, LLC , in the County of Franklin and State of Illinois, their successors and assigns, under the laws of the State of Illinois hereinafter termed "The Petitioner" request permission and authority to locate, construct, operate and maintain a water management pipeline on and across Franklin County Right-of-Way in Franklin County, State of Illinois, described as follows:

- **A 22" HDPE DR13.5 water management pipeline to be installed across Freeman Spur Blacktop and Freeman Spur Road.**

WHEREAS, it is understood that the cost of construction, location, operation and maintaining of said water management pipeline will be borne by the Petitioner.

NOW THEREFORE BE IT RESOLVED, by the Franklin County Engineer, who is authorized to grant said Petitioner, their successors and assigns, permission and authority to locate, construct, operate and maintain a water management pipeline on and across the roads on Franklin County Right-of-Way, in accordance with Section 561 of the "Standard Specifications for Road and Bridge Construction" adopted January 1, 2016. This permission is given accordingly to the stipulations set forth by the County Board to all utilities, subject to the following conditions and restrictions:

FIRST: That said water management pipeline be located as close to the R.O.W. lines as conditions will permit, it being understood that the location and construction of said water management pipeline shall be satisfactory to the Franklin County Engineer.

SECOND: That said Petitioner shall assume all risks and liabilities for accidents and damages that may accrue to persons or property during the prosecution of the work and at

any time during the life of the working permit by reasons of the locations, construction, operation or maintenance of said water management pipeline.

THIRD: That should it be necessary to damage any roads in Franklin County mentioned above, then the said Petitioner shall make such repairs to the road and will restore substantially to the same condition as it was formerly, or pay to the County the actual cost of repairs for damages done to the roads, it being understood that this repair work will be satisfactory to the Franklin County Engineer.

FOURTH: That if it be necessary to relocate or adjust said water management pipeline due to road improvements; said Petitioner shall relocate the water management pipeline promptly at the expense of the Petitioner.

FIFTH: It is specified that a working permit substantially in the form set forth in "Exhibit A" attached and made a part hereof be issued for each individual installation and must bear the approval of the Franklin County Engineer. Working Permit shall be signed by the Superintendent of Williamson Energy, LLC.

SIXTH: All water management pipeline road crossings shall be installed by the simultaneous boring and jacking methods with protective casing and no open trenches will be allowed. The length of the casing should go from ditchline to ditchline.

SEVENTH: When final inspection of work is made by the Petitioner and the Contractor, the Franklin County Engineer shall be notified of the time and place of final inspection, so that they can go along to make sure all items of work pertaining to the County can be inspected and approved by said Franklin County Engineer.

EIGHTH: Petitioner shall be a member of J.U.L.I.E.

NINTH: That one-ay traffic be maintained during the period of construction when possible and adequate protection for the safety of the traveling public be maintained at all times. IDOT Local Road traffic standards shall be used if road closures are necessary.

TENTH: It being understood that this permission is given only insofar as the Franklin County Engineer have jurisdiction over said County Roads.

Permission is hereby granted this 7th day of March, 2018

Franklin County Engineer

ACCEPTED:

Williamson Energy. LLC. - Authorized Person

EXHIBIT "A"

Work Permit

Williamson Energy, LLC, Johnson City, ILLINOIS

February 5, 2018

Mr. Mike Rolla, Franklin County Engineer

Dear Sir:

Subject to the conditions and restrictions of the petition granted by the Franklin County Engineer dated March 7, 2018 permission is hereby requested to perform the following work on Franklin County Highway Right-of-Way.

To locate, construct, operate and maintain a water management pipeline across the above mentioned road.

Work to be started about June 1st, 2018.

Williamson Energy, LLC. - Authorized Person

Pennission given this 7th Day of March, 2018, on condition that the work be completed within 90 days of permit issuance by IDNR; otherwise the permit becomes null and void.

Franklin County Engineer

ILLINOIS DEPARTMENT OF TRANSPORTATION

The following IDOT permits are provided as information only. These permits were good for 180 days from the approval date of February 22, 2017. Therefore, these permits have expired.

Upon approval of Application 456 and prior to any construction for boring beneath State Route 37 and Interstate 57, valid IDOT permits will be renewed and copies will be submitted to the Department.

ILLINOIS DEPARTMENT OF TRANSPORTATION
INTERSTATE 57 UTILITY PERMIT &
STATE ROUTE 37 UTILITY PERMIT

R05787

Illinois Department of Transportation

Utility Permit

Public Improvement ☐ Yes ☒ No
IDOT Permit No. 9U-Z609-17
Utility Reference No. _____

I (We) Adena Resources, LLC (Name of Applicant) . PO Box 99 (Mailing Address)

Johnston City (City) . Il (State & Zip) . hereinafter termed the Permittee,

request permission and authority to occupy, and to do certain work herein described on, the right-of-way of the State highway

known as FAI 57(Interstate 57) . Section (X1-4) 1 T8S R2E .

from 36+31 to _____ in Williamson County.

The work is described in detail below and/or on the attached sketch or plans.

Jack and Bore 22" diameter casing with 18" diameter HDPE SDR-17 carrying pipe (non-potable water) under FAI Route 57 at or near station in Williamson County. Location is approximately 2.4 miles north of the Johnston City interchange (Exit 59).
Proposed installation shall be shown on the attached Plan and Profile detail.
Access from through travel lanes for installing or servicint of utility facilities will not be allowed.
Applicant will utilize a Licensed Professional Engineer to ensure the proper placement and construction of the proposed water main.

This permit covers the operation and presence of specified equipment, material or facility on the right-of-way that may be related to the authorized work. A copy of this permit must be present when crews or equipment occupy highway right-of way. Failure to comply may result in the cessation of all construction.

This permit is subject to conditions and restrictions of Part 530 of Title 92 of the Illinois Administrative Code, Accommodation of Utilities on Right-of-Way of the Illinois State Highway System. The removal, relocation or modification of facilities permitted to occupy the right-of-way is governed by Section 9-113 of the Illinois Highway Code, as amended by Public Act 92-0470. The Permittee agrees to comply with the requirements of these laws and with all terms and conditions established by this permit. This permit is subject to revocation by the Department on violation of the terms and conditions governing its use.

_____ 2/15/17
Signature of Agent for Permittee — Date

INFORMATION ONLY

Adena Resources, LLC
Name of Permittee (Print or Type)

PO Box 99
Mailing Address

Johnston City (City) Il (State) 62951 (Zip)

The work authorized by this permit shall be completed by _____ or within 180 days after the date of approval by the Department, otherwise the permit will be considered null and void.

Public Improvement Projects only: The anticipated letting date is _____

This permit allowing occupancy and work on state right-of-way is approved. The Utility Coordination Council established by the Department in the area covered by this permit is _____

Jeffrey L Keirn
Department of Transportation — 2/22/17 Date

Printed 2/14/2017

OPER 1113 (Rev. 08/07)

This permit is subject to the conditions and restrictions established in accordance with the Illinois Highway Code and Part 530 of Title 92 of the Illinois Administrative Code including but not limited to the following:

(1) The applicant represents all parties in interest and shall furnish material, do all work, pay all costs and shall in a reasonable length of time restore the damaged portions of the highway to a condition similar or equal to that existing before the commencement of the described work, including any landscape restoration necessary. (See Section 530.250 of Title 92).

(2) The proposed work shall be located and constructed to the satisfaction of the Regional Engineer or his duly authorized representative. No revisions or additions shall be made to the proposed work on the right-of-way without the written permission of the Regional Engineer or his duly authorized representative (See Section 530.200 of Title 92). In certain circumstances the Department may require that the construction plans and/or the as-built documents be sealed by an Illinois Registered Professional Engineer. Typical of such projects would be petroleum or gas pipelines.

(3) The applicant shall at all times conduct the work in such a manner as to minimize hazards to vehicular and pedestrian traffic. All signs, barricades, flaggers, etc., required for traffic control shall be furnished by the applicant. (See Section 530.240 of Title 92).

(4) The applicant must ascertain the presence of Highway Authority Agreements established in accordance with 35 Ill. Admin. Code Section 742.1020 in the path of its proposed installation and take precautions to protect its workers, human health and the environment in those areas. (See Section 530.240 of Title 92). Where contamination is encountered through excavation in the ROW, it should be managed offsite and IDOT's generator number for the appropriate county may be used.

(5) The applicant shall not trim, cut or in any way disturb any trees or shrubbery along the highway without the approval of the Regional Engineer or his duly authorized representative. (See Section 530.600 of Title 92).

(6) The facilities authorized to occupy the right-of-way by this permit are subject to removal, relocation or modification by the permittee at no expense to the State on notice given by the Department in accordance with Section 9-113 of the Illinois Highway Code, as amended. Participation by the permittee in the UTILITY Coordination Council identified on page one of this permit is required as a condition of this permit. Permittee shall cooperate with the Department with the scheduling of any removal, relocation or modification deemed necessary for highway or highway safety purposes, and, if Utility Coordination Council participation is required by this permit, with the activities of the council identified on the first page of this permit. (See Section 9-113 of the Illinois Highway Code.) Use of and compliance with current IDOT Traffic Control Standards will be required.

(7) If the applicant and the District cannot agree either on whether the permit should be issued or on what conditions would be appropriate, the applicant may, within 30 days of the issuance of written notice of the District's position, appeal the District's determination to the Chief of the Department's Central Bureau of Operations. (See Section 530.900 of Title 92).

(8) The permittee agrees to fully comply with the following legal obligations in advance of entering and while upon any Right-of-way within the Illinois State Highway System.

a) Only a permit issued by the Department under this Part will satisfy the "written consent" requirement of Section 9-113 of the Illinois Highway Code (the Code).
b) A permit from the Department grants a license only to undertake certain activities in accordance with this Part on a State right-of-way, and does not create a property right or grant authority to the permittee to impinge on the rights of others who may have an interest in the right-of-way. Such others might include an owner of an underlying fee simple interest if the right-of-way is owned as an easement or dedication of right of way, an owner of an easement, or another permittee.
c) It shall be the responsibility of the permittee to ascertain the presence and location of existing above-ground or underground facilities on the highway right-of-way to be occupied by their proposed facilities. The Department will make its permit records available to a permittee for the purpose of identifying possible facilities. When notified of an excavation or when requested by the Department, a permittee shall locate, physically mark, and indicate the depth of its underground facilities within 48 hours excluding weekends and holidays.
d) The permittee shall avoid conflicts with any existing underground or above-ground facilities on or near the highway right-of-way. Both the Department and J.U.L.I.E. are to be contacted for assistance during the application process.
e) The permittee shall comply with all other applicable laws relating to the placement of utility lines.
f) The issuance of a utility permit by the Department does not excuse the permittee from complying with any existing statutes, local regulations or requirements of other Department (e.g., oversize and overweight vehicles) or the requirements of other State agencies including, but not limited to, the following:

Illinois Commerce Commission, Illinois Department of Agriculture
Illinois Department of Natural Resources, Illinois Department of Mines and Minerals
Illinois Environmental Protection Agency, Illinois Historic Preservation Agency

g) Rights of abutting and underlying property owners are protected by common law and Sections 9-113 and 9-127 of the Code. The permittee will address these rights prior to initiating activities on State right-of-way. The Department will not be a party in any negotiations between the utility and abutting property owners.
h) In no case shall the permit give or be construed to give an entity any easement, leasehold or other property interest of any kind in, upon, under, above or along the State highway right-of-way.
i) Each person responsible for a utility, in place on the effective date of this Part, on a State highway right-of-way shall notify the Department in writing, if that facility does not comply with this Part. The Department shall treat such a notice as a request for a variance under Section 530.130. Until informed that a variance will not be granted, a person responsible for a pre-existing utility will not be in violation of this Part. The failure to provide such notice constitutes a violation of this Part and of the utility accommodation permit (if any) and would justify the imposition of the sanctions set forth in Section 530.810.

Work to be coordinated with Department Representatives:

_____ Phone ( )_____

_____ Phone ( )_____

Utility Contact Person: _____ Phone ( )_____

Work to be done by:

Contractor: _____

Daytime Phone: ( )_____ Emergency Phone: ( )_____

Traffic control operation:

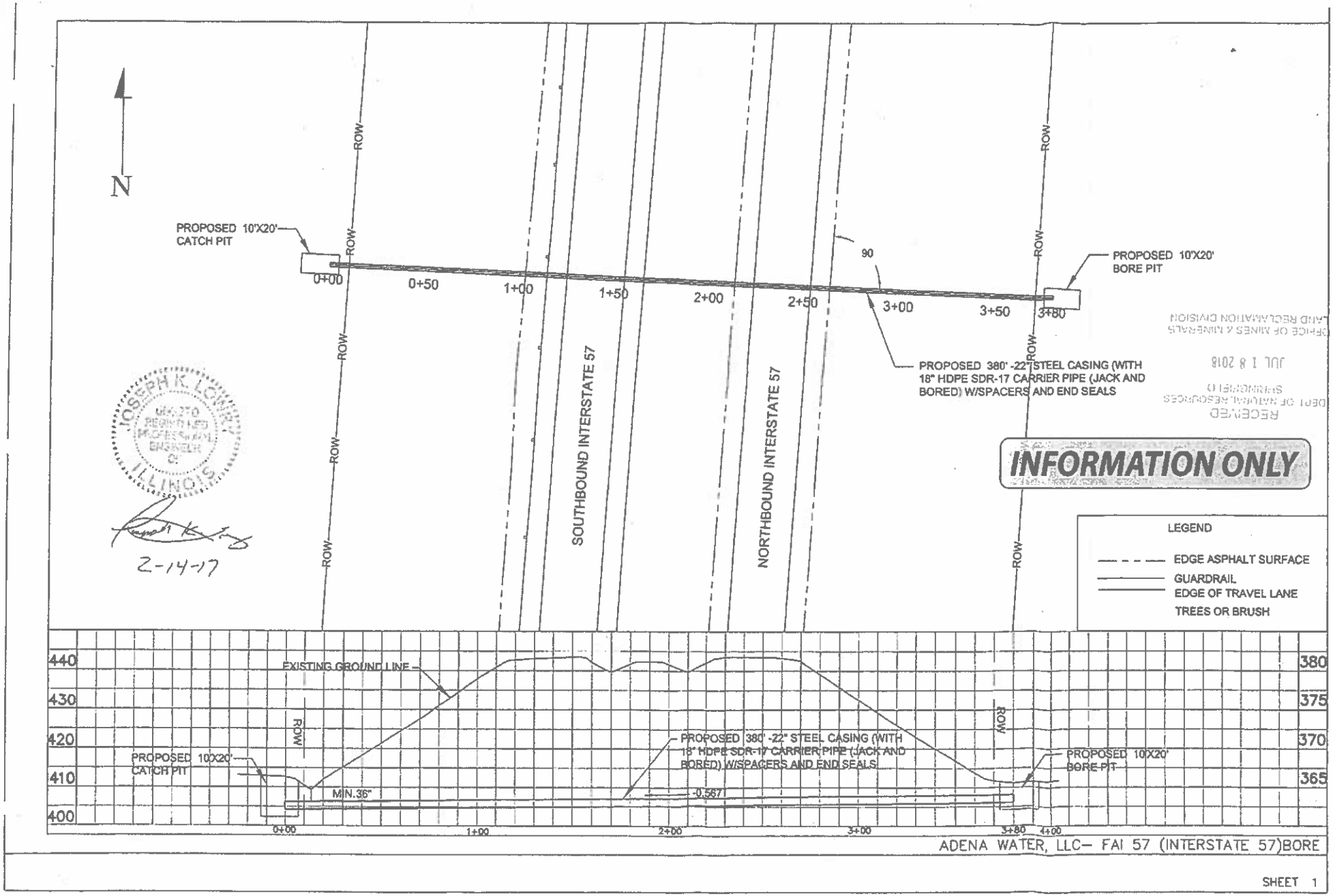
Number of lane closures: _____ Time of closures: _____

INFORMATION ONLY

Printed 2/14/2017

OPER 1113 (Rev. 08/07)

R05789



RECEIVED
DEPT OF NATURAL RESOURCES
SPRINGFIELD
JUL 18 2018
OFFICE OF MINES & MINERALS
LAND RECLAMATION DIVISION

ADENA WATER, LLC– FAI 57 (INTERSTATE 57)BORE

SHEET 1

R05790

Illinois Department of Transportation

Utility Permit

Public Improvement ☐ Yes ☒ No
IDOT Permit No. 9U-2610-17
Utility Reference No. _____

I (We) Adena Resources, LLC (Name of Applicant) . PO Box 99 (Mailing Address)

Johnston City (City) . Il (State & Zip) . hereinafter termed the Permittee,

request permission and authority to occupy, and to do certain work herein described on, the right-of-way of the State highway

known as State Rte 37 (SBI 37) . Section (12) 12 T8S R2E .

from 519+55 to _____ in Williamson County.

The work is described in detail below and/or on the attached sketch or plans.

Jack and Bore 22" diameter casing with 18" diameter HDPE SDR-17 carrying pipe (non-potable water) under State Route 37 at or near station in Williamson County. Location is approximately 2.4 miles north of the Johnston City interchange (Exit 59).. Proposed installation shall be shown on the attached Plan and Profile detail.
Access from through travel lanes for installing or servicint of utility facilities will not be allowed.
Applicant will utilize a Licensed Professional Engineer to ensure the proper placement and construction of the proposed water main.

This permit covers the operation and presence of specified equipment, material or facility on the right-of-way that may be related to the authorized work. A copy of this permit must be present when crews or equipment occupy highway right-of way. Failure to comply may result in the cessation of all construction.

This permit is subject to conditions and restrictions of Part 530 of Title 92 of the Illinois Administrative Code, Accommodation of Utilities on Right-of-Way of the Illinois State Highway System. The removal, relocation or modification of facilities permitted to occupy the right-of-way is governed by Section 9-113 of the Illinois Highway Code, as amended by Public Act 92-0470. The Permittee agrees to comply with the requirements of these laws and with all terms and conditions established by this permit. This permit is subject to revocation by the Department on violation of the terms and conditions governing its use.

_____ 2/15/17
Signature of Agent for Permittee — Date

INFORMATION ONLY

Adena Resources, LLC
Name of Permittee (Print or Type)

PO Box 99
Mailing Address

Johnston City (City) Il (State) 62951 (Zip)

The work authorized by this permit shall be completed by _____ or within 180 days after the date of approval by the Department, otherwise the permit will be considered null and void.

Public Improvement Projects only: The anticipated letting date is _____

This permit allowing occupancy and work on state right-of-way is approved. The Utility Coordination Council established by the Department in the area covered by this permit is _____

Jeffrey L. Keirn — Department of Transportation — 2/22/17 — Date

Printed 2/15/2017

OPER 1113 (Rev. 08/07)

This permit is subject to the conditions and restrictions established in accordance with the Illinois Highway Code and Part 530 of Title 92 of the Illinois Administrative Code including but not limited to the following:

(1) The applicant represents all parties in interest and shall furnish material, do all work, pay all costs and shall in a reasonable length of time restore the damaged portions of the highway to a condition similar or equal to that existing before the commencement of the described work, including any landscape restoration necessary. (See Section 530.250 of Title 92).

(2) The proposed work shall be located and constructed to the satisfaction of the Regional Engineer or his duly authorized representative. No revisions or additions shall be made to the proposed work on the right-of-way without the written permission of the Regional Engineer or his duly authorized representative (See Section 530.200 of Title 92). In certain circumstances the Department may require that the construction plans and/or the as-built documents be sealed by an Illinois Registered Professional Engineer. Typical of such projects would be petroleum or gas pipelines.

(3) The applicant shall at all times conduct the work in such a manner as to minimize hazards to vehicular and pedestrian traffic. All signs, barricades, flaggers, etc., required for traffic control shall be furnished by the applicant. (See Section 530.240 of Title 92).

(4) The applicant must ascertain the presence of Highway Authority Agreements established in accordance with 35 Ill. Admin. Code Section 742.1020 in the path of its proposed installation and take precautions to protect its workers, human health and the environment in those areas. (See Section 530.240 of Title 92). Where contamination is encountered through excavation in the ROW, it should be managed offsite and IDOT's generator number for the appropriate county may be used.

(5) The applicant shall not trim, cut or in any way disturb any trees or shrubbery along the highway without the approval of the Regional Engineer or his duly authorized representative. (See Section 530.600 of Title 92).

(6) The facilities authorized to occupy the right-of-way by this permit are subject to removal, relocation or modification by the permittee at no expense to the State on notice given by the Department in accordance with Section 9-113 of the Illinois Highway Code, as amended. Participation by the permittee in the UTILITY Coordination Council identified on page one of this permit is required as a condition of this permit. Permittee shall cooperate with the Department with the scheduling of any removal, relocation or modification deemed necessary for highway or highway safety purposes, and, if Utility Coordination Council participation is required by this permit, with the activities of the council identified on the first page of this permit. (See Section 9-113 of the Illinois Highway Code.) Use of and compliance with current IDOT Traffic Control Standards will be required.

(7) If the applicant and the District cannot agree either on whether the permit should be issued or on what conditions would be appropriate, the applicant may, within 30 days of the issuance of written notice of the District's position, appeal the District's determination to the Chief of the Department's Central Bureau of Operations. (See Section 530.900 of Title 92).

(8) The permittee agrees to fully comply with the following legal obligations in advance of entering and while upon any Right-of-way within the Illinois State Highway System.

a) Only a permit issued by the Department under this Part will satisfy the "written consent" requirement of Section 9-113 of the Illinois Highway Code (the Code).
b) A permit from the Department grants a license only to undertake certain activities in accordance with this Part on a State right-of-way, and does not create a property right or grant authority to the permittee to impinge on the rights of others who may have an interest in the right-of-way. Such others might include an owner of an underlying fee simple interest if the right-of-way is owned as an easement or dedication of right of way, an owner of an easement, or another permittee.
c) It shall be the responsibility of the permittee to ascertain the presence and location of existing above-ground or underground facilities on the highway right-of-way to be occupied by their proposed facilities. The Department will make its permit records available to a permittee for the purpose of identifying possible facilities. When notified of an excavation or when requested by the Department, a permittee shall locate, physically mark, and indicate the depth of its underground facilities within 48 hours excluding weekends and holidays.
d) The permittee shall avoid conflicts with any existing underground or above-ground facilities on or near the highway right-of-way. Both the Department and J.U.L.I.E. are to be contacted for assistance during the application process.
e) The permittee shall comply with all other applicable laws relating to the placement of utility lines.
f) The issuance of a utility permit by the Department does not excuse the permittee from complying with any existing statutes, local regulations or requirements of other Department (e.g., oversize and overweight vehicles) or the requirements of other State agencies including, but not limited to, the following:

Illinois Commerce Commission, Illinois Department of Agriculture
Illinois Department of Natural Resources, Illinois Department of Mines and Minerals
Illinois Environmental Protection Agency, Illinois Historic Preservation Agency

g) Rights of abutting and underlying property owners are protected by common law and Sections 9-113 and 9-127 of the Code. The permittee will address these rights prior to initiating activities on State right-of-way. The Department will not be a party in any negotiations between the utility and abutting property owners.
h) In no case shall the permit give or be construed to give an entity any easement, leasehold or other property interest of any kind in, upon, under, above or along the State highway right-of-way.
i) Each person responsible for a utility, in place on the effective date of this Part, on a State highway right-of-way shall notify the Department in writing, if that facility does not comply with this Part. The Department shall treat such a notice as a request for a variance under Section 530.130. Until informed that a variance will not be granted, a person responsible for a pre-existing utility will not be in violation of this Part. The failure to provide such notice constitutes a violation of this Part and of the utility accommodation permit (if any) and would justify the imposition of the sanctions set forth in Section 530.810.

Work to be coordinated with Department Representatives:

_____ Phone ( )_____

_____ Phone ( )_____

Utility Contact Person: _____ Phone ( )_____

Work to be done by:

Contractor: _____

Daytime Phone: ( )_____ Emergency Phone: ( )_____

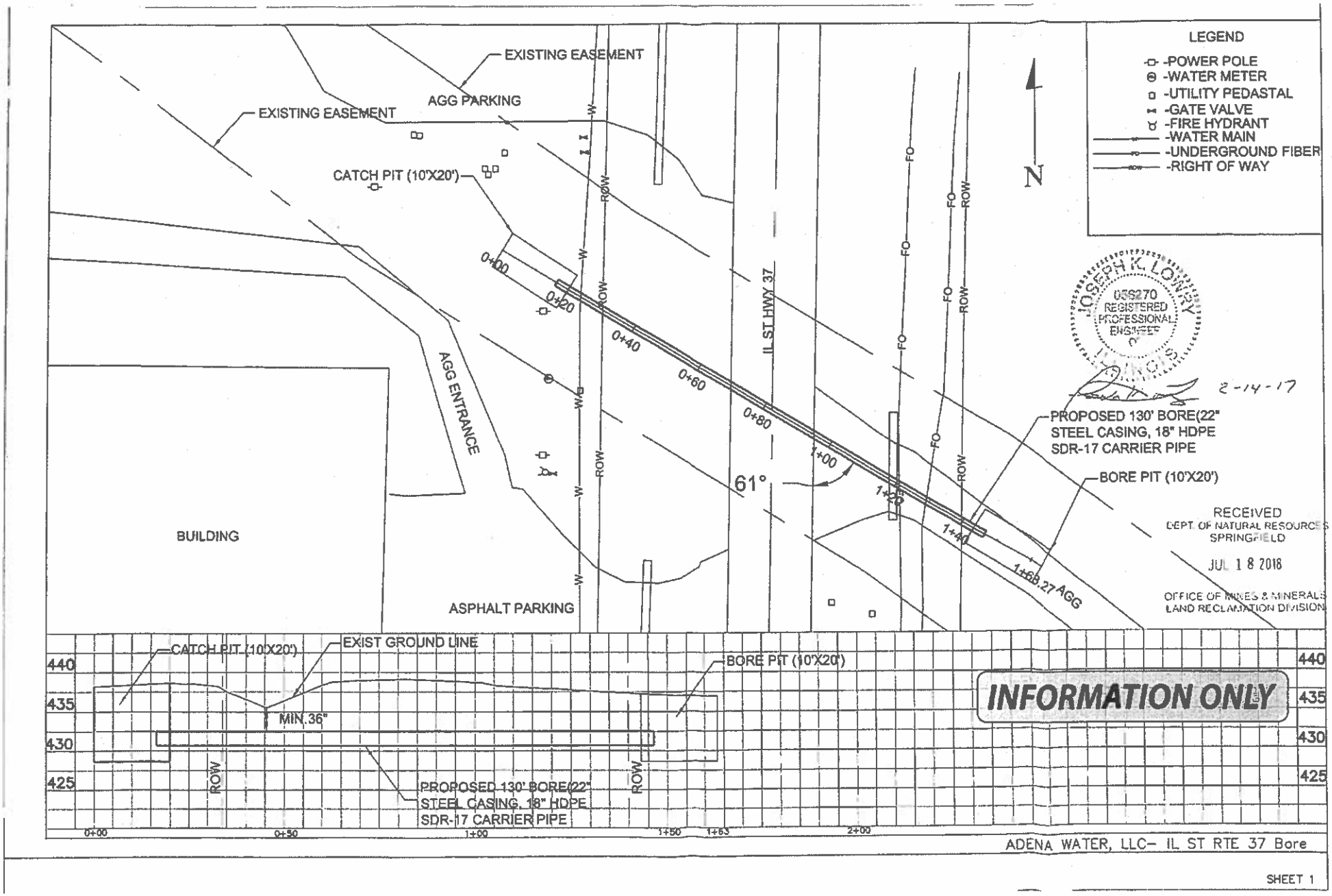
Traffic control operation:

Number of lane closures: _____ Time of closures: _____

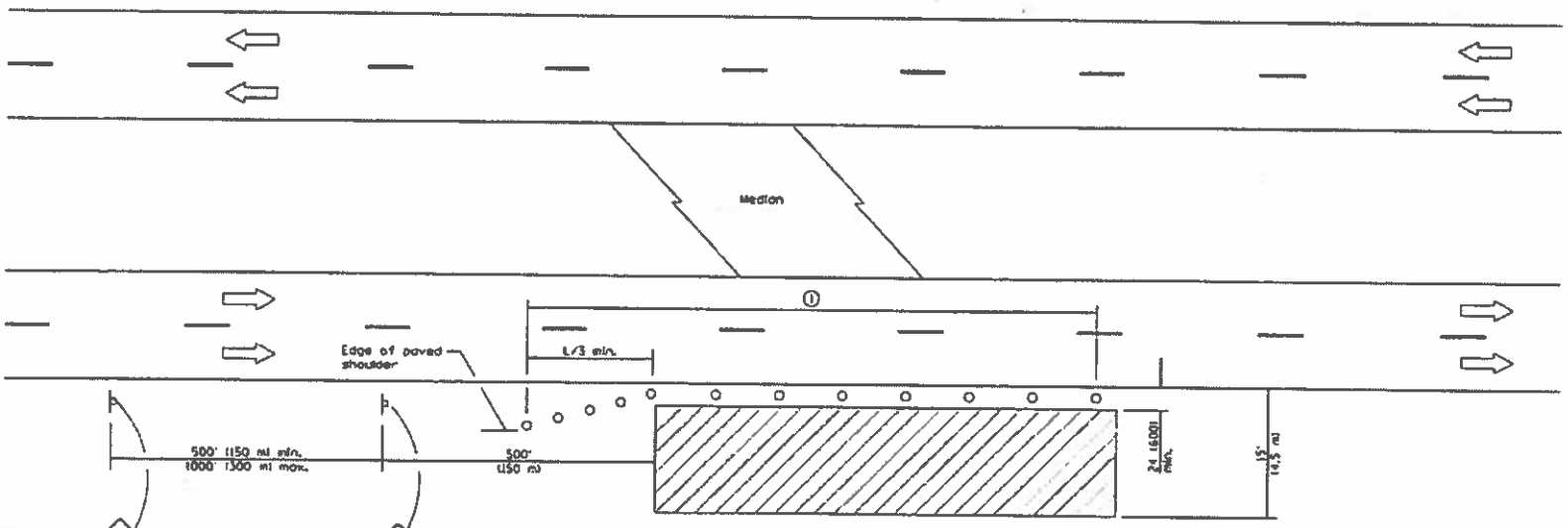
INFORMATION ONLY

Printed 2/14/2017

OPER 1113 (Rev. 08/07)


LEGEND
-POWER POLE
-WATER METER
-UTILITY PEDASTAL
-GATE VALVE
-FIRE HYDRANT
-WATER MAIN
-UNDERGROUND FIBER
-RIGHT OF WAY
EXISTING EASEMENT
AGG PARKING
EXISTING EASEMENT
CATCH PIT (10'X20')
IL ST HWY 37
AGG ENTRANCE
BUILDING
ASPHALT PARKING
61°
0+00
0+20
0+40
0+60
0+80
1+00
1+20
1+40
1+68.27 AGG
PROPOSED 130' BORE(22" STEEL CASING, 18" HDPE SDR-17 CARRIER PIPE
BORE PIT (10'X20')
ROW
FO
W
N
JOSEPH K. LONEY
062270
REGISTERED PROFESSIONAL ENGINEER
ILLINOIS
2-14-17
RECEIVED
DEPT OF NATURAL RESOURCES
SPRINGFIELD
JUL 18 2018
OFFICE OF MINES & MINERALS
LAND RECLAMATION DIVISION
CATCH PIT (10'X20')
EXIST GROUND LINE
MIN. 36"
BORE PIT (10'X20')
PROPOSED 130' BORE(22" STEEL CASING, 18" HDPE SDR-17 CARRIER PIPE
440
435
430
425
0+00
0+50
1+00
1+50
1+63
2+00
INFORMATION ONLY
ADENA WATER, LLC- IL ST RTE 37 Bore
SHEET 1

R05792



For contract construction projects



W20-1103(D)-48



W21-1(D)-48

For maintenance and utility projects



W20-1(D)-48

TYPICAL APPLICATIONS

Utility operations
Culvert extensions
Side slope changes
Guardrail installation and maintenance
Delineator installation
Landscaping operations
Shoulder repair
Sign installation and maintenance

① When the work operation exceeds one hour, cones, drums or barricades shall be placed at 25' (8 m) centers for L/3 distance, and at 50' (15 m) centers through the remainder of the work area.

SYMBOLS

Work area

Sign

Cone, drum or barricade

GENERAL NOTES

This Standard is used where any vehicles, equipment, workers or their activities will encroach in the area 15' (4.5 m) to 24' (600) from the edge of pavement.

Calculate L as follows:

SPEED LIMIT	FORMULAS	
	English	Metric
40 mph (70 km/h) or less:	$L=\frac{WS^2}{60}$	$L=\frac{WS^2}{150}$
45 mph (80 km/h) or greater:	L=WXS	L=0.65(WXS)

W = Width of offset in feet (meters).

S = Normal posted speed mph (km/h).

All dimensions are in inches (millimeters) unless otherwise shown.

DATE	REVISIONS
4-1-16	Corrected typo in title.
1-1-14	Revised workers sign
	number to agree with
	current MUTCD.

OFF-RD OPERATIONS, MULTILANE, 15' (4.5 m) TO 24" (600 mm) FROM PAVEMENT EDGE

STANDARD 701101-05

Illinois Department of Transportation

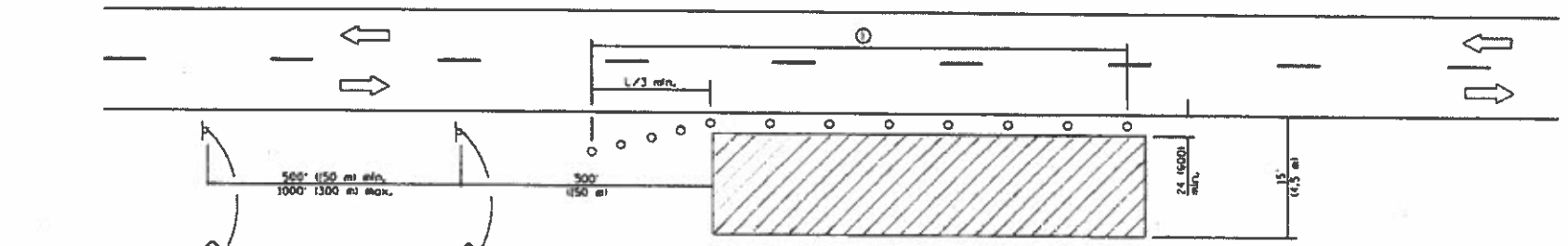
APPROVED _____ DEC 1 2015

APPROVED _____ DEC 1 2015

701101-05

INFORMATION ONLY

R05793



For contract construction projects



W20-1103(D)-48



W21-1101-48

For maintenance and utility projects



W20-1101-48

TYPICAL APPLICATIONS

Utility operations
Culvert extensions
Side slope changes
Guardrail installation and maintenance
Delineator installation
Landscaping operations
Shoulder repair
Sign installation and maintenance

SYMBOLS

Work area

Sign

Cone, drum or barricade

① When the work operation exceeds one hour, cones, drums or barricades shall be placed at 25' (8 m) centers for L/3 distance, and at 50' (15 m) centers through the remainder of the work area.

GENERAL NOTES

This Standard is used where any vehicles, equipment, workers or their activities will encroach in the area 15' (4.5 m) to 24 (600) from the edge of pavement.

Calculate L as follows:

SPEED LIMIT	FORMULAS	
	English	(Metric)
40 mph (70 km/h) or less:	$L = \frac{WS^2}{60}$	$L = \frac{WS^2}{150}$
45 mph (80 km/h) or greater:	L=(WXS)	L=0.65(WXS)

W = Width of offset in feet (meters).

S = Normal posted speed mph (km/h).

All dimensions are in inches (millimeters) unless otherwise shown.

Illinois Department of Transportation

APPROVED _____ January 1, 2014
Engineer of Bureau of Operations

APPROVED _____ January 1, 2014
Secretary of Illinois Department of Transportation

1-1-14 DRAFT

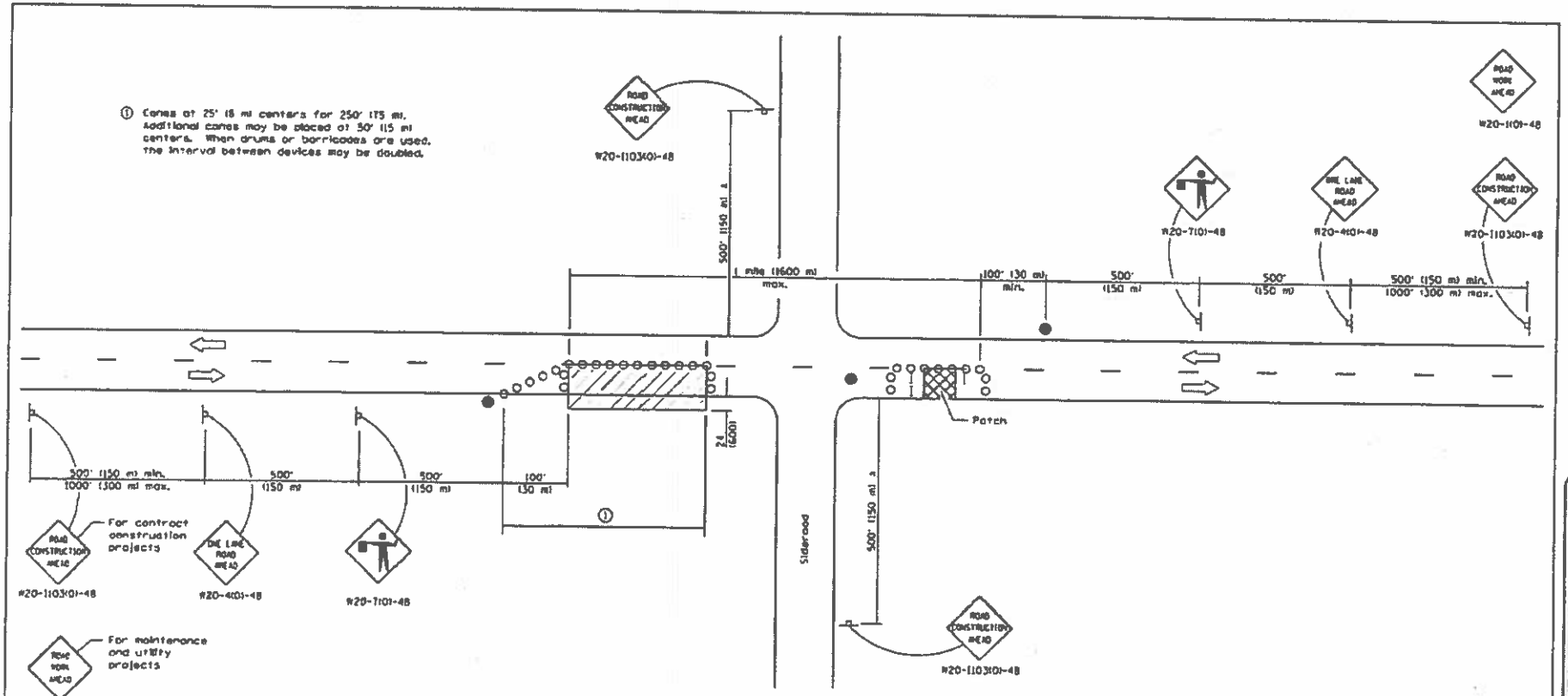
DATE	REVISIONS
1-1-14	Revised workers sign
	number 10 cones with
	current MUTCD.
1-1-13	Omitted text 'WORKERS'
	sign.

OFF-RD OPERATIONS, 2L, 2W, 15' (4.5 m) TO 24" (600 mm) FROM PAVEMENT EDGE

STANDARD 701006-05

INFORMATION ONLY

R05794



TYPICAL APPLICATIONS

Isolated patching
Utility operations
Storm sewer
Culverts
Cable placement

SYMBOLS

- Work area
- Sign
- Barricade or drum
- Cone, drum or barricade
- Flagger with traffic control sign

GENERAL NOTES

This Standard is used where at any time, any vehicles, equipment, workers or their activities will encroach in the area between the center line and a line 24' (600) outside the edge of pavement for daylight operation.

When the distance between successive work areas exceeds 2000' (600 m), additional warning signs, flaggers, and taper shall be placed as shown.

All dimensions are in inches (millimeters) unless otherwise shown.

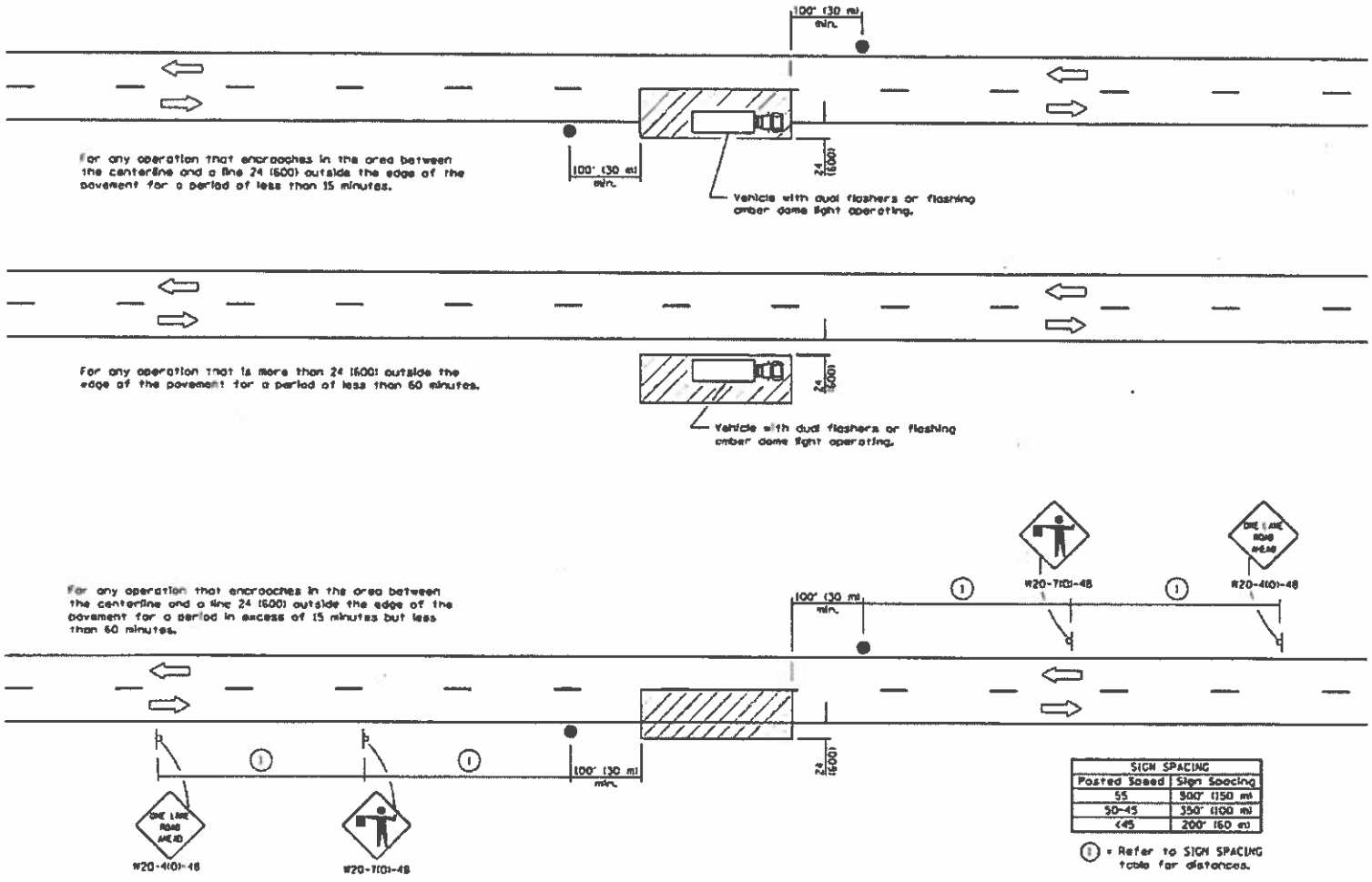
DATE	REVISIONS
1-1-11	Revised flagger sign.
1-1-09	Switched units to English (metric).
	Corrected sign No. s.

LANE CLOSURE, 2L, 2W, DAY ONLY, FOR SPEEDS ≥ 45 MPH

STANDARD 701201-04

INFORMATION ONLY

R05795



TYPICAL APPLICATIONS

Marking patches
Field survey
String line
Utility operations
Cleaning up debris on pavement

SYMBOLS

Work area
Sign on portable or permanent support
Flagger with traffic control sign

All dimensions are in inches (millimeters) unless otherwise shown.

Illinois Department of Transportation

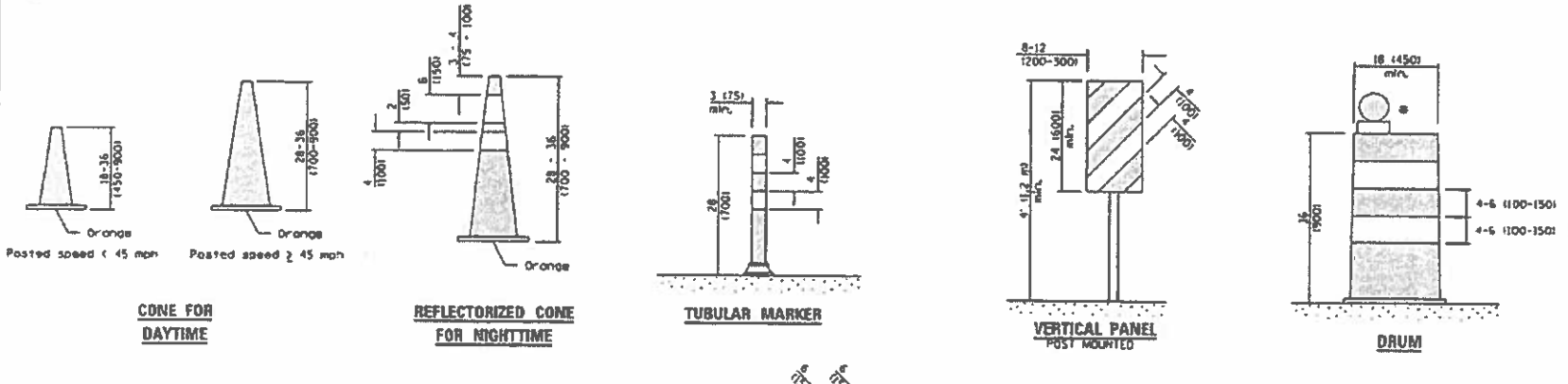
DATE	REVISIONS
1-1-11	Revised flagger sign.
1-1-09	Switched units to English (metric).

LANE CLOSURE, 2L, 2W, SHORT TIME OPERATIONS

STANDARD 701301-04

INFORMATION ONLY

R05796



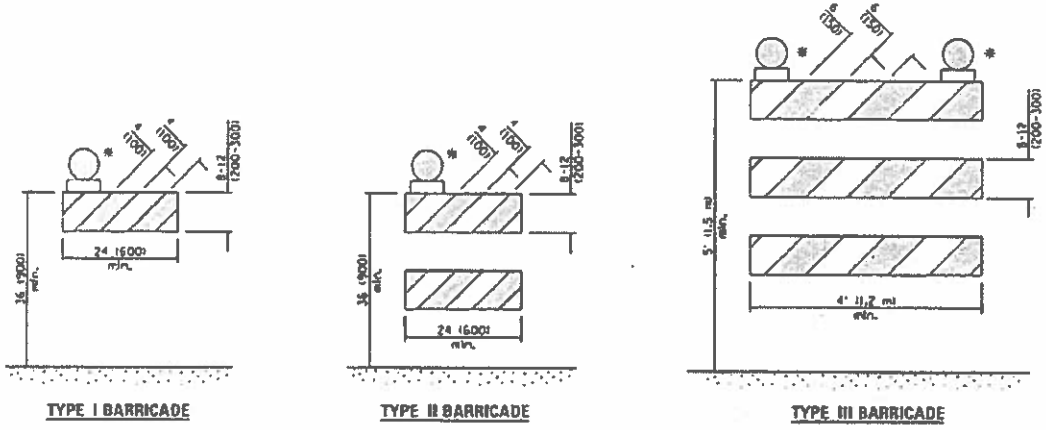
CONE FOR DAYTIME

REFLECTORIZED CONE FOR NIGHTTIME

TUBULAR MARKER

VERTICAL PANEL POST MOUNTED

DRUM



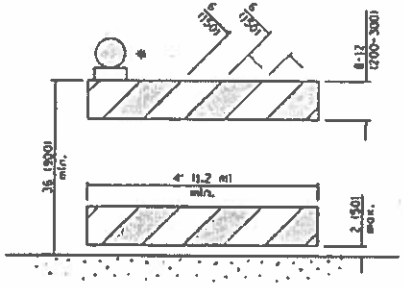
TYPE I BARRICADE

TYPE II BARRICADE

TYPE III BARRICADE

DIRECTION INDICATOR BARRICADE

VERTICAL BARRICADE



DETECTABLE PEDESTRIAN CHANNELIZING BARRICADE

* Warning lights (if required)

GENERAL NOTES

All heights shown shall be measured above the pavement surface.

All dimensions are in inches (millimeters) unless otherwise shown.

DATE	REVISIONS
1-1-17	Changed FIXING DEVICE to TUBULAR MARKER.
4-1-16	Add dim's to barricades. Rev. note for post mnt. signs.
	Rev. cone dim. Add #12-1103.

TRAFFIC CONTROL DEVICES

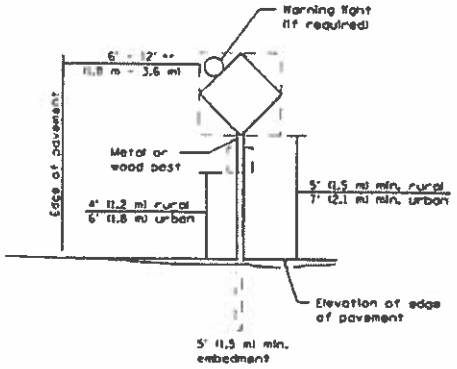
(Sheet 1 of 3)

STANDARD 701901-06

Illinois Department of Transportation

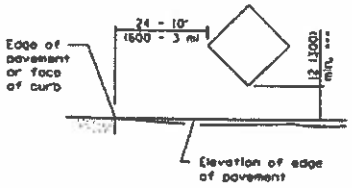
INFORMATION ONLY

R05797



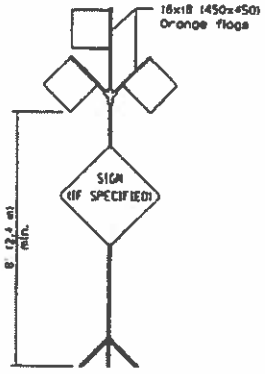
POST MOUNTED SIGNS

** When curb or paved shoulder are present this dimension shall be 24 (600) to the face of curb or 6' (1.8 m) to the outside edge of the paved shoulder.

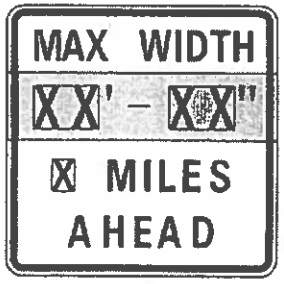


SIGNS ON TEMPORARY SUPPORTS

*** When work operations exceed four days, this dimension shall be 5' (1.5 m) min. If located behind other devices, the height shall be sufficient to be seen completely above the devices.



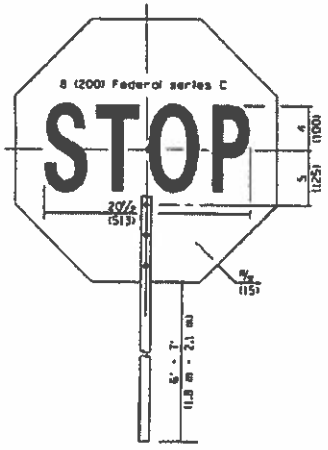
HIGH LEVEL WARNING DEVICE



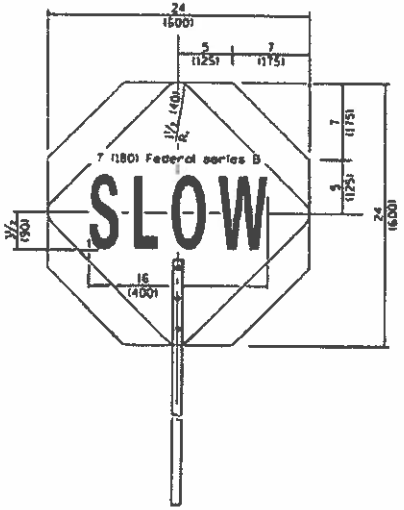
W12-1103-4848

WIDTH RESTRICTION SIGN

XX'-XX" width and X miles are variable.



FRONT SIDE



REVERSE SIDE

FLAGGER TRAFFIC CONTROL SIGN

ROAD CONSTRUCTION NEXT X MILES

G20-1104(01)-6036

END CONSTRUCTION

G20-1105(01)-6024

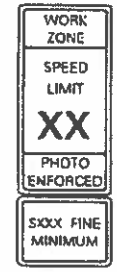
This signing is required for all projects 2 miles (3200 m) or more in length.

ROAD CONSTRUCTION NEXT X MILES sign shall be placed 500' (150 m) in advance of project limits.

END CONSTRUCTION sign shall be erected at the end of the job unless another job is within 2 miles (3200 m).

Dual sign displays shall be utilized on multi-lane highways.

WORK LIMIT SIGNING



W21-1(05)01-3618

R2-1-3648

R10-1108o-3618 ****

R2-1106o-3618

Sign assembly as shown on Standards or as allowed by District Operations.



G20-1103(01)-6036

This sign shall be used when the above sign assembly is used.

HIGHWAY CONSTRUCTION SPEED ZONE SIGNS

**** R10-1108p shall only be used along roadways under the jurisdiction of the State.

Illinois Department of Transportation

APPROVED January 1, 2017

BUREAU OF OPERATIONS

APPROVED January 1, 2017

BUREAU CHIEF OF TRAFFIC OPERATIONS

CANCELS

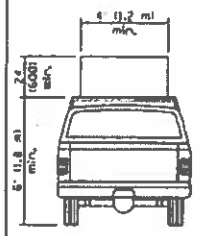
TRAFFIC CONTROL DEVICES

Sheet 2 of 31

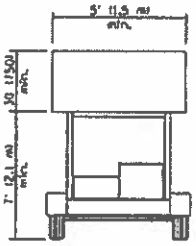
STANDARD 701901-06

INFORMATION ONLY

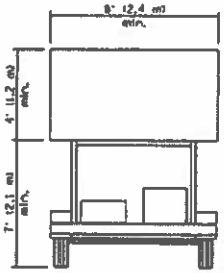
R05798



TYPE A
ROOF
MOUNTED

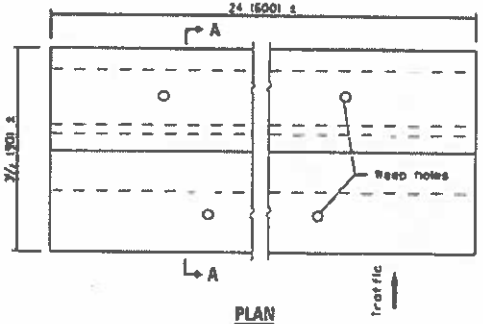


TYPE B
ROOF OR TRAILER
MOUNTED

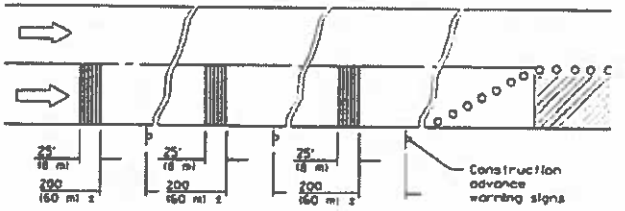


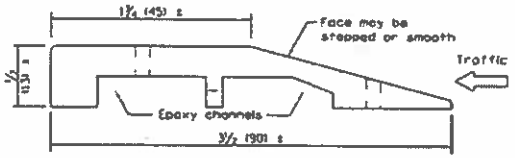
TYPE C
TRAILER
MOUNTED

ARROW BOARDS

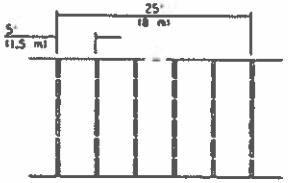


PLAN



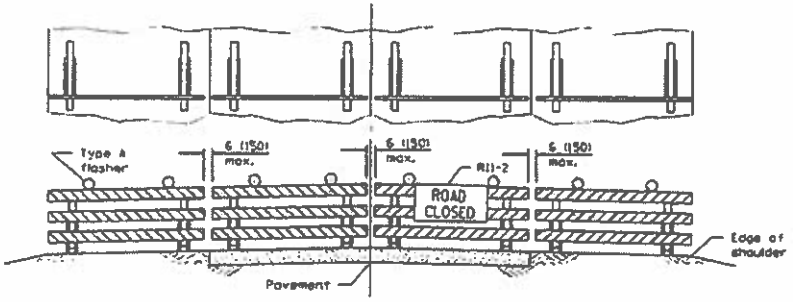


SECTION A–A



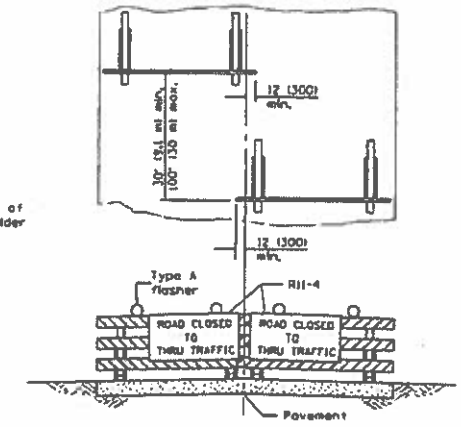
TYPICAL INSTALLATION

TEMPORARY RUMBLE STRIPS



ROAD CLOSED TO ALL TRAFFIC

Reflectorized striping may be omitted on the back side of the barricades. If a Type III barricade with an attached sign panel which meets NCHRP 350 is not available, the sign may be mounted on an NCHRP 350 temporary sign support directly in front of the barricade.



ROAD CLOSED TO THRU TRAFFIC

Reflectorized striping shall appear on both sides of the barricades. If a Type III barricade with an attached sign panel which meets NCHRP 350 is not available, the signs may be mounted on NCHRP 350 temporary sign supports directly in front of the barricade.

TYPICAL APPLICATIONS OF
TYPE III BARRICADES CLOSING A ROAD

Illinois Department of Transportation

APPROVED _____ 20__
ENGINEER OF OPERATIONS
APPROVED _____ 20__
ENGINEER OF BUREAU OF TRAFFIC AND ILLUMINATION

35483 X-31

TRAFFIC CONTROL DEVICES

(Sheet 3 of 3)

STANDARD 701901-06

INFORMATION ONLY

R05799

Acceptable - This is an example of an **acceptable** sign. It may be new, or in new condition. There are abrasions on the surface but very little loss of lettering. There has been no touch-up of the lettering.



Marginal - This is an example of a sign with **marginal** acceptability. Of the many surface abrasions throughout the sign face, many are within the individual letters of the message. The sign surface is free of any residue. Although some color fading is evident, the background color and reflectivity are still apparent at night.



Unacceptable - This is an example of an **unacceptable** sign. Signs with asphalt splatter and/or cement slurry or any combination of missing and/or covered reflective material similar in area presented make a sign **unacceptable**. Some letters have a loss of more than 50 percent. There is noticeable color fading.



Please Note: Orange work zone signs shall be fluorescent orange in color. Signs shall have retroreflective sheeting. Signs with bends and dents that alter the size and/or shape of the sign are unacceptable. These photos are examples of the condition of the sheeting.

INFORMATION ONLY

Verify this is the correct version by checking IDOT's website www.dot.il.gov/workzone/zhd2310.pdf

PART I ATTACHMENT I.12.C.2
LIST OF OCCUPIED DWELLING WAIVERS

WILLIAMSON ENERGY, LLC - WATER MANAGEMENT FACILITY
ATTACHMENT I.12.C.2 - 300 FT OCCUPIED DWELLING WAIVERS

PIN (MAP #)	GRANTOR	MAILING ADDRESS	TYPE	DATE SIGNED
11-30-400-004	BEARDEN, BRIAN & LINDA	7059 LAKE CREEK ROAD, WEST FRANKFORT, IL 62896	WAIVER	06/17/2016
11-32-100-009	RICH, MAHLON L. & SANDRA	7550 LAKE CREEK ROAD, WEST FRANKFORT, IL 62896	WAIVER	05/20/2016
11-29-300-007	LASWELL, JOSEPH L.	7635 LAKE CREEK ROAD, WEST FRANKFORT, IL 62896	WAIVER	08/29/2016
11-29-300-003	FITCH, WARREN D.	7357 LAKE CREEK ROAD, WEST FRANKFORT, IL 62896	WAIVER	06/07/2016
11-29-300-014	SMITH, WILLIAM D & CONNIE J	7145 LAKE CREEK RD, WEST FRANKFORT, IL 62896	WAIVER	08/04/2016
11-32-100-003	FITCH, JAMES & PEGGY	7322 LAKE CREEK RD, WEST FRANKFORT, IL 62896	WAIVER	08/12/2016
11-32-100-003	BURNETT, CHRISTINE	7322 LAKE CREEK RD, WEST FRANKFORT, IL 62896	WAIVER	08/12/2016
11-32-100-004	SUMMERS, KEVIN J	7414 LAKE CREEK RD, WEST FRANKFORT, IL 62896	WAIVER	08/01/2016
11-32-100-005	CLARK, KENNETH L & JANE L	7434 LAKE CREEK RD, WEST FRANKFORT, IL 62896	WAIVER	08/01/2016
11-32-100-007	CLARK, STEVE	7434 LAKE CREEK RD, WEST FRANKFORT, IL 62896	WAIVER	08/01/2016
11-32-100-008	COLYER, PEARL	7528 LAKE CREEK RD, WEST FRANKFORT, IL 62896	WAIVER	08/01/2016
11-29-400-005	SURGALSKI, LARRY B & KENDRA SUE	7727 LAKE CREEK RD, WEST FRANKFORT, IL 62896	WAIVER	08/01/2016
11-30-400-006	FITCH, LINDELL	6931 LAKE CREEK RD, WEST FRANKFORT, IL 62896	WAIVER	08/01/2016
11-33-100-009	HUMERICKHOUSE, CYNTHIA & MICHAEL	953 SANDBURG RD, WEST FRANKFORT, IL 62896	WAIVER	06/13/2016
11-34-200-005	PARKER, CLYDE	10579 HORSESHOE ROAD, WEST FRANKFORT, IL 62896	WAIVER	07/20/2016
02-02-200-006	GRIZZELL, DALLAS D.	18097 COLLINS RD, WEST FRANKFORT, IL 62896	WAIVER	10/04/2016
02-12-200-004	MCVEY, TERRY L.	17259 RT 37 NORTH, JOHNSTON CITY, IL 62951	WAIVER	09/19/2016
02-12-200-005	MCVEY, TERRY L.	17259 RT 37 NORTH, JOHNSTON CITY, IL 62951	WAIVER	09/19/2016
03-07-300-022	MAHAN, EVELYN ETAL	16875 MONROE ROAD, WEST FRANKFORT, IL 62896	WAIVER	10/18/2016
03-07-326-006	BYERS & PAYNE, FLOSSIE & LEAH	16873 DUNCAN ROAD, JOHNSTON CITY, IL 62951	WAIVER	11/28/2016
03-08-328-003	BLADES, SHIRLEY ANN	16442 OLD FRANKFORT ROAD, JOHNSTON CITY, IL 62951	WAIVER	09/12/2016
03-08-326-002	SMITH, MATTHEW	P.O. BOX 128, 404 S. LOGAN, WEST FRANKFORT, IL 62896	WAIVER	09/23/2016
03-08-326-003	LAYNE, ZACKERY D. & VIVIAN L.	77 ORCHARD DRIVE, HERRIN, IL 62948	WAIVER	09/21/2016
03-08-326-004	LAYNE, STEVEN & RHONDA	13872 EBERHARDT RD, JOHNSTON CITY, IL 62951	WAIVER	09/21/2016
02-12-200-002	MURPHY, JUDITH ANN	STATE ROUTE 37, JOHNSTON CITY, IL 62951	WAIVER	09/21/2016
03-07-326-002	BALL, PAULA JEAN	16830 MONROE RD, WEST FRANKFORT, IL 62896	WAIVER	09/29/2016

PART I ATTACHMENT I.11
PUBLIC NOTICE

Williamson Energy, LLC
Attachment I.11.

PUBLIC NOTICE

Pursuant to the Surface Coal Mining Land Conservation and Reclamation Act (PA-81-1015, as amended) and the Rules and Regulations of the Act, Williamson Energy LLC, P. O. Box 300, Johnston City, IL 62951, hereby gives notice that on _____ 2018, a permit application (Permit 456) was determined to be complete by the Illinois Department of Natural Resources, Office of Mines and Minerals, to construct a water management facility.

The permit areas are located in:

Williamson County, Township 8 South, Range 2 East, Sections 1, 2 & 12; Township 8 South, Range 3 East, Sections 7, 8, 9, 11, 14, 15, 16 & 17 and Franklin County, Township 7 South, Range 2 East, Sections 27, 28, 29, 30, 31, 32, 34 & 35.

Approval is also requested to operate within 100 feet of the outside right-of-way of public roads which are located as follows:

Liberty School Road along the southeast side of Township 8 South, Range 3 East, Section 11; Williams Prairie Road along the northwest quarter of Township 8 South, Range 3 East, Section 14; Harris School Road along the northwest quarter of Township 8 South, Range 3 East, Section 15 and northeast quarter of Township 8 South, Range 3 East, Section 16; Old Ben Road along the northeast quarter of Township 8 South, Range 3 East, Section 17; Intersection of Old Frankfort Road and Eberhardt Road along the northwest quarter of Township 8 South, Range 4 East, Section 17; Eberhardt Road along the northwest quarter of Township 8 South, Range 3 East, Section 8; Duncan Road and Monroe Road in the southwest quarter of Township 8 South, Range 3 East, Section 7; State Route 37 along the northeast quarter of Township 8 South, Range 2 East, Section 12; Interstate 57 in the southwest quarter of Township 8 South, Range 2 East, Section 1; Collin Road in the southwest quarter of Township 8 South, Range 2 East, Section 1 and northeast quarter of Township 8 South, Range 2 East, Section 2; Horseshoe Road along the northeast quarter of Township 7 South, Range 2 East, Section 34 and the northwest quarter of Township 7 South, Range 2 East, Section 34; State Route 6 along the northwest quarter of Township 7 South, Range 2 East, Section 34; Deason Road runs north/south at the corners of southeast quarter of Township 7 South, Range 2 East, Section 28, southwest quarter of Township 7 South, Range 2 East, Section 27, northwest quarter of Township 7 South, Range 2 East, Section 34 and the northeast quarter of Township 7 South, Range 2 East, Section 33; Sandburg Road in the southwest quarter of Township 7 South, Range 2 East, Section 28 and the northwest quarter of Township 7 South, Range 2 East, Section 33; Intersection of Freeman Spur Road and Lake Creek Road in the southeast quarter of Township 7 South, Range 2 East, Section 29 and the northeast quarter of Township 7 South, Range 2 East, Section 32; Intersection of Gossage Road and Lake Creek Road in the southeast quarter of Township 7 South, Range 2 East, Section 29 and the northeast quarter of Township 7 South, Range 2 East, Section 32; Lake Creek Road runs along the south border of Township 7 South, Range 2 East, Section 29 & 30 and the north border Township 7 South, Range 2 East, Sections 31 and 32; Intersection of Cheatman Road and Lake Creek Road in the southwest quarter of Township 7 South, Range 2 East, Sections 29, the southeast quarter of Township 7 South, Range 2 East, Sections 30, northeast quarter of Township 7 South, Range 2 East, Sections 31 and the northwest quarter of Township 7 South, Range 2 East, Section 32

Activities to be conducted within 100 feet of the outside right-of-way of public roads can include, but not be limited to, the construction/installation of a pipeline. Construction activities will include the boring beneath roads, trenching adjacent to roads, laying pipeline, backfilling trenches and vegetating disturbances.

Copies of the application for this permit request are available for inspection at the following locations:

Williamson County Clerk's Office, Marion, IL 62959, Franklin County Clerk's Office, 100 Public Square, Benton, IL and Illinois Department of Natural Resources, Office of Mines and Minerals, Land Reclamation Division, One Natural Resources Way, Springfield, Illinois 62702-1271.

Written comments, objections, request for informal conferences, or request for public hearings may be submitted to the Department at the above addresses.

Note: The above public notice is to be published in the Marion Daily Republican newspaper and Benton Evening News.

2019-2018

WILLIAMSON ENERGY LLC, JOHNSTON CITY, 62951

NPDES ID: IL0077666
FRS ID: 110023026884
Other NPDES IDs associated with this FRS ID: None
TRI ID(s): None
Facility Type: NON-POTW
Permit Type: NPDES Individual Permit
Permit Effective Date: 07/01/2005
Permit Expiration Date: 07/31/2010
Major/Non-Major Indicator: Non-Major
Permit Issuance: STATE OF ILLINOIS
Approved Pretreatment Program: N/A
Combined Sewer Overflow (CSO) Outfall: N/A
County: WILLIAMSON
Congressional District: Illinois's 12th District

Latitude: 37.841222
Longitude: -88.827944
Facility Design Flow (Permit Application) (MGD): --
Actual Average Facility Flow (Permit Application) (MGD): --
Average Facility Flow in 2019 (MGD): 0.0288
4-Digit SIC Code: 1222 - BITUMINOUS COAL & LIG, UNDERGR
6-Digit NAICS Code: --
Likely Point Source Category: 434 - Coal mining
C View Detailed Facility Report

Select Reporting Year: 2019

Top Pollutants by Pounds (DMR, 201

Pollutant Name	Total Pounds (lb/yr)	Max Allo
Sulfate	22,141	
Chloride	12,317	
Solids, total suspended	970	
Acidity, total (as CaCO3)	417	
Iron	110	
Manganese	0	

WILLIAMSON ENERGY LLC, JOHNSTON CITY, 62951

NPDES ID: IL0077666
FRS ID: 110023026884
Other NPDES IDs associated with this FRS ID: None
TRI ID(s): None
Facility Type: NON-POTW
Permit Type: NPDES Individual Permit
Permit Effective Date: 07/01/2005
Permit Expiration Date: 07/31/2010
Major/Non-Major Indicator: Non-Major
Permit Issuance: STATE OF ILLINOIS
Approved Pretreatment Program: N/A
Combined Sewer Overflow (CSO) Outfall: N/A
County: WILLIAMSON
Congressional District: Illinois's 12th District

Latitude: 37.841222
Longitude: -88.827944
Facility Design Flow (Permit Application) (MGD): --
Actual Average Facility Flow (Permit Application) (MGD): --
Average Facility Flow in 2018 (MGD): 0.0300
4-Digit SIC Code: 1222 - BITUMINOUS COAL & LIG, UNDERGR
6-Digit NAICS Code: --
Likely Point Source Category: 434 - Coal mining
C View Detailed Facility Report
E View Effluent Charts
P View Permit Limits and Monitoring Requirements
F View NPDES Monitoring Data Download
M View DMR and TRI Multi-Year Loading Report

Select Reporting Year: 2018

Top Pollutants | Facility Loading Calculations

Top Pollutants by Pounds (DMR, 2018)

Pollutant Name	Total Pounds (lb/yr)	Max Allowable Load (lb/yr)
Sulfate	149,025	46,570
Chloride	149,025	46,570
Iron	104	279
Manganese	13.41	93.14
Solids, total suspended	0	3,260
Acidity, total (as CaCO3)	0	

Top Pollutants by Toxic-Weighted Pounds (TWPE) (DMR, 2018)

Pollutant Name	Total TWPE (lb-eq/yr)	Max Allowable Load (lb-eq/yr)
Chloride	3.63	1.13
Manganese	1.38	9.59
Sulfate	0.8345	0.2608
Iron	0.5837	1.56

Download All Data

R05805

2017-2016

WILLIAMSON ENERGY LLC, JOHNSTON CITY, 62951

NPDES ID: IL0077666
FRS ID: 110023026884
Other NPDES IDs associated with this FRS ID: None
TRI ID(s): None
Facility Type: NON-POTW
Permit Type: NPDES Individual Permit
Permit Effective Date: 07/01/2005
Permit Expiration Date: 07/31/2010
Major/Non-Major Indicator: Non-Major
Permit Issuance: STATE OF ILLINOIS
Approved Pretreatment Program: N/A
Combined Sewer Overflow (CSO) Outfall: N/A
County: WILLIAMSON
Congressional District: Illinois's 12th District

Latitude: 37.841222
Longitude: -88.827944
Facility Design Flow (Permit Application) (MGD): --
Actual Average Facility Flow (Permit Application) (MGD): --
Average Facility Flow in 2017 (MGD): 0.0720
4-Digit SIC Code: 1222 - BITUMINOUS COAL & LIG, UNDERGR
6-Digit NAICS Code: --
Likely Point Source Category: 434 - Coal mining

C View Detailed Facility Report
E View Effluent Charts
P View Permit Limits and Monitoring Requirements
F View NPDES Monitoring Data Download
M View DMR and TRI Multi-Year Loading Report

Select Reporting Year: 2017

Top Pollutants | Facility Loading Calculations

Top Pollutants by Pounds (DMR, 2017)

Pollutant Name	Total Pounds (lb/yr)	Max Allowable Load (lb/yr)
Sulfate	525,089	111,769
Chloride	521,512	111,769
Solids, total suspended	2,012	7,824
Iron	116	671
Acidity, total (as CaCO3)	0	
Manganese	0	

Top Pollutants by Toxic-Weighted Pounds (TWPE) (DMR, 2017)

Pollutant Name	Total TWPE (lb-eq/yr)	Max Allowable Load (lb-eq/yr)
Chloride	12.70	2.72
Sulfate	2.94	0.6259
Iron	0.6509	3.76
Manganese	0	

Download All Data

Latitude: 37.841222
Longitude: -88.827944
Facility Design Flow (Permit Application) (MGD): --
Actual Average Facility Flow (Permit Application) (MGD): --
Average Facility Flow in 2016 (MGD): 0.5452
4-Digit SIC Code: 1222 - BITUMINOUS COAL & LIG, UNDERGR
6-Digit NAICS Code: --
Likely Point Source Category: 434 - Coal mining

C View Detailed Facility Report
E View Effluent Charts
P View Permit Limits and Monitoring Requirements
F View NPDES Monitoring Data Download
M View DMR and TRI Multi-Year Loading Report

Select Reporting Year: 2016

Top Pollutants | Facility Loading Calculations

Top Pollutants by Pounds (DMR, 2016)

Pollutant Name	Total Pounds (lb/yr)	Max Allowable Load (lb/yr)
Chloride	3,595,527	831,755
Sulfate	2,634,291	831,755
Solids, total suspended	60,628	58,223
Acidity, total (as CaCO3)	12,460	
Iron	711	4,991
Manganese	496	1,113

Top Pollutants by Toxic-Weighted Pounds (TWPE) (DMR, 2016)

Pollutant Name	Total TWPE (lb-eq/yr)	Max Allowable Load (lb-eq/yr)
Chloride	87.54	20.25
Manganese	51.07	115
Sulfate	14.75	4.66
Iron	3.98	27.95

Download All Data

R05806

2015-2014

WILLIAMSON ENERGY LLC, JOHNSTON CITY, 62951

NPDES ID: IL0077666
FRS ID: 110023026884
Other NPDES IDs associated with this FRS ID: None
TRI ID(s): None
Facility Type: NON-POTW
Permit Type: NPDES Individual Permit
Permit Effective Date: 07/01/2005
Permit Expiration Date: 07/31/2010
Major/Non-Major Indicator: Non-Major
Permit Issuance: STATE OF ILLINOIS
Approved Pretreatment Program: N/A
Combined Sewer Overflow (CSO) Outfall: N/A
County: WILLIAMSON
Congressional District: Illinois's 12th District

Latitude: 37.841222
Longitude: -88.827944
Facility Design Flow (Permit Application) (MGD): --
Actual Average Facility Flow (Permit Application) (MGD): --
Average Facility Flow in 2015 (MGD): 0.1849
4-Digit SIC Code: 1222 - BITUMINOUS COAL & LIG, UNDERGR
6-Digit NAICS Code: --
Likely Point Source Category: 434 - Coal mining
C View Detailed Facility Report
E View Effluent Charts
P
F
M

Select Reporting Year: 2015

Top Pollutants by Pounds (DMR, 2015)

Pollutant Name	Total Pounds (lb/yr)	Max Allowable Load (lb/yr)
Chloride	2,332,240	284,639
Sulfate	1,442,488	284,639
Solids, total suspended	15,569	19,925
Acidity, total (as CaCO3)	13,310	
Iron	225	1,708
Manganese	69.88	155

WILLIAMSON ENERGY LLC, JOHNSTON CITY, 62951

NPDES ID: IL0077666
FRS ID: 110023026884
Other NPDES IDs associated with this FRS ID: None
TRI ID(s): None
Facility Type: NON-POTW
Permit Type: NPDES Individual Permit
Permit Effective Date: 07/01/2005
Permit Expiration Date: 07/31/2010
Major/Non-Major Indicator: Non-Major
Permit Issuance: STATE OF ILLINOIS
Approved Pretreatment Program: N/A
Combined Sewer Overflow (CSO) Outfall: N/A
County: WILLIAMSON
Congressional District: Illinois's 12th District

Latitude: 37.841222
Longitude: -88.827944
Facility Design Flow (Permit Application) (MGD): --
Actual Average Facility Flow (Permit Application) (MGD): --
Average Facility Flow in 2014 (MGD): 0
4-Digit SIC Code: 1222 - BITUMINOUS COAL & LIG, UNDERGR
6-Digit NAICS Code: --
Likely Point Source Category: 434 - Coal mining
C View Detailed Facility Report
E View Effluent Charts
P View Permit Limits and Monitoring Requirements
F View NPDES Monitoring Data Download
M View DMR and TRI Multi-Year Loading Report

Select Reporting Year: 2014

Top Pollutants | Facility Loading Calculations

Top Pollutants by Pounds (DMR, 2014)

Pollutant Name	Total Pounds (lb/yr)	Max Allowable Load (lb/yr)
Solids, total suspended	0	
Manganese	0	
Chloride	0	
Sulfate	0	
Acidity, total (as CaCO3)	0	
Iron	0	

Top Pollutants by Toxic-Weighted Pounds (TWPE) (DMR, 2014)

Pollutant Name	Total TWPE (lb-eq/yr)	Max Allowable Load (lb-eq/yr)
Iron	0	
Sulfate	0	
Chloride	0	
Manganese	0	

Download All Data

R05807

2013-2012

WILLIAMSON ENERGY LLC, JOHNSTON CITY, 62951

NPDES ID: IL0077666
FRS ID: 110023026884
Other NPDES IDs associated with this FRS ID: None
TRI ID(s): None
Facility Type: NON-POTW
Permit Type: NPDES Individual Permit
Permit Effective Date: 07/01/2005
Permit Expiration Date: 07/31/2010
Major/Non-Major Indicator: Non-Major
Permit Issuance: STATE OF ILLINOIS
Approved Pretreatment Program: N/A
Combined Sewer Overflow (CSO) Outfall: N/A
County: WILLIAMSON
Congressional District: Illinois's 12th District

Latitude: 37.841222
Longitude: -88.827944
Facility Design Flow (Permit Application) (MGD): --
Actual Average Facility Flow (Permit Application) (MGD): --
Average Facility Flow in 2013 (MGD): 0
4-Digit SIC Code: 1222 - BITUMINOUS COAL & LIG, UNDERGR
6-Digit NAICS Code: --
Likely Point Source Category: 434 - Coal mining
C View Detailed Facility Report
E View Effluent Charts
P View Permit Limits and Monitoring Requirements
F View NPDES Monitoring Data Download
M View DMR and TRI Multi-Year Loading Report

Select Reporting Year: 2013

Top Pollutants | Facility Loading Calculations

Top Pollutants by Pounds (DMR, 2013)

Pollutant Name	Total Pounds (lb/yr)	Max Allowable Load (lb/yr)
Solids, total suspended	0	
Manganese	0	
Chloride	0	
Sulfate	0	
Acidity, total (as CaCO3)	0	
Iron	0	

Top Pollutants by Toxic-Weighted Pounds (TWPE) (DMR, 2013)

Pollutant Name	Total TWPE (lb-eq/yr)	Max Allowable Load (lb-eq/yr)
Iron	0	
Sulfate	0	
Chloride	0	
Manganese	0	

Download All Data

Latitude: 37.841222
Longitude: -88.827944
Facility Design Flow (Permit Application) (MGD): --
Actual Average Facility Flow (Permit Application) (MGD): --
Average Facility Flow in 2012 (MGD): 0
4-Digit SIC Code: 1222 - BITUMINOUS COAL & LIG, UNDERGR
6-Digit NAICS Code: --
Likely Point Source Category: 434 - Coal mining
C View Detailed Facility Report
E View Effluent Charts
P View Permit Limits and Monitoring Requirements
F View NPDES Monitoring Data Download
M View DMR and TRI Multi-Year Loading Report

County: WILLIAMSON
Congressional District: Illinois's 12th District

Select Reporting Year: 2012

Top Pollutants | Facility Loading Calculations

Top Pollutants by Pounds (DMR, 2012)

Pollutant Name	Total Pounds (lb/yr)	Max Allowable Load (lb/yr)
Solids, total suspended	0	
Manganese	0	
Chloride	0	
Sulfate	0	
Acidity, total (as CaCO3)	0	
Iron	0	

Top Pollutants by Toxic-Weighted Pounds (TWPE) (DMR, 2012)

Pollutant Name	Total TWPE (lb-eq/yr)	Max Allowable Load (lb-eq/yr)
Iron	0	
Sulfate	0	
Chloride	0	
Manganese	0	

Download All Data

R05808

WILLIAMSON ENERGY LLC, JOHNSTON CITY, 62951

NPDES ID: IL0077666
FRS ID: 110023026884
Other NPDES IDs associated with this FRS ID: None
TRI ID(s): None
Facility Type: NON-POTW
Permit Type: NPDES Individual Permit
Permit Effective Date: 07/01/2005
Permit Expiration Date: 07/31/2010
Major/Non-Major Indicator: Non-Major
Permit Issuance: STATE OF ILLINOIS
Approved Pretreatment Program: N/A
Combined Sewer Overflow (CSO) Outfall: N/A
County: WILLIAMSON
Congressional District: Illinois's 12th District

Latitude: 37.841222
Longitude: -88.827944
Facility Design Flow (Permit Application) (MGD): --
Actual Average Facility Flow (Permit Application) (MGD): --
Average Facility Flow in 2011 (MGD): 0.2048
4-Digit SIC Code: 1222 - BITUMINOUS COAL & LIG, UNDERGR
6-Digit NAICS Code: --
Likely Point Source Category: 434 - Coal mining
C View Detailed Facility Report
E View Effluent Charts
P View Permit Limits and Monitoring Requirements
F View NPDES Monitoring Data Download
M View DMR and TRI Multi-Year Loading Report

Select Reporting Year: 2011

Top Pollutants | Facility Loading Calculations

Top Pollutants by Pounds (DMR, 2011)

Pollutant Name	Total Pounds (lb/yr)	Max Allowable Load (lb/yr)
Chloride	108,071	313,260
Sulfate	101,818	313,260
Solids, total suspended	12,267	21,928
Iron	175	1,880
Manganese	33.14	310
Acidity, total (as CaCO3)	0	

Top Pollutants by Toxic-Weighted Pounds (TWPE) (DMR, 2011)

Pollutant Name	Total TWPE (lb-eq/yr)	Max Allowable Load (lb-eq/yr)
Manganese	3.41	31.89
Chloride	2.63	7.63
Iron	0.9789	10.53
Sulfate	0.5702	1.75

Download All Data

e: 37.841222
de: -88.827944
Design Flow (Permit Application) (MGD): --
Average Facility Flow (Permit Application) (MGD): --
Facility Flow in 2010 (MGD): 0.2800
SIC Code: 1222 - BITUMINOUS COAL & LIG, UNDERGR
NAICS Code: --
oint Source Category: 434 - Coal mining
v Detailed Facility Report
v Effluent Charts
v Permit Limits and Monitoring Requirements
v NPDES Monitoring Data Download
v DMR and TRI Multi-Year Loading Report

Congressional District: Illinois's 12th District

Select Reporting Year: 2010

Top Pollutants | Facility Loading Calculations

Top Pollutants by Pounds (DMR, 2010)

Pollutant Name	Total Pounds (lb/yr)	Max Allowable Load (lb/yr)
Chloride	144,833	393,171
Sulfate	133,310	393,171
Solids, total suspended	7,723	27,522
Acidity, total (as CaCO3)	869	
Iron	131	2,359
Manganese	47.32	310

Top Pollutants by Toxic-Weighted Pounds (TWPE) (DMR, 2010)

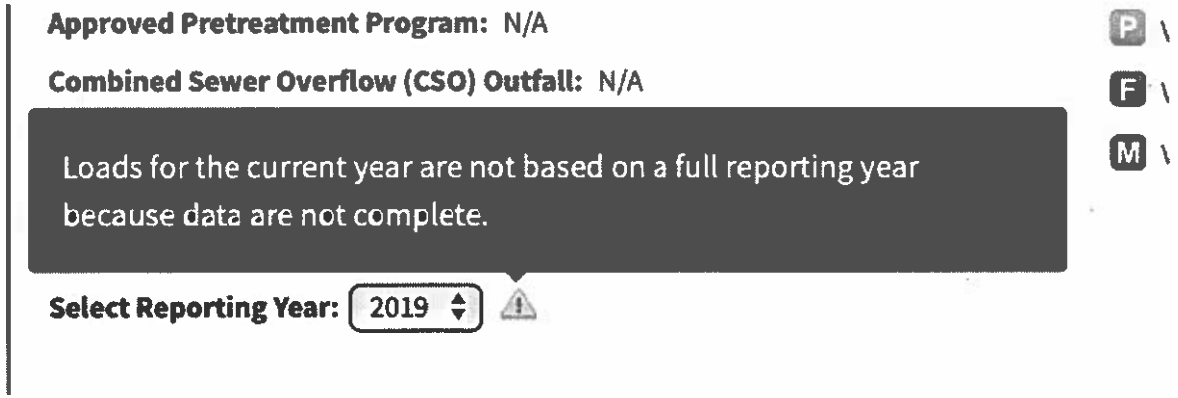
Pollutant Name	Total TWPE (lb-eq/yr)	Max Allowable Load (lb-eq/yr)
Manganese	4.87	31.96
Chloride	3.53	9.57
Sulfate	0.7465	2.20
Iron	0.7361	13.21

Download All Data

R05809

From 2019-2010, the site shows the same triangular warning symbols that the data is incomplete for all years on the EPA site https://echo.epa.gov/trends/loading-tool/reports/dmr-pollutant-loading?permit_id=IL0077666&year=2009

What data is missing and why is the state not enforcing that all data reported be complete and accurate?



R05810

Illinois Environmental Protection Agency
DWPC/FOS - Mine Pollution Control Program
Field Inspection Report

Company:	Williamson Energy, LLC
Mine:	Pond Creek Mine #1
County:	Williamson
Location:	Johnston City
NPDES #:	IL0077666
BOW ID:	W1998590001
Inspection Date:	August 30, 2018
Inspected by:	Brian Rodely
Accompanied by:	Bruce Rodely
Type of Inspection:	CSI & IEMA IL-2018-0717
Contact Person(s):	Nick Culbreth-& Brenton Mumford (Engineering)
Arrival Time:	9:15 AM
Departure Time	11:30 AM
Weather:	Sunny, 83F

Compliance Sampling & IEMA Follow-Up

August 30, 2018 Compliance Sampling and IEMA Report Follow Up:
A compliance sampling inspection was conducted at the above-referenced 540-acre NPDES permitted underground mine resulting from report IL-2018-0717 received by the Illinois EPA Emergency Response Unit.

The report narrative indicated that an unnamed tributary crossing Dean Road near the intersection of Dean Road and Liberty School Road adjacent to the Pond Creek Mine contained a black water as follows: "A slurry silt is going into a Creek west of the Gob Hill of Mach Coal Mine in between Liberty School Rd. and Dwina Rd. The Coal Mine is pumping the slurry silt with water out of the coal mine directly into creek. The creek does not have enough water to dilute it and it is black. Caller is concerned because he has land nearby. This creek runs into Pond Creek. This Mach Mines is just East of Johnston City."

The mine site includes drainage control structures, eight sediment basins, slope, preparation plant, coal stockpile, refuse disposal area, railroad loop, roads, ventilation shafts, parking areas, coal conveyors, and office/maintenance buildings. NPDES permit IL0077666 was issued/effective June 28, 2005 with an expiration date of July 1, 2010 has been administratively continued through timely renewal submissions and contains the discharge limitations for permitted outfalls at the site.

Findings: The attached 5 photo pages, site plan, and water flow diagram should be consulted to clarify the following activities. We arrived at the unnamed tributary to Pond Creek crossing Dean Road about ½ mile east of the intersection of Dean Road and Liberty School Road at approximately 9:15 am. The stream appeared to have moderate flow (approximately 750 gpm) of slightly turbid water with mostly natural conditions as shown in photo 1. We were immediately met by Williamson Energy Engineer James Plumley, then OMM representatives William Gillespie and Natalia Montano

arrived at the bridge. Pond Creek Mine Engineer Nick Culbreth arrived while discussing the conditions of the unnamed tributary to Pond Creek and operating conditions at the mine with Plumley and OMM. Culbreth said that he was contacted by IDNR-OMM last night about the incident report and that mine engineers were on site from 9:00 pm until midnight attempting to find the "release". Culbreth said that they did not find anything during their investigation. Gillespie said that he was on site at "daylight" (around 6:00 am) and he noted no adverse conditions of the unnamed tributary to Pond Creek or Pond Creek at Liberty School Road. Gillespie said the conditions appeared the same as they do at the time of our inspection. I advised the group that I needed to look at the water handling system, observe the outfalls, and sample any discharges occurring. Culbreth told me that he would have Brenton Mumford in the engineering department take me to the outfalls on their sampling UTV. During the time at the bridge on Dean Road, I noted a track hoe that had recently been removing sludge from pond 1 that was temporarily stacked on the pond berm. I suggested to the group that if no other discharges of slurry are found, the presence of the excavator and piling of sediment from pond 1 may be the catalyst for the call to IEMA. Consequently, while Mumford and I observed all the sedimentation structures and outfalls, I asked Bruce Rodely to document the conditions of the sediment removal and outfall of pond 001.

First, I observed pond 002 with outfall 002 where the contents of pond 002 has been pumped to the freshwater pond as shown in photo 2. Outfall 006 was noted to be discharging at approximately 250 gpm where sample PCM006 was taken as shown in photo 3. The HDPE pipe shown in the effluent tile of pond 006 is the water returned from pond 002 discharging into pond 6 near the outlet tile. Next, ponds 007 and 008 with associated outfalls were observed with no discharge as shown in photos 4 and 5, respectively. Mumford then took me to newly constructed outfall 009 that was not and has never discharged. Photos 6 through 8 show the non-discharging outfalls of ponds 003, 004, and 005.

I met with Bruce Rodely in the office parking lot where he reported that outfall 001 was not discharging as shown in photo 9. Sediment in pond 001has been removed, placed on the pond berm, and silt fence was utilized around the pond to contain any potential erosion by precipitation as shown in photo 10.

Finally, we observed the conditions of Pond Creek at Liberty School Road downstream of the commingled unnamed tributary from the mine discharge. Conditions of Pond Creek appeared mostly natural as were observed in the unnamed tributary discussed above.

Subsequent Information: Sample results for PCM006 are attached and provided below:

Parameter	TSS	Fe	Alk/Acid	Sulfates	Chlorides	Mn	Hardness
Permit (mg/L)	70	6.0	Acid<=Alk	500	500	1	N/A
Sample (mg/L)	17	0.122	440<552	2120	1420	0.073	359

Apparent Violations: The following effluent violations were noted during the complaint and CSI Inspection at Pond Creek Mine #1.

Effluent: Section 12(a) & 12(f) of the Act; Subtitle C Sections 304.105, 304.106; Subtitle D Section 406.202, and Permit

Summary: No adverse conditions were noted in Pond Creek or the unnamed tributary receiving stream from the mine discharge. Recent controlled dredging of pond 001 may have been the catalyst for the call to IEMA. Outfall 006 (Acid Mine Drainage) receives pumped water from pond 002 (Alkaline Mine Drainage) and was the only discharging outfall at the time of inspection. Sample PC006 taken at outfall 006 resulting in excursions of WQS and permit limits for sulfates and chlorides. Sulfates and Chlorides concentrations of PC006 were 2,120 and 1,420 mg/L, respectively. Permit and WQS limits for both parameters are 500 mg/L.

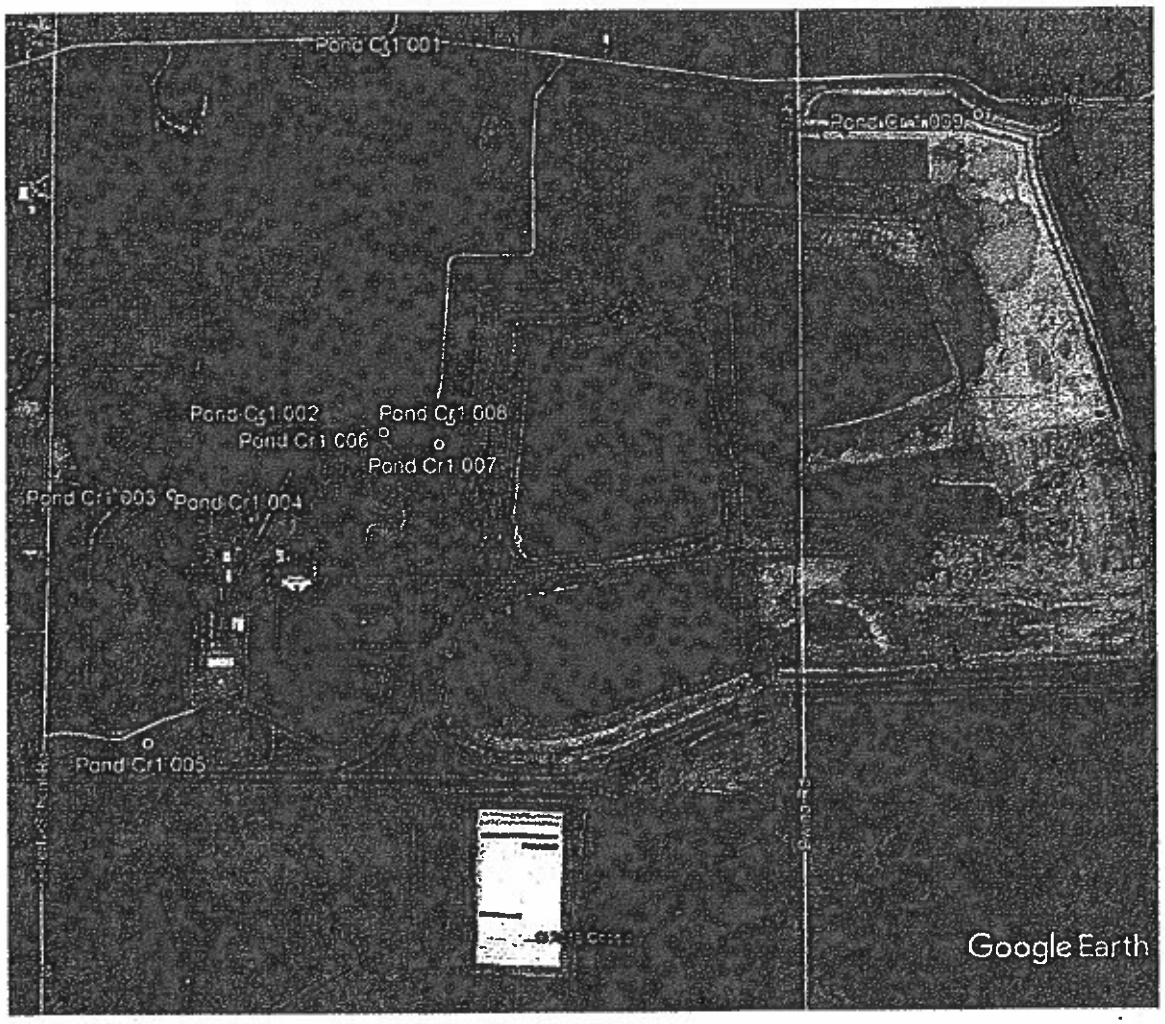
Brian Rodely

Brian Rodely
Environmental Protection Engineer
IEPA/DWPC/FOS

Attachments: 1 Site Plan Pages
5 Photo Pages
1 Williamson Energy, LLC Water Flow Diagram
4 Sample Result Pages
1 IEMA IL-2018-0717

Original: BOW/MPCP/Marion
BOW/DWPC/CAS
IDNR/OMM

Pond Creek Mine #1- 180830



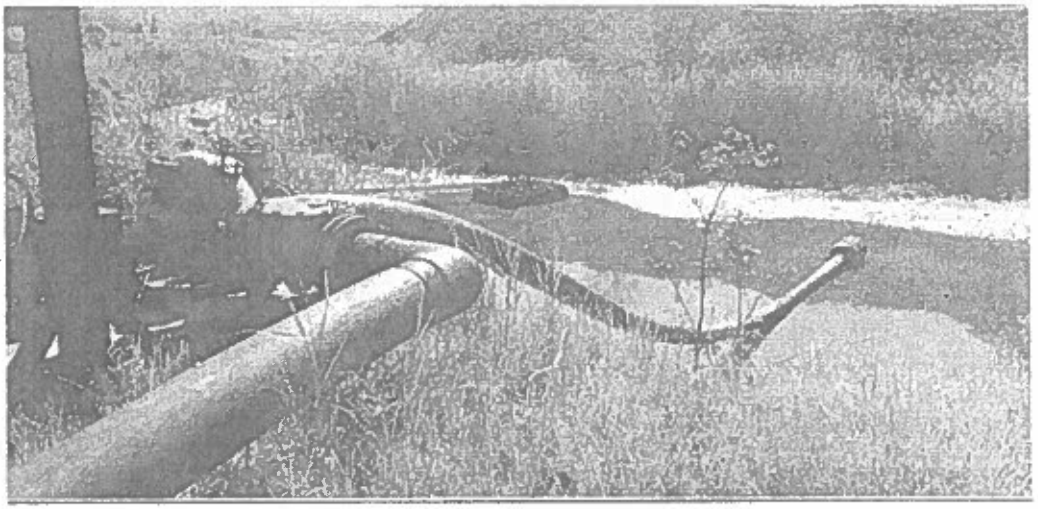
Satellite view of Pond Creek Mine #1 is shown above with the outfalls appearing as bull's eye with their respective label. At the time of inspection, a pump located in pond 2 discharges water into pond 6 though a HDPE pipe running up though the discharge culvert of outfall 006. Outfall 006 was the only discharging outfall noted at the site and sample PCM006 was taken at that time.

MINE INSPECTION DIGITAL PHOTOGRAPH PHOTOCOPIES

Photo # Williamson Energy 1
Date: August 30, 2018
Time: 9:17 a.m.
Taken By: Brian Rodely BOW/FOS
Facility: Pond Creek Mine
Location: N Dean Road @ Unnamed.
Notes: Photograph of natural conditions of the the unnamed tributary to Pond Creek immediately north of Dean Road. Note the lack of staining in the stream bed and the clarity of water.



Photo # Williamson Energy 2
Date: August 30, 2018
Time: 9:56 a.m.
Taken By: Brian Rodely BOW/FOS
Facility: Pond Creek Mine
Location: Pond 2 Face E.
Notes: Pond 2 is shown to be pumped down where the water is discharged to pond 6. Outfall 002 is located to the photo left and was not discharging.

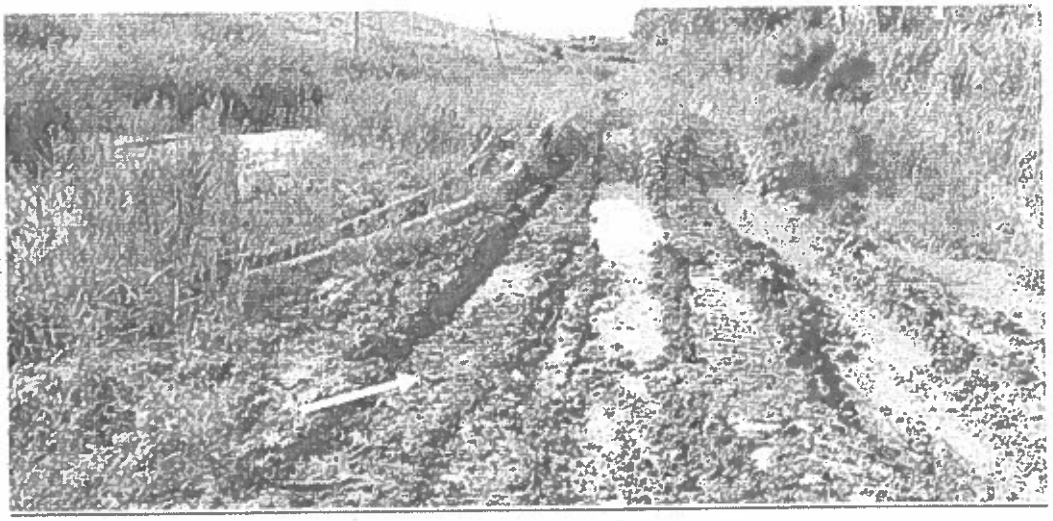


MINE INSPECTION DIGITAL PHOTOGRAPH PHOTOCOPIES

oto #: Williamson Energy 3
e: August 30, 2018
ne: 10:07 a.m.
ken By: Brian Rodely BOW/FOS
ility: Pond Creek Mine
cation: Outfall 006 Face NW.
tes: Discharging outfall 006 with sample PCM006 is shown in the adjacent photo. Outfall 006 was discharging at an estimated 250 gallons per minute with mostly clear effluent. Note the HDPE pipe that is run up through outfall 006 culvert that discharges into pond 6.



oto #: Williamson Energy 4
te: August 30, 2018
ne: 10:20 a.m.
ken By: Brian Rodely BOW/FOS
ility: Pond Creek Mine
cation: Outfall 007 Face S.
tes: Outfall 007 is shown with no discharge occurring at the time of inspection. The HDPE pipes shown in the photo were described as tied into the water return circuit to the fresh water lake for use in the preparation plant.



MINE INSPECTION DIGITAL PHOTOGRAPH PHOTOCOPIES

Photo #: Williamson Energy 5
Date: August 30, 2018
Time: 10:21 a.m.
Taken By: Brian Rodely BOW/FOS
Facility: Pond Creek Mine
Location: Outfall 008 Face S.
Notes: Outfall 008 is shown with no discharge occurring at the time of inspection. The HDPE pipes shown in the photo were described as tied into the water return circuit to the fresh water lake for use in the preparation plant.

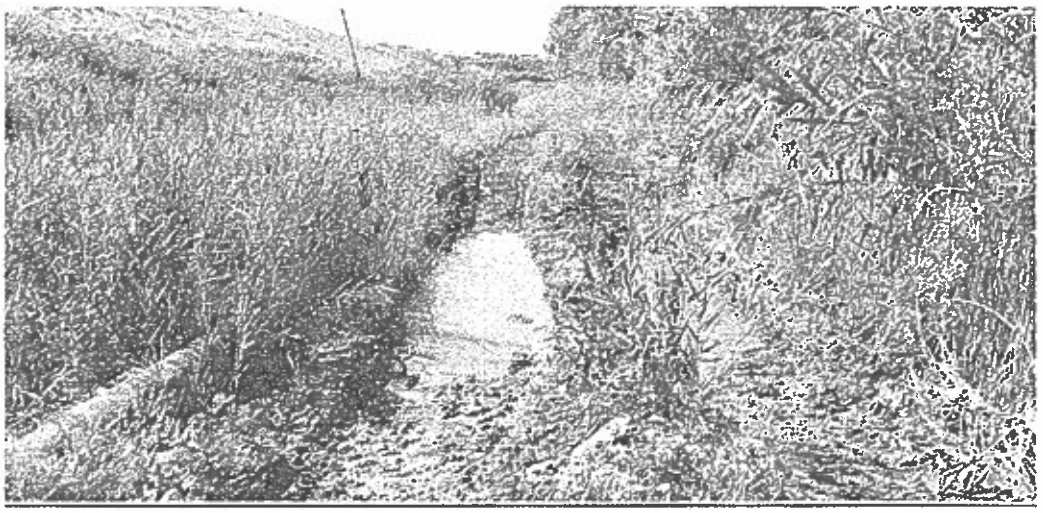
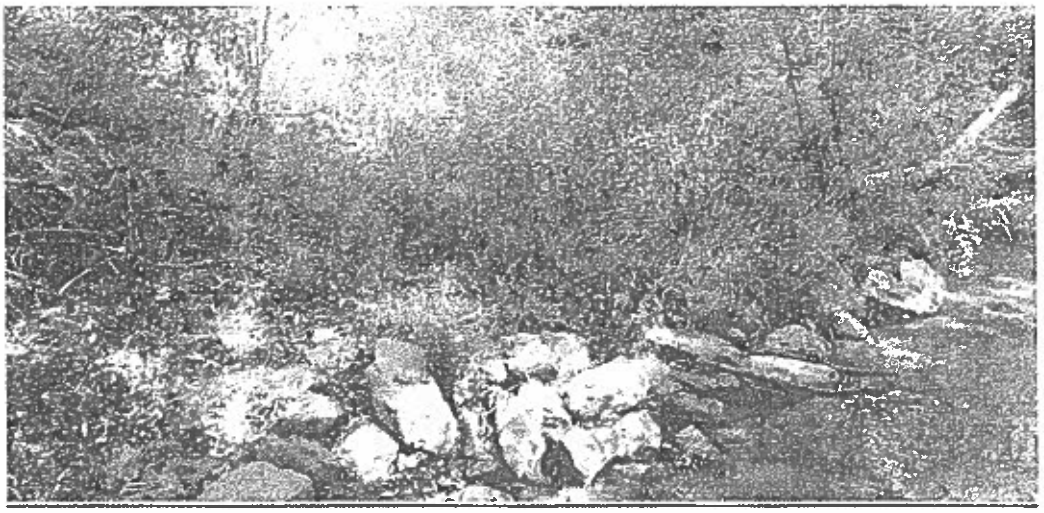
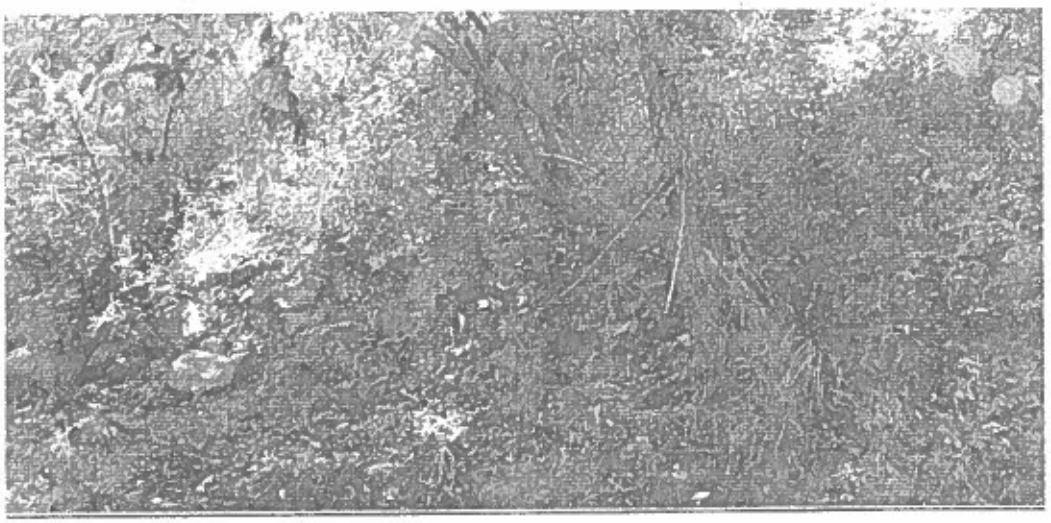


Photo #: Williamson Energy 6
Date: August 30, 2018
Time: 10:38 a.m.
Taken By: Brian Rodely BOW/FOS
Facility: Outfall 003 Face W.
Location: Outfall 003 is shown with no discharge occurring at the time of inspection.

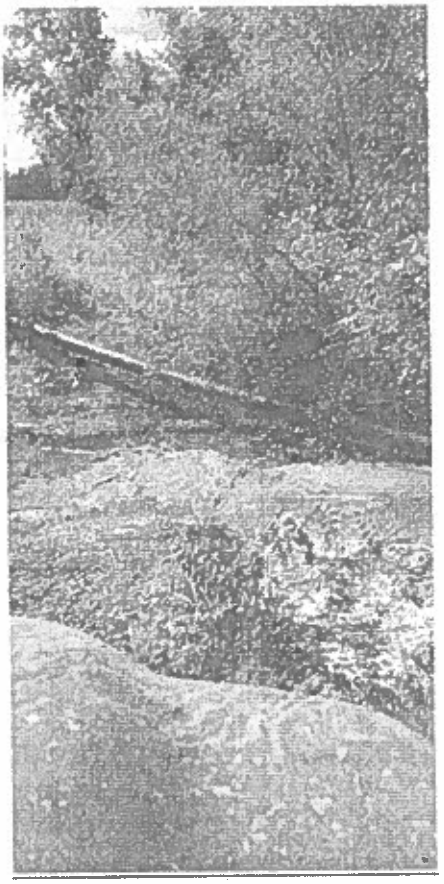


MINE INSPECTION DIGITAL PHOTOGRAPH PHOTOCOPIES

)to # Williamson Energy 7
e: August 30, 2018
ne: 10:39 a.m.
:en By: Brian Rodely BOW/FOS
ility: Pond Creek Mine
:ation: Outfall 004 Face E.
les: Outfall 004 is shown with no discharge occurring at the time of inspection.



)to # Williamson Energy 8
te: August 30, 2018
ne: 10:41 a.m.
:en By: Brian Rodely BOW/FOS
:ility: Pond Creek Mine
:ation: Outfall 005 Face S.
tes: Outfall 005 is shown with no discharge occurring at the time of inspection.



MINE INSPECTION DIGITAL PHOTOGRAPH PHOTOCOPIES

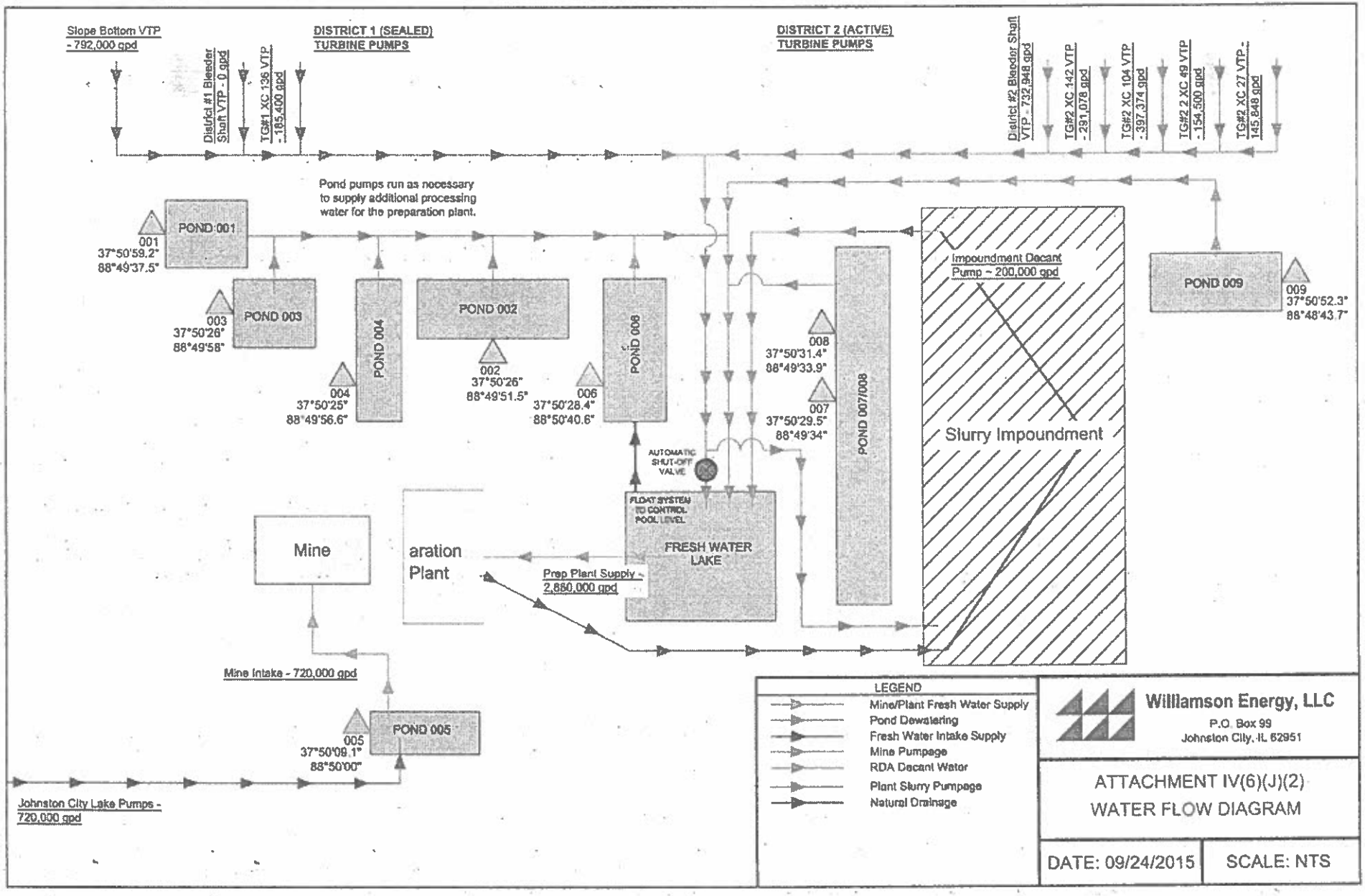
Photo #
Date: Williamson Energy 9
Time: August 30, 2018
Taken By: 10:41 a.m.
Facility: Bruce Rodely BOW/FOS
Location: Pond Creek Mine
Notes: Outfall 001 Face E. Outfall 001 is shown with no discharge occurring at the time of inspection.



Photo #
Date: Williamson Energy 10
Time: August 30, 2018
Taken By: 10:41 a.m.
Facility: Bruce Rodely BOW/FOS
Location: Pond Creek Mine
Notes: NE Pond1 Face SW Recent dredging of pond 1 is shown in the adjacent photo. Note the dark dredging placed on the berm that is visible from Dean Road located approximately 30 feet to the right of the photograph.



R05820


Slope Bottom VTP - 792,000 gpd
DISTRICT 1 (SEALED) TURBINE PUMPS
DISTRICT 2 (ACTIVE) TURBINE PUMPS
District #1 Bleeder Shaft VTP - 0 gpd
TG#1 XC 136 VTP - 185,400 gpd
District #2 Bleeder Shaft VTP - 732,948 gpd
TG#2 XC 142 VTP - 291,078 gpd
TG#2 XC 104 VTP - 397,374 gpd
TG#2 2 XC 49 VTP - 154,500 gpd
TG#2 XC 27 VTP - 145,848 gpd
Pond pumps run as necessary to supply additional processing water for the preparation plant.
POND 001
001 37°50'59.2" 88°49'37.5"
POND 003
003 37°50'26" 88°49'58"
POND 004
004 37°50'25" 88°49'56.6"
POND 002
002 37°50'26" 88°49'51.5"
POND 006
006 37°50'28.4" 88°50'40.6"
008 37°50'31.4" 88°49'33.9"
007 37°50'29.5" 88°49'34"
POND 007/008
Impoundment Decant Pump - 200,000 gpd
Slurry Impoundment
POND 009
009 37°50'52.3" 88°48'43.7"
AUTOMATIC SHUT-OFF VALVE
FLOAT SYSTEM TO CONTROL POOL LEVEL
FRESH WATER LAKE
Mine
aration Plant
Prep Plant Supply - 2,660,000 gpd
Mine Intake - 720,000 gpd
POND 005
005 37°50'09.1" 88°50'00"
Johnston City Lake Pumps - 720,000 gpd
LEGEND
Mine/Plant Fresh Water Supply
Pond Dewatering
Fresh Water Intake Supply
Mine Pumpage
RDA Decant Water
Plant Slurry Pumpage
Natural Drainage
Williamson Energy, LLC
P.O. Box 99
Johnston City, IL 62951
ATTACHMENT IV(6)(J)(2)
WATER FLOW DIAGRAM
DATE: 09/24/2015
SCALE: NTS

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Name:	WILLIAMSON ENERGY POND CREEK MINE		
Project/Facility Number:	IL0077666	Date Received :	08/31/18
Funding Code:	WPZ6	Visit Number:	
Trip ID:		Temperature C:	4.00
Client Sample ID:	PCM006	Lab Sample ID:	18H1423-01
Matrix:	Water	Date/Time Collected:	08/30/18 10:07
Sample Type:	Field pH:	Collected By:	

Acidity by Standard Method 2310B

Method:	2310B	Prepared:	09/11/18 10:00
Units:	mg CaCO3/L	Analyzed:	09/11/18 10:00

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Acidity	-440		197	

Alkalinity by Standard Method 310.2

Method:	310.2	Prepared:	09/07/18 09:05
Units:	mg/L	Analyzed:	09/07/18 13:12

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Alkalinity	552		10.0	

Chloride by Ion Chromatography 300.0

Method:	EPA 300.0	Prepared:	09/11/18 07:00
Units:	mg/L	Analyzed:	09/20/18 12:24

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Chloride	1420		10.0	

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety. Test results meet all requirements of NELAC (accredited by Florida DOH #E37645). If you have any questions about this report, please contact Tom Weiss, Laboratory Manager, at 217.782.9780.

Reported:
09/21/18 15:34

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Name:	WILLIAMSON ENERGY POND CREEK MINE		
Project/Facility Number:	IL0077666	Date Received :	08/31/18
Funding Code:	WPZ6	Visit Number:	
Trip ID:		Temperature C:	4.00
Client Sample ID:	PCM006	Lab Sample ID:	18H1423-01
Matrix:	Water	Date/Time Collected:	08/30/18 10:07
Sample Type:	Field pH:	Collected By:	

Metals by EPA Method 200.7 - ICP/Hardness by Standard Method 2340B

Method:	200.7/2340B	Prepared:	09/13/18 10:21
Units:	ug/L	Analyzed:	09/14/18 10:33

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Aluminum	135		60.0	40000
Arsenic	ND		10.0	
Barium	49.1		5.00	
Beryllium	ND		1.00	
Boron	1210		10.0	
Cadmium	ND		3.00	
Calcium	73500		300	100000
Chromium	ND		5.00	
Cobalt	ND		10.0	
Copper	13.3		10.0	
Iron	122		50.0	40000
Lead	ND		5.00	
Magnesium	39200		300	100000
Manganese	73.0		15.0	
Nickel	21.5		5.00	
Potassium	26000		1400	100000
Selenium	ND		20.0	
Silver	ND		3.00	
Sodium	2080000		3000	
Strontium	1720		5.00	
Vanadium	ND		5.00	
Zinc	ND		25.0	
Hardness	359000		1980	

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Reported:
09/21/18 15:34

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Name:	WILLIAMSON ENERGY POND CREEK MINE		
Project/Facility Number:	IL0077666	Date Received :	08/31/18
Funding Code:	WPZ6	Visit Number:	
Trip ID:		Temperature C:	4.00
Client Sample ID:	PCM006	Lab Sample ID:	18H1423-01
Matrix:	Water	Date/Time Collected:	08/30/18 10:07
Sample Type:	Field pH:	Collected By:	

pH

Method:	SM 4500H+B	Prepared:	09/06/18 14:00
Units:	PH	Analyzed:	09/06/18 14:04

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Laboratory pH	8.4	Q	0.1	

Sulfate by Ion Chromatography 300.0

Method:	300.0	Prepared:	09/11/18 07:00
Units:	mg/L	Analyzed:	09/20/18 12:24

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Sulfate	2120		100	

Total Suspended Solids by Standard Method 2540D

Method:	SM 2540D	Prepared:	09/04/18 09:40
Units:	mg/L	Analyzed:	09/05/18 09:27

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Total Suspended Solids	17		4	

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety. Test results meet all requirements of NELAC (accredited by Florida DOH #E37645). If you have any questions about this report, please contact Tom Weiss, Laboratory Manager, at 217.782.9780.

Reported:
09/21/18 15:34

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Name:	WILLIAMSON ENERGY POND CREEK MINE		
Project/Facility Number:	IL0077666	Date Received :	08/31/18
Funding Code:	WPZ6	Visit Number:	
Trip ID:		Temperature C:	4.00

Notes and Definitions

Q	Maximum holding time exceeded.
ND	Analyte NOT DETECTED at or above the reporting limit
*	Non-NELAP accredited

The acidity of the sample is measured to pH 8.3. If a negative value is reported, the absolute value of this negative value should be equivalent to the net alkalinity.

Report Authorized by:

Tom Weiss
Laboratory Manager

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety. Test results meet all requirements of NELAC (accredited by Florida DOH #E37645). If you have any questions about this report, please contact Tom Weiss, Laboratory Manager, at 217.782.9780.

Reported:
09/21/18 15:34

Illinois Incident Report

Incident #: IL-2018-0717
Entered By: Shelbourne, Lisa (IEMA) **on** 2018-08-29 19:58:12
Data Input Status: Closed

INCIDENT INFORMATION			
Caller Name:	Kevin Norris		
Caller Represents:	Concerned Citizen		
Callback Phone:	618/983-9953		
Type of Incident:	General Report		
Incident Location:	Dean Rd. on Northside of Gob Hill for Mach Coal Mine		
County:	Williamson	City:	Marion
Primary IEMA Region:	11	Secondary IEMA Region:	Not Applicable
Full Address:	Dean Rd. on Northside of Gob Hill for Mach Coal Mine, Marion, IL		
Latitude:		Longitude:	
Number of People:			
Date Out:		Date In:	

AGENCIES OR PERSONS NOTIFIED			
Agency	Date/Time	Name of Person	Notification Action
IEPA	2018-08-29 19:50	Blaine Kinsley	Contacted
IDNR Mines and Minerals	2018-08-29 19:50	Tony Mayville	Contacted
IEPA and IDNR Mines and Minerals	2018-08-29 19:58	Emailed	Report Sent

Narrative:

A slurry silt is going into a Creek west of the Gob Hill of Mach Coal Mine in between Liberty School Rd. and Dwina Rd. The Coal Mine is pumping the slurry silt with water out of the coal mine directly into creek. The creek does not have enough water to dilute it and it is black. Caller is concerned because he has land near by. This creek runs into Pond Creek. This Mach Mines is just East of Johnson City.

Illinois Environmental Protection Agency
DWPC/FOS - Mine Pollution Control Program
Field Inspection Report

Company:	Williamson Energy, LLC
Mine:	Pond Creek Mine #1
County:	Williamson
Location:	Johnston City
NPDES #:	IL0077666
BOW ID:	W1998590001
Inspection Date:	August 29, 2019
Inspected by:	Brian Rodely
Type of Inspection:	Compliance Sampling
Contact Person(s):	Clayton Cross, Chris Skelton, Gary Vancil
Arrival Time:	9:15 AM
Departure Time	12:50 PM
Weather:	Sunny, 89°F.

Compliance Sampling Inspection

August 29, 2019 Compliance Sampling: A compliance sampling inspection was conducted at the above-referenced 540-acre NPDES permitted underground mine. The mine site includes drainage control structures, eight sediment basins, slope, preparation plant, coal stockpile, refuse disposal area, railroad loop, roads, ventilation shafts, parking areas, coal conveyors, and office/maintenance buildings.

Permitting: NPDES permit IL0077666 was issued/effective June 28, 2005 with an expiration date of July 1, 2010 has been administratively continued through timely renewal submissions and contains the discharge limitations for permitted outfalls at the site. The permit was modified February 7, 2013 reflect a name change to Williamson Energy, L.L.C., Pond Creek Mine No. 1.

Discharge Monitoring Reports: Quarterly DMR's are to be received by the Agency's DWPC, Compliance Assurance Section, by the 15th day of April, July, October, and January for the preceding three months. An annual storm water monitoring and sampling plan is due by November 1st of each year.

Drainage Control & Water Treatment: There are 8 NPDES permitted outfalls at this site each associated with a sedimentation basin. Outfalls 001, 002, 003, 004, and 005 are classified as Alkaline Mine Drainage. Outfalls 006, 007, and 008 are classified as Acid Mine Drainage. Sedimentation basins control runoff from three refuse disposal areas (RDA), coal stock piles, and approximately 2.7 million gallons per day of groundwater infiltration into the mine. All outfalls report to unnamed tributaries to Pond Creek.

Findings: The attached 7 photo pages, site plan, and water flow diagram should be consulted to clarify the following activities. I arrived at the unnamed tributary to Pond Creek crossing Dean Road about ½ mile east of the intersection of Dean Road and Liberty School Road at approximately 9:15 am. The stream appeared to have a small flow (approximately 100 gpm) of clear water. A nearby

property owner was working along Dean Road near the unnamed tributary bridge across Dean Road. The owner told me that I need to take samples on Saturday or Sunday when the ditch is rolling "dark gob water" released when the mine knows it will not be caught. I told the land owner that he could file a complaint. The land owner said that when he complained the last time the mine "gave him a hard time". Sample PCDR was taken in the unnamed tributary upstream (south) of Dean Road as documented in photo 1. I proceeded to pond 009 along Dean Road and turned into an actively used entrance to assess the emergency spillway at pond 009. I noted that the emergency spillway had over 2 feet of freeboard before discharge as shown in photo 2. Water was running into pond 009 from the direction of RDA3 and pumps appeared operational in the western end of the pond as shown in photo 3. I called Clayton Cross and was unable to make contact. Next, I called Gary Vancil and explained that I was at the Pond Creek Mine where I needed to conduct an NPDES inspection of the site. Vancil told me that Cross was with him but on another call. Vancil said that he would attempt to contact Brenton Mumford the Pond Creek Mine Engineer or someone to meet me at the Mine Gate. Vancil called back and told me that he was coming with Chris Skelton to meet me at the mine and take me where I needed to go. Cross then returned my call and said that he may be down to the mine later to meet with me.

Vancil and Skelton arrived at the mine and I explained that I needed to observe the mine's water collection and management system including collection ditches, sedimentation basins, and outfalls. We proceeded to outfall 002 that was observed to be non-discharging at the time of inspection as shown in photo 4. Pond 002 collects runoff from the raw coal pile and water is pumped to the freshwater for use in the prep plant. Photo 5 shows the non-discharging culvert outfall 006. It was noted that water has recently discharged from 006 due to water remaining in the corrugated pipe as indicated by the yellow arrow in photo 5. Sample PC006DS shown in the foreground of photo 5 was taken of standing water in the receiving stream of 006 as indicated by the white arrow. The receiving stream appeared to have slight staining on the stream bank vegetation that was recently lodged due to significant water flow with no recent precipitation. I then observed outfalls 008 and 007 that were not discharging as shown in photos 6 and 7. Clayton Cross met with us at outfalls 007 and 008 where we discussed the operations at Pond Creek Mine. Cross left the group and we proceeded to non-discharging outfalls 005, 003, 004, and 001 as shown in photos 8 through 11. I noted that newly constructed water holding cells located north of the mine office along Liberty School Road appeared to only contain storm water with no piping to receive or discharge mine process water. Finally, we walked the collection ditch south of RDA 3 progressing east from Dwina Road. The southern collection ditch is shown in photo 12 where water is actively pumped to the ditch from the southern cell of RDA 3. We walked east then approximately ¼ mile north to a retention dam with a large elevation change resulting in an approximate 15-foot waterfall as shown in photo 13. Vancil and Skelton advised me that specific information about the collection system and sedimentation ponds could be provided by Pond Creek Mine Engineer Brenton Mumford. I left the mine at approximately 12:50 pm.

Subsequent Information: 9/3/19: IDNR inspector Will Gillespie called and told me he heard there was a "leak" at the Pond Creek Mine. I told Gillespie that I conducted an inspection at the mine and found a wet culvert at 006 with standing water in the receiving stream that I sampled. I also discussed the possibility of mine discharges occurring during off hours as reported by a

nearby land owner. Gillespie indicated that he has received similar information about off-hour discharges from multiple sources. Gillespie also told me that he has been attempting to have the mine dredge some sedimentation ponds with limited results at this time.

09/19/19: Sample results were received at the Marion Regional Office for Sample PCDR taken at Dean Road and PC006DS taken downstream from outfall 006.

35 IAC Subtitle C Part 302 Subpart B General Use Water Quality Standards calculated or provided Acute Standard Water Quality Standard (ASWQS) are shown below with the reported sample results.

Sample results for PCDR are attached and provided below:

Parameter	Fe	Sulfates	Chlorides	Mn	Hardness
ASWQS (mg/L)	1.0	1391	500	9.24	N/A
PCDR (mg/L)	0.069	1790	1150	0.03	289

Sample results for PC006DS are attached and provided below:

Parameter	Fe	Sulfates	Chlorides	Mn	Hardness
ASWQS (mg/L)	1.0	1180	500	7.79	N/A
PC006DS (mg/L)	ND	1780	1140	0.04	230

General Use Water Quality Standards are exceeded for Sulfates and Chlorides as shown above. Sulfates are calculated using the maximum value of 500 for Chlorides.

Discharge Monitoring Report Submittal: Discharge monitoring reports have been evaluated for all outfalls from January 2018 through March 2019. DMR's appear to have been submitted with no discharge reported during non-precipitation events despite the daily influent of approximately 2.7 million gallons of underground mine water. The water mass balance of influent water and discharged water does not appear consistent.

Apparent Violations: The following apparent monitoring and effluent violations were noted during the CSI Inspection at Pond Creek Mine #1.

General Use Water Quality Standards are exceeded for 35 IAC Subtitle C Part 302 Subpart B Sections 302.203 (staining downstream) and 302.208 (numerical ASWQS).

Monitoring Violations: Analysis not conducted of discharges, inadequate frequency of sampling, and invalid/unrepresentative sample as required by permit.

Summary: All affected areas of the mine appear to drain to sedimentation ponds and the collection system appears adequate with no unpermitted discharges noted. Samples were taken in the unnamed tributary to Pond Creek downstream from the mine immediately south of Dean Road. A local land owner indicated that the unnamed tributary to Pond Creek has heavy dark flow during non-business hours due to mine water release. A sample was also taken of the unnamed tributary immediately downstream from outfall 006 that appeared to recently discharge due to water in the corrugated tile, staining on receiving stream vegetation, and remaining pools of water in the stream bed. No discharges have been reported from January 2018 through March 2019 during non-precipitation events despite the estimated 2.7 million gallons of daily mine water pumped to the surface collection system. Sample Results PCDR and PC006DS show excursions of General Use Water Quality Standards for Sulfates and Chlorides.

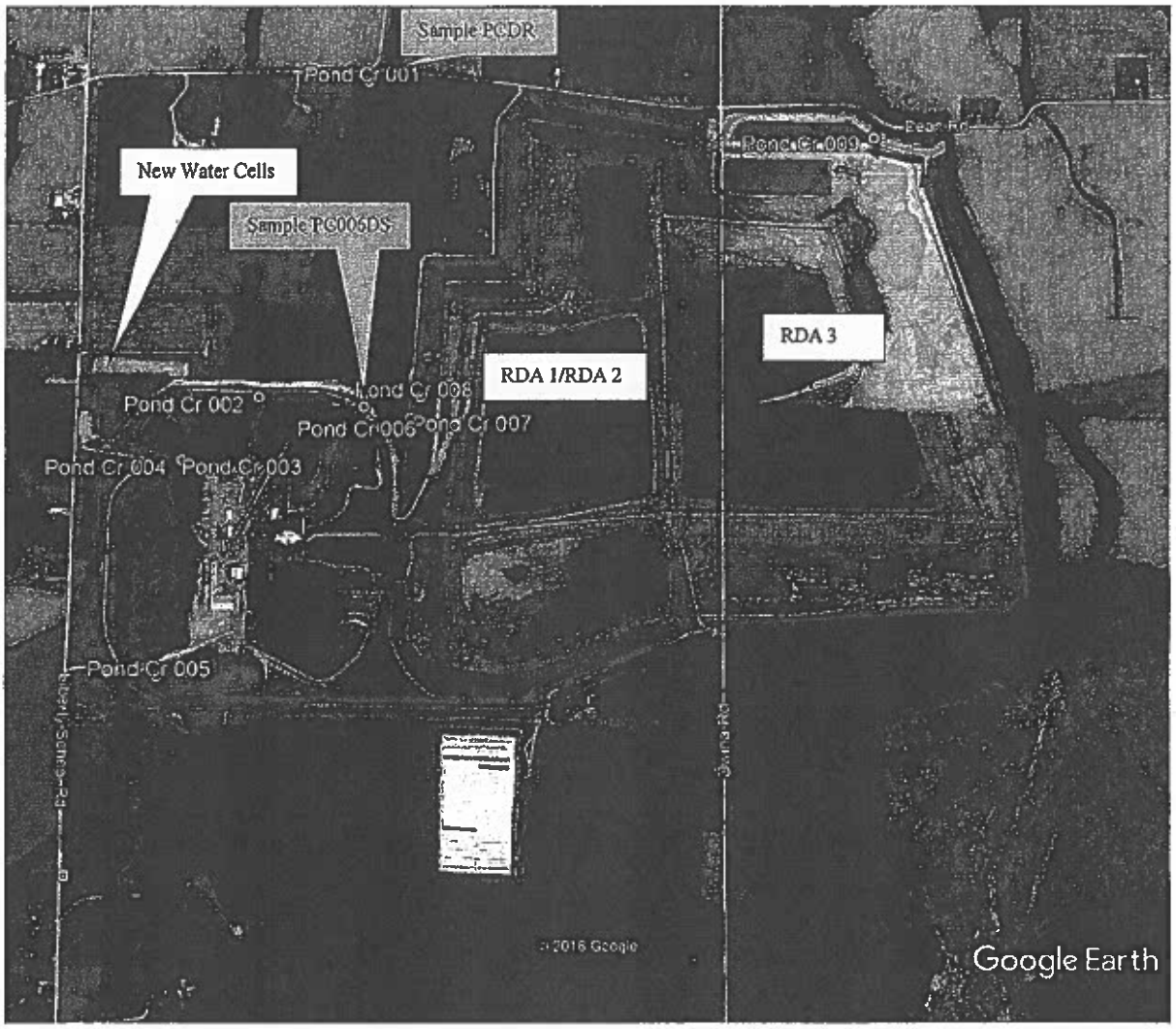
Brian Rodely

Brian Rodely
Environmental Protection Engineer
IEPA/DWPC/FOS
BER: pond creek mine insp 190829.doc

Attachments: 1 Site Plan Pages
7 Photo Pages
1 Williamson Energy, LLC Water Flow Diagram
7 Laboratory Results Pages

Original: BOW/MPCP/Marion
BOW/DWPC/CAS
IDNR/OMM

Pond Creek Mine #1- 190829



Satellite view of Pond Creek Mine #1 is shown above with the outfalls appearing as bull's eye with their respective label. Collection ditch flow is indicated with a red arrow and sample points are shown with orange indicators. No discharge was occurring at any of the outfalls at the time of inspection. Staining on vegetation and the presence of pooled water downstream from outfall 006 gives the appearance of recent discharge. Sample PC006DS was taken immediately downstream from outfall 006 and sample PCDR was taken in the unnamed tributary to Pond Creek immediately south of Dean Road. All water appears to report to the collection system controlled by sedimentation basins. Outfall 009 is not permitted to discharge and appeared to have 2 feet of freeboard prior to discharging through the emergency spill way of pond 009. Water is continuously discharged to pond 009 from RDA 3 under drains and by the RDA 3 collection ditch. Water is pumped from 009 to RDA 3 or freshwater lake used as makeup water for the preparation plant. RDA 3 water is pumped to the fresh water lake or pond 006. Pond 005 receives water from Johnston City Lake and the collection ditch north of RDA 2. Water is pumped from pond 005 to the mine works.

MINE INSPECTION DIGITAL PHOTOGRAPH PHOTOCOPIES

Photo # Williamson Energy 1
Date: August 29, 2019
Time: 9:37 a.m.
Taken By: Brian Rodely BOW/FOS
Facility: Pond Creek Mine
Location: S Dean Road @ Unnamed.
Notes: Photograph of conditions of the unnamed tributary to Pond Creek immediately south of Dean Road. Sample PCDR was taken in the unnamed tributary noted ot be running approximately 100 gpm.

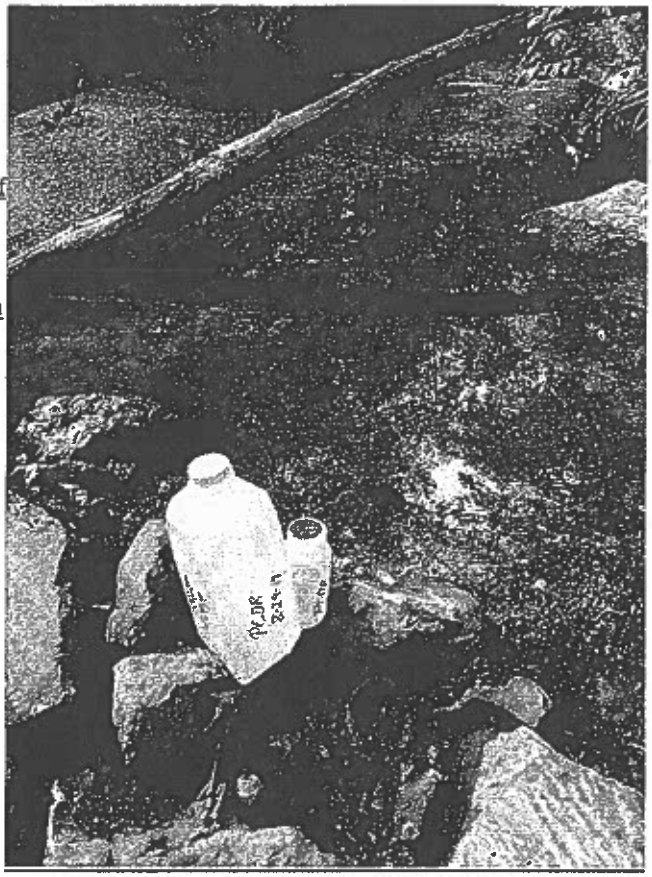


Photo # Williamson Energy 2
Date: August 29, 2019
Time: 9:47 a.m.
Taken By: Brian Rodely BOW/FOS
Facility: Pond Creek Mine
Location: Pond 009 Face SW.
Notes: Pond 009 is shown with the emergency spillway indicated by the yellow arrow. The pond appears to have approximately 2 feet of freeboard prior to discharging through the unpermitted spillway. RDA 3 can be seen in the photo backdrop of pond 009. The collection ditch south RDA 3 drains east, north then west to pond 009 on the north side of RDA 3.



MINE INSPECTION DIGITAL PHOTOGRAPH PHOTOCOPIES

Photo # Williamson Energy 3
Date: August 29, 2019
Time: 9:49 a.m.
Taken By: Brian Rodely BOW/FOS
Facility: Pond Creek Mine
Location: Pond 009 face SSW.
Notes: Some under drains and the collection ditch from RDA 3 drain into pond 009 as shown in the photo. Water must be continuously pumped to RDA 3 and the fresh water lake from pond 009.

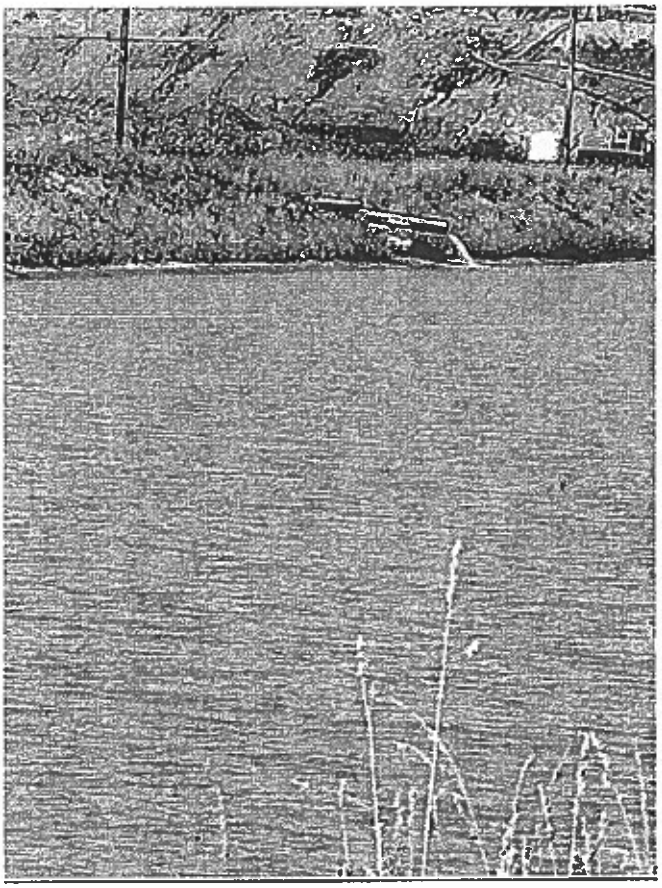
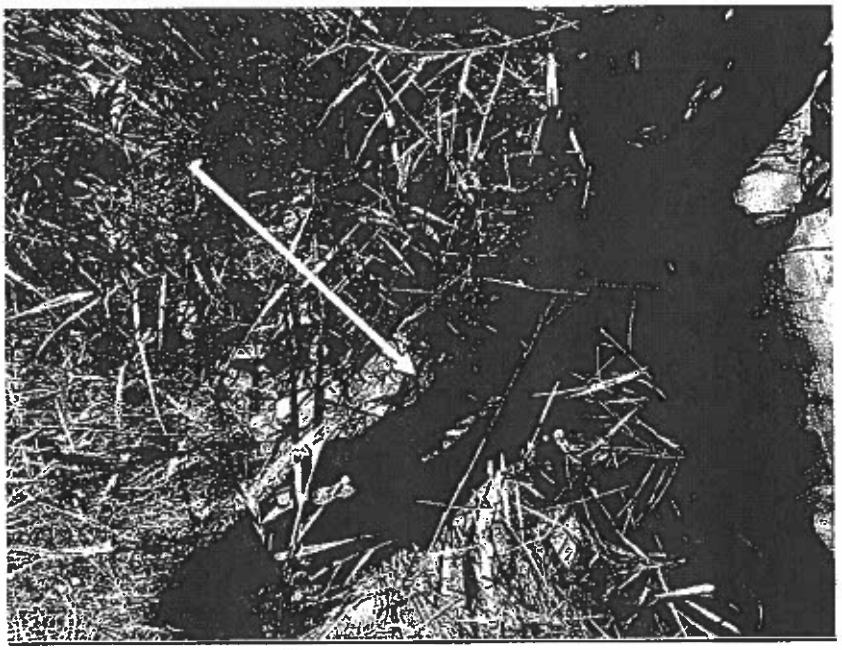


Photo # Williamson Energy 4
Date: August 29, 2019
Time: 10:41 a.m.
Taken By: Brian Rodely BOW/FOS
Facility: Pond Creek Mine
Location: Outfall 002 Face W.
Notes: Outfall 002 is shown with no discharge occurring at the time of inspection. Some water is noted by the white arrow pooled in the outfall with no evidence of recent discharge.



MINE INSPECTION DIGITAL PHOTOGRAPH PHOTOCOPIES

Photo # Williamson Energy 5
Date: August 29, 2019
Time: 11:02 a.m.
Taken By: Brian Rodely BOW/FOS
Facility: Pond Creek Mine
Location: Outfall 006 Face SW.
Notes: Outfall 006 is shown with no discharge occurring at the time of inspection. The yellow arrow shows water standing in the corrugated tile with recent staining noted on the vegetation along the 006-receiving stream. Sample PC006DS is shown in the photo taken from the standing water in the receiving stream indicated by the white arrow.

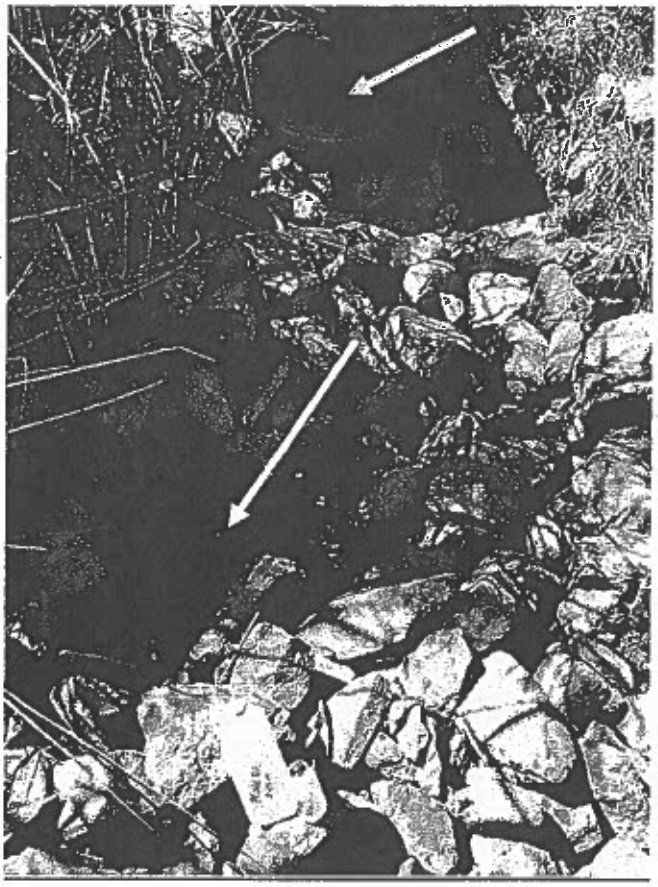


Photo # Williamson Energy 6
Date: August 29, 2019
Time: 11:15 a.m.
Taken By: Brian Rodely BOW/FOS
Facility: Outfall 008 Face S.
Location: Outfall 008 is shown with no discharge occurring at the time of inspection.



MINE INSPECTION DIGITAL PHOTOGRAPH PHOTOCOPIES

Photo #
Date: Williamson Energy 7
Time: August 29, 2019
Taken By: 11:17 a.m.
Facility: Brian Rodely BOW/FOS
Location: Pond Creek Mine
Notes: Outfall 007 Face N. Outfall 007 is shown with no discharge occurring at the time of inspection. Standing water shown in the photo is from traffic creating holes where water ponding occurs.

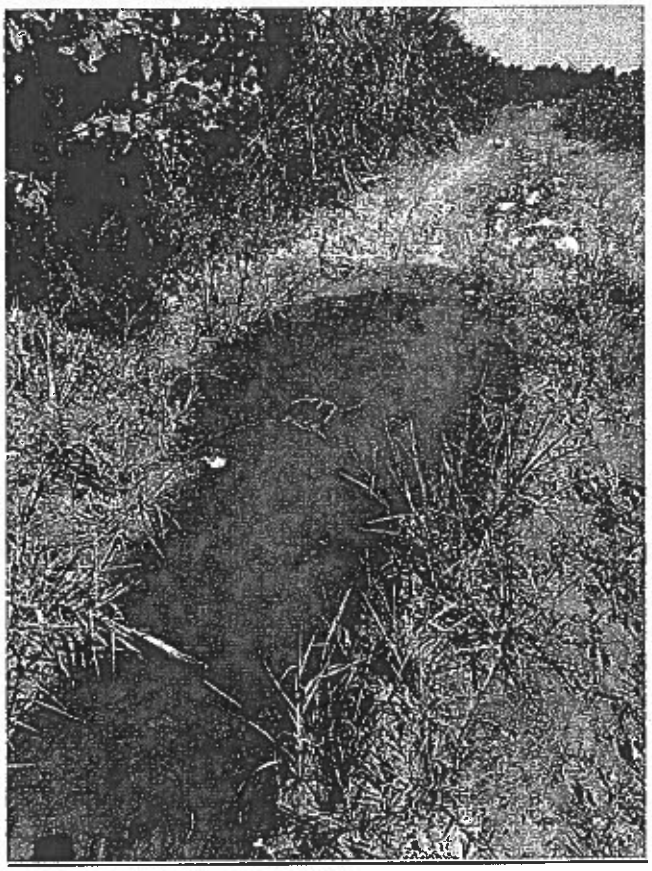
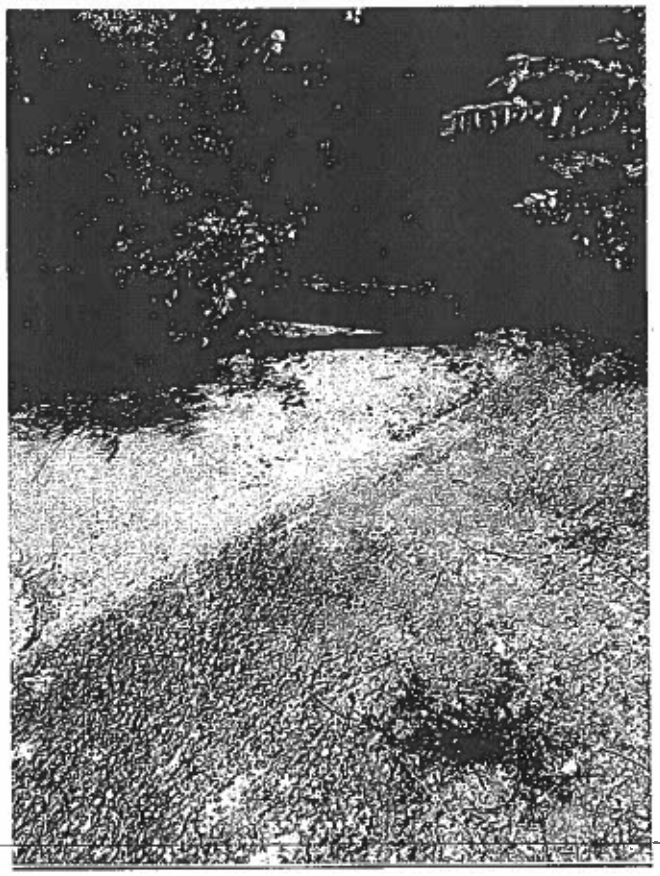


Photo #
Date: Williamson Energy 8
Time: August 29, 2019
Taken By: 11:26 a.m.
Facility: Brian Rodely BOW/FOS
Location: Pond Creek Mine
Notes: Outfall 005 Face S. Outfall 005 is shown with no discharge occurring at the time of inspection.



MINE INSPECTION DIGITAL PHOTOGRAPH PHOTOCOPIES

Photo #: Williamson Energy 9
Date: August 29, 2019
Time: 11:31 a.m.
Taken By: Brian Rodely BOW/FOS
Facility: Pond Creek Mine
Location: Outfall 003 Face NW.
Notes: Outfall 003 is shown with no discharge occurring at the time of inspection.



Photo #: Williamson Energy 10
Date: August 29, 2019
Time: 11:31 a.m.
Taken By: Brian Rodely BOW/FOS
Facility: Pond Creek Mine
Location: Outfall 004 Face E.
Notes: Outfall 004 is shown with no discharge occurring at the time of inspection.



MINE INSPECTION DIGITAL PHOTOGRAPH PHOTOCOPIES

Photo #
Date: Williamson Energy 11
Time: August 29, 2019
Taken By: 11:40 a.m.
Facility: Brian Rodely BOW/FOS
Location: Pond Creek Mine
Notes: Outfall 001 Face S.
Outfall 001 is shown with no discharge occurring at the time of inspection.

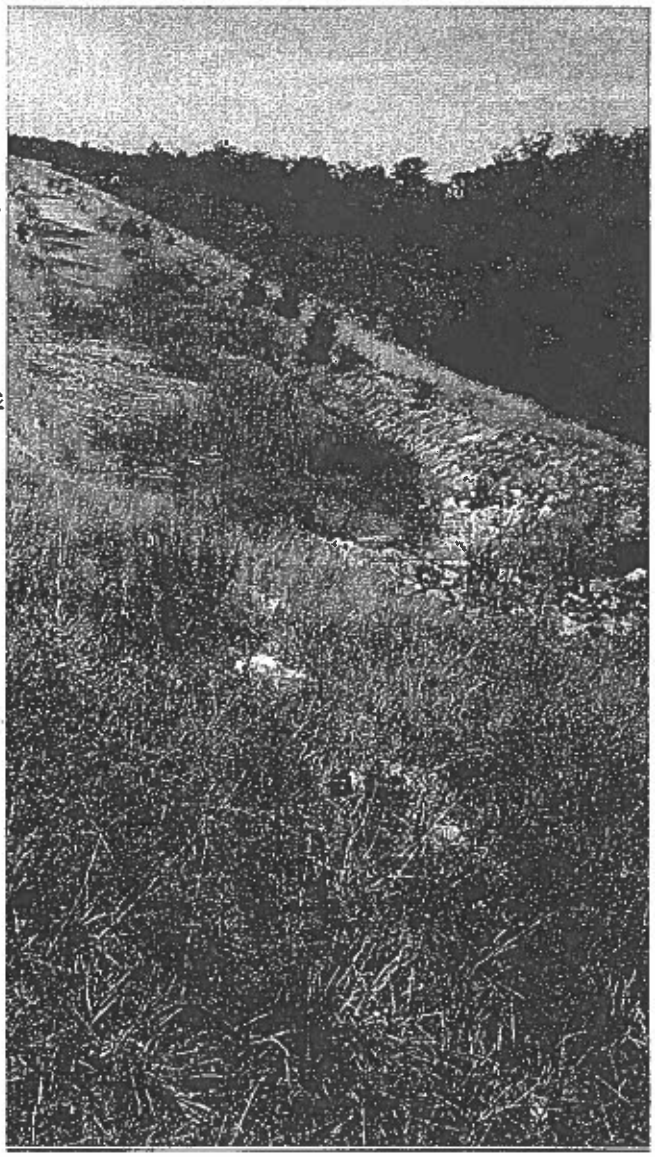


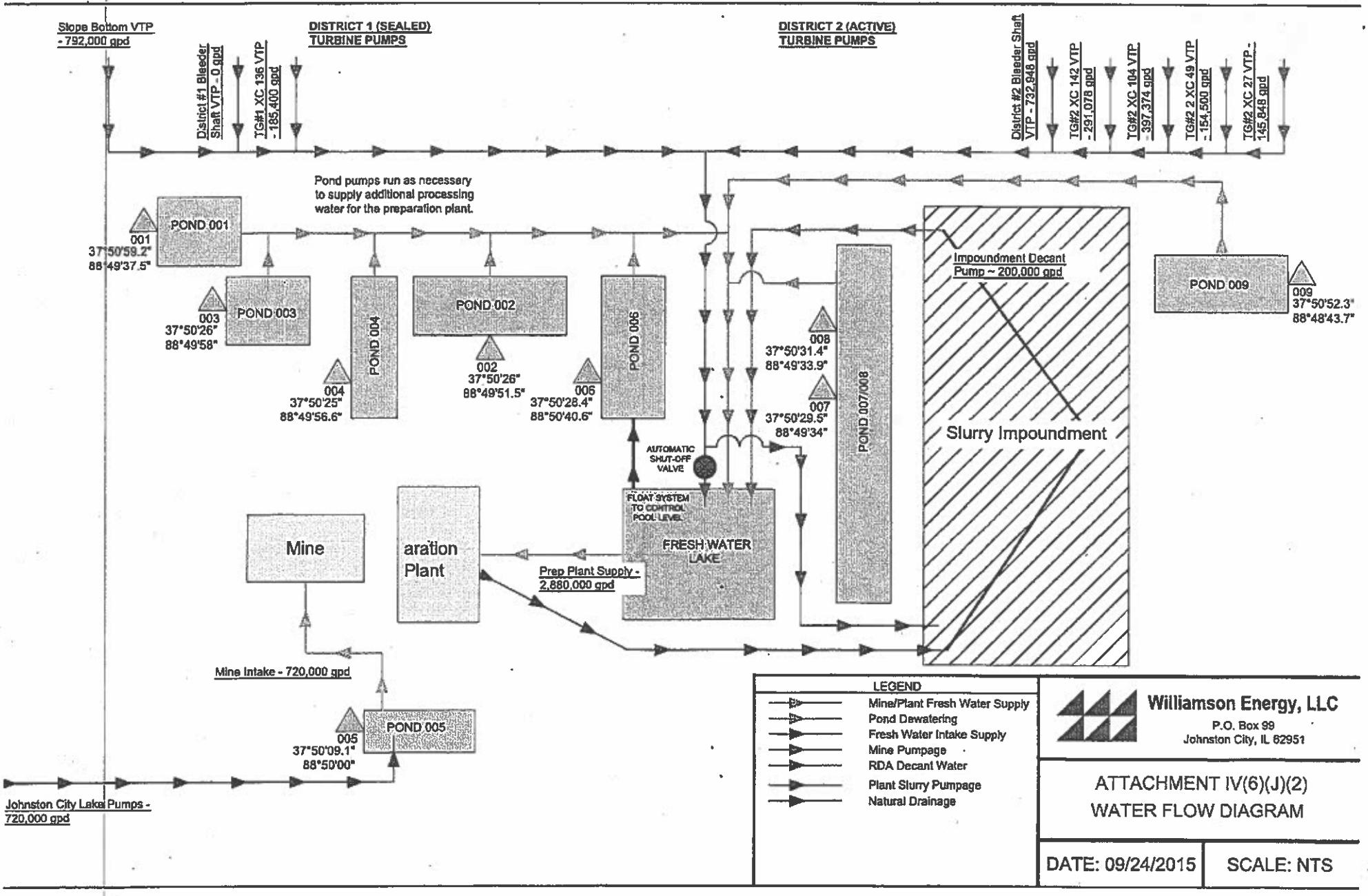
Photo #
Date: Williamson Energy 12
Time: August 29, 2019
Taken By: 11:58 a.m.
Facility: Brian Rodely BOW/FOS
Location: Pond Creek Mine
Notes: S RDA 3 Face E
The collection ditch south of RDA 3 is shown in the adjacent photo. Water is pumped to the ditch from the southern cell of RDA 3 then drains east and north to pond 009. Several check dams are located in the collection ditch to control flow to pond 009.



MINE INSPECTION DIGITAL PHOTOGRAPH PHOTOCOPIES

Photo # Williamson Energy 13
Date: August 29, 2019
Time: 12:17 p.m.
Taken By: Brian Rodely BOW/FOS
Facility: Pond Creek Mine
Location: E RDA 3 Face N
Notes: The collection ditch east of RDA 3 is shown in the adjacent photo. Water drains to the ditch through under drains and surface runoff. Note the elevation change that occurs from the camera dropping approximately 15 feet.




Slope Bottom VTP - 792,000 gpd
DISTRICT 1 (SEALED) TURBINE PUMPS
District #1 Bleeder Shaft VTP - 0 gpd
TG#1 XC 136 VTP - 185,400 gpd
DISTRICT 2 (ACTIVE) TURBINE PUMPS
District #2 Bleeder Shaft VTP - 732,948 gpd
TG#2 XC 142 VTP - 291,078 gpd
TG#2 XC 104 VTP - 397,374 gpd
TG#2 2 XC 49 VTP - 154,500 gpd
TG#2 XC 27 VTP - 145,848 gpd
Pond pumps run as necessary to supply additional processing water for the preparation plant.
POND 001
001 37°50'59.2" 88°49'37.5"
POND 003
003 37°50'26" 88°49'58"
POND 004
004 37°50'25" 88°49'56.6"
POND 002
002 37°50'26" 88°49'51.5"
POND 006
006 37°50'28.4" 88°50'40.6"
008 37°50'31.4" 88°49'33.9"
007 37°50'29.5" 88°49'34"
POND 007/008
Impoundment Decant Pump ~ 200,000 gpd
Slurry Impoundment
POND 009
009 37°50'52.3" 88°48'43.7"
AUTOMATIC SHUT-OFF VALVE
FLOAT SYSTEM TO CONTROL POOL LEVEL
FRESH WATER LAKE
Mine
aration Plant
Prep Plant Supply - 2,880,000 gpd
Mine Intake - 720,000 gpd
POND 005
005 37°50'09.1" 88°50'00"
Johnston City Lake Pumps - 720,000 gpd
LEGEND
Mine/Plant Fresh Water Supply
Pond Dewatering
Fresh Water Intake Supply
Mine Pumpage
RDA Decant Water
Plant Slurry Pumpage
Natural Drainage
Williamson Energy, LLC
P.O. Box 99
Johnston City, IL 62951
ATTACHMENT IV(6)(J)(2)
WATER FLOW DIAGRAM
DATE: 09/24/2015
SCALE: NTS

R05841

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Name:	WILLIAMSON ENERGY POND CREEK MINE		
Project/Facility Number:	IL0077666	Date Received :	08/30/19
Funding Code:	WPZ6	Visit Number:	
Trip ID:		Temperature C:	6.00
Client Sample ID:	PC006DS	Lab Sample ID:	19H1164-01
Matrix:	Water	Date/Time Collected:	08/29/19 11:01
Sample Type:	Grab Field pH:	Collected By:	BER

Acidity by Standard Method 2310B

Method:	2310B	Prepared:	09/10/19 09:01
Units:	mg CaCO3/L	Analyzed:	09/10/19 10:00

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Acidity	-475		197	

Alkalinity by Standard Method 310.2

Method:	310.2	Prepared:	09/05/19 15:26
Units:	mg/L	Analyzed:	09/09/19 13:19

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Alkalinity	526		10.0	

Chloride by Ion Chromatography 300.0

Method:	300.0	Prepared:	09/03/19 07:42
Units:	mg/L	Analyzed:	09/03/19 16:13

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Chloride	1140		10.0	

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety. Test results meet all requirements of NELAC (accredited by Florida DOH #E37645). If you have any questions about this report, please contact Tom Weiss, Laboratory Manager, at 217.782.9780.

Reported:
09/17/19 13:11

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Name:	WILLIAMSON ENERGY POND CREEK MINE		
Project/Facility Number:	IL0077666	Date Received :	08/30/19
Funding Code:	WPZ6	Visit Number:	
Trip ID:		Temperature C:	6.00
Client Sample ID:	**PC006DS**	Lab Sample ID:	**19H1164-01**
Matrix:	Water	Date/Time Collected:	08/29/19 11:01
Sample Type:	Grab Field pH:	Collected By:	BER

Metals by EPA Method 200.7 - ICP/Hardness by Standard Method 2340B

Method:	200.7/2340B	Prepared:	09/04/19 08:57
Units:	ug/L	Analyzed:	09/12/19 11:54

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Aluminum	**75.1**		60.0	40000
Arsenic	ND		10.0	
Barium	**40.1**		5.00	
Beryllium	ND		1.00	
Boron	**1170**		10.0	
Cadmium	ND		3.00	
Calcium	**52100**		300	100000
Chromium	ND		5.00	
Cobalt	ND		10.0	
Copper	ND		10.0	
Iron	ND		50.0	40000
Lead	ND		5.00	
Magnesium	**24200**		300	100000
Manganese	**242**		15.0	
Nickel	**17.9**		5.00	
Potassium	**23700**		1400	100000
Selenium	ND		20.0	
Silver	ND		3.00	
Sodium	**1710000**		3000	
Strontium	**1370**		5.00	
Vanadium	ND		5.00	
Zinc	ND		25.0	
Hardness	**230000**		1980	

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Reported:
09/17/19 13:11

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Name:	WILLIAMSON ENERGY POND CREEK MINE		
Project/Facility Number:	IL0077666	Date Received :	08/30/19
Funding Code:	WPZ6	Visit Number:	
Trip ID:		Temperature C:	6.00
Client Sample ID:	PC006DS	Lab Sample ID:	19H1164-01
Matrix:	Water	Date/Time Collected:	08/29/19 11:01
Sample Type:	Grab Field pH:	Collected By:	BER

pH

Method:	SM 4500H+B	Prepared:	08/30/19 14:26
Units:	PH	Analyzed:	08/30/19 14:26

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Laboratory pH	8.1	Q	0.1	

Sulfate by Ion Chromatography 300.0

Method:	300.0	Prepared:	09/03/19 07:42
Units:	mg/L	Analyzed:	09/03/19 16:13

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Sulfate	1780		100	

Total Suspended Solids by Standard Method 2540D

Method:	SM 2540D	Prepared:	09/03/19 09:00
Units:	mg/L	Analyzed:	09/03/19 09:00

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Total Suspended Solids	9		4	

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Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Name:	WILLIAMSON ENERGY POND CREEK MINE		
Project/Facility Number:	IL0077666	Date Received :	08/30/19
Funding Code:	WPZ6	Visit Number:	
Trip ID:		Temperature C:	6.00
Client Sample ID:	**PCDR**	Lab Sample ID:	**19H1164-02**
Matrix:	Water	Date/Time Collected:	08/29/19 9:37
Sample Type:	Composite Field pH:	Collected By:	BER

Acidity by Standard Method 2310B

Method:	2310B	Prepared:	09/10/19 09:01
Units:	mg CaCO3/L	Analyzed:	09/10/19 10:00

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Acidity	-405		197	

Alkalinity by Standard Method 310.2

Method:	310.2	Prepared:	09/05/19 15:26
Units:	mg/L	Analyzed:	09/09/19 13:19

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Alkalinity	472		10.0	

Chloride by Ion Chromatography 300.0

Method:	300.0	Prepared:	09/03/19 07:42
Units:	mg/L	Analyzed:	09/03/19 16:22

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Chloride	1150		10.0	

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Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Name:	WILLIAMSON ENERGY POND CREEK MINE		
Project/Facility Number:	IL0077666	Date Received :	08/30/19
Funding Code:	WPZ6	Visit Number:	
Trip ID:		Temperature C:	6.00
Client Sample ID:	PCDR	Lab Sample ID:	19H1164-02
Matrix:	Water	Date/Time Collected:	08/29/19 9:37
Sample Type:	Composite Field pH:	Collected By:	BER

Metals by EPA Method 200.7 - ICP/Hardness by Standard Method 2340B

Method:	200.7/2340B	Prepared:	09/04/19 08:57
Units:	ug/L	Analyzed:	09/12/19 11:59

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Aluminum	116		60.0	40000
Arsenic	ND		10.0	
Barium	55.4		5.00	
Beryllium	ND		1.00	
Boron	970		10.0	
Cadmium	ND		3.00	
Calcium	68600		300	100000
Chromium	ND		5.00	
Cobalt	ND		10.0	
Copper	ND		10.0	
Iron	69.4		50.0	40000
Lead	ND		5.00	
Magnesium	28500		300	100000
Manganese	30.6		15.0	
Nickel	11.5		5.00	
Potassium	20700		1400	100000
Selenium	ND		20.0	
Silver	ND		3.00	
Sodium	1680000		3000	
Strontium	1090		5.00	
Vanadium	ND		5.00	
Zinc	ND		25.0	
Hardness	289000		1980	

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety. Test results meet all requirements of NELAC (accredited by Florida DOH #E37645). If you have any questions about this report, please contact Tom Weiss, Laboratory Manager, at 217.782.9780.

Reported:
09/17/19 13:11

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Name:	WILLIAMSON ENERGY POND CREEK MINE		
Project/Facility Number:	IL0077666	Date Received :	08/30/19
Funding Code:	WPZ6	Visit Number:	
Trip ID:		Temperature C:	6.00
Client Sample ID:	**PCDR**	Lab Sample ID:	**19H1164-02**
Matrix:	Water	Date/Time Collected:	08/29/19 9:37
Sample Type:	Composite	Field pH:	Collected By: BER

pH

Method:	SM 4500H+B	Prepared:	08/30/19 14:26
Units:	PH	Analyzed:	08/30/19 14:26

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Laboratory pH	**8.0**	Q	0.1	

Sulfate by Ion Chromatography 300.0

Method:	300.0	Prepared:	09/03/19 07:42
Units:	mg/L	Analyzed:	09/03/19 16:22

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Sulfate	1790		100	

Total Suspended Solids by Standard Method 2540D

Method:	SM 2540D	Prepared:	09/03/19 09:00
Units:	mg/L	Analyzed:	09/03/19 09:00

Analyte	Result	Qualifier	Reporting Limit	Regulatory Level
Total Suspended Solids	ND		4	

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety. Test results meet all requirements of NELAC (accredited by Florida DOH #E37645). If you have any questions about this report, please contact Tom Weiss, Laboratory Manager, at 217.782.9780.

Reported:
09/17/19 13:11

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Name:	WILLIAMSON ENERGY POND CREEK MINE		
Project/Facility Number:	IL0077666	Date Received :	08/30/19
Funding Code:	WPZ6	Visit Number:	
Trip ID:		Temperature C:	6.00

Notes and Definitions

Q	Maximum holding time exceeded.
ND	Analyte NOT DETECTED at or above the reporting limit
.*	Non-NELAP accredited

The acidity of the sample is measured to pH 8.3. If a negative value is reported, the absolute value of this negative value should be equivalent to the net alkalinity.

Report Authorized by:

Tom Weiss
Laboratory Manager

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety. Test results meet all requirements of NELAC (accredited by Florida DOH #E37645). If you have any questions about this report, please contact Tom Weiss, Laboratory Manager, at 217.782.9780.

Reported:
09/17/19 13:11

Chicago Tribune December 5, 2019

Illinois has cut its EPA workforce by 38% in the past decade — more than any other state, report shows

By MICHAEL HAWTHORNE

Years before President Donald Trump's industry-backed appointees began rolling back enforcement of environmental laws, Illinois had begun shedding inspectors and slowing the policing of air and water pollution.

A pair of new reports document how funding for the Illinois Environmental Protection Agency steadily declined during the past decade, dropping by more than 25% in inflation-adjusted dollars as the agency's responsibilities expanded and became more complex.

Illinois also cut its environmental agency's workforce by 38% during the same period — more than any other state.

With a smaller staff and less money, the state agency has failed repeatedly to identify hazards to public health and hold polluters accountable, said Eric Schaeffer, a former top U.S. EPA enforcement official who directs the nonprofit Environmental Integrity Project and **compiled one of the reports**.

In several cases, federal officials have stepped in to address some of the state's biggest environmental problems. But federal enforcement regionally and nationally has declined sharply since Trump took office in 2017, according to records provided by the union for U.S. EPA workers.

Schaeffer and two former Illinois EPA directors urged Gov. J.B. Pritzker and the Democratic-controlled General Assembly to tweak the way the state agency is funded. Since 2003, when lawmakers stopped sharing a portion of the state's general fund with the agency, it has relied largely on federal payments and permit fees that aren't adjusted to keep pace with inflation or the rising cost of employee pensions and health care.

"We're jeopardizing the health and safety of Illinois citizens and the economic well-being of its businesses that rely on the Illinois EPA for timely permits and even-handed enforcement," said Mary Gade, who led the agency under former Republican Gov. Jim Edgar and later served as the regional U.S. EPA administrator under President George W. Bush.

Illinois ranks among the top 10 states for the amount of industrial air and water pollution released into the environment each year, according to federal records. Federal data also show that Illinoisans face some of the highest risks in the nation for cancer, lung disease and other health problems linked to toxic chemicals from industry smokestacks.

Yet state inspections of air polluters dropped 81% during the last decade, **according to a report** compiled by Gade, former Illinois EPA Director Doug Scott and the Abrams Environmental Law Clinic at the University of Chicago. "If you aren't looking for violations you aren't going to find any," Gade said. Often it takes persistent citizens, lawsuits from nonprofit groups and the glare of media attention to force environmental regulators into action.

For instance, the Illinois EPA refused to crack down on coal-fired power plants in Chicago and the suburbs, despite records documenting multiple violations of clean air laws. Market forces eventually priced the coal plants out of electricity markets, and most ended up closing under legal pressure from community groups, Chicago aldermen and the U.S. EPA.

The state agency also has been largely absent from investigations of brain-damaging manganese pollution contaminating Chicago's Southeast Side and lead-tainted yards in the Pilsen neighborhood. It took a citizen lawsuit and a federal investigation to force changes in the regulation of confined hog and cattle farms downstate, but the Illinois EPA still lacks dedicated inspectors to ensure the operations aren't spilling manure into the state's creeks and rivers.

"You can have all the rules in the world, but if you don't have the staff or the expertise to implement them, it's useless," said a veteran Illinois EPA official, who requested anonymity for fear of reprisals. "Morale is horrible. Employees have no guidance or tools to do their jobs."

Pritzker has signaled that he understands the problems and plans to fix them. Among other things, his administration has posted 161 job openings at the Illinois EPA this year, compared with 276 posted between 2013 and 2017.

"The governor believes the IEPA plays an important role ... and appreciates the bipartisan agreement of leaders from years past that we need to invest in critical government services to better serve the people of Illinois," Jordan Abudayyeh, a Pritzker spokeswoman, said in a statement.

Another reason enforcement is on the decline across Illinois is the agency has **cut back sharply** on using its most powerful tool: referring cases to the state attorney general's office for civil or criminal prosecution.

The **Tribune reported last year** that during former Republican Gov. Bruce Rauner's first year in office, the Illinois EPA referred 73 cases to the attorney general — by far the lowest number since 1991. The annual average during Rauner's first three years as governor was 80.

By contrast, the agency sent 198 referrals a year on average during former Democratic Gov. Rod Blagojevich's first three years in office and 144 during the same time under former Democratic Gov. Pat Quinn, the Tribune analysis found.

There have been 89 referrals since Pritzker took office this year, according to records provided by the attorney general's office.
The steady erosion of money and expertise at the Illinois EPA is even more alarming when considering the Trump administration's anti-regulatory policies, Schaeffer said.

Trump promised during his campaign to eliminate the U.S. EPA. Andrew Wheeler, a former coal industry lobbyist who serves as Trump's EPA administrator, has pushed to cede more authority to states. At the same time, the Trump administration has proposed steep cuts in federal support for state environmental programs.

But one of the reasons former Republican President Richard Nixon created the U.S. EPA in 1970 was leaders in both political parties had concluded states were incapable of holding polluters accountable — or were unwilling to do so.

The late William Ruckelshaus , an Indiana Republican who served as U.S. EPA administrator under Nixon and former President Ronald Reagan, often said the agency "represents one of the clearest examples of our political system listening and responding to the American people."

"Budget cuts that hurt programs that states now have in place to meet those duties run the risk of returning us to a time when some states offered industries a free lunch, creating havens for polluters," Ruckelshaus wrote in a **2017 opinion piece**. "This could leave states with strong environmental programs supported by the public at a competitive disadvantage compared to states with weak programs. In other words, it could lead to a race to the bottom."

mhawthorne@chicagotribune.com

Exhibit 392

From: Wils Evans
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine
Date: Friday, January 17, 2020 4:59:11 PM

Hello,

I would like to submit a comment about the Pond Creek Mine proposal.

I love fishing and kayaking in southern Illinois, and I spend a lot of time outdoors. I am thirteen years old, and I live in southern Illinois. My family enjoys the many outdoor opportunities that this area provides, and I would not like to see it polluted. Please do not let the Pond Creek Mine put any more pollution into the Big Muddy river!

Sincerely,

Wils Evans
2114 Market RD
Marion Illinois 62959

Exhibit 393

From: Amanda Pankau
To: EPA.PublicHearingCom
Cc: Andrew Rehn; Jeff Kohmstedt
Subject: [External] Pond Creek Mine (IL0077666)
Date: Friday, January 17, 2020 5:42:06 PM
Attachments: PRN Community Letter_Pond Creek Mine (IL0077666).pdf

---

Dear Ms. Lieberoff and other IEPA officials,

Please see the attached comment letter signed by 274 concerned community members in regards to the draft renewed National Pollutant Discharge Elimination System (NPDES) permit for the Pond Creek Mine.

On behalf of the many signers,
Amanda Pankau

--
Amanda Pankau
Energy Campaign Coordinator
Prairie Rivers Network
Illinois Affiliate of the National Wildlife Federation
1605 South State Street, Suite 1
Champaign IL 61820-7231.

tel: (217) 344-2371 x 214 | cell: (217) 840-3057

Prairie Rivers Network is Illinois' advocate for clean water and healthy rivers.

prairieriversnetwork

PRAIRIE RIVERS NETWORK
1605 South State Street, Suite 1
Champaign, Illinois 61820
217 / 344-2371
217 / 344-2381 fax
www.PrairieRivers.org

Re: Pond Creek Mine (IL0077666)

Dear Ms. Lieberoff and other IEPA officials,

We are writing with concerns about the draft renewed National Pollutant Discharge Elimination System (NPDES) permit (IL0077666) for the Pond Creek Mine. Please deny the proposal by Williamson Energy to pump polluted mine wastewater over 12 miles from the Pond Creek Mine into the Big Muddy River and to increase pollution into Pond Creek.

The IEPA should deny the draft water discharge permit because:

1. Williamson Energy's plan to discharge high chloride and high sulfate water into the Big Muddy River and Pond Creek will harm mussels, fish, and other aquatic organisms. The draft permit and antidegradation assessment do not adequately address impacts to these organisms or require pre- or post- construction biological sampling.

2. Williamson Energy's plan to monitor chloride concentrations is complex and requires monitoring of several parameters and a conductivity correlation, yet gives no way for the Agency or public to evaluate if the permittee is doing that monitoring properly. The mine proposes to continually balance their high-chloride effluent with the chloride levels already in the river. Given the public interest in this project and the company's history of past violations, the proposed monitoring plan is insufficient and infeasible.

3. The draft permit and antidegradation assessment have failed to take into consideration potential increases of Methyl-Mercury levels or other pollutants like copper, iron, selenium and nickel.

4. The antidegradation assessment has not adequately or accurately considered the economic impacts of the proposed project. New reports have indicated a continuing and projected decline of coal production in the Illinois Basin and Murray Energy, the parent company of Williamson Energy, filed for bankruptcy in fall 2019. The IEPA's estimates of local economic impact and jobs have failed to consider these developments.

Thank you for the opportunity to comment on the draft renewed National Pollutant Discharge Elimination System (NPDES) permit (IL0077666) for the Pond Creek Mine.

Sincerely,

Prairie Rivers Network Members, Supporters, and Concerned Community Members

Carolyn Schimpler, Urbana, IL
Mark Coats, Mount Vernon, IL
Scott Kozoll, Champaign, IL
Gene Ray, Paris, IL
Kristin Camp, Collison, IL
Charlotte Jones, Elmhurst, IL
George Onion, , IL
Kent Brown, Palatine, IL

Christine Allen, Urbana, IL
Alison Colgrove, Urbana, IL
John Massman, Antioch, IL
Daniel Carney, Bolingbrook, IL
Ed DeWalt, Champaign, IL
Melody Neuenburg, Chico, CA
Paul Schutt, Chicago, IL
Paul Kosuth, Murphysboro, IL
Joanna Cheistophee, Gorham, IL
Michael Anderson, Minneapolis, MN
george pellum, Champaign, IL
Carol Poland, Warrensburg, IL
Lara Orr, Urbana, IL
Bridget Frerichs, White Heath, IL
David Stanley, Champaign, IL
James Moore, Highland Park, OH
Logan Boyce, Carbondale, IL
Elizabeth Ruby, Urbana, IL
JoAnn Monge, Naperville, IL
Jill Pankau, Monticello, IL
Tamima Itani, Evanston, IL
Lori Mccollum, Rock Island, IL
Rebecca Lytle, Galesburg, IL
Jean Todd, Carbondale, IL
Andrea Johnson, Chicago, IL
R Levy, Naperville, IL
Kelly Armstrong, Geneseo, IL
Mary J Sleeth, Saint Joseph, IL
J. Beverly, Urbana, IL
Sarah Kilpatrick, Cobden, IL
Bryan Duff, Chicago, IL
Cindy Shepherd, Urbana, IL
Skyler Johnson, Potomac, IL
Sara Verhaeghe, , IL
Candace Davis, Carbondale, IL
Anna Keck, Mahomet, IL
Kathleen Kircher, Mendon, IL
Linda Wing, Chicago, IL
Annette Musil, West Chicago, IL
Kristin Hoganson, Champaign, IL
Carolyn Mullally, Champaign, IL
Stephen Nickels, Simpson, IL
Madalyn Liberman, Sumner, IL
Audrey Wagner, Carbondale, IL
Jill Adams, Makanda, IL
Ellen Baranowski, Urbana, IL
Scott Doudera, Murphysboro, IL
Darby Ortolano, Murphysboro, IL
Kenneth Hannan, Westville, IL
Charla Morrow, Marion, IL
Martin Kemper, Nashville, IL
Christopher Gjesfjeld, Bloomington, IL
Mara Eisenstein, Champaign, IL
Peter Gunther, Chicago, IL
Fred Segovich, Champaign, IL
Jim Vandenbosch, Lemont, IL
Joanne Stowe, Barrington, IL
Mary Rajcok, Cobden, IL
Marilea White, Normal, IL
MARION MICKE, Bloomington, IL
Karen Kane, Champaign, IL
Teresa Fix, Carbondale, IL
William Maass, Delavan, IL
Noah Sabich, Ph.d., Milwaukee, WI
Jill Plotke, Glendale Heights, IL
Laurie Geiger, Carbondale, IL
Janine Prillaman, Champaign, IL
Jennifer Bull, Murphysboro, IL
Karen Baumann, Paducah, KY
Melody Shimada, Carbondale, IL
Kendall Busse, Lake Zurich, IL
Avis and Jeff Fisher, McHenry, IL

Heather Rabbitt, Vernon Hills, IL
Kevin Green, Fithian, IL
Ann Blanchfield, Farmington, MO
Amanda Kelley, ,
Cassidy Steel, Woodridge, IL
Ann Burger, Urbana, IL
Ronald Deering, Champaign, IL
Brian Wurtz, Chicago, IL
Tod Satterthwaite, Champaign, IL
Deana Viano, Peoria, IL
Heather McMeekan, Macomb, IL
Lucas Zuklic, Murray, KY
Carolyn Isham, Springfield, IL
Mary Preston, Homer, IL
Ronald Moore, Decatur, IL
richard mcelligott, lee, IL
Aisha Sobh, Urbana, IL
Madison Bishop, Gifford, IL
Matthew Kerr, Washington, IL
Jane Ward, Peoria, IL
C Todd Bieri, Island Lake, IL
Nancy Voss, Champaign, IL
Kevin Daugherty, Westmont, IL
Mary Anthony, Darien, IL
Annie White, Carbondale, IL
Penni Livingston, Fairview Heights, IL
Jeffrey Haas, Urbana, IL
Sharon Irish, Urbana, IL
Greg Jahiel, Urbana, IL
Seth Bishop, Gifford, IL
Thomas Bik, Carbondale, IL
bill lamorte, Worth, IL
Beth Chato, Urbana, IL
Barbara Niechciol, Cobden, IL
troy waldschmidt, Peoria Heights, IL
Kathryn Gunderson, ,
Chris Dietrich, Urbana, IL
Paula Luesse, Urbana, IL
John Chick, Godfrey, IL
Michael Bingaman, Oak Park, IL
Ken Shimada, Madison, WI
Brian Allan, Mahomet, IL
Ginnie Judd, Glen Ellyn, IL
David Marriott, Saint Joseph, IL
Craig Wilson, Carbondale, IL
Daniel Goldberg, Normal, IL
Therese Freehill-Davis, Gibson City, IL
Janet McCready, Murphysboro, IL
Rebecca LaGesse, Elgin, IL
Christine Main, Champaign, IL
Terri Kobel, Champaign, IL
Joe Dittmer, Carbondale, IL
Nick George, Marion, IL
Harold Enstrom, Park City, IL
Colleen Arturi, Riverside, IL
Shannon Nosbisch, Dieterich, IL
Carole Spencer, Georgetown, IL
Ryan Griffis, Chicago, IL
Jenny Cassel, Chicago, IL
Benjamin Rathert, Du Quoin, IL
Bob Fisher, Downers Grove, IL
Charlotte Westcott, Urbana, IL
John Leonard, ,
Paula Enstrom, Charleston, IL
Erin Benincasa, Chicago, IL
Alison Edmund, Carbondale, IL
Edward Michael, Highland Park, IL
Priscilla Skalac, Bourbonnais, IL
Tamara Foiles, Alton, IL
Anne Bargar, Urbana, IL
Michael Jeffords, Champaign, IL
Dawn Albanese, Elk Grove Village, IL

Roger Digges, Urbana, IL
Caroline Cummings, Morris, IL
Patricia Lamorte, Worth, IL
Amanda Pankau, Monticello, IL
Nancy Goodall, Sidell, IL
Knox Long, Chicago, IL
Francine Snider, Goreville, IL
Carole Pooler, Chicago, IL
Kim Cochran, Champaign, IL
Abra Jacobs, Vernon Hills, IL
Geoff Freymuth, Mahomet, IL
Scott Baseler, Champaign, IL
Bonnie Duman, Deerfield, IL
Kathy Coleman, Hammond, IN
Mary Sampson, Decatur, IL
Emily Cadwell, Vernon Hills, IL
Richard Larimore, Urbana, IL
Lois Kain, Urbana, IL
Kenneth Craig, Cobden, IL
Richard Livingston, Carterville, IL
Nicole Stresak, Chicago, IL
Marcia Vansant, Grayslake, IL
Megan Sobotka, Wheaton, IL
Maryanne Chrisman, Carbondale, IL
Todd Kinney, Urbana, IL
Douglas Mills, Champaign, IL
Kevin Cahill, Champaign, IL
Courtney Haddick, Murphysboro, IL
Juli Claussen, Murphysboro, IL
Nel Battrell, Carbondale, IL
Shira Epstein, Champaign, IL
Tyler Lobdell, Boise, ID
Sheila Voss, Edwardsville, IL
Alicia Henry, Bloomington, IL
Clark Bullatd, Urbana, IL
Magda Roth, Homewood, IL
Andy Wszalek, Urbana, IL
Daniel Curtis, Champaign, IL
Janet Hamilton, Champaign, IL
Julie Weinert, Carbondale, IL
Marge Snyder, Hoffman Estates, IL
Joseph Anthony, Champaign, IL
Christa Weiss, Urbana, IL
James Payne, Cerro Gordo, IL
Bradley Tallon, Chicago, IL
Thomas Schmidt, Urbana, IL
James Stuhlmacher, Wheaton, IL
Antonio Acevedo, Chicago, IL
Margaret Howard, Carbondale, IL
Nancy Drook, Mahomet, IL
Sharon DeCelle, Urbana, IL
Jennifer Rhude, Carbondale, IL
Geoff Stroud-Settles, Hurricane, UT
Clark Bullard, Urbana, IL
Melanie Hoekstra, Chicago, IL
Andrea Stader, Carbondale, IL
Brad Gentry, Virden, IL
Drew Bergstrom, Peoria, IL
Heidi Kiesler, Glencoe, IL
Sharon McDannold, Bloomington, IL
Joseph Hincks, Macomb, IL
Amy McMorrow Hunter, Makanda, IL
Kerry Helms, Urbana, IL
Melinda Hilker, Murphysboro, IL
Joe Ulmer, Chicago, IL
Philip Solter, Urbana, IL
Eric Jason, Joliet, IL
Greg West, Pekin, IL
Lauren Cain, Henry, IL
Amy Russell, West Frankfort, IL
Eric Edwards, West Chicago, IL
Robert McKim, Mahomet, IL

Mary Clevenger, Collison, IL
Zachary Sutton, Urbana, IL
Alan Sherman, Wheeling, IL
Melodie Huffman, Danville, IL
Karen Folk, Urbana, IL
Nancy Smith, Oak Lawn, IL
Scott Smith, Johnston City, IL
Jeffrey Sanders, Evanston, IL
Marcia Heitz, Cuba, IL
Carol Gloor, Savanna, IL
Anne Coladarci, Chicago, IL
Jill B., San Francisco, CA
charles lansford, Champaign, IL
Jason Knauff, Mahomet, IL
Marguerite Torrey, Danville, IL
George Strunk, Johnston City, IL
Patricia Dunleavy, , IL
Lorraine Schwass, Toluca, IL
Beverly Rauchfuss, Urbana, IL
Jane Conwell, Lockport, IL
Rebecca Wright, Anna, IL
Julie Sanfilippo, Forest Park, IL
Benjamin Thompson, Urbana, IL
Elizabeth Letterly, Springfield, IL
Angela Paik, Chicago, IL
Alice Travers, Carterville, IL
Jamie Jones, , IL
Greg Lucas, Elgin, IL
Kathy Ruopp, Chicago, IL
Joanne Gara, Barrington, IL
Sarah Smith, Argenta, IL
Ronald Trimmer, Granite City, IL
Verlyn Rosenberger, Decatur, IL
Kathryn Head, Carbondale, IL
Leslie Rice, Glen Carbon, IL
Rachel Fowler, Evanston, IL
Debbie Insana, Urbana, IL
James Parr, Bloomington, IL
George Ordal, Urbana, IL
Sarah Graham, Champaign, IL
Ryan Adams, Chicago, IL
Bryan Eubanks, Neoga, IL
Jen Conwell, Murphysboro, IL
Nancy Melin, Champaign, IL
Lindsey Oliver, ,
Spencer Bingham, Huntley, IL
George Roth, Homewood, IL
Matthew Bryant, Monticello, IL
CL Broughton, Springfield, IL
Stephanie Alexander, Mahomet, IL

Exhibit 394

From: Ola Snyder
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine
Date: Friday, January 17, 2020 5:47:18 PM

I oppose allowing additional mine discharge into Southern Illinois waterways.

Thank you for consideration!

Exhibit 395

From: Joyce Blumenshine
To: EPA.PublicHearingCom
Subject: [External] Pond Creek Mine IL0077666 Public Comment
Date: Friday, January 17, 2020 6:51:53 PM
Attachments: Pond Creek Mine IL0077666 Public Comment Blumenshine.pdf

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Please find my public comment attached to this email.

Thank you,
Joyce Blumenshine
Peoria, IL

January 17, 2020

Illinois Environmental Protection Agency
RE: Pond Creek Mine NPDES
1021 North Grand Ave. East
P.O. Box 19276
Springfield, IL 62794-9276

Sent via email to: epa.publichearingcom@illinois.gov

Public Comment: IL0077666 Pond Creek Mine NPDES

To the Illinois Environmental Protection Agency:

This letter is to request that the IEPA deny the draft reissued permit incorporating seven modifications to NPDES IL0077666, Pond Creek Mine No. 1, because it fails in multiple ways to ensure it can safely protect the resources of the state of Illinois as specified under the NPDES program. This permit risks direct harm to the Muddy River, which is listed by the Illinois Department of Natural Resources as a water of the state for public use[1] and risks increased toxicity to aquatic life reproduction and health and fish kills impacting both human and wildlife uses of the river. The past history of permit compliance problems for this mine gives no confidence that they can operate to meet standards that are proposed and if a discharge over permitted levels happens, damage could occur before any steps could be taken to address the problem. The draft permit Anti-Degradation statement is incomplete and has numerous inaccurate statements. It is lacking any consideration of the costs this permit will impose on public health, environmental health, present and future recreational uses and economic values of the Big Muddy River and affected stream corridors, and the environmental well-being of the state of Illinois, this nation and the climate.

Harm to the Big Muddy River Ecosystem

I am very concerned that discharges as described will cause direct harm to the Big Muddy River through negative impacts on fish, other aquatic creatures and insects, wildlife and the ecosystem of the area. The river hosts various catfish, gar, buffalo and other fish commercially harvested[2] and which are part of the recreational opportunities of the area. Other wildlife, from eagles to otters, raccoons, mink and other creatures are part of this river ecosystem, depending on it for food sources and habitats[3]. Discharges to the Big Muddy are also being planned by the Sugar Camp Mine, located to the north. Consideration should be given to the combined impacts of high chloride, sulfate and other constituents loading the river and what this could mean over an extended period of time.

---

[1] Illinois Department of Natural Resources Map at: https://www.dnr.illinois.gov/WaterResources/Pages/GISMaps.aspx
[2] 2017 Commercial Catch Report Exclusive of Lake Michigan, Illinois Department of Natural Resources, Division of Fisheries, Alton, IL
[3] Phone conversation with Charles McCann, retired commercial fisherman, Big Muddy River, December 10, 2019

Inadequate Assessment of Alternatives

The November 18, 2016, Williamson Energy, L.L.C. – Anti-Degradation Document for Pond Creek Mine NPDES Permit IL0077666 claims that the mine needs to discharge to the Big Muddy River because an aquifer above the coal seam has caused an influx groundwater into the mine.[4] The mine does not appear to have provided any consideration of relocating their active mining face to remedy this problem. A listing of alternatives to the proposed Big Muddy discharge does not include anything regarding adjustments that could be made in mining operations. There is also no mention of the profits this mine is making or what percentage the costs of an alternative treatment process would be of this mine's profits. The Foresight Energy webpage claims the Pond Creek Mine is one of the most productive underground mines in the United States with some of the lowest per ton costs of produced coal[5] yet much of the reason discharge to the Big Muddy appears to be preferred is because it is the lowest cost option for the mine.

Lack of History of Compliance with Permits

The Sugar Camp Energy Mine and the Pond Creek Mine are both Foresight Energy/Murray Energy mines with a history of problems with water permit compliance, including violations that have been taken to the Illinois Pollution Control Board by the Illinois Attorney General. The proposed discharge to the Big Muddy utilizes an out-of-sight diffuser and relies on the daily monitoring and reporting of the mine for safe operations. Millions of gallons of an out-of-compliance discharge cannot be whistled back. It can take years for a water pollution violation to make its way through agencies and the Illinois Pollution Control Board. The proposed permit appears to me to be a high risk gamble that Williamson Energy will operate responsibly without incurring any accidents or problems.

Full Economic Costs Are Not Considered

The costs to land uses, local resources, and environment and citizen health are not considered in the Anti-Degradation statement. The Illinois Department of Natural Resources Williamson Energy mining permit No. 417 for the Pond Creek Mine indicated that productive agricultural land, forested wetlands and an intermediate stream would be destroyed for building the expansion of the New Disposal Area Number 3, which is part of the draft reissued permit under consideration. Wetland soils existing prior to construction of the Disposal Area 3 mean mine pollutants may disperse more quickly and in unpredicted directions below. The coal seam under Disposal Area 3 was already long-wall mined, meaning rock layers are fissured and contamination problems for future generations may occur. Forest and agricultural lands can be sustainable sources of income and resources for the public good for generations to come. This coal mine is time limited and will leave lands that cannot be used for agriculture or forests. The U.S. Energy Information Administration 2019 Illinois Report includes that Illinois is a leader in wind-powered energy capacity and has the largest number of nuclear power plants in the country, producing more energy than it uses.[6] Pond Creek Mine claims that "coal is essential to the generation of electricity in Illinois" yet Illinois has a multi-faceted energy supply, including natural gas plants, solar and wind energy. Coal plants have higher costs in utilizing high sulfur Illinois coal and Powder River Western Basin Coal will continue to be cheaper, but even that coal is not

[4] Williamson Energy, L.L.C.-AntiDegradation Document for Pond Creek Mine NPDES Permit IL—0077666, November 18,2016.page 5/145

[5] Foresight Energy Operations, Williamson Energy web listing at http://www.foresight.com/operations/ 01/16/2020

[6] United States Energy Information Administration, Illinois State Profile and Energy Estimates, April 18, 2019 at https://www.eia.gov/state/analysis.php?sid=IL

as low cost as natural gas for power generation.[7] The demand for Illinois coal and the value of Illinois coal shows marked declines. The January 13, 2020, price per ton average of Illinois is listed as $34.20, which is down $.30 per ton since December, 2019.[8] No consideration is given to the health costs of burning coal in Illinois, which include more heart-attacks and other respiratory problems estimated for 2016 to cause 2,300 asthma attacks and more than 350 premature deaths.[9] Climate change is real and in rapid advance costly billions in flooding, fires and other natural disasters. I think action must be taken now to reduce the increase of climate change gasses, although I respect that is not part of the existing NPDES regulations, burning coal is a large contributor of climate change and certainly has extraordinary social and economic costs.

I attended the IEPA Public Hearing December 18, 2019, in Marion, Illinois and waived my opportunity for public comment because it was clear there was not enough time for all who signed up, even though the Hearing Officer graciously extended the time for the hearing. I want to thank the IEPA for the professional manner in which the hearing was conducted.

A very wide-range of concerns were presented by the public at the hearing. Certainly the full existing regulations must be applied to this draft permit and need to be critically evaluated aspect by aspect because of the many impacts it contains.

Sincerely,

Joyce Blumenshine
2419 E. Reservoir
Peoria, IL 61614
joblumen@yahoo.com

[7] Vela, Heidi, "Mining Illinois: Is It Time Up for Coal Mining?" Mining Technology, November 7, 2019 at https://www.mining-technology.com/features/mining-illinois-is-it-time-up-for-coal-mining/
[8] U.S. Energy Information Administration, Coal Markets, January 13, 2020 at https://www.eia.gov/coal/markets/
[9] Stark, Kevin, "Science Group to Illinois: Close More Coal Plants, and Do It Quickly," Energy News Network, October 26, 2018 at https://energynews.us/2018/10/26/midwest/science-group-to-illinois-close-more-coal-plants-and-do-it-quickly/

Exhibit 396

From: Klubek, Brian P
To: EPA.PublicHearingCom
Subject: [External] Pond Creek
Date: Friday, January 17, 2020 11:57:08 PM

I am requesting the EPA to ban any discharges of coal slurry into the Pond Creek watershed. The high concentration of sulfates, heavy metals, arsenates, selenates, and chlorides are a significant threat to these wetlands, wildlife, and water quality of the Big Muddy River basin. These slurries must remain contained in their holding ponds.

Brian Klubek
Emeritus Professor of Soil Microbiology
Department of Plant, Soil and Agricultural Systems
Southern Illinois University
Carbondale, IL 62966

Exhibit 397

From: Jane Cogie
To: EPA.PublicHearingCom
Subject: [External] NPDES Permit No. IL0077666, Notice 7516c-Williamson
Date: Saturday, January 18, 2020 1:03:24 AM

Barb Lieberoff, Mail Code #5
Re: Pond Creek Mine NPDES
Illinois Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276

Sent via email to epa.publichearingcom@illinois.gov

Re: NPDES Permit No. IL0077666, Notice 7516c-Williamson

Dear Ms. Lieberoff and Other Illinois EPA Officials:

I am writing to oppose the Pond Creek Mine pipeline permit application to dump millions of gallons a day of this mine's waste into the Big Muddy River. The reasons for my opposition are stated below.

1.) Sufficient monitoring to determine the impact of the mine's waste water on the Big Muddy's river water has not been set up. As has been testified, the amount of daily flow will regularly come close to exceeding the maximum allowed. Therefore daily measurements of the impact of the mine's effluents on the river should without question be required—and indeed measured by a neutral party, such as the USGS. Another rationale for requiring daily monitoring of the Big Muddy by a neutral party is that Pond Creek Mine's owner, Williamson Energy LLC, has been cited numerous times for infractions, for dumping that exceeds the agreed upon amount.

2.) Additionally, the Pond Creek Mine permit application should not be approved since the data that should have been supplied prior to the public comment period is incomplete. That is, the data that was supplied doesn't take into account the toxicity resulting from the interaction of the chloride and sulphate from mine's waste water with other chemicals such as mercury. Nor does it take into account the waste water that will flow down stream if and when the Sugar Camp Mine pipeline has been completed and activated.

3.) An additional reason against approval of the PCM pipeline permit is that approval of this permit would be counter to the IEPA's mission as stated on its own website: "to safeguard environmental quality, consistent with the social and economic needs of the State, so as to protect health, welfare, property and the quality of life." Even if one looks solely to the economic needs of the area, it is clear that, counter to IEPA statements that the PCM permit should be approved in light of the mine's economic importance to the area, approval of the permit would in fact harm not only the area's health, quality of life and welfare. Williamson LLC can no longer been seen as reliable economic engine. Its stock has recently fallen precipitously, from $17 to $.08. And Murray Energy declared bankruptcy, in October 2019; can Williamson LLC be far behind?

The coal industry in general and these companies in particular are in a perilous state not because of having to pay to clean up its own waste (as it should—why should the public have to pay?), but rather because of its inability to compete with low priced natural gas. Propping up Williamson LLC by approving this pipeline, trying to hold onto the belief that it's good for business in Illinois, would be a betrayal of the public trust and of the IEPA's mission.

4.) I'll add that the other economic activities connected to the Big Muddy have a right to use of the river. As I person who lives just a short distance from the Big Muddy River and knows a great number of people who regularly depend on it for canoeing and recreational fishing. With water being an increasingly valuable and scarce resource, particularly clean water, the focus should be on seeing that the river's health be not only safeguarded but also improved.

I indeed am hopeful that you will follow the wider public interest your mission statement asks you to attend to and reject the PCM permit application.

Respectfully submitted,

Dr. Jane Cogie
1010 S, Oakland Avenue
Carbondale, IL 62901
Jane.cogie@gmail.com
(618) 713-7024

Exhibit 398

From: Zeivel, Christine
To: EPA.PublicHearingCom
Subject: FW: [External] Mine water
Date: Thursday, January 30, 2020 10:09:35 AM

-----Original Message-----
From: Kimberly Ford <kimberlyford65@icloud.com>
Sent: Wednesday, January 15, 2020 1:55 PM
To: Zeivel, Christine <Christine.Zeivel@illinois.gov>
Subject: [External] Mine water

Hello, My name is Kim Ford, from De Soto, Illinois.

Do Not let them dump all this waste water from the mines into our river. Illinois has enough problems without adding another crisis.

Do Not believe people when they say it will be safe. I'm sure that was exactly what was said to officials prior to putting things into Flint, Michigan.

We know it's not safe nor environmentally sound to dump waste into a river. And when this river flows right through so many towns and people use this river to fish and their recreation or live off the banks of it. And the fact that it flows into the Mississippi. We already know that this area is susceptible to flooding. This year alone, so much of the areas impacted by state of emergency will be impacted. In addition tens of thousands more. Many people have not had a chance to recover, and this is on the table with a deadline of August 12, 2019 to show opposition. We still have road closures. People still with water damage. People still batching it as they cannot go home yet. I know supporters of this atrocity are thinking this is perfect time to slide this through so people will be so distracted they can't oppose.

You can make a difference. This is your opportunity to do the Right thing. You can stop this now.

If you do Not stop this we are going to have more flooding, reduction in wildlife survival, humans being impacted by the chemicals. It will not only be a nightmare for southern Illinois but for southeast Missouri, Kentucky, Tennessee, Arkansas, Mississippi, Louisiana and Gulf of Mexico. This will be much bigger than the outrage of Flint. I know you probably Do Not want to harm people, nor tarnish your name with such a harmful and negligent decision as to letting them dump all this waste water into our river which is a tributary into one of America's largest rivers.

I'm pleading with you, please stand up and do the Right Thing. For the people, the wildlife, our environment. Just say No to dumping waste water into the Big Muddy River.

This mining company, committee, and state of Illinois will any and all responsible for surveying all property around the big muddy river, loss of income from businesses which include farmers which may or may not be able to get their crops planted or harvested. These entities will also be 100% responsible for any adverse effects to persons in or around these communities that surround the Big Muddy River and water quality. Taxes will be absorbed by the above entities due to any loss of property or employment. Any alterations in food due to the mine water will also be absorbed 100% by the above entities. This includes plant based and any animal based which may have been exposed to water or the vegetation exposure to water. The above will be 100% responsible for any birth defects, poisonings, carcinogenic or any other diseases or maladies that are even questionable that it may have occurred in relation to the mine water. If this water was so safe then why disperse it in agriculture and drinking water yet refuse to keep it around your mine? You all know the answer to that.

Any surveys will also be 100% absorbed by above entities in and around Big Muddy River. Property Taxes for people around the Big Muddy River will be greatly reduced due to encroachment of mine water.

Everyone that I have sent this to will be agreeable to all the above terms unless they publicly spell this out prior to any decisions.

Thank You for your time and consideration

Kim Ford

Sent from my iPhone

State of Illinois - CONFIDENTIALITY NOTICE: The information contained in this communication is confidential, may be attorney-client privileged or attorney work product, may constitute inside information or internal deliberative staff communication, and is intended only for the use of the addressee. Unauthorized use, disclosure or copying of this communication or any part thereof is strictly prohibited and may be unlawful. If you have received this communication in error, please notify the sender immediately by return e-mail and destroy this communication and all copies thereof, including all attachments. Receipt by an unintended recipient does not waive attorney-client privilege, attorney work product privilege, or any other exemption from disclosure.

Barb Lieberoff, Mail Code #5

Exhibit 399

Re: Pond Creek Mine NPDES

Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276

RECEIVED IN
JAN 16 2020
THE OFFICE OF THE DIRECTOR

Re: Pond Creek Mine (IL0077666)

Greetings,

I would like to add my comments to the chorus.

We, the people of southern Illinois, participated in democracy when we came out on a cold night just before Christmas to speak at a public hearing held by the Illinois Environmental Protection Agency.

There were more than a hundred of us, with varied voices sharing the specifics of concerns on the same topic.

We included farmers who are concerned about flooding leaving residue on fields.
We included fisherman concerned about the poisoning of fish and the people who eat them.
We included people who moved to this area as adults and people who have lived here all their lives.
We included people who boat on the river, swim in the river and live on the river.

We, the people of Southern Illinois shared the same request....

Please do not allow Williamson Energy, L.L.C. to pour waste water from their mining operation into the Big Muddy River.

Please do not allow a mining company with a long history of environmental violations to self-monitor the dumping of "acid and alkaline mine drainage" into the Big Muddy River.

Please do not allow a mining company that may go bankrupt and disappear to degrade our land and our water forever.

Please do not allow the mining company to add toxic chemical waste to the Big Muddy River, with all the resultant impacts on the environment....

Because this is where we, the people of Southern Illinois, boat, fish, farm and live.

Please, protect our environment and deny the permit

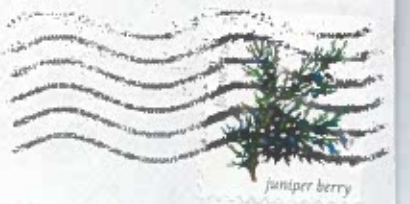
Julie O Murphy

Julie O Murphy
2910 Wing Hill Road
Cobden, Illinois 62920

FRANCIS MURPHY
JULIE O. MURPHY
PO BOX 995
CARBONDALE, IL 62903

SAINT LOUIS MO 630

13 JAN 2020 PM 8 L



Barb Lieberoff - Mail Code #5
Illinois EPA
1021 N. Grand Ave East
P.O. Box 19276
Springfield, IL 62794-9276

62794-927676

R05884

DOCUMENT

16

2445 / 16-H
Due date 1-3-20
R05886

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020 Fax: 618-983-3017

December 17, 2019

Mrs. Iwona Ward
ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
2309 West Main Street, Suite 116
Marion, IL 62959

Re: Williamson Energy, LLC – Supplemental information concerning the Anti-Degradation Document for Pond Creek Mine, Big Muddy Flood Analysis, and Modeling of Big Muddy River Chloride dispersion downstream of the proposed mixing zone.
NPDES Permit IL0077666

Dear Mrs. Ward:

Please find attached one (1) copies of the Supplemental information concerning the Anti-Degradation Document for Pond Creek Mine, Big Muddy Flood Analysis, and Modeling of Big Muddy River Chloride dispersion downstream of the proposed mixing zone regarding the NPDES permit IL0077666 for Williamson Energy, LLC's Pond Creek Mine.

Two copies of this submittal have also been submitted to Mr. Lecrone at the IEPA Office in Springfield.

We appreciate your assistance with the matter. If you have any questions or require additional information, please contact me at (618) 969-8259.

Respectfully submitted,

WILLIAMSON ENERGY, LLC

James Plumley

James Plumley, P.E.

RECEIVED
DEC 17 2019
IL Environmental Protection Agency
MARION REGIONAL OFFICE

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020 Fax: 618-983-3017

December 17, 2019

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ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
2309 West Main Street, Suite 116
Marion, IL 62959

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We appreciate your assistance with the matter. If you have any questions or require additional information, please contact me at (618) 969-8259.

Respectfully submitted,

WILLIAMSON ENERGY, LLC

James Plumley

James Plumley, P.E.

Alternative 2: Do Not Mine

Presently, and for the foreseeable future, coal remains essential. The need for low cost electricity in today's economy is crucial. The coal industry and this mine in particular are vital to the economic health of the local economy. The direct impact of this alternative would mean the loss of tens of millions of dollars that are generated from this mine for the local economy through 235 direct mining jobs, taxes and support industry jobs.

If no mining is conducted at this site, the following economic losses are estimated to occur:

- Loss of approximately 235 direct jobs with a payroll of approximately $20.2 million annually. Many of these employees are long term miners and are not currently trained for other employment. In addition to the direct employees, approximately 100 additional persons such as truck drivers, engineers, and support personnel are employed full time through operation of the mine. Further, based on an economic formula widely accepted in the state of three persons employed in indirect or induced jobs per each direct coal industry job (ICA), an additional 705 persons are employed as a result of this mine.

- The mining industry is particularly important to the local economy of Williamson County, the surrounding counties, as well as to the region and state. Williamson Energy contributes approximately $1.5 million in federal taxes and approximately $0.7 million in local and state taxes.

- Since over 30% of the electricity produced in the U.S. and nearly 30% of the electricity produced in Illinois comes from coal-fired plants, it is vital to the local, state and national economy that available high quality coal be mined to maintain a continuous supply of fuel to the coal-fired plants. Economic losses beyond the local economy will occur if sufficient electricity is not provided to private and commercial energy consumers. If the Mine produced no coal, approximately 4.7 million American households' worth of energy would have to be replaced (likely at a higher cost) or foregone to meet the world's energy demand. (6m clean coal tons * 8,141 kwh/ton generated / 10,400 kwh/yr average household energy use)

- The loss in tax revenue of approximately 2.216 million dollars to Illinois, Williamson County, and Franklin County, both direct and indirect, would be significant, particularly when a replacement industry is unknown.

In addition, the Mine has significant resources invested in the acquisition of land, approximately 360 million tons of remaining proven and probable coal reserves, permitting expenses, mining equipment, and more into this project. The economic loss to the company,

should mining at the site cease, would be considerable. The substantial investment made by the company using a business plan on maximizing recovery of the coal reserve yields the "Do Not Mine" alternative as a reasonable or feasible option.

Alternative 3: Reverse Osmosis (RO)

Reverse Osmosis (RO) is a water purification process that uses partially permeable membranes to remove dissolved salt and other unwanted particles in suspension from the water stream. The RO process includes a pre-treatment pond, ultra-filtration system, high-pressure pumps, membrane assembly, clean water discharge, and wastewater discharge. At a design capacity of 3.5 million gallons per day, approximately 2.625 million gallons of de-salinized water (75%) and .875 million gallons of highly brackish water (25%) are created by this process. The de-salinized water can be discharged through an approved NPDES outlet or reused in the mining process. The concentrated brackish water must then be treated through an additional process for long-term management such as Deep Well Injection or Crystallization and solid waste land fill.

A single plant could be designed to meet the required capacity to treat the initial proposed discharge. A plant of this size would cost approximately $15 million of up-front capital investment. The operational and maintenance expenditures amount to approximately $200,000 per month. After the RO process is completed a highly concentrated waste stream of brackish water is created and requires the development of additional technology to dispose of the highly concentrated brackish water utilizing Deep Well Injection (Alternative 4) or Crystallization (Alternative 8).

Using deep well injection to dispose of the concentrated waste has a capital cost of approximately $39 million with an annual operation budget of $0.90 million. Therefore, the RO with Deep Well Injection would have a capital cost of $54 million and an annual operating cost of $3.30 million. A comparable sized RO plant is currently in operation at an affiliated company (coal mine) nearby and this system has experienced low plant utilization and lower than design throughput due to the plugging of filters and membranes. This RO plant also uses deep well injection for the disposal of the concentrated brackish water. When the two deep wells are operational, they are only able to accept of about 25% of the required discharge; therefore, the remaining concentrate stream must be stored in a large holding facility. They are currently reviewing additional alternatives to dispose of the excess brackish water. Due to the negative experience with deep well injection at the affiliated operation for secondary treatment, crystallization and solid waste land fill would be the most reliable method. Likening to a comparable sized operation at an affiliated company (coal mine) in the Appalachian region, the anticipated capital cost for crystallization and solid waste land fill is $65 million with an annual

operation budget of $6.70 million. Therefore, the RO system with crystallization and the solid waste land fill would have a capital cost of $79 million and an annual operating cost of $9.10 million.

Considering the above, RO technology has not proven to be a reliable method of treating excess water from similar mines. It is not cost effective and creates a waste stream more hazardous that the water prior to treatment that creates another set of disposal problems. Therefore, RO is not considered applicable or feasible as a long term solution for this type of application.

Alternative 4: Deep Well Injection of the Mine Infiltration Water

The mine infiltration water could be discharged directly to an Underground Injection Control (UIC) well (often referred to as a deep well). Deep well injection is an unreliable and impractical alternative to dispose of the amount of water infiltrating the Williamson coal mine.

The injection wells must be installed at extreme depths to ensure they do not affect potential aquifers used for public consumption and into a geologic formation that is capable of receiving excess water. The receiving formation has a limited amount of volume it can receive instantaneously and long term. As the formation is filled with excess water, its acceptance can be diminished. Consequently, multiple wells cannot be installed in close proximity to one another or they will negatively influence one another and restrict flow.

An affiliated company nearby operates two deep injection wells. Each deep injection well has an up-front capital investment of approximately $4 million. In order to completely utilize this technology at Williamson, it is estimated that nine (9) deep injection wells spaced an adequate distance apart would be needed. Additionally, miles of pipeline conveying water to each individual well. An ultra-filtration system would also be needed to remove any suspended solids from the water prior to injection. The anticipated up-front capital investment would be approximately $39 million with an anticipated operation cost of $0.9 million per year. At the affiliated mine, ongoing operation of water disposal has been hampered by excess pressures, scaling of injection tubing, and plugging off the receiving geologic formation. Due to these operational challenges, the wells have been inactive for several years. When injecting during optimal conditions, the wells only accepted a fraction of the amount of water Williamson would need to dispose of.

Considering the cost and operational difficulties that can be experienced when attempting to discharge to a deep well, deep well injection of the mine infiltration water is not considered either applicable or feasible for the operation of the Mine.

Alternative 6: Evaporation

Evaporation works by constructing ponds with large surface area, filling the ponds with water and exposing water to the forces of nature. The groundwater would be evaporated, leaving a TDS residue in a constructed evaporation pond. Criteria for design include being located in a moisture deficient area, sufficient surface area to evaporate the total annual waste water volume plus precipitation that would fall on the pond, using the maximum wet year, and using the minimum evaporation year of record. Evaporation ponds require large land areas, and the area would not be expected to be productive once it is used for this purpose (salt accumulation). It is recommended that the land for this system be naturally flat or the pond be designed to provide a uniform depth, and that a large land area be available. The current anticipated maximum flow rate for the collection of the groundwater is 3.5 mgd.

Williamson developed a conceptual design for an evaporation system was reviewed. Typical hourly weather reports for Marion, Illinois were used to construct a model from January 1980 to December 2016 to predict the monthly average climate conditions. The air capacity to hold water vapor was considered and adjusted according to temperature in 5-degree increments and air dew point. Humidity and average wind speeds were taken into consideration during these calculations. Based on these climatic conditions, a 7-month evaporation season from April to October was identified. Average evaporation rates were estimated between 20% and 35 % of the total water throughput for each evaporator during any 24-hour period. This conceptual design assumed the evaporators would be placed on floating platforms along the outside of the water storage lake and operated 214 days per year. In order to evaporate 3.5 million gallons per calendar day during the estimated 214-day period, 1,621 evaporators would be required. During the non-evaporative season, a 1,600 acre-ft pond would have to be constructed to store the excess water during this time. This extremely large pond would have an enormous footprint (approximately 160 surface acres, 10-feet deep) because it would have to collect unevaporated water and salt that falls back to the surface. Furthermore, this conceptual evaporation design does not remedy the continuous salt accumulation that remains after evaporation of the liquid leaving the land in an unproductive condition. The anticipated capital cost of this system, excluding the 1,600 acre-ft storage pond, is $30 million with an annual operating budget of $4.2 million.

The climate at this location is not conducive to evaporation techniques because it is not considered moisture deficient. After the evaporators have finished concentrating the salt water then some additional technology is required to dispose of the salt concentrates (Ex: Deep well injection or Crystallization and Solid Waste Land Fill). Given the inefficient system, high capital and operational costs, operational difficulties to maintain a system of this magnitude, and additional alternatives to dispose of the salt mechanical evaporation is not a viable alternative. This option is not considered applicable or economically feasible to dispose of water at Williamson.

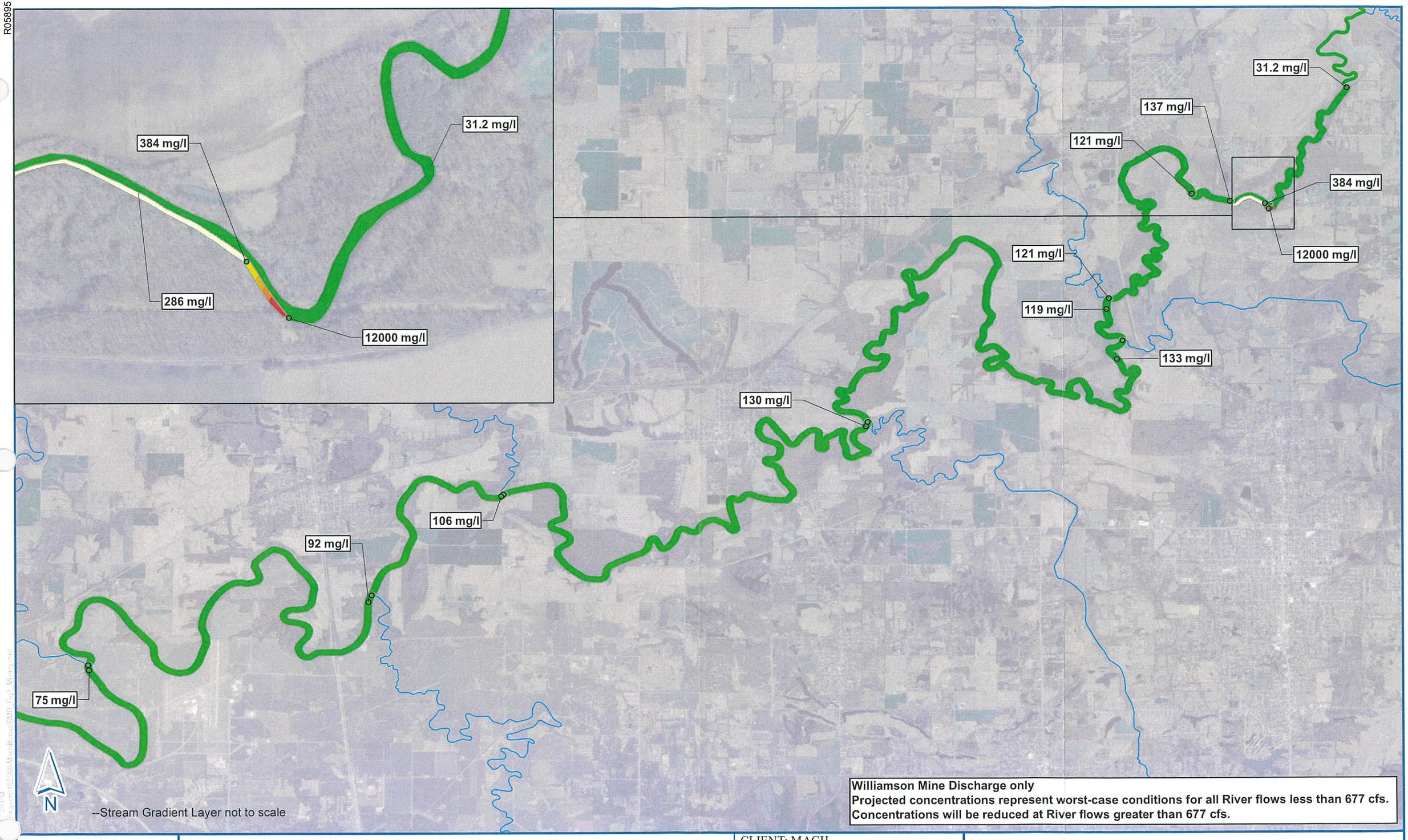
Alternative 8: Crystallization

Crystallization is the process that converts the concentrated brackish water generated in a mechanical evaporator or reverse osmosis process to create a disposable salt cake. This process offers an alternative to deep well injection for the brackish reject stream from a reverse osmosis or mechanical evaporator system.

It is possible that the salt cake can be sold, but unlikely due to the various salt compositions that are captured in a mine related RO process. This process usually culminates in the utilization of a large lined landfill to dispose of the waste that consumes large tracts of land that would otherwise not be impacted. Crystallization equipment is energy intensive, expensive to construct, install, operate and maintain. Based in the design and construction cost of another affiliated operation using crystallization and solid waste land fill, the anticipated capital cost is $65 million with an annual operation budget of $6.70 million.

Considering the above, crystallization is not a standalone treatment option and it is not considered either applicable or feasible as a treatment system for the operation of the mine as a long-term solution.

R05895



Williamson Mine Discharge only
Projected concentrations represent worst-case conditions for all River flows less than 677 cfs.
Concentrations will be reduced at River flows greater than 677 cfs.

AquAeTer

1 inch = 6,500 feet

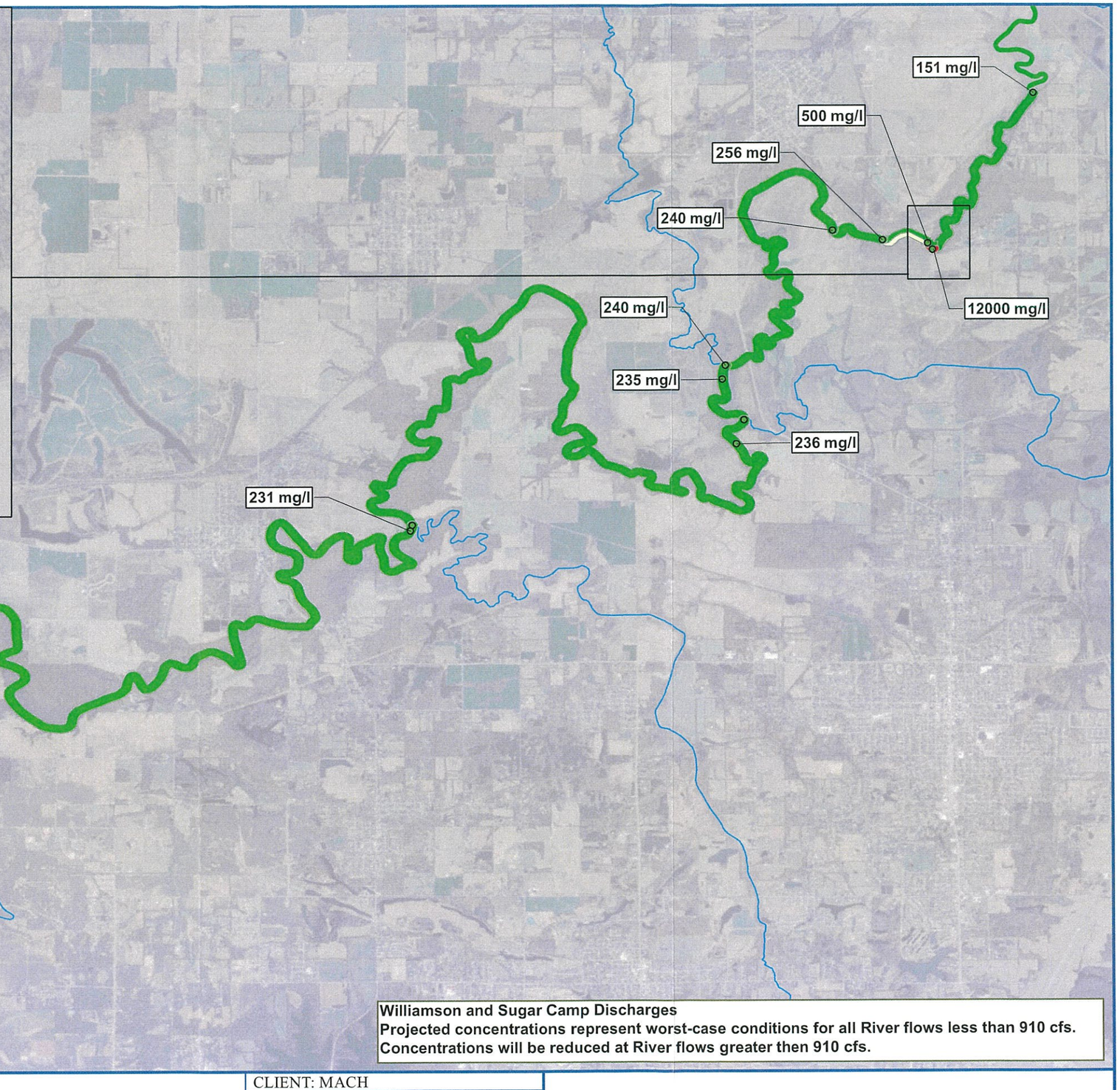
0 0.5 1 2 3 4 Miles

CLIENT: MACH	
LOCATION: IL	
PROJECT FILE: 192590	

Figure 1
BMR

R05896





Williamson and Sugar Camp Discharges
Projected concentrations represent worst-case conditions for all River flows less than 910 cfs.
Concentrations will be reduced at River flows greater then 910 cfs.

AquAeTer

1 inch = 6,500 feet

0 0.5 1 2 3 4 Miles

CLIENT: MACH
LOCATION: IL
PROJECT FILE: 192590

Figure 2
BMR

Alliance Consulting, Inc.
Engineers · Constructors · Scientists

December 17, 2019

Project No. B18-435-1413, Task 2

Mr. James Plumley
FORESIGHT ENERGY LLC
16824 Liberty School Road
Marion, IL 62959

Flood Study Results
Williamson Energy Multiport Outfall Diffuser
Franklin County, Illinois

Dear Mr. Plumley:

Per your request, Alliance Consulting, Inc. (Alliance) has completed a Phase 1 flood study to determine the change in water surface elevations resulting from the discharge of the proposed Williamson Energy Multiport Outfall Diffuser (Williamson Diffuser) into the Big Muddy River. Flows for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year, 24-hour storm events were obtained from StreamStats for use in the study. The Williamson Diffuser's expected maximum discharge of 11.1 cfs was added to these flows to provide a basis for comparison of the pre-construction and post-construction water surface elevations for each storm event.

A HEC-RAS steady flow model was utilized to route the pre-construction and post-construction flows along an approximately 53-mile reach of the Big Muddy River, beginning near Plumfield, IL (approximately 1.5 miles upstream of the Williamson Diffuser) and extending to a point approximately 3 miles downstream of the 20th Street Bridge in Murphysboro, IL. A total of 213 cross-sections were created at intervals along the reach. Cross-section geometry was created using countywide LiDAR data for Franklin, Jackson, and Williamson Counties as a primary data source. A pilot channel was used to ensure consistency of the bottom elevations of the main channel in the HEC-RAS model, given the use of different LiDAR datasets for each county. A total of 10 bridge crossings were input into the model using a combination of field survey data and information sourced from the Illinois Department of Transportation, both of which were provided by Foresight Energy LLC.

USGS stream gages of the Big Muddy River at Plumfield, IL and Murphysboro, IL were used to calibrate the HEC-RAS model to recorded flood stages and discharges and to assist in developing downstream boundary conditions for the HEC-RAS model. However, the calibration was limited by the small number of recorded discharges that corresponded to the lesser frequency storm events.

The results of the flood study show that the effects from the expected maximum discharge of Williamson Diffuser on the 2-year through 500- year water surface elevations and the flood extents are minimal. The maximum increase in water surface elevation along the simulated reach was approximately 0.009 feet, occurring during the 2-year, 24-hour storm event with the

Williamson Diffuser discharging at 11.1 cfs. A table listing the results of each flow scenario is attached.

Phase 2 of the study modeled the Williamson Diffuser and the Sugar Camp Diffuser discharges at 11.1 cfs simultaneously, for a total of 22.2 cfs. The results of this Phase 2 flood study show that the effects from the expected maximum discharge of the diffusers on the 2-year through 500- year water surface elevations and the flood extents are minimal. The maximum increase in water surface elevation along the simulated reach was approximately 0.017 feet, occurring during the 2-year, 24-hour storm event with both discharging at 11.1 cfs. A table listing the results of each flow scenario is attached.

If you have questions or require additional information, please do not hesitate to contact us.

Sincerely,

ALLIANCE CONSULTING, INC.

Brian C. Shorts
Project Engineer

Claudio E. Yon, P.E.
Senior Project Manager

BCS/CEY:kjs

Attachments

File: Y:\Projects\Williamson Energy (1413)\2018\B18-435-1413\18435-02.doc

Rain Event Table for Flood Study

Frequency	Duration (Hours)	Rainfall (Inches)
2-Yr	24-Hr	4.07
5-Yr	24-Hr	4.89
10-Yr	24-Hr	5.55
25-Yr	24-Hr	6.42
50-Yr	24-Hr	7.06
100-Yr	24-Hr	7.68
500-Yr	24-Hr	8.99

Rainfall Depths for the 2-Year, 24-Hour through the 500-Year, 24-Hour Rainfall Events for Franklin County, Illinois (Source: Frequency Distributions of Heavy Precipitation in Illinois Updated Bulletin 70, Illinois State Water Survey, March 2019)

Two Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	2 Yr 24 Hr	0.0	8,600	8,600	0.007
Big Muddy	53.23	2 Yr 24 Hr	0.0	8,600	8,600	0.007
Big Muddy	53.04	2 Yr 24 Hr	0.0	8,600	8,600	0.007
Big Muddy	52.82	2 Yr 24 Hr	0.0	8,600	8,600	0.007
Big Muddy	52.56	2 Yr 24 Hr	0.0	8,600	8,600	0.007
Big Muddy	52.40	2 Yr 24 Hr	0.0	8,600	8,600	0.008
Big Muddy	52.04	2 Yr 24 Hr	0.0	8,600	8,600	0.008
Big Muddy	51.89	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	51.49	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	51.21	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	51.12	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	51.11	2 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	51.03	2 Yr 24 Hr	11.1	8,600	8,611.1	0.009
Big Muddy	50.77	2 Yr 24 Hr	11.1	8,600	8,611.1	0.009
Big Muddy	50.54	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	50.15	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	49.86	2 Yr 24 Hr	11.1	8,600	8,611.1	0.009
Big Muddy	49.62	2 Yr 24 Hr	11.1	8,600	8,611.1	0.009
Big Muddy	49.45	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	49.28	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	48.95	2 Yr 24 Hr	11.1	8,600	8,611.1	0.007
Big Muddy	48.55	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	48.04	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	47.59	2 Yr 24 Hr	11.1	8,600	8,611.1	0.007
Big Muddy	47.27	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	46.90	2 Yr 24 Hr	11.1	8,600	8,611.1	0.007
Big Muddy	46.84	2 Yr 24 Hr	11.1	8,600	8,611.1	0.007
Big Muddy	46.54	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	46.17	2 Yr 24 Hr	11.1	8,600	8,611.1	0.007
Big Muddy	46.16	2 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	2 Yr 24 Hr	11.1	8,600	8,611.1	0.008
Big Muddy	46.11	2 Yr 24 Hr	11.1	8,600	8,611.1	0.007
Big Muddy	45.90	2 Yr 24 Hr	11.1	8,610	8,621.1	0.008
Big Muddy	45.78	2 Yr 24 Hr	11.1	8,610	8,621.1	0.008
Big Muddy	45.56	2 Yr 24 Hr	11.1	8,610	8,621.1	0.008
Big Muddy	45.34	2 Yr 24 Hr	11.1	8,610	8,621.1	0.008
Big Muddy	45.12	2 Yr 24 Hr	11.1	8,610	8,621.1	0.008
Big Muddy	44.91	2 Yr 24 Hr	11.1	8,610	8,621.1	0.007
Big Muddy	44.74	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	44.54	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	44.35	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	44.17	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	44.12	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	44.03	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	43.88	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	43.46	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	43.25	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008

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Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	43.08	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	42.87	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	42.39	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	42.19	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	41.86	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	41.66	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	41.44	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	41.12	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	40.75	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	40.41	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	40.11	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	39.80	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	39.55	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	39.44	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	39.27	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	39.02	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	38.80	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	38.48	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	38.21	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	38.04	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	37.88	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	37.53	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	37.29	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	36.90	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	36.79	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	36.35	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	36.19	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	36.01	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	35.90	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	35.61	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	35.15	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	34.92	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	34.53	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	34.20	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	33.67	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	33.10	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	32.44	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	32.06	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	31.71	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	31.48	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	31.35	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	30.99	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	30.60	2 Yr 24 Hr	11.1	9,580	9,591.1	0.008
Big Muddy	30.26	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	29.81	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	29.68	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	29.46	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	29.36	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007

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Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	29.35	2 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	29.16	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	29.02	2 Yr 24 Hr	11.1	9,580	9,591.1	0.006
Big Muddy	28.93	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	28.21	2 Yr 24 Hr	11.1	9,580	9,591.1	0.006
Big Muddy	28.10	2 Yr 24 Hr	11.1	9,580	9,591.1	0.006
Big Muddy	27.89	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	27.72	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	27.03	2 Yr 24 Hr	11.1	9,580	9,591.1	0.006
Big Muddy	26.47	2 Yr 24 Hr	11.1	9,580	9,591.1	0.006
Big Muddy	26.03	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	25.82	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	25.46	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	25.25	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	24.97	2 Yr 24 Hr	11.1	9,580	9,591.1	0.006
Big Muddy	23.69	2 Yr 24 Hr	11.1	9,580	9,591.1	0.006
Big Muddy	23.44	2 Yr 24 Hr	11.1	9,580	9,591.1	0.007
Big Muddy	23.19	2 Yr 24 Hr	11.1	11,200	11,211.1	0.007
Big Muddy	23.14	2 Yr 24 Hr	11.1	11,200	11,211.1	0.006
Big Muddy	22.88	2 Yr 24 Hr	11.1	11,200	11,211.1	0.006
Big Muddy	22.66	2 Yr 24 Hr	11.1	11,200	11,211.1	0.006
Big Muddy	22.55	2 Yr 24 Hr	11.1	11,200	11,211.1	0.006
Big Muddy	22.23	2 Yr 24 Hr	11.1	11,200	11,211.1	0.006
Big Muddy	21.73	2 Yr 24 Hr	11.1	11,200	11,211.1	0.006
Big Muddy	21.38	2 Yr 24 Hr	11.1	11,200	11,211.1	0.006
Big Muddy	21.25	2 Yr 24 Hr	11.1	11,200	11,211.1	0.006
Big Muddy	21.23	2 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	2 Yr 24 Hr	11.1	11,200	11,211.1	0.006
Big Muddy	21.13	2 Yr 24 Hr	11.1	11,200	11,211.1	0.006
Big Muddy	20.90	2 Yr 24 Hr	11.1	11,200	11,211.1	0.006
Big Muddy	20.63	2 Yr 24 Hr	11.1	11,200	11,211.1	0.006
Big Muddy	20.40	2 Yr 24 Hr	11.1	11,200	11,211.1	0.006
Big Muddy	20.05	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	19.73	2 Yr 24 Hr	11.1	12,500	12,511.1	0.006
Big Muddy	19.41	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	19.29	2 Yr 24 Hr	11.1	12,500	12,511.1	0.006
Big Muddy	19.28	2 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	19.25	2 Yr 24 Hr	11.1	12,500	12,511.1	0.006
Big Muddy	19.24	2 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	2 Yr 24 Hr	11.1	12,500	12,511.1	0.006
Big Muddy	19.17	2 Yr 24 Hr	11.1	12,500	12,511.1	0.006
Big Muddy	18.64	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	18.37	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	18.04	2 Yr 24 Hr	11.1	12,500	12,511.1	0.006
Big Muddy	17.67	2 Yr 24 Hr	11.1	12,500	12,511.1	0.006
Big Muddy	17.52	2 Yr 24 Hr	11.1	12,500	12,511.1	0.006

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Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	17.44	2 Yr 24 Hr	11.1	12,500	12,511.1	0.006
Big Muddy	17.09	2 Yr 24 Hr	11.1	12,500	12,511.1	0.006
Big Muddy	16.56	2 Yr 24 Hr	11.1	12,500	12,511.1	0.006
Big Muddy	16.46	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	16.02	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	15.85	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	15.60	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	15.35	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	15.06	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	14.90	2 Yr 24 Hr	11.1	12,500	12,511.1	0.006
Big Muddy	14.64	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	14.42	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	14.25	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	14.03	2 Yr 24 Hr	11.1	12,500	12,511.1	0.006
Big Muddy	13.81	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	13.61	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	13.45	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	13.20	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	12.94	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	12.59	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	12.34	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	12.25	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	11.99	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	11.57	2 Yr 24 Hr	11.1	12,500	12,511.1	0.005
Big Muddy	11.32	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	11.02	2 Yr 24 Hr	11.1	15,900	15,911.1	0.006
Big Muddy	10.71	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	10.42	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	10.15	2 Yr 24 Hr	11.1	15,900	15,911.1	0.006
Big Muddy	9.93	2 Yr 24 Hr	11.1	15,900	15,911.1	0.006
Big Muddy	9.63	2 Yr 24 Hr	11.1	15,900	15,911.1	0.006
Big Muddy	9.42	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	9.24	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	9.07	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	8.83	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	8.60	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	8.33	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	8.05	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	7.90	2 Yr 24 Hr	11.1	15,900	15,911.1	0.006
Big Muddy	7.74	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	7.57	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	7.30	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	7.07	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	6.87	2 Yr 24 Hr	11.1	15,900	15,911.1	0.006
Big Muddy	6.59	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	6.26	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	6.02	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	5.84	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005

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Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	5.60	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	5.36	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	5.34	2 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	2 Yr 24 Hr	11.1	15,900	15,911.1	0.006
Big Muddy	5.33	2 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	5.13	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	4.77	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	4.76	2 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	4.22	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	3.96	2 Yr 24 Hr	11.1	15,900	15,911.1	0.004
Big Muddy	3.40	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	3.14	2 Yr 24 Hr	11.1	15,900	15,911.1	0.004
Big Muddy	3.08	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	3.07	2 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	2.92	2 Yr 24 Hr	11.1	15,900	15,911.1	0.004
Big Muddy	2.61	2 Yr 24 Hr	11.1	15,900	15,911.1	0.004
Big Muddy	2.47	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	2.15	2 Yr 24 Hr	11.1	15,900	15,911.1	0.004
Big Muddy	1.99	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	1.79	2 Yr 24 Hr	11.1	15,900	15,911.1	0.004
Big Muddy	1.58	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	1.46	2 Yr 24 Hr	11.1	15,900	15,911.1	0.004
Big Muddy	1.17	2 Yr 24 Hr	11.1	15,900	15,911.1	0.004
Big Muddy	1.06	2 Yr 24 Hr	11.1	15,900	15,911.1	0.005
Big Muddy	0.94	2 Yr 24 Hr	11.1	15,900	15,911.1	0.004
Big Muddy	0.62	2 Yr 24 Hr	11.1	16,000	16,011.1	0.004
Big Muddy	0.48	2 Yr 24 Hr	11.1	16,000	16,011.1	0.005
Big Muddy	0.18	2 Yr 24 Hr	11.1	16,000	16,011.1	0.005
Big Muddy	0.00	2 Yr 24 Hr	11.1	16,000	16,011.1	0.004

Five Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	5 Yr 24 Hr	0.0	13,200	13,200	0.005
Big Muddy	53.23	5 Yr 24 Hr	0.0	13,200	13,200	0.005
Big Muddy	53.04	5 Yr 24 Hr	0.0	13,200	13,200	0.005
Big Muddy	52.82	5 Yr 24 Hr	0.0	13,200	13,200	0.005
Big Muddy	52.56	5 Yr 24 Hr	0.0	13,200	13,200	0.005
Big Muddy	52.40	5 Yr 24 Hr	0.0	13,200	13,200	0.006
Big Muddy	52.04	5 Yr 24 Hr	0.0	13,200	13,200	0.006
Big Muddy	51.89	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	51.49	5 Yr 24 Hr	11.1	13,200	13,211.1	0.005
Big Muddy	51.21	5 Yr 24 Hr	11.1	13,200	13,211.1	0.005
Big Muddy	51.12	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	51.11	5 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	51.03	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	50.77	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	50.54	5 Yr 24 Hr	11.1	13,200	13,211.1	0.005
Big Muddy	50.15	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	49.86	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	49.62	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	49.45	5 Yr 24 Hr	11.1	13,200	13,211.1	0.005
Big Muddy	49.28	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	48.95	5 Yr 24 Hr	11.1	13,200	13,211.1	0.005
Big Muddy	48.55	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	48.04	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	47.59	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	47.27	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	46.90	5 Yr 24 Hr	11.1	13,200	13,211.1	0.005
Big Muddy	46.84	5 Yr 24 Hr	11.1	13,200	13,211.1	0.005
Big Muddy	46.54	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	46.17	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	46.16	5 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	46.11	5 Yr 24 Hr	11.1	13,200	13,211.1	0.006
Big Muddy	45.90	5 Yr 24 Hr	11.1	13,300	13,311.1	0.006
Big Muddy	45.78	5 Yr 24 Hr	11.1	13,300	13,311.1	0.006
Big Muddy	45.56	5 Yr 24 Hr	11.1	13,300	13,311.1	0.005
Big Muddy	45.34	5 Yr 24 Hr	11.1	13,300	13,311.1	0.005
Big Muddy	45.12	5 Yr 24 Hr	11.1	13,300	13,311.1	0.006
Big Muddy	44.91	5 Yr 24 Hr	11.1	13,300	13,311.1	0.006
Big Muddy	44.74	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	44.54	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	44.35	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	44.17	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	44.12	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	44.03	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	43.88	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	43.46	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	43.25	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006

Five Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	43.08	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	42.87	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	42.39	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	42.19	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	41.86	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	41.66	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	41.44	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	41.12	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	40.75	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	40.41	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	40.11	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	39.80	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	39.55	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	39.44	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	39.27	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	39.02	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	38.80	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	38.48	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	38.21	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	38.04	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	37.88	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	37.53	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	37.29	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	36.90	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	36.79	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	36.35	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	36.19	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	36.01	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	35.90	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	35.61	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	35.15	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	34.92	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	34.53	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	34.20	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	33.67	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	33.10	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	32.44	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	32.06	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	31.71	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	31.48	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	31.35	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	30.99	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	30.60	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	30.26	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	29.81	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	29.68	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	29.46	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	29.36	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005

Five Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	29.35	5 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	29.16	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	29.02	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	28.93	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	28.21	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	28.10	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	27.89	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	27.72	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	27.03	5 Yr 24 Hr	11.1	14,800	14,811.1	0.006
Big Muddy	26.47	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	26.03	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	25.82	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	25.46	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	25.25	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	24.97	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	23.69	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	23.44	5 Yr 24 Hr	11.1	14,800	14,811.1	0.005
Big Muddy	23.19	5 Yr 24 Hr	11.1	17,100	17,111.1	0.005
Big Muddy	23.14	5 Yr 24 Hr	11.1	17,100	17,111.1	0.004
Big Muddy	22.88	5 Yr 24 Hr	11.1	17,100	17,111.1	0.005
Big Muddy	22.66	5 Yr 24 Hr	11.1	17,100	17,111.1	0.005
Big Muddy	22.55	5 Yr 24 Hr	11.1	17,100	17,111.1	0.004
Big Muddy	22.23	5 Yr 24 Hr	11.1	17,100	17,111.1	0.004
Big Muddy	21.73	5 Yr 24 Hr	11.1	17,100	17,111.1	0.005
Big Muddy	21.38	5 Yr 24 Hr	11.1	17,100	17,111.1	0.004
Big Muddy	21.25	5 Yr 24 Hr	11.1	17,100	17,111.1	0.004
Big Muddy	21.23	5 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	5 Yr 24 Hr	11.1	17,100	17,111.1	0.004
Big Muddy	21.13	5 Yr 24 Hr	11.1	17,100	17,111.1	0.005
Big Muddy	20.90	5 Yr 24 Hr	11.1	17,100	17,111.1	0.005
Big Muddy	20.63	5 Yr 24 Hr	11.1	17,100	17,111.1	0.004
Big Muddy	20.40	5 Yr 24 Hr	11.1	17,100	17,111.1	0.005
Big Muddy	20.05	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	19.73	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	19.41	5 Yr 24 Hr	11.1	19,000	19,011.1	0.005
Big Muddy	19.29	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	19.28	5 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	19.25	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	19.24	5 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	19.17	5 Yr 24 Hr	11.1	19,000	19,011.1	0.005
Big Muddy	18.64	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	18.37	5 Yr 24 Hr	11.1	19,000	19,011.1	0.005
Big Muddy	18.04	5 Yr 24 Hr	11.1	19,000	19,011.1	0.005
Big Muddy	17.67	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	17.52	5 Yr 24 Hr	11.1	19,000	19,011.1	0.005

Five Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	17.44	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	17.09	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	16.56	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	16.46	5 Yr 24 Hr	11.1	19,000	19,011.1	0.005
Big Muddy	16.02	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	15.85	5 Yr 24 Hr	11.1	19,000	19,011.1	0.005
Big Muddy	15.60	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	15.35	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	15.06	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	14.90	5 Yr 24 Hr	11.1	19,000	19,011.1	0.005
Big Muddy	14.64	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	14.42	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	14.25	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	14.03	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	13.81	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	13.61	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	13.45	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	13.20	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	12.94	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	12.59	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	12.34	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	12.25	5 Yr 24 Hr	11.1	19,000	19,011.1	0.005
Big Muddy	11.99	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	11.57	5 Yr 24 Hr	11.1	19,000	19,011.1	0.004
Big Muddy	11.32	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	11.02	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	10.71	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	10.42	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	10.15	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	9.93	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	9.63	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	9.42	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	9.24	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	9.07	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	8.83	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	8.60	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	8.33	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	8.05	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	7.90	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	7.74	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	7.57	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	7.30	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	7.07	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	6.87	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	6.59	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	6.26	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	6.02	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	5.84	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004

Five Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	5.60	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	5.36	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	5.34	5 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	5.33	5 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	5.13	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	4.77	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	4.76	5 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	4.22	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	3.96	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	3.40	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	3.14	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	3.08	5 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	3.07	5 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	2.92	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	2.61	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	2.47	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	2.15	5 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	1.99	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	1.79	5 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	1.58	5 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	1.46	5 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	1.17	5 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	1.06	5 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	0.94	5 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	0.62	5 Yr 24 Hr	11.1	24,200	24,211.1	0.004
Big Muddy	0.48	5 Yr 24 Hr	11.1	24,200	24,211.1	0.004
Big Muddy	0.18	5 Yr 24 Hr	11.1	24,200	24,211.1	0.003
Big Muddy	0.00	5 Yr 24 Hr	11.1	24,200	24,211.1	0.003

Ten Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	10 Yr 24 Hr	0.0	16,500	16,500	0.005
Big Muddy	53.23	10 Yr 24 Hr	0.0	16,500	16,500	0.005
Big Muddy	53.04	10 Yr 24 Hr	0.0	16,500	16,500	0.004
Big Muddy	52.82	10 Yr 24 Hr	0.0	16,500	16,500	0.005
Big Muddy	52.56	10 Yr 24 Hr	0.0	16,500	16,500	0.005
Big Muddy	52.40	10 Yr 24 Hr	0.0	16,500	16,500	0.005
Big Muddy	52.04	10 Yr 24 Hr	0.0	16,500	16,500	0.005
Big Muddy	51.89	10 Yr 24 Hr	11.1	16,500	16,511.1	0.006
Big Muddy	51.49	10 Yr 24 Hr	11.1	16,500	16,511.1	0.006
Big Muddy	51.21	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	51.12	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	51.11	10 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	51.03	10 Yr 24 Hr	11.1	16,500	16,511.1	0.006
Big Muddy	50.77	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	50.54	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	50.15	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	49.86	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	49.62	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	49.45	10 Yr 24 Hr	11.1	16,500	16,511.1	0.006
Big Muddy	49.28	10 Yr 24 Hr	11.1	16,500	16,511.1	0.006
Big Muddy	48.95	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	48.55	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	48.04	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	47.59	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	47.27	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	46.90	10 Yr 24 Hr	11.1	16,500	16,511.1	0.006
Big Muddy	46.84	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	46.54	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	46.17	10 Yr 24 Hr	11.1	16,500	16,511.1	0.006
Big Muddy	46.16	10 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	10 Yr 24 Hr	11.1	16,500	16,511.1	0.006
Big Muddy	46.11	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	45.90	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	45.78	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	45.56	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	45.34	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	45.12	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	44.91	10 Yr 24 Hr	11.1	16,500	16,511.1	0.005
Big Muddy	44.74	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	44.54	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	44.35	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	44.17	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	44.12	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	44.03	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	43.88	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	43.46	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	43.25	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006

Ten Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	43.08	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	42.87	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	42.39	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	42.19	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	41.86	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	41.66	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	41.44	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	41.12	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	40.75	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	40.41	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	40.11	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	39.80	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	39.55	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	39.44	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	39.27	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	39.02	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	38.80	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	38.48	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	38.21	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	38.04	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	37.88	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	37.53	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	37.29	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	36.90	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	36.79	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	36.35	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	36.19	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	36.01	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	35.90	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	35.61	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	35.15	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	34.92	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	34.53	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	34.20	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	33.67	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	33.10	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	32.44	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	32.06	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	31.71	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	31.48	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	31.35	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	30.99	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	30.60	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	30.26	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	29.81	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	29.68	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	29.46	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	29.36	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005

Ten Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	29.35	10 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	29.16	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	29.02	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	28.93	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	28.21	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	28.10	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	27.89	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	27.72	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	27.03	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	26.47	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	26.03	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	25.82	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	25.46	10 Yr 24 Hr	11.1	18,400	18,411.1	0.006
Big Muddy	25.25	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	24.97	10 Yr 24 Hr	11.1	18,400	18,411.1	0.005
Big Muddy	23.69	10 Yr 24 Hr	11.1	18,400	18,411.1	0.004
Big Muddy	23.44	10 Yr 24 Hr	11.1	18,400	18,411.1	0.004
Big Muddy	23.19	10 Yr 24 Hr	11.1	21,200	21,211.1	0.004
Big Muddy	23.14	10 Yr 24 Hr	11.1	21,200	21,211.1	0.004
Big Muddy	22.88	10 Yr 24 Hr	11.1	21,200	21,211.1	0.005
Big Muddy	22.66	10 Yr 24 Hr	11.1	21,200	21,211.1	0.005
Big Muddy	22.55	10 Yr 24 Hr	11.1	21,200	21,211.1	0.004
Big Muddy	22.23	10 Yr 24 Hr	11.1	21,200	21,211.1	0.004
Big Muddy	21.73	10 Yr 24 Hr	11.1	21,200	21,211.1	0.004
Big Muddy	21.38	10 Yr 24 Hr	11.1	21,200	21,211.1	0.004
Big Muddy	21.25	10 Yr 24 Hr	11.1	21,200	21,211.1	0.004
Big Muddy	21.23	10 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	10 Yr 24 Hr	11.1	21,200	21,211.1	0.004
Big Muddy	21.13	10 Yr 24 Hr	11.1	21,200	21,211.1	0.004
Big Muddy	20.90	10 Yr 24 Hr	11.1	21,200	21,211.1	0.004
Big Muddy	20.63	10 Yr 24 Hr	11.1	21,200	21,211.1	0.004
Big Muddy	20.40	10 Yr 24 Hr	11.1	21,200	21,211.1	0.004
Big Muddy	20.05	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	19.73	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	19.41	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	19.29	10 Yr 24 Hr	11.1	23,500	23,511.1	0.005
Big Muddy	19.28	10 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	19.25	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	19.24	10 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	19.17	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	18.64	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	18.37	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	18.04	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	17.67	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	17.52	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004

Ten Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	17.44	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	17.09	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	16.56	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	16.46	10 Yr 24 Hr	11.1	23,500	23,511.1	0.005
Big Muddy	16.02	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	15.85	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	15.60	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	15.35	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	15.06	10 Yr 24 Hr	11.1	23,500	23,511.1	0.005
Big Muddy	14.90	10 Yr 24 Hr	11.1	23,500	23,511.1	0.003
Big Muddy	14.64	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	14.42	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	14.25	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	14.03	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	13.81	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	13.61	10 Yr 24 Hr	11.1	23,500	23,511.1	0.003
Big Muddy	13.45	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	13.20	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	12.94	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	12.59	10 Yr 24 Hr	11.1	23,500	23,511.1	0.003
Big Muddy	12.34	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	12.25	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	11.99	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	11.57	10 Yr 24 Hr	11.1	23,500	23,511.1	0.004
Big Muddy	11.32	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	11.02	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	10.71	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	10.42	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	10.15	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	9.93	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	9.63	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	9.42	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	9.24	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	9.07	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	8.83	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	8.60	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	8.33	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	8.05	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	7.90	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	7.74	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	7.57	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	7.30	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	7.07	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	6.87	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	6.59	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	6.26	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	6.02	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	5.84	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004

Ten Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	5.60	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	5.36	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	5.34	10 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	5.33	10 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	5.13	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	4.77	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	4.76	10 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	4.22	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	3.96	10 Yr 24 Hr	11.1	29,800	29,811.1	0.004
Big Muddy	3.40	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	3.14	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	3.08	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	3.07	10 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	2.92	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	2.61	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	2.47	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	2.15	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	1.99	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	1.79	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	1.58	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	1.46	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	1.17	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	1.06	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	0.94	10 Yr 24 Hr	11.1	29,800	29,811.1	0.003
Big Muddy	0.62	10 Yr 24 Hr	11.1	29,900	29,911.1	0.003
Big Muddy	0.48	10 Yr 24 Hr	11.1	29,900	29,911.1	0.003
Big Muddy	0.18	10 Yr 24 Hr	11.1	29,900	29,911.1	0.003
Big Muddy	0.00	10 Yr 24 Hr	11.1	29,900	29,911.1	0.003

Twenty Five Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	25 Yr 24 Hr	0.0	20,700	20,700	0.003
Big Muddy	53.23	25 Yr 24 Hr	0.0	20,700	20,700	0.004
Big Muddy	53.04	25 Yr 24 Hr	0.0	20,700	20,700	0.003
Big Muddy	52.82	25 Yr 24 Hr	0.0	20,700	20,700	0.004
Big Muddy	52.56	25 Yr 24 Hr	0.0	20,700	20,700	0.004
Big Muddy	52.40	25 Yr 24 Hr	0.0	20,700	20,700	0.004
Big Muddy	52.04	25 Yr 24 Hr	0.0	20,700	20,700	0.004
Big Muddy	51.89	25 Yr 24 Hr	11.1	20,700	20,711.1	0.003
Big Muddy	51.49	25 Yr 24 Hr	11.1	20,700	20,711.1	0.003
Big Muddy	51.21	25 Yr 24 Hr	11.1	20,700	20,711.1	0.003
Big Muddy	51.12	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	51.11	25 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	51.03	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	50.77	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	50.54	25 Yr 24 Hr	11.1	20,700	20,711.1	0.003
Big Muddy	50.15	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	49.86	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	49.62	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	49.45	25 Yr 24 Hr	11.1	20,700	20,711.1	0.003
Big Muddy	49.28	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	48.95	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	48.55	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	48.04	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	47.59	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	47.27	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	46.90	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	46.84	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	46.54	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	46.17	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	46.16	25 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	46.11	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	45.90	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	45.78	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	45.56	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	45.34	25 Yr 24 Hr	11.1	20,700	20,711.1	0.003
Big Muddy	45.12	25 Yr 24 Hr	11.1	20,700	20,711.1	0.004
Big Muddy	44.91	25 Yr 24 Hr	11.1	20,700	20,711.1	0.003
Big Muddy	44.74	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	44.54	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	44.35	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	44.17	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	44.12	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	44.03	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	43.88	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	43.46	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	43.25	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004

Twenty Five Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	43.08	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	42.87	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	42.39	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	42.19	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	41.86	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	41.66	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	41.44	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	41.12	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	40.75	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	40.41	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	40.11	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	39.80	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	39.55	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	39.44	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	39.27	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	39.02	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	38.80	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	38.48	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	38.21	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	38.04	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	37.88	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	37.53	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	37.29	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	36.90	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	36.79	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	36.35	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	36.19	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	36.01	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	35.90	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	35.61	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	35.15	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	34.92	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	34.53	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	34.20	25 Yr 24 Hr	11.1	23,100	23,111.1	0.003
Big Muddy	33.67	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	33.10	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	32.44	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	32.06	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	31.71	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	31.48	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	31.35	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	30.99	25 Yr 24 Hr	11.1	23,100	23,111.1	0.003
Big Muddy	30.60	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	30.26	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	29.81	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	29.68	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	29.46	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	29.36	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004

Twenty Five Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	29.35	25 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	29.16	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	29.02	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	28.93	25 Yr 24 Hr	11.1	23,100	23,111.1	0.003
Big Muddy	28.21	25 Yr 24 Hr	11.1	23,100	23,111.1	0.003
Big Muddy	28.10	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	27.89	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	27.72	25 Yr 24 Hr	11.1	23,100	23,111.1	0.003
Big Muddy	27.03	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	26.47	25 Yr 24 Hr	11.1	23,100	23,111.1	0.003
Big Muddy	26.03	25 Yr 24 Hr	11.1	23,100	23,111.1	0.003
Big Muddy	25.82	25 Yr 24 Hr	11.1	23,100	23,111.1	0.003
Big Muddy	25.46	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	25.25	25 Yr 24 Hr	11.1	23,100	23,111.1	0.003
Big Muddy	24.97	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	23.69	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	23.44	25 Yr 24 Hr	11.1	23,100	23,111.1	0.004
Big Muddy	23.19	25 Yr 24 Hr	11.1	26,400	26,411.1	0.004
Big Muddy	23.14	25 Yr 24 Hr	11.1	26,400	26,411.1	0.004
Big Muddy	22.88	25 Yr 24 Hr	11.1	26,400	26,411.1	0.003
Big Muddy	22.66	25 Yr 24 Hr	11.1	26,400	26,411.1	0.004
Big Muddy	22.55	25 Yr 24 Hr	11.1	26,400	26,411.1	0.003
Big Muddy	22.23	25 Yr 24 Hr	11.1	26,400	26,411.1	0.004
Big Muddy	21.73	25 Yr 24 Hr	11.1	26,400	26,411.1	0.003
Big Muddy	21.38	25 Yr 24 Hr	11.1	26,400	26,411.1	0.004
Big Muddy	21.25	25 Yr 24 Hr	11.1	26,400	26,411.1	0.003
Big Muddy	21.23	25 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	25 Yr 24 Hr	11.1	26,400	26,411.1	0.004
Big Muddy	21.13	25 Yr 24 Hr	11.1	26,400	26,411.1	0.004
Big Muddy	20.90	25 Yr 24 Hr	11.1	26,400	26,411.1	0.004
Big Muddy	20.63	25 Yr 24 Hr	11.1	26,400	26,411.1	0.004
Big Muddy	20.40	25 Yr 24 Hr	11.1	26,400	26,411.1	0.004
Big Muddy	20.05	25 Yr 24 Hr	11.1	29,200	29,211.1	0.004
Big Muddy	19.73	25 Yr 24 Hr	11.1	29,200	29,211.1	0.004
Big Muddy	19.41	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	19.29	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	19.28	25 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	19.25	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	19.24	25 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	19.17	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	18.64	25 Yr 24 Hr	11.1	29,200	29,211.1	0.004
Big Muddy	18.37	25 Yr 24 Hr	11.1	29,200	29,211.1	0.004
Big Muddy	18.04	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	17.67	25 Yr 24 Hr	11.1	29,200	29,211.1	0.004
Big Muddy	17.52	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003

Twenty Five Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	17.44	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	17.09	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	16.56	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	16.46	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	16.02	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	15.85	25 Yr 24 Hr	11.1	29,200	29,211.1	0.004
Big Muddy	15.60	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	15.35	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	15.06	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	14.90	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	14.64	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	14.42	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	14.25	25 Yr 24 Hr	11.1	29,200	29,211.1	0.004
Big Muddy	14.03	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	13.81	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	13.61	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	13.45	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	13.20	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	12.94	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	12.59	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	12.34	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	12.25	25 Yr 24 Hr	11.1	29,200	29,211.1	0.004
Big Muddy	11.99	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	11.57	25 Yr 24 Hr	11.1	29,200	29,211.1	0.003
Big Muddy	11.32	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	11.02	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	10.71	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	10.42	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	10.15	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	9.93	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	9.63	25 Yr 24 Hr	11.1	37,000	37,011.1	0.004
Big Muddy	9.42	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	9.24	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	9.07	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	8.83	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	8.60	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	8.33	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	8.05	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	7.90	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	7.74	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	7.57	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	7.30	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	7.07	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	6.87	25 Yr 24 Hr	11.1	37,000	37,011.1	0.004
Big Muddy	6.59	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	6.26	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	6.02	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	5.84	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003

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Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	5.60	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	5.36	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	5.34	25 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	5.33	25 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	5.13	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	4.77	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	4.76	25 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	4.22	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	3.96	25 Yr 24 Hr	11.1	37,000	37,011.1	0.002
Big Muddy	3.40	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	3.14	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	3.08	25 Yr 24 Hr	11.1	37,000	37,011.1	0.002
Big Muddy	3.07	25 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	2.92	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	2.61	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	2.47	25 Yr 24 Hr	11.1	37,000	37,011.1	0.002
Big Muddy	2.15	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	1.99	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	1.79	25 Yr 24 Hr	11.1	37,000	37,011.1	0.002
Big Muddy	1.58	25 Yr 24 Hr	11.1	37,000	37,011.1	0.002
Big Muddy	1.46	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	1.17	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	1.06	25 Yr 24 Hr	11.1	37,000	37,011.1	0.003
Big Muddy	0.94	25 Yr 24 Hr	11.1	37,000	37,011.1	0.002
Big Muddy	0.62	25 Yr 24 Hr	11.1	37,100	37,111.1	0.003
Big Muddy	0.48	25 Yr 24 Hr	11.1	37,100	37,111.1	0.003
Big Muddy	0.18	25 Yr 24 Hr	11.1	37,100	37,111.1	0.003
Big Muddy	0.00	25 Yr 24 Hr	11.1	37,100	37,111.1	0.003

Fifty Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	50 Yr 24 Hr	0.0	24,100	24,100	0.002
Big Muddy	53.23	50 Yr 24 Hr	0.0	24,100	24,100	0.001
Big Muddy	53.04	50 Yr 24 Hr	0.0	24,100	24,100	0.002
Big Muddy	52.82	50 Yr 24 Hr	0.0	24,100	24,100	0.001
Big Muddy	52.56	50 Yr 24 Hr	0.0	24,100	24,100	0.001
Big Muddy	52.40	50 Yr 24 Hr	0.0	24,100	24,100	0.001
Big Muddy	52.04	50 Yr 24 Hr	0.0	24,100	24,100	0.002
Big Muddy	51.89	50 Yr 24 Hr	11.1	24,100	24,111.1	0.001
Big Muddy	51.49	50 Yr 24 Hr	11.1	24,100	24,111.1	0.002
Big Muddy	51.21	50 Yr 24 Hr	11.1	24,100	24,111.1	0.002
Big Muddy	51.12	50 Yr 24 Hr	11.1	24,100	24,111.1	0.002
Big Muddy	51.11	50 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	50 Yr 24 Hr	11.1	24,100	24,111.1	0.001
Big Muddy	51.03	50 Yr 24 Hr	11.1	24,100	24,111.1	0.001
Big Muddy	50.77	50 Yr 24 Hr	11.1	24,100	24,111.1	0.002
Big Muddy	50.54	50 Yr 24 Hr	11.1	24,100	24,111.1	0.002
Big Muddy	50.15	50 Yr 24 Hr	11.1	24,100	24,111.1	0.001
Big Muddy	49.86	50 Yr 24 Hr	11.1	24,100	24,111.1	0.001
Big Muddy	49.62	50 Yr 24 Hr	11.1	24,100	24,111.1	0.001
Big Muddy	49.45	50 Yr 24 Hr	11.1	24,100	24,111.1	0.006
Big Muddy	49.28	50 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	48.95	50 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	48.55	50 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	48.04	50 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	47.59	50 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	47.27	50 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	46.90	50 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	46.84	50 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	46.54	50 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	46.17	50 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	46.16	50 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	50 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	46.11	50 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	45.90	50 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	45.78	50 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	45.56	50 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	45.34	50 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	45.12	50 Yr 24 Hr	11.1	24,100	24,111.1	0.004
Big Muddy	44.91	50 Yr 24 Hr	11.1	24,100	24,111.1	0.003
Big Muddy	44.74	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	44.54	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	44.35	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	44.17	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	44.12	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	44.03	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	43.88	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	43.46	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	43.25	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003

Fifty Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	43.08	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	42.87	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	42.39	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	42.19	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	41.86	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	41.66	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	41.44	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	41.12	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	40.75	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	40.41	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	40.11	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	39.80	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	39.55	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	39.44	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	39.27	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	39.02	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	38.80	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	38.48	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	38.21	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	38.04	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	37.88	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	37.53	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	37.29	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	36.90	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	36.79	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	36.35	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	36.19	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	36.01	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	35.90	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	35.61	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	35.15	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	34.92	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	34.53	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	34.20	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	33.67	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	33.10	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	32.44	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	32.06	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	31.71	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	31.48	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	31.35	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	30.99	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	30.60	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	30.26	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	29.81	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	29.68	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	29.46	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	29.36	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004

Fifty Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	29.35	50 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	29.16	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	29.02	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	28.93	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	28.21	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	28.10	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	27.89	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	27.72	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	27.03	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	26.47	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	26.03	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	25.82	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	25.46	50 Yr 24 Hr	11.1	26,800	26,811.1	0.004
Big Muddy	25.25	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	24.97	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	23.69	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	23.44	50 Yr 24 Hr	11.1	26,800	26,811.1	0.003
Big Muddy	23.19	50 Yr 24 Hr	11.1	30,500	30,511.1	0.003
Big Muddy	23.14	50 Yr 24 Hr	11.1	30,500	30,511.1	0.004
Big Muddy	22.88	50 Yr 24 Hr	11.1	30,500	30,511.1	0.003
Big Muddy	22.66	50 Yr 24 Hr	11.1	30,500	30,511.1	0.003
Big Muddy	22.55	50 Yr 24 Hr	11.1	30,500	30,511.1	0.003
Big Muddy	22.23	50 Yr 24 Hr	11.1	30,500	30,511.1	0.003
Big Muddy	21.73	50 Yr 24 Hr	11.1	30,500	30,511.1	0.003
Big Muddy	21.38	50 Yr 24 Hr	11.1	30,500	30,511.1	0.003
Big Muddy	21.25	50 Yr 24 Hr	11.1	30,500	30,511.1	0.003
Big Muddy	21.23	50 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	50 Yr 24 Hr	11.1	30,500	30,511.1	0.003
Big Muddy	21.13	50 Yr 24 Hr	11.1	30,500	30,511.1	0.003
Big Muddy	20.90	50 Yr 24 Hr	11.1	30,500	30,511.1	0.003
Big Muddy	20.63	50 Yr 24 Hr	11.1	30,500	30,511.1	0.003
Big Muddy	20.40	50 Yr 24 Hr	11.1	30,500	30,511.1	0.004
Big Muddy	20.05	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	19.73	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	19.41	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	19.29	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	19.28	50 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	50 Yr 24 Hr	11.1	33,700	33,711.1	0.004
Big Muddy	19.25	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	19.24	50 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	19.17	50 Yr 24 Hr	11.1	33,700	33,711.1	0.004
Big Muddy	18.64	50 Yr 24 Hr	11.1	33,700	33,711.1	0.004
Big Muddy	18.37	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	18.04	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	17.67	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	17.52	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003

Fifty Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	17.44	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	17.09	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	16.56	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	16.46	50 Yr 24 Hr	11.1	33,700	33,711.1	0.004
Big Muddy	16.02	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	15.85	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	15.60	50 Yr 24 Hr	11.1	33,700	33,711.1	0.004
Big Muddy	15.35	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	15.06	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	14.90	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	14.64	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	14.42	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	14.25	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	14.03	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	13.81	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	13.61	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	13.45	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	13.20	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	12.94	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	12.59	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	12.34	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	12.25	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	11.99	50 Yr 24 Hr	11.1	33,700	33,711.1	0.003
Big Muddy	11.57	50 Yr 24 Hr	11.1	33,700	33,711.1	0.002
Big Muddy	11.32	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	11.02	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	10.71	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	10.42	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	10.15	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	9.93	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	9.63	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	9.42	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	9.24	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	9.07	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	8.83	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	8.60	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	8.33	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	8.05	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	7.90	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	7.74	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	7.57	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	7.30	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	7.07	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	6.87	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	6.59	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	6.26	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	6.02	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	5.84	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003

Fifty Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	5.60	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	5.36	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	5.34	50 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	5.33	50 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	5.13	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	4.77	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	4.76	50 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	4.22	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	3.96	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	3.40	50 Yr 24 Hr	11.1	42,700	42,711.1	0.002
Big Muddy	3.14	50 Yr 24 Hr	11.1	42,700	42,711.1	0.002
Big Muddy	3.08	50 Yr 24 Hr	11.1	42,700	42,711.1	0.002
Big Muddy	3.07	50 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	50 Yr 24 Hr	11.1	42,700	42,711.1	0.002
Big Muddy	2.92	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	2.61	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	2.47	50 Yr 24 Hr	11.1	42,700	42,711.1	0.002
Big Muddy	2.15	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	1.99	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	1.79	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	1.58	50 Yr 24 Hr	11.1	42,700	42,711.1	0.002
Big Muddy	1.46	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	1.17	50 Yr 24 Hr	11.1	42,700	42,711.1	0.003
Big Muddy	1.06	50 Yr 24 Hr	11.1	42,700	42,711.1	0.002
Big Muddy	0.94	50 Yr 24 Hr	11.1	42,700	42,711.1	0.002
Big Muddy	0.62	50 Yr 24 Hr	11.1	42,800	42,811.1	0.003
Big Muddy	0.48	50 Yr 24 Hr	11.1	42,800	42,811.1	0.002
Big Muddy	0.18	50 Yr 24 Hr	11.1	42,800	42,811.1	0.002
Big Muddy	0.00	50 Yr 24 Hr	11.1	42,800	42,811.1	0.002

One Hundred Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	100 Yr 24 Hr	0.0	27,200	27,200	0.003
Big Muddy	53.23	100 Yr 24 Hr	0.0	27,200	27,200	0.004
Big Muddy	53.04	100 Yr 24 Hr	0.0	27,200	27,200	0.003
Big Muddy	52.82	100 Yr 24 Hr	0.0	27,200	27,200	0.003
Big Muddy	52.56	100 Yr 24 Hr	0.0	27,200	27,200	0.003
Big Muddy	52.40	100 Yr 24 Hr	0.0	27,200	27,200	0.003
Big Muddy	52.04	100 Yr 24 Hr	0.0	27,200	27,200	0.003
Big Muddy	51.89	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	51.49	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	51.21	100 Yr 24 Hr	11.1	27,200	27,211.1	0.004
Big Muddy	51.12	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	51.11	100 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	100 Yr 24 Hr	11.1	27,200	27,211.1	0.004
Big Muddy	51.03	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	50.77	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	50.54	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	50.15	100 Yr 24 Hr	11.1	27,200	27,211.1	0.004
Big Muddy	49.86	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	49.62	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	49.45	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	49.28	100 Yr 24 Hr	11.1	27,200	27,211.1	0.004
Big Muddy	48.95	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	48.55	100 Yr 24 Hr	11.1	27,200	27,211.1	0.004
Big Muddy	48.04	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	47.59	100 Yr 24 Hr	11.1	27,200	27,211.1	0.004
Big Muddy	47.27	100 Yr 24 Hr	11.1	27,200	27,211.1	0.004
Big Muddy	46.90	100 Yr 24 Hr	11.1	27,200	27,211.1	0.004
Big Muddy	46.84	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	46.54	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	46.17	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	46.16	100 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	46.11	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	45.90	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	45.78	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	45.56	100 Yr 24 Hr	11.1	27,200	27,211.1	0.004
Big Muddy	45.34	100 Yr 24 Hr	11.1	27,200	27,211.1	0.004
Big Muddy	45.12	100 Yr 24 Hr	11.1	27,200	27,211.1	0.003
Big Muddy	44.91	100 Yr 24 Hr	11.1	27,200	27,211.1	0.004
Big Muddy	44.74	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	44.54	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	44.35	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	44.17	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	44.12	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	44.03	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	43.88	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	43.46	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	43.25	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004

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Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	43.08	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	42.87	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	42.39	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	42.19	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	41.86	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	41.66	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	41.44	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	41.12	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	40.75	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	40.41	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	40.11	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	39.80	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	39.55	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	39.44	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	39.27	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	39.02	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	38.80	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	38.48	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	38.21	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	38.04	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	37.88	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	37.53	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	37.29	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	36.90	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	36.79	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	36.35	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	36.19	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	36.01	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	35.90	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	35.61	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	35.15	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	34.92	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	34.53	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	34.20	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	33.67	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	33.10	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	32.44	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	32.06	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	31.71	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	31.48	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	31.35	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	30.99	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	30.60	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	30.26	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	29.81	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	29.68	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	29.46	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	29.36	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003

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Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	29.35	100 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	29.16	100 Yr 24 Hr	11.1	30,300	30,311.1	0.004
Big Muddy	29.02	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	28.93	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	28.21	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	28.10	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	27.89	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	27.72	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	27.03	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	26.47	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	26.03	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	25.82	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	25.46	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	25.25	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	24.97	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	23.69	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	23.44	100 Yr 24 Hr	11.1	30,300	30,311.1	0.003
Big Muddy	23.19	100 Yr 24 Hr	11.1	34,400	34,411.1	0.003
Big Muddy	23.14	100 Yr 24 Hr	11.1	34,400	34,411.1	0.003
Big Muddy	22.88	100 Yr 24 Hr	11.1	34,400	34,411.1	0.003
Big Muddy	22.66	100 Yr 24 Hr	11.1	34,400	34,411.1	0.004
Big Muddy	22.55	100 Yr 24 Hr	11.1	34,400	34,411.1	0.004
Big Muddy	22.23	100 Yr 24 Hr	11.1	34,400	34,411.1	0.003
Big Muddy	21.73	100 Yr 24 Hr	11.1	34,400	34,411.1	0.003
Big Muddy	21.38	100 Yr 24 Hr	11.1	34,400	34,411.1	0.003
Big Muddy	21.25	100 Yr 24 Hr	11.1	34,400	34,411.1	0.004
Big Muddy	21.23	100 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	100 Yr 24 Hr	11.1	34,400	34,411.1	0.003
Big Muddy	21.13	100 Yr 24 Hr	11.1	34,400	34,411.1	0.004
Big Muddy	20.90	100 Yr 24 Hr	11.1	34,400	34,411.1	0.003
Big Muddy	20.63	100 Yr 24 Hr	11.1	34,400	34,411.1	0.003
Big Muddy	20.40	100 Yr 24 Hr	11.1	34,400	34,411.1	0.003
Big Muddy	20.05	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	19.73	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	19.41	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	19.29	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	19.28	100 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	19.25	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	19.24	100 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	19.17	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	18.64	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	18.37	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	18.04	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	17.67	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	17.52	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003

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Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	17.44	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	17.09	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	16.56	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	16.46	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	16.02	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	15.85	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	15.60	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	15.35	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	15.06	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	14.90	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	14.64	100 Yr 24 Hr	11.1	38,000	38,011.1	0.002
Big Muddy	14.42	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	14.25	100 Yr 24 Hr	11.1	38,000	38,011.1	0.002
Big Muddy	14.03	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	13.81	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	13.61	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	13.45	100 Yr 24 Hr	11.1	38,000	38,011.1	0.002
Big Muddy	13.20	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	12.94	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	12.59	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	12.34	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	12.25	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	11.99	100 Yr 24 Hr	11.1	38,000	38,011.1	0.003
Big Muddy	11.57	100 Yr 24 Hr	11.1	38,000	38,011.1	0.002
Big Muddy	11.32	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	11.02	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	10.71	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	10.42	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	10.15	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	9.93	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	9.63	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	9.42	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	9.24	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	9.07	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	8.83	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	8.60	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	8.33	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	8.05	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	7.90	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	7.74	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	7.57	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	7.30	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	7.07	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	6.87	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	6.59	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	6.26	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	6.02	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	5.84	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003

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Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	5.60	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	5.36	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	5.34	100 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	5.33	100 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	5.13	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	4.77	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	4.76	100 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	4.22	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	3.96	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	3.40	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	3.14	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	3.08	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	3.07	100 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	2.92	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	2.61	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	2.47	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	2.15	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	1.99	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	1.79	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	1.58	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	1.46	100 Yr 24 Hr	11.1	48,100	48,111.1	0.002
Big Muddy	1.17	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	1.06	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	0.94	100 Yr 24 Hr	11.1	48,100	48,111.1	0.003
Big Muddy	0.62	100 Yr 24 Hr	11.1	48,200	48,211.1	0.002
Big Muddy	0.48	100 Yr 24 Hr	11.1	48,200	48,211.1	0.002
Big Muddy	0.18	100 Yr 24 Hr	11.1	48,200	48,211.1	0.002
Big Muddy	0.00	100 Yr 24 Hr	11.1	48,200	48,211.1	0.002

Five Hundred Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	500 Yr 24 Hr	0.0	35,200	35,200	0.003
Big Muddy	53.23	500 Yr 24 Hr	0.0	35,200	35,200	0.002
Big Muddy	53.04	500 Yr 24 Hr	0.0	35,200	35,200	0.002
Big Muddy	52.82	500 Yr 24 Hr	0.0	35,200	35,200	0.003
Big Muddy	52.56	500 Yr 24 Hr	0.0	35,200	35,200	0.003
Big Muddy	52.40	500 Yr 24 Hr	0.0	35,200	35,200	0.003
Big Muddy	52.04	500 Yr 24 Hr	0.0	35,200	35,200	0.002
Big Muddy	51.89	500 Yr 24 Hr	11.1	35,200	35,211.1	0.002
Big Muddy	51.49	500 Yr 24 Hr	11.1	35,200	35,211.1	0.002
Big Muddy	51.21	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	51.12	500 Yr 24 Hr	11.1	35,200	35,211.1	0.002
Big Muddy	51.11	500 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	500 Yr 24 Hr	11.1	35,200	35,211.1	0.002
Big Muddy	51.03	500 Yr 24 Hr	11.1	35,200	35,211.1	0.002
Big Muddy	50.77	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	50.54	500 Yr 24 Hr	11.1	35,200	35,211.1	0.002
Big Muddy	50.15	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	49.86	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	49.62	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	49.45	500 Yr 24 Hr	11.1	35,200	35,211.1	0.002
Big Muddy	49.28	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	48.95	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	48.55	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	48.04	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	47.59	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	47.27	500 Yr 24 Hr	11.1	35,200	35,211.1	0.002
Big Muddy	46.90	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	46.84	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	46.54	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	46.17	500 Yr 24 Hr	11.1	35,200	35,211.1	0.002
Big Muddy	46.16	500 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	500 Yr 24 Hr	11.1	35,200	35,211.1	0.003
Big Muddy	46.11	500 Yr 24 Hr	11.1	35,200	35,211.1	0.002
Big Muddy	45.90	500 Yr 24 Hr	11.1	35,300	35,311.1	0.003
Big Muddy	45.78	500 Yr 24 Hr	11.1	35,300	35,311.1	0.003
Big Muddy	45.56	500 Yr 24 Hr	11.1	35,300	35,311.1	0.003
Big Muddy	45.34	500 Yr 24 Hr	11.1	35,300	35,311.1	0.003
Big Muddy	45.12	500 Yr 24 Hr	11.1	35,300	35,311.1	0.002
Big Muddy	44.91	500 Yr 24 Hr	11.1	35,300	35,311.1	0.002
Big Muddy	44.74	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	44.54	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	44.35	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	44.17	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	44.12	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	44.03	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	43.88	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	43.46	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	43.25	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003

Five Hundred Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	43.08	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	42.87	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	42.39	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	42.19	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	41.86	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	41.66	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	41.44	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	41.12	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	40.75	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	40.41	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	40.11	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	39.80	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	39.55	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	39.44	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	39.27	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	39.02	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	38.80	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	38.48	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	38.21	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	38.04	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	37.88	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	37.53	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	37.29	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	36.90	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	36.79	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	36.35	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	36.19	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	36.01	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	35.90	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	35.61	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	35.15	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	34.92	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	34.53	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	34.20	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	33.67	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	33.10	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	32.44	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	32.06	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	31.71	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	31.48	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	31.35	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	30.99	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	30.60	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	30.26	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	29.81	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	29.68	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	29.46	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	29.36	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003

Five Hundred Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	29.35	500 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	29.16	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	29.02	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	28.93	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	28.21	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	28.10	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	27.89	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	27.72	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	27.03	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	26.47	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	26.03	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	25.82	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	25.46	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	25.25	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	24.97	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	23.69	500 Yr 24 Hr	11.1	39,200	39,211.1	0.003
Big Muddy	23.44	500 Yr 24 Hr	11.1	39,200	39,211.1	0.002
Big Muddy	23.19	500 Yr 24 Hr	11.1	44,200	44,211.1	0.003
Big Muddy	23.14	500 Yr 24 Hr	11.1	44,200	44,211.1	0.002
Big Muddy	22.88	500 Yr 24 Hr	11.1	44,200	44,211.1	0.003
Big Muddy	22.66	500 Yr 24 Hr	11.1	44,200	44,211.1	0.003
Big Muddy	22.55	500 Yr 24 Hr	11.1	44,200	44,211.1	0.003
Big Muddy	22.23	500 Yr 24 Hr	11.1	44,200	44,211.1	0.003
Big Muddy	21.73	500 Yr 24 Hr	11.1	44,200	44,211.1	0.002
Big Muddy	21.38	500 Yr 24 Hr	11.1	44,200	44,211.1	0.002
Big Muddy	21.25	500 Yr 24 Hr	11.1	44,200	44,211.1	0.003
Big Muddy	21.23	500 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	500 Yr 24 Hr	11.1	44,200	44,211.1	0.002
Big Muddy	21.13	500 Yr 24 Hr	11.1	44,200	44,211.1	0.003
Big Muddy	20.90	500 Yr 24 Hr	11.1	44,200	44,211.1	0.002
Big Muddy	20.63	500 Yr 24 Hr	11.1	44,200	44,211.1	0.003
Big Muddy	20.40	500 Yr 24 Hr	11.1	44,200	44,211.1	0.003
Big Muddy	20.05	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	19.73	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	19.41	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	19.29	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	19.28	500 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	19.25	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	19.24	500 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	19.17	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	18.64	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	18.37	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	18.04	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	17.67	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	17.52	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002

Five Hundred Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	17.44	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	17.09	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	16.56	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	16.46	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	16.02	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	15.85	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	15.60	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	15.35	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	15.06	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	14.90	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	14.64	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	14.42	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	14.25	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	14.03	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	13.81	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	13.61	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	13.45	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	13.20	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	12.94	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	12.59	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	12.34	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	12.25	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	11.99	500 Yr 24 Hr	11.1	48,700	48,711.1	0.002
Big Muddy	11.57	500 Yr 24 Hr	11.1	48,700	48,711.1	0.003
Big Muddy	11.32	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	11.02	500 Yr 24 Hr	11.1	61,700	61,711.1	0.003
Big Muddy	10.71	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	10.42	500 Yr 24 Hr	11.1	61,700	61,711.1	0.003
Big Muddy	10.15	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	9.93	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	9.63	500 Yr 24 Hr	11.1	61,700	61,711.1	0.003
Big Muddy	9.42	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	9.24	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	9.07	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	8.83	500 Yr 24 Hr	11.1	61,700	61,711.1	0.003
Big Muddy	8.60	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	8.33	500 Yr 24 Hr	11.1	61,700	61,711.1	0.003
Big Muddy	8.05	500 Yr 24 Hr	11.1	61,700	61,711.1	0.003
Big Muddy	7.90	500 Yr 24 Hr	11.1	61,700	61,711.1	0.003
Big Muddy	7.74	500 Yr 24 Hr	11.1	61,700	61,711.1	0.003
Big Muddy	7.57	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	7.30	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	7.07	500 Yr 24 Hr	11.1	61,700	61,711.1	0.003
Big Muddy	6.87	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	6.59	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	6.26	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	6.02	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	5.84	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002

Five Hundred Year 24 Hr Rain Eventing Williamson Only

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	5.60	500 Yr 24 Hr	11.1	61,700	61,711.1	0.003
Big Muddy	5.36	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	5.34	500 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	500 Yr 24 Hr	11.1	61,700	61,711.1	0.003
Big Muddy	5.33	500 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	5.13	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	4.77	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	4.76	500 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	500 Yr 24 Hr	11.1	61,700	61,711.1	0.003
Big Muddy	4.22	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	3.96	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	3.40	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	3.14	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	3.08	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	3.07	500 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	2.92	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	2.61	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	2.47	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	2.15	500 Yr 24 Hr	11.1	61,700	61,711.1	0.001
Big Muddy	1.99	500 Yr 24 Hr	11.1	61,700	61,711.1	0.001
Big Muddy	1.79	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	1.58	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	1.46	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	1.17	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	1.06	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	0.94	500 Yr 24 Hr	11.1	61,700	61,711.1	0.002
Big Muddy	0.62	500 Yr 24 Hr	11.1	61,800	61,811.1	0.002
Big Muddy	0.48	500 Yr 24 Hr	11.1	61,800	61,811.1	0.002
Big Muddy	0.18	500 Yr 24 Hr	11.1	61,800	61,811.1	0.002
Big Muddy	0.00	500 Yr 24 Hr	11.1	61,800	61,811.1	0.002

Two Year 24 Hr Rain Eventing Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	2 Yr 24 Hr	0.0	8,600	8,600	0.013
Big Muddy	53.23	2 Yr 24 Hr	0.0	8,600	8,600	0.013
Big Muddy	53.04	2 Yr 24 Hr	0.0	8,600	8,600	0.013
Big Muddy	52.82	2 Yr 24 Hr	0.0	8,600	8,600	0.013
Big Muddy	52.56	2 Yr 24 Hr	0.0	8,600	8,600	0.014
Big Muddy	52.40	2 Yr 24 Hr	0.0	8,600	8,600	0.015
Big Muddy	52.04	2 Yr 24 Hr	0.0	8,600	8,600	0.015
Big Muddy	51.89	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	51.49	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	51.21	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	51.12	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	51.11	2 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	51.03	2 Yr 24 Hr	22.2	8,600	8,622.2	0.016
Big Muddy	50.77	2 Yr 24 Hr	22.2	8,600	8,622.2	0.016
Big Muddy	50.54	2 Yr 24 Hr	22.2	8,600	8,622.2	0.016
Big Muddy	50.15	2 Yr 24 Hr	22.2	8,600	8,622.2	0.016
Big Muddy	49.86	2 Yr 24 Hr	22.2	8,600	8,622.2	0.017
Big Muddy	49.62	2 Yr 24 Hr	22.2	8,600	8,622.2	0.016
Big Muddy	49.45	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	49.28	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	48.95	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	48.55	2 Yr 24 Hr	22.2	8,600	8,622.2	0.016
Big Muddy	48.04	2 Yr 24 Hr	22.2	8,600	8,622.2	0.016
Big Muddy	47.59	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	47.27	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	46.90	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	46.84	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	46.54	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	46.17	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	46.16	2 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	2 Yr 24 Hr	22.2	8,600	8,622.2	0.016
Big Muddy	46.11	2 Yr 24 Hr	22.2	8,600	8,622.2	0.015
Big Muddy	45.90	2 Yr 24 Hr	22.2	8,610	8,632.2	0.015
Big Muddy	45.78	2 Yr 24 Hr	22.2	8,610	8,632.2	0.015
Big Muddy	45.56	2 Yr 24 Hr	22.2	8,610	8,632.2	0.015
Big Muddy	45.34	2 Yr 24 Hr	22.2	8,610	8,632.2	0.015
Big Muddy	45.12	2 Yr 24 Hr	22.2	8,610	8,632.2	0.016
Big Muddy	44.91	2 Yr 24 Hr	22.2	8,610	8,632.2	0.015
Big Muddy	44.74	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	44.54	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	44.35	2 Yr 24 Hr	22.2	9,580	9,602.2	0.016
Big Muddy	44.17	2 Yr 24 Hr	22.2	9,580	9,602.2	0.016
Big Muddy	44.12	2 Yr 24 Hr	22.2	9,580	9,602.2	0.016
Big Muddy	44.03	2 Yr 24 Hr	22.2	9,580	9,602.2	0.016
Big Muddy	43.88	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	43.46	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	43.25	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015

Two Year 24 Hr Rain Eventing Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	43.08	2 Yr 24 Hr	22.2	9,580	9,602.2	0.016
Big Muddy	42.87	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	42.39	2 Yr 24 Hr	22.2	9,580	9,602.2	0.016
Big Muddy	42.19	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	41.86	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	41.66	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	41.44	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	41.12	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	40.75	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	40.41	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	40.11	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	39.80	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	39.55	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	39.44	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	39.27	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	39.02	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	38.80	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	38.48	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	38.21	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	38.04	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	37.88	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	37.53	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	37.29	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	36.90	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	36.79	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	36.35	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	36.19	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	36.01	2 Yr 24 Hr	22.2	9,580	9,602.2	0.015
Big Muddy	35.90	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	35.61	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	35.15	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	34.92	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	34.53	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	34.20	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	33.67	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	33.10	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	32.44	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	32.06	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	31.71	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	31.48	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	31.35	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	30.99	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	30.60	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	30.26	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	29.81	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	29.68	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	29.46	2 Yr 24 Hr	22.2	9,580	9,602.2	0.014
Big Muddy	29.36	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013

Two Year 24 Hr Rain Eventing Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	29.35	2 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	29.16	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	29.02	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	28.93	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	28.21	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	28.10	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	27.89	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	27.72	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	27.03	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	26.47	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	26.03	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	25.82	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	25.46	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	25.25	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	24.97	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	23.69	2 Yr 24 Hr	22.2	9,580	9,602.2	0.012
Big Muddy	23.44	2 Yr 24 Hr	22.2	9,580	9,602.2	0.013
Big Muddy	23.19	2 Yr 24 Hr	22.2	11,200	11,222.2	0.013
Big Muddy	23.14	2 Yr 24 Hr	22.2	11,200	11,222.2	0.012
Big Muddy	22.88	2 Yr 24 Hr	22.2	11,200	11,222.2	0.012
Big Muddy	22.66	2 Yr 24 Hr	22.2	11,200	11,222.2	0.012
Big Muddy	22.55	2 Yr 24 Hr	22.2	11,200	11,222.2	0.012
Big Muddy	22.23	2 Yr 24 Hr	22.2	11,200	11,222.2	0.012
Big Muddy	21.73	2 Yr 24 Hr	22.2	11,200	11,222.2	0.012
Big Muddy	21.38	2 Yr 24 Hr	22.2	11,200	11,222.2	0.012
Big Muddy	21.25	2 Yr 24 Hr	22.2	11,200	11,222.2	0.012
Big Muddy	21.23	2 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	2 Yr 24 Hr	22.2	11,200	11,222.2	0.011
Big Muddy	21.13	2 Yr 24 Hr	22.2	11,200	11,222.2	0.012
Big Muddy	20.90	2 Yr 24 Hr	22.2	11,200	11,222.2	0.012
Big Muddy	20.63	2 Yr 24 Hr	22.2	11,200	11,222.2	0.012
Big Muddy	20.40	2 Yr 24 Hr	22.2	11,200	11,222.2	0.011
Big Muddy	20.05	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	19.73	2 Yr 24 Hr	22.2	12,500	12,522.2	0.012
Big Muddy	19.41	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	19.29	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	19.28	2 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	19.25	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	19.24	2 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	2 Yr 24 Hr	22.2	12,500	12,522.2	0.012
Big Muddy	19.17	2 Yr 24 Hr	22.2	12,500	12,522.2	0.012
Big Muddy	18.64	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	18.37	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	18.04	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	17.67	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	17.52	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011

Two Year 24 Hr Rain Eventing Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	17.44	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	17.09	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	16.56	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	16.46	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	16.02	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	15.85	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	15.60	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	15.35	2 Yr 24 Hr	22.2	12,500	12,522.2	0.010
Big Muddy	15.06	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	14.90	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	14.64	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	14.42	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	14.25	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	14.03	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	13.81	2 Yr 24 Hr	22.2	12,500	12,522.2	0.010
Big Muddy	13.61	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	13.45	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	13.20	2 Yr 24 Hr	22.2	12,500	12,522.2	0.010
Big Muddy	12.94	2 Yr 24 Hr	22.2	12,500	12,522.2	0.010
Big Muddy	12.59	2 Yr 24 Hr	22.2	12,500	12,522.2	0.010
Big Muddy	12.34	2 Yr 24 Hr	22.2	12,500	12,522.2	0.011
Big Muddy	12.25	2 Yr 24 Hr	22.2	12,500	12,522.2	0.010
Big Muddy	11.99	2 Yr 24 Hr	22.2	12,500	12,522.2	0.010
Big Muddy	11.57	2 Yr 24 Hr	22.2	12,500	12,522.2	0.010
Big Muddy	11.32	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	11.02	2 Yr 24 Hr	22.2	15,900	15,922.2	0.011
Big Muddy	10.71	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	10.42	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	10.15	2 Yr 24 Hr	22.2	15,900	15,922.2	0.011
Big Muddy	9.93	2 Yr 24 Hr	22.2	15,900	15,922.2	0.011
Big Muddy	9.63	2 Yr 24 Hr	22.2	15,900	15,922.2	0.011
Big Muddy	9.42	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	9.24	2 Yr 24 Hr	22.2	15,900	15,922.2	0.011
Big Muddy	9.07	2 Yr 24 Hr	22.2	15,900	15,922.2	0.011
Big Muddy	8.83	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	8.60	2 Yr 24 Hr	22.2	15,900	15,922.2	0.011
Big Muddy	8.33	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	8.05	2 Yr 24 Hr	22.2	15,900	15,922.2	0.011
Big Muddy	7.90	2 Yr 24 Hr	22.2	15,900	15,922.2	0.011
Big Muddy	7.74	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	7.57	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	7.30	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	7.07	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	6.87	2 Yr 24 Hr	22.2	15,900	15,922.2	0.011
Big Muddy	6.59	2 Yr 24 Hr	22.2	15,900	15,922.2	0.011
Big Muddy	6.26	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	6.02	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	5.84	2 Yr 24 Hr	22.2	15,900	15,922.2	0.011

Two Year 24 Hr Rain Eventing Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	5.60	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	5.36	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	5.34	2 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	2 Yr 24 Hr	22.2	15,900	15,922.2	0.011
Big Muddy	5.33	2 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	5.13	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	4.77	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	4.76	2 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	4.22	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	3.96	2 Yr 24 Hr	22.2	15,900	15,922.2	0.009
Big Muddy	3.40	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	3.14	2 Yr 24 Hr	22.2	15,900	15,922.2	0.009
Big Muddy	3.08	2 Yr 24 Hr	22.2	15,900	15,922.2	0.009
Big Muddy	3.07	2 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	2 Yr 24 Hr	22.2	15,900	15,922.2	0.010
Big Muddy	2.92	2 Yr 24 Hr	22.2	15,900	15,922.2	0.009
Big Muddy	2.61	2 Yr 24 Hr	22.2	15,900	15,922.2	0.009
Big Muddy	2.47	2 Yr 24 Hr	22.2	15,900	15,922.2	0.009
Big Muddy	2.15	2 Yr 24 Hr	22.2	15,900	15,922.2	0.009
Big Muddy	1.99	2 Yr 24 Hr	22.2	15,900	15,922.2	0.009
Big Muddy	1.79	2 Yr 24 Hr	22.2	15,900	15,922.2	0.009
Big Muddy	1.58	2 Yr 24 Hr	22.2	15,900	15,922.2	0.009
Big Muddy	1.46	2 Yr 24 Hr	22.2	15,900	15,922.2	0.008
Big Muddy	1.17	2 Yr 24 Hr	22.2	15,900	15,922.2	0.008
Big Muddy	1.06	2 Yr 24 Hr	22.2	15,900	15,922.2	0.009
Big Muddy	0.94	2 Yr 24 Hr	22.2	15,900	15,922.2	0.008
Big Muddy	0.62	2 Yr 24 Hr	22.2	16,000	16,022.2	0.008
Big Muddy	0.48	2 Yr 24 Hr	22.2	16,000	16,022.2	0.009
Big Muddy	0.18	2 Yr 24 Hr	22.2	16,000	16,022.2	0.009
Big Muddy	0.00	2 Yr 24 Hr	22.2	16,000	16,022.2	0.009

Five Year 24 Hr Rain Eventing Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	5 Yr 24 Hr	0.0	13,200	13,200	0.010
Big Muddy	53.23	5 Yr 24 Hr	0.0	13,200	13,200	0.010
Big Muddy	53.04	5 Yr 24 Hr	0.0	13,200	13,200	0.010
Big Muddy	52.82	5 Yr 24 Hr	0.0	13,200	13,200	0.010
Big Muddy	52.56	5 Yr 24 Hr	0.0	13,200	13,200	0.010
Big Muddy	52.40	5 Yr 24 Hr	0.0	13,200	13,200	0.011
Big Muddy	52.04	5 Yr 24 Hr	0.0	13,200	13,200	0.011
Big Muddy	51.89	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	51.49	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	51.21	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	51.12	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	51.11	5 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	51.03	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	50.77	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	50.54	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	50.15	5 Yr 24 Hr	22.2	13,200	13,222.2	0.012
Big Muddy	49.86	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	49.62	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	49.45	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	49.28	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	48.95	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	48.55	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	48.04	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	47.59	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	47.27	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	46.90	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	46.84	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	46.54	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	46.17	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	46.16	5 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	46.11	5 Yr 24 Hr	22.2	13,200	13,222.2	0.011
Big Muddy	45.90	5 Yr 24 Hr	22.2	13,300	13,322.2	0.011
Big Muddy	45.78	5 Yr 24 Hr	22.2	13,300	13,322.2	0.012
Big Muddy	45.56	5 Yr 24 Hr	22.2	13,300	13,322.2	0.011
Big Muddy	45.34	5 Yr 24 Hr	22.2	13,300	13,322.2	0.011
Big Muddy	45.12	5 Yr 24 Hr	22.2	13,300	13,322.2	0.011
Big Muddy	44.91	5 Yr 24 Hr	22.2	13,300	13,322.2	0.012
Big Muddy	44.74	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	44.54	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	44.35	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	44.17	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	44.12	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	44.03	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	43.88	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	43.46	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	43.25	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011

Five Year 24 Hr Rain Eventing Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	43.08	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	42.87	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	42.39	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	42.19	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	41.86	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	41.66	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	41.44	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	41.12	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	40.75	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	40.41	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	40.11	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	39.80	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	39.55	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	39.44	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	39.27	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	39.02	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	38.80	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	38.48	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	38.21	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	38.04	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	37.88	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	37.53	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	37.29	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	36.90	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	36.79	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	36.35	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	36.19	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	36.01	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	35.90	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	35.61	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	35.15	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	34.92	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	34.53	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	34.20	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	33.67	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	33.10	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	32.44	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	32.06	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	31.71	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	31.48	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	31.35	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	30.99	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	30.60	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	30.26	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	29.81	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	29.68	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	29.46	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	29.36	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011

Five Year 24 Hr Rain Eventing Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	29.35	5 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	29.16	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	29.02	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	28.93	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	28.21	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	28.10	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	27.89	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	27.72	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	27.03	5 Yr 24 Hr	22.2	14,800	14,822.2	0.011
Big Muddy	26.47	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	26.03	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	25.82	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	25.46	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	25.25	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	24.97	5 Yr 24 Hr	22.2	14,800	14,822.2	0.009
Big Muddy	23.69	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	23.44	5 Yr 24 Hr	22.2	14,800	14,822.2	0.010
Big Muddy	23.19	5 Yr 24 Hr	22.2	17,100	17,122.2	0.010
Big Muddy	23.14	5 Yr 24 Hr	22.2	17,100	17,122.2	0.009
Big Muddy	22.88	5 Yr 24 Hr	22.2	17,100	17,122.2	0.009
Big Muddy	22.66	5 Yr 24 Hr	22.2	17,100	17,122.2	0.009
Big Muddy	22.55	5 Yr 24 Hr	22.2	17,100	17,122.2	0.009
Big Muddy	22.23	5 Yr 24 Hr	22.2	17,100	17,122.2	0.009
Big Muddy	21.73	5 Yr 24 Hr	22.2	17,100	17,122.2	0.010
Big Muddy	21.38	5 Yr 24 Hr	22.2	17,100	17,122.2	0.009
Big Muddy	21.25	5 Yr 24 Hr	22.2	17,100	17,122.2	0.009
Big Muddy	21.23	5 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	5 Yr 24 Hr	22.2	17,100	17,122.2	0.009
Big Muddy	21.13	5 Yr 24 Hr	22.2	17,100	17,122.2	0.009
Big Muddy	20.90	5 Yr 24 Hr	22.2	17,100	17,122.2	0.009
Big Muddy	20.63	5 Yr 24 Hr	22.2	17,100	17,122.2	0.009
Big Muddy	20.40	5 Yr 24 Hr	22.2	17,100	17,122.2	0.009
Big Muddy	20.05	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	19.73	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	19.41	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	19.29	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	19.28	5 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	19.25	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	19.24	5 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	19.17	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	18.64	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	18.37	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	18.04	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	17.67	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	17.52	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009

Five Year 24 Hr Rain Eventing Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	17.44	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	17.09	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	16.56	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	16.46	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	16.02	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	15.85	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	15.60	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	15.35	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	15.06	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	14.90	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	14.64	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	14.42	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	14.25	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	14.03	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	13.81	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	13.61	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	13.45	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	13.20	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	12.94	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	12.59	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	12.34	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	12.25	5 Yr 24 Hr	22.2	19,000	19,022.2	0.009
Big Muddy	11.99	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	11.57	5 Yr 24 Hr	22.2	19,000	19,022.2	0.008
Big Muddy	11.32	5 Yr 24 Hr	22.2	24,100	24,122.2	0.009
Big Muddy	11.02	5 Yr 24 Hr	22.2	24,100	24,122.2	0.009
Big Muddy	10.71	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	10.42	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	10.15	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	9.93	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	9.63	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	9.42	5 Yr 24 Hr	22.2	24,100	24,122.2	0.009
Big Muddy	9.24	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	9.07	5 Yr 24 Hr	22.2	24,100	24,122.2	0.009
Big Muddy	8.83	5 Yr 24 Hr	22.2	24,100	24,122.2	0.009
Big Muddy	8.60	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	8.33	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	8.05	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	7.90	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	7.74	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	7.57	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	7.30	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	7.07	5 Yr 24 Hr	22.2	24,100	24,122.2	0.009
Big Muddy	6.87	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	6.59	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	6.26	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	6.02	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	5.84	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008

Five Year 24 Hr Rain Eventing Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	5.60	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	5.36	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	5.34	5 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	5.33	5 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	5.13	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	4.77	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	4.76	5 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	5 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	4.22	5 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	3.96	5 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	3.40	5 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	3.14	5 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	3.08	5 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	3.07	5 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	5 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	2.92	5 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	2.61	5 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	2.47	5 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	2.15	5 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	1.99	5 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	1.79	5 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	1.58	5 Yr 24 Hr	22.2	24,100	24,122.2	0.006
Big Muddy	1.46	5 Yr 24 Hr	22.2	24,100	24,122.2	0.006
Big Muddy	1.17	5 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	1.06	5 Yr 24 Hr	22.2	24,100	24,122.2	0.006
Big Muddy	0.94	5 Yr 24 Hr	22.2	24,100	24,122.2	0.006
Big Muddy	0.62	5 Yr 24 Hr	22.2	24,200	24,222.2	0.007
Big Muddy	0.48	5 Yr 24 Hr	22.2	24,200	24,222.2	0.007
Big Muddy	0.18	5 Yr 24 Hr	22.2	24,200	24,222.2	0.006
Big Muddy	0.00	5 Yr 24 Hr	22.2	24,200	24,222.2	0.006

Ten Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	10 Yr 24 Hr	0.0	16,500	16,500	0.010
Big Muddy	53.23	10 Yr 24 Hr	0.0	16,500	16,500	0.010
Big Muddy	53.04	10 Yr 24 Hr	0.0	16,500	16,500	0.009
Big Muddy	52.82	10 Yr 24 Hr	0.0	16,500	16,500	0.010
Big Muddy	52.56	10 Yr 24 Hr	0.0	16,500	16,500	0.010
Big Muddy	52.40	10 Yr 24 Hr	0.0	16,500	16,500	0.010
Big Muddy	52.04	10 Yr 24 Hr	0.0	16,500	16,500	0.010
Big Muddy	51.89	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	51.49	10 Yr 24 Hr	22.2	16,500	16,522.2	0.011
Big Muddy	51.21	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	51.12	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	51.11	10 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	51.03	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	50.77	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	50.54	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	50.15	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	49.86	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	49.62	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	49.45	10 Yr 24 Hr	22.2	16,500	16,522.2	0.011
Big Muddy	49.28	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	48.95	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	48.55	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	48.04	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	47.59	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	47.27	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	46.90	10 Yr 24 Hr	22.2	16,500	16,522.2	0.011
Big Muddy	46.84	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	46.54	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	46.17	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	46.16	10 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	46.11	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	45.90	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	45.78	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	45.56	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	45.34	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	45.12	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	44.91	10 Yr 24 Hr	22.2	16,500	16,522.2	0.010
Big Muddy	44.74	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	44.54	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	44.35	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	44.17	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	44.12	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	44.03	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	43.88	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	43.46	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	43.25	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010

Ten Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	43.08	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	42.87	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	42.39	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	42.19	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	41.86	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	41.66	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	41.44	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	41.12	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	40.75	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	40.41	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	40.11	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	39.80	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	39.55	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	39.44	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	39.27	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	39.02	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	38.80	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	38.48	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	38.21	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	38.04	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	37.88	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	37.53	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	37.29	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	36.90	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	36.79	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	36.35	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	36.19	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	36.01	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	35.90	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	35.61	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	35.15	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	34.92	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	34.53	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	34.20	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	33.67	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	33.10	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	32.44	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	32.06	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	31.71	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	31.48	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	31.35	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	30.99	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	30.60	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	30.26	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	29.81	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	29.68	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	29.46	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	29.36	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010

Ten Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	29.35	10 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	29.16	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	29.02	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	28.93	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	28.21	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	28.10	10 Yr 24 Hr	22.2	18,400	18,422.2	0.011
Big Muddy	27.89	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	27.72	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	27.03	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	26.47	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	26.03	10 Yr 24 Hr	22.2	18,400	18,422.2	0.009
Big Muddy	25.82	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	25.46	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	25.25	10 Yr 24 Hr	22.2	18,400	18,422.2	0.009
Big Muddy	24.97	10 Yr 24 Hr	22.2	18,400	18,422.2	0.010
Big Muddy	23.69	10 Yr 24 Hr	22.2	18,400	18,422.2	0.008
Big Muddy	23.44	10 Yr 24 Hr	22.2	18,400	18,422.2	0.008
Big Muddy	23.19	10 Yr 24 Hr	22.2	21,200	21,222.2	0.008
Big Muddy	23.14	10 Yr 24 Hr	22.2	21,200	21,222.2	0.009
Big Muddy	22.88	10 Yr 24 Hr	22.2	21,200	21,222.2	0.009
Big Muddy	22.66	10 Yr 24 Hr	22.2	21,200	21,222.2	0.009
Big Muddy	22.55	10 Yr 24 Hr	22.2	21,200	21,222.2	0.009
Big Muddy	22.23	10 Yr 24 Hr	22.2	21,200	21,222.2	0.009
Big Muddy	21.73	10 Yr 24 Hr	22.2	21,200	21,222.2	0.008
Big Muddy	21.38	10 Yr 24 Hr	22.2	21,200	21,222.2	0.008
Big Muddy	21.25	10 Yr 24 Hr	22.2	21,200	21,222.2	0.008
Big Muddy	21.23	10 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	10 Yr 24 Hr	22.2	21,200	21,222.2	0.009
Big Muddy	21.13	10 Yr 24 Hr	22.2	21,200	21,222.2	0.008
Big Muddy	20.90	10 Yr 24 Hr	22.2	21,200	21,222.2	0.008
Big Muddy	20.63	10 Yr 24 Hr	22.2	21,200	21,222.2	0.008
Big Muddy	20.40	10 Yr 24 Hr	22.2	21,200	21,222.2	0.008
Big Muddy	20.05	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	19.73	10 Yr 24 Hr	22.2	23,500	23,522.2	0.009
Big Muddy	19.41	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	19.29	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	19.28	10 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	19.25	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	19.24	10 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	19.17	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	18.64	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	18.37	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	18.04	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	17.67	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	17.52	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008

Ten Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	17.44	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	17.09	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	16.56	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	16.46	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	16.02	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	15.85	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	15.60	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	15.35	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	15.06	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	14.90	10 Yr 24 Hr	22.2	23,500	23,522.2	0.007
Big Muddy	14.64	10 Yr 24 Hr	22.2	23,500	23,522.2	0.007
Big Muddy	14.42	10 Yr 24 Hr	22.2	23,500	23,522.2	0.007
Big Muddy	14.25	10 Yr 24 Hr	22.2	23,500	23,522.2	0.007
Big Muddy	14.03	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	13.81	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	13.61	10 Yr 24 Hr	22.2	23,500	23,522.2	0.007
Big Muddy	13.45	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	13.20	10 Yr 24 Hr	22.2	23,500	23,522.2	0.007
Big Muddy	12.94	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	12.59	10 Yr 24 Hr	22.2	23,500	23,522.2	0.007
Big Muddy	12.34	10 Yr 24 Hr	22.2	23,500	23,522.2	0.007
Big Muddy	12.25	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	11.99	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	11.57	10 Yr 24 Hr	22.2	23,500	23,522.2	0.008
Big Muddy	11.32	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	11.02	10 Yr 24 Hr	22.2	29,800	29,822.2	0.008
Big Muddy	10.71	10 Yr 24 Hr	22.2	29,800	29,822.2	0.008
Big Muddy	10.42	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	10.15	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	9.93	10 Yr 24 Hr	22.2	29,800	29,822.2	0.008
Big Muddy	9.63	10 Yr 24 Hr	22.2	29,800	29,822.2	0.008
Big Muddy	9.42	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	9.24	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	9.07	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	8.83	10 Yr 24 Hr	22.2	29,800	29,822.2	0.008
Big Muddy	8.60	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	8.33	10 Yr 24 Hr	22.2	29,800	29,822.2	0.008
Big Muddy	8.05	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	7.90	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	7.74	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	7.57	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	7.30	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	7.07	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	6.87	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	6.59	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	6.26	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	6.02	10 Yr 24 Hr	22.2	29,800	29,822.2	0.008
Big Muddy	5.84	10 Yr 24 Hr	22.2	29,800	29,822.2	0.008

Ten Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	5.60	10 Yr 24 Hr	22.2	29,800	29,822.2	0.008
Big Muddy	5.36	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	5.34	10 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	5.33	10 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	5.13	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	4.77	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	4.76	10 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	4.22	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	3.96	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	3.40	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	3.14	10 Yr 24 Hr	22.2	29,800	29,822.2	0.007
Big Muddy	3.08	10 Yr 24 Hr	22.2	29,800	29,822.2	0.006
Big Muddy	3.07	10 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	10 Yr 24 Hr	22.2	29,800	29,822.2	0.006
Big Muddy	2.92	10 Yr 24 Hr	22.2	29,800	29,822.2	0.006
Big Muddy	2.61	10 Yr 24 Hr	22.2	29,800	29,822.2	0.006
Big Muddy	2.47	10 Yr 24 Hr	22.2	29,800	29,822.2	0.006
Big Muddy	2.15	10 Yr 24 Hr	22.2	29,800	29,822.2	0.006
Big Muddy	1.99	10 Yr 24 Hr	22.2	29,800	29,822.2	0.006
Big Muddy	1.79	10 Yr 24 Hr	22.2	29,800	29,822.2	0.006
Big Muddy	1.58	10 Yr 24 Hr	22.2	29,800	29,822.2	0.006
Big Muddy	1.46	10 Yr 24 Hr	22.2	29,800	29,822.2	0.005
Big Muddy	1.17	10 Yr 24 Hr	22.2	29,800	29,822.2	0.006
Big Muddy	1.06	10 Yr 24 Hr	22.2	29,800	29,822.2	0.006
Big Muddy	0.94	10 Yr 24 Hr	22.2	29,800	29,822.2	0.006
Big Muddy	0.62	10 Yr 24 Hr	22.2	29,900	29,922.2	0.006
Big Muddy	0.48	10 Yr 24 Hr	22.2	29,900	29,922.2	0.006
Big Muddy	0.18	10 Yr 24 Hr	22.2	29,900	29,922.2	0.006
Big Muddy	0.00	10 Yr 24 Hr	22.2	29,900	29,922.2	0.005

Twenty Five Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	25 Yr 24 Hr	0.0	20,700	20,700	0.007
Big Muddy	53.23	25 Yr 24 Hr	0.0	20,700	20,700	0.007
Big Muddy	53.04	25 Yr 24 Hr	0.0	20,700	20,700	0.007
Big Muddy	52.82	25 Yr 24 Hr	0.0	20,700	20,700	0.007
Big Muddy	52.56	25 Yr 24 Hr	0.0	20,700	20,700	0.007
Big Muddy	52.40	25 Yr 24 Hr	0.0	20,700	20,700	0.007
Big Muddy	52.04	25 Yr 24 Hr	0.0	20,700	20,700	0.008
Big Muddy	51.89	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	51.49	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	51.21	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	51.12	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	51.11	25 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	51.03	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	50.77	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	50.54	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	50.15	25 Yr 24 Hr	22.2	20,700	20,722.2	0.008
Big Muddy	49.86	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	49.62	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	49.45	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	49.28	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	48.95	25 Yr 24 Hr	22.2	20,700	20,722.2	0.008
Big Muddy	48.55	25 Yr 24 Hr	22.2	20,700	20,722.2	0.008
Big Muddy	48.04	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	47.59	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	47.27	25 Yr 24 Hr	22.2	20,700	20,722.2	0.008
Big Muddy	46.90	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	46.84	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	46.54	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	46.17	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	46.16	25 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	25 Yr 24 Hr	22.2	20,700	20,722.2	0.008
Big Muddy	46.11	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	45.90	25 Yr 24 Hr	22.2	20,700	20,722.2	0.008
Big Muddy	45.78	25 Yr 24 Hr	22.2	20,700	20,722.2	0.008
Big Muddy	45.56	25 Yr 24 Hr	22.2	20,700	20,722.2	0.008
Big Muddy	45.34	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	45.12	25 Yr 24 Hr	22.2	20,700	20,722.2	0.008
Big Muddy	44.91	25 Yr 24 Hr	22.2	20,700	20,722.2	0.007
Big Muddy	44.74	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	44.54	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	44.35	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	44.17	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	44.12	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	44.03	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	43.88	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	43.46	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	43.25	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007

Twenty Five Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	43.08	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	42.87	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	42.39	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	42.19	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	41.86	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	41.66	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	41.44	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	41.12	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	40.75	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	40.41	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	40.11	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	39.80	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	39.55	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	39.44	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	39.27	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	39.02	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	38.80	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	38.48	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	38.21	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	38.04	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	37.88	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	37.53	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	37.29	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	36.90	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	36.79	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	36.35	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	36.19	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	36.01	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	35.90	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	35.61	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	35.15	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	34.92	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	34.53	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	34.20	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	33.67	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	33.10	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	32.44	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	32.06	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	31.71	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	31.48	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	31.35	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	30.99	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	30.60	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	30.26	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	29.81	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	29.68	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	29.46	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	29.36	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007

Twenty Five Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	29.35	25 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	29.16	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	29.02	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	28.93	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	28.21	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	28.10	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	27.89	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	27.72	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	27.03	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	26.47	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	26.03	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	25.82	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	25.46	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	25.25	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	24.97	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	23.69	25 Yr 24 Hr	22.2	23,100	23,122.2	0.007
Big Muddy	23.44	25 Yr 24 Hr	22.2	23,100	23,122.2	0.008
Big Muddy	23.19	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	23.14	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	22.88	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	22.66	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	22.55	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	22.23	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	21.73	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	21.38	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	21.25	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	21.23	25 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	21.13	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	20.90	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	20.63	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	20.40	25 Yr 24 Hr	22.2	26,400	26,422.2	0.007
Big Muddy	20.05	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	19.73	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	19.41	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	19.29	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	19.28	25 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	19.25	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	19.24	25 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	19.17	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	18.64	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	18.37	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	18.04	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	17.67	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	17.52	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006

Twenty Five Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	17.44	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	17.09	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	16.56	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	16.46	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	16.02	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	15.85	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	15.60	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	15.35	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	15.06	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	14.90	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	14.64	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	14.42	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	14.25	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	14.03	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	13.81	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	13.61	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	13.45	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	13.20	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	12.94	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	12.59	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	12.34	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	12.25	25 Yr 24 Hr	22.2	29,200	29,222.2	0.007
Big Muddy	11.99	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	11.57	25 Yr 24 Hr	22.2	29,200	29,222.2	0.006
Big Muddy	11.32	25 Yr 24 Hr	22.2	37,000	37,022.2	0.007
Big Muddy	11.02	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	10.71	25 Yr 24 Hr	22.2	37,000	37,022.2	0.007
Big Muddy	10.42	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	10.15	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	9.93	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	9.63	25 Yr 24 Hr	22.2	37,000	37,022.2	0.007
Big Muddy	9.42	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	9.24	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	9.07	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	8.83	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	8.60	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	8.33	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	8.05	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	7.90	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	7.74	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	7.57	25 Yr 24 Hr	22.2	37,000	37,022.2	0.007
Big Muddy	7.30	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	7.07	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	6.87	25 Yr 24 Hr	22.2	37,000	37,022.2	0.007
Big Muddy	6.59	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	6.26	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	6.02	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	5.84	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006

Twenty Five Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	5.60	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	5.36	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	5.34	25 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	5.33	25 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	25 Yr 24 Hr	22.2	37,000	37,022.2	0.005
Big Muddy	5.13	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	4.77	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	4.76	25 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	4.22	25 Yr 24 Hr	22.2	37,000	37,022.2	0.005
Big Muddy	3.96	25 Yr 24 Hr	22.2	37,000	37,022.2	0.005
Big Muddy	3.40	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	3.14	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	3.08	25 Yr 24 Hr	22.2	37,000	37,022.2	0.005
Big Muddy	3.07	25 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	2.92	25 Yr 24 Hr	22.2	37,000	37,022.2	0.005
Big Muddy	2.61	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	2.47	25 Yr 24 Hr	22.2	37,000	37,022.2	0.005
Big Muddy	2.15	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	1.99	25 Yr 24 Hr	22.2	37,000	37,022.2	0.006
Big Muddy	1.79	25 Yr 24 Hr	22.2	37,000	37,022.2	0.005
Big Muddy	1.58	25 Yr 24 Hr	22.2	37,000	37,022.2	0.005
Big Muddy	1.46	25 Yr 24 Hr	22.2	37,000	37,022.2	0.005
Big Muddy	1.17	25 Yr 24 Hr	22.2	37,000	37,022.2	0.005
Big Muddy	1.06	25 Yr 24 Hr	22.2	37,000	37,022.2	0.005
Big Muddy	0.94	25 Yr 24 Hr	22.2	37,000	37,022.2	0.005
Big Muddy	0.62	25 Yr 24 Hr	22.2	37,100	37,122.2	0.005
Big Muddy	0.48	25 Yr 24 Hr	22.2	37,100	37,122.2	0.006
Big Muddy	0.18	25 Yr 24 Hr	22.2	37,100	37,122.2	0.005
Big Muddy	0.00	25 Yr 24 Hr	22.2	37,100	37,122.2	0.006

Fifty Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	50 Yr 24 Hr	0.0	24,100	24,100	0.005
Big Muddy	53.23	50 Yr 24 Hr	0.0	24,100	24,100	0.004
Big Muddy	53.04	50 Yr 24 Hr	0.0	24,100	24,100	0.005
Big Muddy	52.82	50 Yr 24 Hr	0.0	24,100	24,100	0.005
Big Muddy	52.56	50 Yr 24 Hr	0.0	24,100	24,100	0.005
Big Muddy	52.40	50 Yr 24 Hr	0.0	24,100	24,100	0.005
Big Muddy	52.04	50 Yr 24 Hr	0.0	24,100	24,100	0.006
Big Muddy	51.89	50 Yr 24 Hr	22.2	24,100	24,122.2	0.005
Big Muddy	51.49	50 Yr 24 Hr	22.2	24,100	24,122.2	0.005
Big Muddy	51.21	50 Yr 24 Hr	22.2	24,100	24,122.2	0.005
Big Muddy	51.12	50 Yr 24 Hr	22.2	24,100	24,122.2	0.005
Big Muddy	51.11	50 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	50 Yr 24 Hr	22.2	24,100	24,122.2	0.005
Big Muddy	51.03	50 Yr 24 Hr	22.2	24,100	24,122.2	0.005
Big Muddy	50.77	50 Yr 24 Hr	22.2	24,100	24,122.2	0.005
Big Muddy	50.54	50 Yr 24 Hr	22.2	24,100	24,122.2	0.005
Big Muddy	50.15	50 Yr 24 Hr	22.2	24,100	24,122.2	0.005
Big Muddy	49.86	50 Yr 24 Hr	22.2	24,100	24,122.2	0.005
Big Muddy	49.62	50 Yr 24 Hr	22.2	24,100	24,122.2	0.005
Big Muddy	49.45	50 Yr 24 Hr	22.2	24,100	24,122.2	0.009
Big Muddy	49.28	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	48.95	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	48.55	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	48.04	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	47.59	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	47.27	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	46.90	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	46.84	50 Yr 24 Hr	22.2	24,100	24,122.2	0.008
Big Muddy	46.54	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	46.17	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	46.16	50 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	46.11	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	45.90	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	45.78	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	45.56	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	45.34	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	45.12	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	44.91	50 Yr 24 Hr	22.2	24,100	24,122.2	0.007
Big Muddy	44.74	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	44.54	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	44.35	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	44.17	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	44.12	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	44.03	50 Yr 24 Hr	22.2	26,800	26,822.2	0.008
Big Muddy	43.88	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	43.46	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	43.25	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007

Fifty Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	43.08	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	42.87	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	42.39	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	42.19	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	41.86	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	41.66	50 Yr 24 Hr	22.2	26,800	26,822.2	0.008
Big Muddy	41.44	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	41.12	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	40.75	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	40.41	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	40.11	50 Yr 24 Hr	22.2	26,800	26,822.2	0.008
Big Muddy	39.80	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	39.55	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	39.44	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	39.27	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	39.02	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	38.80	50 Yr 24 Hr	22.2	26,800	26,822.2	0.008
Big Muddy	38.48	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	38.21	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	38.04	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	37.88	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	37.53	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	37.29	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	36.90	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	36.79	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	36.35	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	36.19	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	36.01	50 Yr 24 Hr	22.2	26,800	26,822.2	0.008
Big Muddy	35.90	50 Yr 24 Hr	22.2	26,800	26,822.2	0.008
Big Muddy	35.61	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	35.15	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	34.92	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	34.53	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	34.20	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	33.67	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	33.10	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	32.44	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	32.06	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	31.71	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	31.48	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	31.35	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	30.99	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	30.60	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	30.26	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	29.81	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	29.68	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	29.46	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	29.36	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007

Fifty Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	29.35	50 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	29.16	50 Yr 24 Hr	22.2	26,800	26,822.2	0.006
Big Muddy	29.02	50 Yr 24 Hr	22.2	26,800	26,822.2	0.006
Big Muddy	28.93	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	28.21	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	28.10	50 Yr 24 Hr	22.2	26,800	26,822.2	0.006
Big Muddy	27.89	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	27.72	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	27.03	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	26.47	50 Yr 24 Hr	22.2	26,800	26,822.2	0.006
Big Muddy	26.03	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	25.82	50 Yr 24 Hr	22.2	26,800	26,822.2	0.006
Big Muddy	25.46	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	25.25	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	24.97	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	23.69	50 Yr 24 Hr	22.2	26,800	26,822.2	0.007
Big Muddy	23.44	50 Yr 24 Hr	22.2	26,800	26,822.2	0.006
Big Muddy	23.19	50 Yr 24 Hr	22.2	30,500	30,522.2	0.006
Big Muddy	23.14	50 Yr 24 Hr	22.2	30,500	30,522.2	0.007
Big Muddy	22.88	50 Yr 24 Hr	22.2	30,500	30,522.2	0.007
Big Muddy	22.66	50 Yr 24 Hr	22.2	30,500	30,522.2	0.006
Big Muddy	22.55	50 Yr 24 Hr	22.2	30,500	30,522.2	0.006
Big Muddy	22.23	50 Yr 24 Hr	22.2	30,500	30,522.2	0.006
Big Muddy	21.73	50 Yr 24 Hr	22.2	30,500	30,522.2	0.006
Big Muddy	21.38	50 Yr 24 Hr	22.2	30,500	30,522.2	0.006
Big Muddy	21.25	50 Yr 24 Hr	22.2	30,500	30,522.2	0.006
Big Muddy	21.23	50 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	50 Yr 24 Hr	22.2	30,500	30,522.2	0.006
Big Muddy	21.13	50 Yr 24 Hr	22.2	30,500	30,522.2	0.006
Big Muddy	20.90	50 Yr 24 Hr	22.2	30,500	30,522.2	0.006
Big Muddy	20.63	50 Yr 24 Hr	22.2	30,500	30,522.2	0.006
Big Muddy	20.40	50 Yr 24 Hr	22.2	30,500	30,522.2	0.006
Big Muddy	20.05	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	19.73	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	19.41	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	19.29	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	19.28	50 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	19.25	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	19.24	50 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	19.17	50 Yr 24 Hr	22.2	33,700	33,722.2	0.007
Big Muddy	18.64	50 Yr 24 Hr	22.2	33,700	33,722.2	0.007
Big Muddy	18.37	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	18.04	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	17.67	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	17.52	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006

Fifty Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	17.44	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	17.09	50 Yr 24 Hr	22.2	33,700	33,722.2	0.005
Big Muddy	16.56	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	16.46	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	16.02	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	15.85	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	15.60	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	15.35	50 Yr 24 Hr	22.2	33,700	33,722.2	0.005
Big Muddy	15.06	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	14.90	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	14.64	50 Yr 24 Hr	22.2	33,700	33,722.2	0.005
Big Muddy	14.42	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	14.25	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	14.03	50 Yr 24 Hr	22.2	33,700	33,722.2	0.005
Big Muddy	13.81	50 Yr 24 Hr	22.2	33,700	33,722.2	0.005
Big Muddy	13.61	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	13.45	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	13.20	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	12.94	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	12.59	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	12.34	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	12.25	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	11.99	50 Yr 24 Hr	22.2	33,700	33,722.2	0.006
Big Muddy	11.57	50 Yr 24 Hr	22.2	33,700	33,722.2	0.005
Big Muddy	11.32	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	11.02	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	10.71	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	10.42	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	10.15	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	9.93	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	9.63	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	9.42	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	9.24	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	9.07	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	8.83	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	8.60	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	8.33	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	8.05	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	7.90	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	7.74	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	7.57	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	7.30	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	7.07	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	6.87	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	6.59	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	6.26	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	6.02	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	5.84	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006

Fifty Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	5.60	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	5.36	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	5.34	50 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	5.33	50 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	5.13	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	4.77	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	4.76	50 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	4.22	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	3.96	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	3.40	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	3.14	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	3.08	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	3.07	50 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	2.92	50 Yr 24 Hr	22.2	42,700	42,722.2	0.006
Big Muddy	2.61	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	2.47	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	2.15	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	1.99	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	1.79	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	1.58	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	1.46	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	1.17	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	1.06	50 Yr 24 Hr	22.2	42,700	42,722.2	0.005
Big Muddy	0.94	50 Yr 24 Hr	22.2	42,700	42,722.2	0.004
Big Muddy	0.62	50 Yr 24 Hr	22.2	42,800	42,822.2	0.005
Big Muddy	0.48	50 Yr 24 Hr	22.2	42,800	42,822.2	0.004
Big Muddy	0.18	50 Yr 24 Hr	22.2	42,800	42,822.2	0.005
Big Muddy	0.00	50 Yr 24 Hr	22.2	42,800	42,822.2	0.004

One Hundred Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	100 Yr 24 Hr	0.0	27,200	27,200	0.006
Big Muddy	53.23	100 Yr 24 Hr	0.0	27,200	27,200	0.007
Big Muddy	53.04	100 Yr 24 Hr	0.0	27,200	27,200	0.006
Big Muddy	52.82	100 Yr 24 Hr	0.0	27,200	27,200	0.007
Big Muddy	52.56	100 Yr 24 Hr	0.0	27,200	27,200	0.006
Big Muddy	52.40	100 Yr 24 Hr	0.0	27,200	27,200	0.007
Big Muddy	52.04	100 Yr 24 Hr	0.0	27,200	27,200	0.006
Big Muddy	51.89	100 Yr 24 Hr	22.2	27,200	27,222.2	0.006
Big Muddy	51.49	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	51.21	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	51.12	100 Yr 24 Hr	22.2	27,200	27,222.2	0.006
Big Muddy	51.11	100 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	51.03	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	50.77	100 Yr 24 Hr	22.2	27,200	27,222.2	0.006
Big Muddy	50.54	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	50.15	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	49.86	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	49.62	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	49.45	100 Yr 24 Hr	22.2	27,200	27,222.2	0.006
Big Muddy	49.28	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	48.95	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	48.55	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	48.04	100 Yr 24 Hr	22.2	27,200	27,222.2	0.006
Big Muddy	47.59	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	47.27	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	46.90	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	46.84	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	46.54	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	46.17	100 Yr 24 Hr	22.2	27,200	27,222.2	0.006
Big Muddy	46.16	100 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	46.11	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	45.90	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	45.78	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	45.56	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	45.34	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	45.12	100 Yr 24 Hr	22.2	27,200	27,222.2	0.006
Big Muddy	44.91	100 Yr 24 Hr	22.2	27,200	27,222.2	0.007
Big Muddy	44.74	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	44.54	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	44.35	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	44.17	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	44.12	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	44.03	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	43.88	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	43.46	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	43.25	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007

One Hundred Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	43.08	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	42.87	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	42.39	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	42.19	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	41.86	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	41.66	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	41.44	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	41.12	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	40.75	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	40.41	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	40.11	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	39.80	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	39.55	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	39.44	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	39.27	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	39.02	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	38.80	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	38.48	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	38.21	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	38.04	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	37.88	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	37.53	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	37.29	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	36.90	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	36.79	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	36.35	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	36.19	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	36.01	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	35.90	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	35.61	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	35.15	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	34.92	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	34.53	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	34.20	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	33.67	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	33.10	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	32.44	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	32.06	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	31.71	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	31.48	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	31.35	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	30.99	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	30.60	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	30.26	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	29.81	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	29.68	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	29.46	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	29.36	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007

One Hundred Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	29.35	100 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	29.16	100 Yr 24 Hr	22.2	30,300	30,322.2	0.007
Big Muddy	29.02	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	28.93	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	28.21	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	28.10	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	27.89	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	27.72	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	27.03	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	26.47	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	26.03	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	25.82	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	25.46	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	25.25	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	24.97	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	23.69	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	23.44	100 Yr 24 Hr	22.2	30,300	30,322.2	0.006
Big Muddy	23.19	100 Yr 24 Hr	22.2	34,400	34,422.2	0.006
Big Muddy	23.14	100 Yr 24 Hr	22.2	34,400	34,422.2	0.006
Big Muddy	22.88	100 Yr 24 Hr	22.2	34,400	34,422.2	0.006
Big Muddy	22.66	100 Yr 24 Hr	22.2	34,400	34,422.2	0.006
Big Muddy	22.55	100 Yr 24 Hr	22.2	34,400	34,422.2	0.006
Big Muddy	22.23	100 Yr 24 Hr	22.2	34,400	34,422.2	0.006
Big Muddy	21.73	100 Yr 24 Hr	22.2	34,400	34,422.2	0.006
Big Muddy	21.38	100 Yr 24 Hr	22.2	34,400	34,422.2	0.006
Big Muddy	21.25	100 Yr 24 Hr	22.2	34,400	34,422.2	0.006
Big Muddy	21.23	100 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	100 Yr 24 Hr	22.2	34,400	34,422.2	0.005
Big Muddy	21.13	100 Yr 24 Hr	22.2	34,400	34,422.2	0.006
Big Muddy	20.90	100 Yr 24 Hr	22.2	34,400	34,422.2	0.005
Big Muddy	20.63	100 Yr 24 Hr	22.2	34,400	34,422.2	0.006
Big Muddy	20.40	100 Yr 24 Hr	22.2	34,400	34,422.2	0.006
Big Muddy	20.05	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	19.73	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	19.41	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	19.29	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	19.28	100 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	19.25	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	19.24	100 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	19.17	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	18.64	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	18.37	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	18.04	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	17.67	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	17.52	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006

One Hundred Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	17.44	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	17.09	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	16.56	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	16.46	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	16.02	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	15.85	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	15.60	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	15.35	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	15.06	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	14.90	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	14.64	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	14.42	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	14.25	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	14.03	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	13.81	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	13.61	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	13.45	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	13.20	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	12.94	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	12.59	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	12.34	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	12.25	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	11.99	100 Yr 24 Hr	22.2	38,000	38,022.2	0.006
Big Muddy	11.57	100 Yr 24 Hr	22.2	38,000	38,022.2	0.005
Big Muddy	11.32	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	11.02	100 Yr 24 Hr	22.2	48,100	48,122.2	0.006
Big Muddy	10.71	100 Yr 24 Hr	22.2	48,100	48,122.2	0.006
Big Muddy	10.42	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	10.15	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	9.93	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	9.63	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	9.42	100 Yr 24 Hr	22.2	48,100	48,122.2	0.006
Big Muddy	9.24	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	9.07	100 Yr 24 Hr	22.2	48,100	48,122.2	0.006
Big Muddy	8.83	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	8.60	100 Yr 24 Hr	22.2	48,100	48,122.2	0.006
Big Muddy	8.33	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	8.05	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	7.90	100 Yr 24 Hr	22.2	48,100	48,122.2	0.006
Big Muddy	7.74	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	7.57	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	7.30	100 Yr 24 Hr	22.2	48,100	48,122.2	0.006
Big Muddy	7.07	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	6.87	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	6.59	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	6.26	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	6.02	100 Yr 24 Hr	22.2	48,100	48,122.2	0.006
Big Muddy	5.84	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005

One Hundred Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	5.60	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	5.36	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	5.34	100 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	5.33	100 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	5.13	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	4.77	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	4.76	100 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	4.22	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	3.96	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	3.40	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	3.14	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	3.08	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	3.07	100 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	2.92	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	2.61	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	2.47	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	2.15	100 Yr 24 Hr	22.2	48,100	48,122.2	0.004
Big Muddy	1.99	100 Yr 24 Hr	22.2	48,100	48,122.2	0.004
Big Muddy	1.79	100 Yr 24 Hr	22.2	48,100	48,122.2	0.004
Big Muddy	1.58	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	1.46	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	1.17	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	1.06	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	0.94	100 Yr 24 Hr	22.2	48,100	48,122.2	0.005
Big Muddy	0.62	100 Yr 24 Hr	22.2	48,200	48,222.2	0.004
Big Muddy	0.48	100 Yr 24 Hr	22.2	48,200	48,222.2	0.004
Big Muddy	0.18	100 Yr 24 Hr	22.2	48,200	48,222.2	0.004
Big Muddy	0.00	100 Yr 24 Hr	22.2	48,200	48,222.2	0.005

Five Hundred Year 24 Hr Rain Event Williamson and Sugar Camp

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	53.44	500 Yr 24 Hr	0.0	35,200	35,200	0.005
Big Muddy	53.23	500 Yr 24 Hr	0.0	35,200	35,200	0.005
Big Muddy	53.04	500 Yr 24 Hr	0.0	35,200	35,200	0.005
Big Muddy	52.82	500 Yr 24 Hr	0.0	35,200	35,200	0.006
Big Muddy	52.56	500 Yr 24 Hr	0.0	35,200	35,200	0.005
Big Muddy	52.40	500 Yr 24 Hr	0.0	35,200	35,200	0.006
Big Muddy	52.04	500 Yr 24 Hr	0.0	35,200	35,200	0.005
Big Muddy	51.89	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	51.49	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	51.21	500 Yr 24 Hr	22.2	35,200	35,222.2	0.006
Big Muddy	51.12	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	51.11	500 Yr 24 Hr	Railroad Bridge			
Big Muddy	51.09	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	51.03	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	50.77	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	50.54	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	50.15	500 Yr 24 Hr	22.2	35,200	35,222.2	0.006
Big Muddy	49.86	500 Yr 24 Hr	22.2	35,200	35,222.2	0.006
Big Muddy	49.62	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	49.45	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	49.28	500 Yr 24 Hr	22.2	35,200	35,222.2	0.006
Big Muddy	48.95	500 Yr 24 Hr	22.2	35,200	35,222.2	0.006
Big Muddy	48.55	500 Yr 24 Hr	22.2	35,200	35,222.2	0.006
Big Muddy	48.04	500 Yr 24 Hr	22.2	35,200	35,222.2	0.006
Big Muddy	47.59	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	47.27	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	46.90	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	46.84	500 Yr 24 Hr	22.2	35,200	35,222.2	0.006
Big Muddy	46.54	500 Yr 24 Hr	22.2	35,200	35,222.2	0.006
Big Muddy	46.17	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	46.16	500 Yr 24 Hr	Route 148 Bridge			
Big Muddy	46.14	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	46.11	500 Yr 24 Hr	22.2	35,200	35,222.2	0.005
Big Muddy	45.90	500 Yr 24 Hr	22.2	35,300	35,322.2	0.006
Big Muddy	45.78	500 Yr 24 Hr	22.2	35,300	35,322.2	0.005
Big Muddy	45.56	500 Yr 24 Hr	22.2	35,300	35,322.2	0.006
Big Muddy	45.34	500 Yr 24 Hr	22.2	35,300	35,322.2	0.006
Big Muddy	45.12	500 Yr 24 Hr	22.2	35,300	35,322.2	0.005
Big Muddy	44.91	500 Yr 24 Hr	22.2	35,300	35,322.2	0.005
Big Muddy	44.74	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	44.54	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	44.35	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	44.17	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	44.12	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	44.03	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	43.88	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005

Five Hundred Year 24 Hr Rain Event Williamson and Sugar Camp

Big Muddy	43.46	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	43.25	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	43.08	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	42.87	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	42.39	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	42.19	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	41.86	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	41.66	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	41.44	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	41.12	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	40.75	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	40.41	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	40.11	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	39.80	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	39.55	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	39.44	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	39.27	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	39.02	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	38.80	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	38.48	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	38.21	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	38.04	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	37.88	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	37.53	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	37.29	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	36.90	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	36.79	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	36.35	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	36.19	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	36.01	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	35.90	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	35.61	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	35.15	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	34.92	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	34.53	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	34.20	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	33.67	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	33.10	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	32.44	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	32.06	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	31.71	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	31.48	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	31.35	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	30.99	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	30.60	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	30.26	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	29.81	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	29.68	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005

Five Hundred Year 24 Hr Rain Event Williamson and Sugar Camp

Big Muddy	29.46	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	29.36	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	29.35	500 Yr 24 Hr	Route 9/Route 184 Bridge			
Big Muddy	29.35	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	29.16	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	29.02	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	28.93	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	28.21	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	28.10	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	27.89	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	27.72	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	27.03	500 Yr 24 Hr	22.2	39,200	39,222.2	0.006
Big Muddy	26.47	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	26.03	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	25.82	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	25.46	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	25.25	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	24.97	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	23.69	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	23.44	500 Yr 24 Hr	22.2	39,200	39,222.2	0.005
Big Muddy	23.19	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	23.14	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	22.88	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	22.66	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	22.55	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	22.23	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	21.73	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	21.38	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	21.25	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	21.23	500 Yr 24 Hr	North Reed Station Road Bridge			
Big Muddy	21.22	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	21.13	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	20.90	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	20.63	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	20.40	500 Yr 24 Hr	22.2	44,200	44,222.2	0.005
Big Muddy	20.05	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	19.73	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	19.41	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	19.29	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	19.28	500 Yr 24 Hr	Railroad Bridge			
Big Muddy	19.26	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	19.25	500 Yr 24 Hr	22.2	48,700	48,722.2	0.004
Big Muddy	19.24	500 Yr 24 Hr	Route 51 Bridge			
Big Muddy	19.22	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	19.17	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	18.64	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	18.37	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	18.04	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005

Five Hundred Year 24 Hr Rain Event Williamson and Sugar Camp

Big Muddy	17.67	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	17.52	500 Yr 24 Hr	22.2	48,700	48,722.2	0.004
Big Muddy	17.44	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	17.09	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	16.56	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	16.46	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	16.02	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	15.85	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	15.60	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	15.35	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	15.06	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	14.90	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	14.64	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	14.42	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	14.25	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	14.03	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	13.81	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	13.61	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	13.45	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	13.20	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	12.94	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	12.59	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	12.34	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	12.25	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	11.99	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	11.57	500 Yr 24 Hr	22.2	48,700	48,722.2	0.005
Big Muddy	11.32	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	11.02	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	10.71	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	10.42	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	10.15	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	9.93	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	9.63	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	9.42	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	9.24	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	9.07	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	8.83	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	8.60	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	8.33	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	8.05	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	7.90	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	7.74	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	7.57	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	7.30	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	7.07	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	6.87	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	6.59	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	6.26	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004

Five Hundred Year 24 Hr Rain Event Williamson and Sugar Camp

Big Muddy	6.02	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	5.84	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	5.60	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	5.36	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	5.34	500 Yr 24 Hr	Route 13 Bridge (Westbound) - Murphysboro			
Big Muddy	5.33	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	5.33	500 Yr 24 Hr	Route 13 Bridge (Eastbound) - Murphysboro			
Big Muddy	5.31	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	5.13	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	4.77	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	4.76	500 Yr 24 Hr	Route 127 Bridge - Murphysboro			
Big Muddy	4.75	500 Yr 24 Hr	22.2	61,700	61,722.2	0.005
Big Muddy	4.22	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	3.96	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	3.40	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	3.14	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	3.08	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	3.07	500 Yr 24 Hr	20th Street Bridge - Murphysboro			
Big Muddy	3.05	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	2.92	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	2.61	500 Yr 24 Hr	22.2	61,700	61,722.2	0.003
Big Muddy	2.47	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	2.15	500 Yr 24 Hr	22.2	61,700	61,722.2	0.003
Big Muddy	1.99	500 Yr 24 Hr	22.2	61,700	61,722.2	0.003
Big Muddy	1.79	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	1.58	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	1.46	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	1.17	500 Yr 24 Hr	22.2	61,700	61,722.2	0.003
Big Muddy	1.06	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	0.94	500 Yr 24 Hr	22.2	61,700	61,722.2	0.004
Big Muddy	0.62	500 Yr 24 Hr	22.2	61,800	61,822.2	0.004
Big Muddy	0.48	500 Yr 24 Hr	22.2	61,800	61,822.2	0.004

DOCUMENT

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AquAeTer

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MEMORANDUM

TO: **James Plumley**
CC:
FROM: John Michael Corn, P.E. (TN)
DATE: December 13, 2019
JOB NO.: 192584
RE: **Mixing Zone Calculations**

AquAeTer previously provided the mixing zone calculations in the Conceptual Diffuser Design report produced in November 2016. This memo summarizes the modeling and describes each model input file.

CORMIX was originally used. The version used was 3.2. **AquAeTer** has performed side-by-side comparison modeling with newer versions of CORMIX. The results were nearly identical. Aside from some new graphical features, the underlying mathematics are still the same. Based on multiple diffuser performance studies performed by **AquAeTer**, CORMIX is expected to provide a very reasonable estimate of the mixing.

Each port was modeled independently for each scenario. The results of the models were then stitched together to determine where the water quality criteria were met. The most stringent point was to meet 500 mg/L for chloride at the edge of the mixing zone. All other mixing zones would be smaller than this one. For the model, we assumed that Sugar Camp's outfall would be in use, resulting in less available mixing for Williamson. The following dispersions were determined based on meeting all applicable water quality criteria. The worse-case required dispersion is 34.0:1 for the total mixing zone. The worse-case acute dispersion required was 3.3:1, for nickel.

PARAMETER	ACUTE / CHRONIC	WQS	CONCENTRATION		DISPERSION REQUIRED (__:1)
			BACKGROUND (mg/L)	MINE (mg/L)	
Chloride	Single Value	500	31.2	12,000	25.5
	Single Value	500	151	12,000	34.0
Sulfate	Single Value	1,182	60.1	2,120	1.8
Iron (total)	Aquatic Organisms	0.5	0.220	1.835	5.8
Nickel (dissolved)	Acute	0.0074	-	0.013	3.3
	Chronic	0.004	-	0.013	3.25
Copper	Acute	0.015	-	0.032	2.1
	Chronic	0.012	-	0.032	2.7

The scenarios and the projected distances to meet the target dispersions are given in the following table.

SCENARIO	RIVER FLOW (cfs)	ACTIVE PORT(S)	TOTAL DISCHARGE (gpm)	ACUTE ZONE DISTANCE (ft)	TOTAL MIXING ZONE DISTANCE (ft)
Case 1, Min.	30	Port 1	102	7.1	50
Case 1, Max.	>=116	Port 1	396	5.8	37
Case 2, Min.	117	Ports 1 & 2	396	4.4	36.6
Case 2, Max.	>=233	Ports 1 & 2	793	6.9	88
Case 3, Min.	234	Ports 1, 2, & 3	793	11.2	46
Case 3, Max.	>=440	Ports 1, 2, & 3	1,499	9.3	116
Case 4, Min.	441	Ports 1, 2, 3, & 4	1,499	13.9	176
Case 4, Max.	>=906	Ports 1, 2, 3, & 4	3,085	11.4	147
Case 5, Min.	907	Ports 1, 2, 3, 4, & 5	3,085	18.2	231.8
Case 5, Max.	>=1,734	Ports 1, 2, 3, 4, & 5	5,905	14.5	251

The CORMIX files followed the naming convention:

MAC + Scenario (1-5) + Port + Normal(N)/Max (X)

The files are listed below:

1. Case 1
    a. MAC1-1N
    b. MAC1-1X
2. Case 2 (as both of these are 3-inch ports with the same flowrate, only one model was run for each scenario in this case).
    a. MAC2-1N
    b. MAC2-1X
3. Case 3 (ports 1 and 2 are the same, so only one model run was made for each scenario)
    a. MAC3-1N
    b. MAC3-3N
    c. MAC3-1X
    d. MAC3-3X
4. Case 4 (ports 1 and 2 are the same, so only one model run was made for each scenario)
    a. MAC4-1N
    b. MAC4-3N
    c. MAC4-4N
    d. MAC4-1X
    e. MAC4-3X
    f. MAC4-4X
5. Case 5 (ports 1 and 2 are the same, so only one model run was made for each scenario)
    a. MAC5-1N
    b. MAC5-3N
    c. MAC5-4N
    d. MAC5-5N
    e. MAC5-1X
    f. MAC5-3X
    g. MAC5-4X
    h. MAC5-5X

If you should have questions or comments concerning our assessment, please call us at (615) 373-8532 or by FAX at (615) 373-8512 or by e-mail at jmcorn@aquaeter.com.

MAC1-1N.CX1

CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111

CORNELL MIXING ZONE EXPERT SYSTEM

Subsystem CORMIX1: Subsystem version:
Submerged Single Port Discharges CORMIX_v.3.20_____September_1996

CASE DESCRIPTION
Site name/label: Mach^Big^Muddy^River
Design case: Case^1^-^1^Port^Normal^Flow
FILE NAME: cormix\sim\Mac1-1N .cx1
Time of Fortran run: 11/08/16--09:41:36

ENVIRONMENT PARAMETERS (metric units)
Bounded section
BS = 12.46 AS = 3.72 QA = 1.07 ICHREG= 2
HA = .30 HD = .30
UA = .287 F = .144 USTAR = .3840E-01
UW = 2.000 UWSTAR= .2198E-02
Uniform density environment
STRCND= U RHOAM = 998.4901

DISCHARGE PARAMETERS (metric units)
BANK = LEFT DISTB = 5.23
D0 = .076 A0 = .005 H0 = .10
THETA = 15.00 SIGMA = .00
U0 = 1.413 Q0 = .006 = .6441E-02
RHO0 = 1013.3900 DRHO0 =-.1490E+02 GP0 =-.1463E+00
C0 = .1000E+04 CUNITS= ppm
IPOLL = 1 KS = .0000E+00 KD = .0000E+00

FLUX VARIABLES (metric units)
Q0 = .6441E-02 M0 = .9099E-02 J0 =-.9427E-03 SIGNJ0= -1.0
Associated length scales (meters)
LQ = .07 LM = .96 Lm = .33 Lb = .04
Lmp = 99999.00 Lbp = 99999.00

NON-DIMENSIONAL PARAMETERS
FR0 = 13.37 R = 4.93

FLOW CLASSIFICATION
11111111111111111111111111111111111111
1 Flow class (CORMIX1) = NH5 1
1 Applicable layer depth HS = .30 1
11111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
C0 = .1000E+04 CUNITS= ppm

MAC1-1N.CX1

```
 NTOX  =  0
 NSTD  =  0
 REGMZ =  0
 XINT  =   1000.00  XMAX  =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         5.23 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

 COANDA ATTACHMENT immediately following the discharge.

      X        Y        Z        S        C        B
      .00      .00      .00     1.0  .100E+04     .05

END OF MOD101: DISCHARGE MODULE
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Bottom-attached jet motion.

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
            Half wall jet, attached to bottom.
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

      X        Y        Z        S        C        B
      .00      .00      .00     1.0  .100E+04     .04
      .19      .00      .00     1.0  .100E+04     .05
      .39      .00      .00     1.2  .846E+03     .07
      .59      .00      .00     1.5  .687E+03     .08
      .79      .00      .00     1.7  .581E+03     .09
      .98      .00      .00     2.0  .504E+03     .10
     1.18      .00      .00     2.2  .447E+03     .11
     1.38      .00      .00     2.5  .402E+03     .12
     1.57      .00      .00     2.7  .366E+03     .12
     1.77      .00      .00     3.0  .336E+03     .13
     1.97      .00      .00     3.2  .311E+03     .14
     2.16      .00      .00     3.4  .290E+03     .15
     2.36      .00      .00     3.7  .272E+03     .15
     2.56      .00      .00     3.9  .256E+03     .16
     2.75      .00      .00     4.1  .242E+03     .16
```

2.95	.00	.00	4.3	.230E+03	.17
3.14	.00	.00	4.6	.219E+03	.18
3.34	.00	.00	4.8	.209E+03	.18
3.54	.00	.00	5.0	.200E+03	.19
3.74	.00	.00	5.2	.192E+03	.19
3.93	.00	.00	5.4	.185E+03	.20
4.13	.00	.00	5.6	.178E+03	.20
4.32	.00	.00	5.8	.172E+03	.20
4.52	.00	.00	6.0	.166E+03	.21
4.72	.00	.00	6.2	.161E+03	.21
4.92	.00	.00	6.4	.156E+03	.22
5.11	.00	.00	6.6	.151E+03	.22
5.31	.00	.00	6.8	.147E+03	.23
5.51	.00	.00	7.0	.143E+03	.23
5.70	.00	.00	7.2	.139E+03	.23
5.90	.00	.00	7.4	.136E+03	.24
6.10	.00	.00	7.5	.133E+03	.24
6.29	.00	.00	7.7	.129E+03	.24
6.49	.00	.00	7.9	.126E+03	.25
6.69	.00	.00	8.1	.124E+03	.25
6.88	.00	.00	8.3	.121E+03	.25
7.08	.00	.00	8.5	.118E+03	.26
7.28	.00	.00	8.6	.116E+03	.26
7.47	.00	.00	8.8	.114E+03	.26
7.67	.00	.00	9.0	.111E+03	.27
7.87	.00	.00	9.2	.109E+03	.27
8.06	.00	.00	9.3	.107E+03	.27
8.26	.00	.00	9.5	.105E+03	.28
8.46	.00	.00	9.7	.103E+03	.28
8.65	.00	.00	9.8	.102E+03	.28
8.85	.00	.00	10.0	.100E+03	.29
9.05	.00	.00	10.2	.983E+02	.29
9.24	.00	.00	10.3	.967E+02	.29
9.44	.00	.00	10.5	.952E+02	.29
9.64	.00	.00	10.7	.938E+02	.30
9.83	.00	.00	10.8	.924E+02	.30

Cumulative travel time = 17. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
9.83	.00	.00	10.8	.924E+02	.30

Profile definitions:

MAC1-1N.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
9.53	.00	.00	10.8	.924E+02	.00	.00	.00	.00
9.59	.00	.00	10.8	.924E+02	.30	.05	.30	.00
9.65	.00	.00	10.8	.924E+02	.30	.08	.30	.00
9.71	.00	.00	10.8	.924E+02	.30	.10	.30	.00
9.77	.00	.00	10.8	.924E+02	.30	.11	.30	.00
9.83	.00	.00	10.8	.924E+02	.30	.12	.30	.00
9.89	.00	.00	11.5	.872E+02	.30	.13	.30	.00
9.95	.00	.00	12.9	.777E+02	.30	.15	.30	.00
10.01	.00	.00	14.1	.708E+02	.30	.16	.30	.00
10.07	.00	.00	14.8	.675E+02	.30	.16	.30	.00
10.13	.00	.00	15.2	.660E+02	.30	.17	.30	.00

Cumulative travel time = 18. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.27 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC1-1N.CX1

Profile definitions:
  BV = top-hat thickness, measured vertically
  BH = top-hat half-width, measured horizontally in Y-direction
  ZU = upper plume boundary (Z-coordinate)
  ZL = lower plume boundary (Z-coordinate)
  S = hydrodynamic average (bulk) dilution
  C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
10.13	.00	.00	15.2	.660E+02	.30	.57	.30	.00
10.23	.00	.00	15.3	.652E+02	.30	.58	.30	.00
10.34	.00	.00	15.5	.645E+02	.29	.59	.29	.00
10.44	.00	.00	15.7	.637E+02	.29	.61	.29	.00
10.54	.00	.00	15.9	.630E+02	.29	.62	.29	.00
10.65	.00	.00	16.1	.623E+02	.28	.63	.28	.00
10.75	.00	.00	16.2	.616E+02	.28	.65	.28	.00
10.85	.00	.00	16.4	.609E+02	.28	.66	.28	.00
10.96	.00	.00	16.6	.602E+02	.28	.67	.28	.00
11.06	.00	.00	16.8	.595E+02	.27	.68	.27	.00
11.16	.00	.00	17.0	.588E+02	.27	.70	.27	.00
11.27	.00	.00	17.2	.581E+02	.27	.71	.27	.00
11.37	.00	.00	17.4	.574E+02	.27	.72	.27	.00
11.47	.00	.00	17.6	.568E+02	.27	.73	.27	.00
11.58	.00	.00	17.8	.561E+02	.27	.74	.27	.00
11.68	.00	.00	18.0	.554E+02	.27	.76	.27	.00
11.78	.00	.00	18.3	.548E+02	.27	.77	.27	.00
11.89	.00	.00	18.5	.541E+02	.26	.78	.26	.00
11.99	.00	.00	18.7	.535E+02	.26	.79	.26	.00
12.09	.00	.00	18.9	.528E+02	.26	.80	.26	.00
12.20	.00	.00	19.2	.522E+02	.26	.81	.26	.00
12.30	.00	.00	19.4	.515E+02	.26	.83	.26	.00
12.40	.00	.00	19.7	.509E+02	.26	.84	.26	.00
12.51	.00	.00	19.9	.503E+02	.26	.85	.26	.00
12.61	.00	.00	20.2	.496E+02	.26	.86	.26	.00
12.71	.00	.00	20.4	.490E+02	.26	.87	.26	.00
12.81	.00	.00	20.7	.484E+02	.26	.88	.26	.00
12.92	.00	.00	20.9	.478E+02	.26	.89	.26	.00
13.02	.00	.00	21.2	.472E+02	.26	.90	.26	.00
13.12	.00	.00	21.5	.466E+02	.26	.91	.26	.00
13.23	.00	.00	21.8	.460E+02	.26	.92	.26	.00
13.33	.00	.00	22.0	.454E+02	.26	.93	.26	.00
13.43	.00	.00	22.3	.448E+02	.26	.94	.26	.00
13.54	.00	.00	22.6	.442E+02	.26	.96	.26	.00
13.64	.00	.00	22.9	.436E+02	.27	.97	.27	.00
13.74	.00	.00	23.2	.431E+02	.27	.98	.27	.00
13.85	.00	.00	23.5	.425E+02	.27	.99	.27	.00

13.95	.00	.00	23.8	.420E+02	.27	1.00	.27	.00
14.05	.00	.00	24.2	.414E+02	.27	1.01	.27	.00
14.16	.00	.00	24.5	.409E+02	.27	1.02	.27	.00
14.26	.00	.00	24.8	.403E+02	.27	1.03	.27	.00
14.36	.00	.00	25.1	.398E+02	.27	1.04	.27	.00
14.47	.00	.00	25.5	.393E+02	.27	1.05	.27	.00
14.57	.00	.00	25.8	.387E+02	.27	1.06	.27	.00
14.67	.00	.00	26.2	.382E+02	.27	1.07	.27	.00
14.78	.00	.00	26.5	.377E+02	.28	1.08	.28	.00
14.88	.00	.00	26.9	.372E+02	.28	1.09	.28	.00
14.98	.00	.00	27.3	.367E+02	.28	1.10	.28	.00
15.09	.00	.00	27.6	.362E+02	.28	1.11	.28	.00
15.19	.00	.00	28.0	.357E+02	.28	1.12	.28	.00
15.29	.00	.00	28.4	.352E+02	.28	1.13	.28	.00

Cumulative travel time = 36. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .229E-02 m^2/s
Horizontal diffusivity (initial value) = .574E-02 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
15.29	.00	.00	28.4	.352E+02	.28	1.13	.28	.00
23.64	.00	.00	35.7	.280E+02	.30	1.34	.30	.00
31.98	.00	.00	40.6	.246E+02	.30	1.52	.30	.00
40.32	.00	.00	45.0	.222E+02	.30	1.68	.30	.00
48.67	.00	.00	49.0	.204E+02	.30	1.83	.30	.00
57.01	.00	.00	52.6	.190E+02	.30	1.97	.30	.00
65.35	.00	.00	56.1	.178E+02	.30	2.10	.30	.00
73.70	.00	.00	59.3	.169E+02	.30	2.22	.30	.00
82.04	.00	.00	62.3	.160E+02	.30	2.33	.30	.00
90.39	.00	.00	65.3	.153E+02	.30	2.44	.30	.00
98.73	.00	.00	68.1	.147E+02	.30	2.55	.30	.00
107.07	.00	.00	70.8	.141E+02	.30	2.65	.30	.00

115.42	.00	.00	73.3	.136E+02	.30	2.74	.30	.00
123.76	.00	.00	75.8	.132E+02	.30	2.84	.30	.00
132.10	.00	.00	78.3	.128E+02	.30	2.93	.30	.00
140.45	.00	.00	80.6	.124E+02	.30	3.02	.30	.00
148.79	.00	.00	82.9	.121E+02	.30	3.10	.30	.00
157.14	.00	.00	85.1	.118E+02	.30	3.18	.30	.00
165.48	.00	.00	87.3	.115E+02	.30	3.26	.30	.00
173.82	.00	.00	89.4	.112E+02	.30	3.34	.30	.00
182.17	.00	.00	91.4	.109E+02	.30	3.42	.30	.00
190.51	.00	.00	93.5	.107E+02	.30	3.50	.30	.00
198.85	.00	.00	95.4	.105E+02	.30	3.57	.30	.00
207.20	.00	.00	97.4	.103E+02	.30	3.64	.30	.00
215.54	.00	.00	99.3	.101E+02	.30	3.71	.30	.00
223.89	.00	.00	101.1	.989E+01	.30	3.78	.30	.00
232.23	.00	.00	102.9	.971E+01	.30	3.85	.30	.00
240.57	.00	.00	104.7	.955E+01	.30	3.92	.30	.00
248.92	.00	.00	106.5	.939E+01	.30	3.98	.30	.00
257.26	.00	.00	108.2	.924E+01	.30	4.05	.30	.00
265.60	.00	.00	109.9	.910E+01	.30	4.11	.30	.00
273.95	.00	.00	111.6	.896E+01	.30	4.18	.30	.00
282.29	.00	.00	113.3	.883E+01	.30	4.24	.30	.00
290.64	.00	.00	114.9	.870E+01	.30	4.30	.30	.00
298.98	.00	.00	116.5	.858E+01	.30	4.36	.30	.00
307.32	.00	.00	118.1	.847E+01	.30	4.42	.30	.00
315.67	.00	.00	119.7	.836E+01	.30	4.48	.30	.00
324.01	.00	.00	121.2	.825E+01	.30	4.54	.30	.00
332.35	.00	.00	122.8	.815E+01	.30	4.59	.30	.00
340.70	.00	.00	124.3	.805E+01	.30	4.65	.30	.00
349.04	.00	.00	125.8	.795E+01	.30	4.70	.30	.00
357.39	.00	.00	127.2	.786E+01	.30	4.76	.30	.00
365.73	.00	.00	128.7	.777E+01	.30	4.81	.30	.00
374.07	.00	.00	130.1	.768E+01	.30	4.87	.30	.00
382.42	.00	.00	131.6	.760E+01	.30	4.92	.30	.00
390.76	.00	.00	133.0	.752E+01	.30	4.97	.30	.00
399.10	.00	.00	134.4	.744E+01	.30	5.03	.30	.00
407.45	.00	.00	135.7	.737E+01	.30	5.08	.30	.00
415.79	.00	.00	137.1	.729E+01	.30	5.13	.30	.00
424.14	.00	.00	138.5	.722E+01	.30	5.18	.30	.00
432.48	.00	.00	139.8	.715E+01	.30	5.23	.30	.00

Cumulative travel time = 1484. sec

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
432.48	5.23	.00	139.8	.715E+01	.30	10.46	.30	.00
443.83	5.23	.00	140.3	.713E+01	.30	10.49	.30	.00
455.18	5.23	.00	140.7	.711E+01	.30	10.53	.30	.00
466.53	5.23	.00	141.2	.708E+01	.30	10.56	.30	.00

477.88	5.23	.00	141.6	.706E+01	.30	10.59	.30	.00
489.23	5.23	.00	142.1	.704E+01	.30	10.63	.30	.00
500.58	5.23	.00	142.5	.702E+01	.30	10.66	.30	.00
511.93	5.23	.00	142.9	.700E+01	.30	10.69	.30	.00
523.28	5.23	.00	143.4	.697E+01	.30	10.73	.30	.00
534.63	5.23	.00	143.8	.695E+01	.30	10.76	.30	.00
545.98	5.23	.00	144.3	.693E+01	.30	10.79	.30	.00
557.33	5.23	.00	144.7	.691E+01	.30	10.83	.30	.00
568.68	5.23	.00	145.1	.689E+01	.30	10.86	.30	.00
580.04	5.23	.00	145.6	.687E+01	.30	10.89	.30	.00
591.39	5.23	.00	146.0	.685E+01	.30	10.92	.30	.00
602.74	5.23	.00	146.4	.683E+01	.30	10.96	.30	.00
614.09	5.23	.00	146.9	.681E+01	.30	10.99	.30	.00
625.44	5.23	.00	147.3	.679E+01	.30	11.02	.30	.00
636.79	5.23	.00	147.7	.677E+01	.30	11.05	.30	.00
648.14	5.23	.00	148.2	.675E+01	.30	11.09	.30	.00
659.49	5.23	.00	148.6	.673E+01	.30	11.12	.30	.00
670.84	5.23	.00	149.0	.671E+01	.30	11.15	.30	.00
682.19	5.23	.00	149.4	.669E+01	.30	11.18	.30	.00
693.54	5.23	.00	149.9	.667E+01	.30	11.21	.30	.00
704.89	5.23	.00	150.3	.665E+01	.30	11.24	.30	.00
716.24	5.23	.00	150.7	.664E+01	.30	11.28	.30	.00
727.59	5.23	.00	151.1	.662E+01	.30	11.31	.30	.00
738.94	5.23	.00	151.5	.660E+01	.30	11.34	.30	.00
750.29	5.23	.00	152.0	.658E+01	.30	11.37	.30	.00
761.64	5.23	.00	152.4	.656E+01	.30	11.40	.30	.00
772.99	5.23	.00	152.8	.654E+01	.30	11.43	.30	.00
784.34	5.23	.00	153.2	.653E+01	.30	11.46	.30	.00
795.69	5.23	.00	153.6	.651E+01	.30	11.49	.30	.00
807.04	5.23	.00	154.0	.649E+01	.30	11.53	.30	.00
818.39	5.23	.00	154.5	.647E+01	.30	11.56	.30	.00
829.74	5.23	.00	154.9	.646E+01	.30	11.59	.30	.00
841.09	5.23	.00	155.3	.644E+01	.30	11.62	.30	.00
852.44	5.23	.00	155.7	.642E+01	.30	11.65	.30	.00
863.80	5.23	.00	156.1	.641E+01	.30	11.68	.30	.00
875.15	5.23	.00	156.5	.639E+01	.30	11.71	.30	.00
886.50	5.23	.00	156.9	.637E+01	.30	11.74	.30	.00
897.85	5.23	.00	157.3	.636E+01	.30	11.77	.30	.00
909.20	5.23	.00	157.7	.634E+01	.30	11.80	.30	.00
920.55	5.23	.00	158.1	.633E+01	.30	11.83	.30	.00
931.90	5.23	.00	158.5	.631E+01	.30	11.86	.30	.00
943.25	5.23	.00	158.9	.629E+01	.30	11.89	.30	.00
954.60	5.23	.00	159.3	.628E+01	.30	11.92	.30	.00
965.95	5.23	.00	159.7	.626E+01	.30	11.95	.30	.00
977.30	5.23	.00	160.1	.625E+01	.30	11.98	.30	.00
988.65	5.23	.00	160.5	.623E+01	.30	12.01	.30	.00
1000.00	5.23	.00	160.9	.622E+01	.30	12.04	.30	.00

Cumulative travel time = 3453. sec

```
 Simulation limit based on maximum specified distance =   1000.00 m.
   This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
CORMIX1: Submerged Single Port Discharges              End of Prediction File
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MAC1-1X.CX1

CORMIX1 PREDICTION FILE:

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CORNELL MIXING ZONE EXPERT SYSTEM

Subsystem CORMIX1: Subsystem version:

Submerged Single Port Discharges CORMIX_v.3.20_____September_1996

CASE DESCRIPTION

Site name/label: Mach^Big^Muddy^River

Design case: Case^1^-^Port^1^Maximum^Flow

FILE NAME: cormix\sim\Mac1-1X .cx1

Time of Fortran run: 11/08/16--14:54:33

ENVIRONMENT PARAMETERS (metric units)

Bounded section

BS	=	16.61	AS	=	8.33	QA = 3.30	ICHREG= 2
HA	=	.50	HD	=	.50		
UA	=	.396	F	=	.121	USTAR = .4872E-01	
UW	=	2.000	UWSTAR=	.2198E-02			

Uniform density environment

STRCND= U RHOAM = 998.4901

DISCHARGE PARAMETERS (metric units)

BANK	=	LEFT	DISTB	=	7.31		
D0	=	.076	A0	=	.005	H0 = .15	
THETA	=	15.00	SIGMA	=	.00		
U0	=	5.487	Q0	=	.025	= .2502E-01	
RHO0	=	1013.3900	DRHO0	=-.1490E+02	GP0	=-.1463E+00	
C0	=	.1000E+04	CUNITS=	ppm			
IPOLL	=	1	KS	= .0000E+00	KD	= .0000E+00	

FLUX VARIABLES (metric units)

Q0	=	.2502E-01	M0	=	.1373E+00	J0	=-.3662E-02	SIGNJ0=	-1.0

Associated length scales (meters)

LQ	=	.07	LM	=	3.73	Lm	= .94	Lb	= .06
						Lmp	= 99999.00	Lbp	= 99999.00

NON-DIMENSIONAL PARAMETERS

FR0	=	51.95	R	=	13.84		

FLOW CLASSIFICATION

1111111111111111111111111111111111111111

1 Flow class (CORMIX1) = NH5 1

1 Applicable layer depth HS = .50 1

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MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS

C0 = .1000E+04 CUNITS= ppm

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =    1000.00  XMAX   =    1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         7.31 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

 COANDA ATTACHMENT immediately following the discharge.

      X        Y        Z        S        C        B
      .00      .00      .00     1.0  .100E+04     .05

END OF MOD101: DISCHARGE MODULE
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Bottom-attached jet motion.

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
            Half wall jet, attached to bottom.
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

      X        Y        Z        S        C        B
      .00      .00      .00     1.0  .100E+04     .04
      .19      .00      .00     1.0  .100E+04     .06
      .37      .00      .00     1.2  .827E+03     .07
      .56      .00      .00     1.5  .660E+03     .09
      .75      .00      .00     1.8  .552E+03     .11
      .93      .00      .00     2.1  .475E+03     .12
     1.12      .00      .00     2.4  .416E+03     .13
     1.31      .00      .00     2.7  .371E+03     .15
     1.49      .00      .00     3.0  .335E+03     .16
     1.68      .00      .00     3.3  .305E+03     .17
     1.87      .00      .00     3.6  .281E+03     .19
     2.06      .00      .00     3.8  .260E+03     .20
     2.25      .00      .00     4.1  .242E+03     .21
     2.43      .00      .00     4.4  .227E+03     .22
     2.62      .00      .00     4.7  .213E+03     .23
```

2.81	.00	.00	5.0	.201E+03	.24
2.99	.00	.00	5.2	.191E+03	.25
3.18	.00	.00	5.5	.181E+03	.26
3.37	.00	.00	5.8	.173E+03	.27
3.56	.00	.00	6.1	.165E+03	.28
3.75	.00	.00	6.3	.158E+03	.29
3.93	.00	.00	6.6	.152E+03	.30
4.12	.00	.00	6.8	.146E+03	.31
4.31	.00	.00	7.1	.141E+03	.32
4.49	.00	.00	7.4	.136E+03	.33
4.68	.00	.00	7.6	.131E+03	.33
4.87	.00	.00	7.9	.127E+03	.34
5.05	.00	.00	8.1	.123E+03	.35
5.24	.00	.00	8.4	.119E+03	.36
5.43	.00	.00	8.6	.116E+03	.37
5.62	.00	.00	8.9	.112E+03	.37
5.81	.00	.00	9.1	.109E+03	.38
5.99	.00	.00	9.4	.106E+03	.39
6.18	.00	.00	9.6	.104E+03	.40
6.37	.00	.00	9.9	.101E+03	.40
6.55	.00	.00	10.1	.987E+02	.41
6.74	.00	.00	10.4	.963E+02	.42
6.93	.00	.00	10.6	.942E+02	.42
7.11	.00	.00	10.9	.921E+02	.43
7.31	.00	.00	11.1	.901E+02	.44
7.49	.00	.00	11.3	.882E+02	.44
7.68	.00	.00	11.6	.864E+02	.45
7.87	.00	.00	11.8	.847E+02	.45
8.05	.00	.00	12.0	.830E+02	.46
8.24	.00	.00	12.3	.814E+02	.47
8.43	.00	.00	12.5	.799E+02	.47
8.61	.00	.00	12.7	.785E+02	.48
8.80	.00	.00	13.0	.771E+02	.48
8.99	.00	.00	13.2	.757E+02	.49
9.18	.00	.00	13.4	.744E+02	.50
9.37	.00	.00	13.7	.732E+02	.50

Cumulative travel time = 7. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
9.37	.00	.00	13.7	.732E+02	.50

Profile definitions:

MAC1-1X.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
8.86	.00	.00	13.7	.732E+02	.00	.00	.00	.00
8.96	.00	.00	13.7	.732E+02	.50	.10	.50	.00
9.06	.00	.00	13.7	.732E+02	.50	.15	.50	.00
9.17	.00	.00	13.7	.732E+02	.50	.18	.50	.00
9.27	.00	.00	13.7	.732E+02	.50	.21	.50	.00
9.37	.00	.00	13.7	.732E+02	.50	.23	.50	.00
9.47	.00	.00	14.5	.691E+02	.50	.25	.50	.00
9.57	.00	.00	16.2	.616E+02	.50	.27	.50	.00
9.67	.00	.00	17.8	.561E+02	.50	.29	.50	.00
9.77	.00	.00	18.7	.535E+02	.50	.31	.50	.00
9.87	.00	.00	19.1	.523E+02	.50	.33	.50	.00

Cumulative travel time = 8. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.65 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC1-1X.CX1

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
9.87	.00	.00	19.1	.523E+02	.50	1.19	.50	.00
10.00	.00	.00	19.3	.519E+02	.50	1.21	.50	.00
10.13	.00	.00	19.4	.515E+02	.50	1.22	.50	.00
10.27	.00	.00	19.6	.511E+02	.50	1.24	.50	.00
10.40	.00	.00	19.7	.507E+02	.49	1.25	.49	.00
10.54	.00	.00	19.9	.503E+02	.49	1.27	.49	.00
10.67	.00	.00	20.0	.499E+02	.49	1.28	.49	.00
10.80	.00	.00	20.2	.495E+02	.49	1.30	.49	.00
10.94	.00	.00	20.3	.491E+02	.49	1.31	.49	.00
11.07	.00	.00	20.5	.488E+02	.49	1.32	.49	.00
11.20	.00	.00	20.7	.484E+02	.48	1.34	.48	.00
11.34	.00	.00	20.8	.480E+02	.48	1.35	.48	.00
11.47	.00	.00	21.0	.476E+02	.48	1.36	.48	.00
11.60	.00	.00	21.2	.472E+02	.48	1.38	.48	.00
11.74	.00	.00	21.3	.468E+02	.48	1.39	.48	.00
11.87	.00	.00	21.5	.465E+02	.48	1.41	.48	.00
12.01	.00	.00	21.7	.461E+02	.48	1.42	.48	.00
12.14	.00	.00	21.9	.457E+02	.48	1.43	.48	.00
12.27	.00	.00	22.1	.453E+02	.48	1.45	.48	.00
12.41	.00	.00	22.2	.450E+02	.48	1.46	.48	.00
12.54	.00	.00	22.4	.446E+02	.48	1.47	.48	.00
12.67	.00	.00	22.6	.442E+02	.48	1.49	.48	.00
12.81	.00	.00	22.8	.439E+02	.48	1.50	.48	.00
12.94	.00	.00	23.0	.435E+02	.48	1.51	.48	.00
13.07	.00	.00	23.2	.432E+02	.48	1.52	.48	.00
13.21	.00	.00	23.4	.428E+02	.48	1.54	.48	.00
13.34	.00	.00	23.6	.424E+02	.48	1.55	.48	.00
13.48	.00	.00	23.8	.421E+02	.48	1.56	.48	.00
13.61	.00	.00	24.0	.417E+02	.48	1.58	.48	.00
13.74	.00	.00	24.2	.414E+02	.48	1.59	.48	.00
13.88	.00	.00	24.4	.410E+02	.48	1.60	.48	.00
14.01	.00	.00	24.6	.407E+02	.48	1.61	.48	.00
14.14	.00	.00	24.8	.403E+02	.48	1.63	.48	.00
14.28	.00	.00	25.0	.400E+02	.48	1.64	.48	.00
14.41	.00	.00	25.2	.396E+02	.48	1.65	.48	.00
14.54	.00	.00	25.4	.393E+02	.48	1.66	.48	.00
14.68	.00	.00	25.7	.390E+02	.48	1.68	.48	.00

14.81	.00	.00	25.9	.386E+02	.48	1.69	.48	.00
14.94	.00	.00	26.1	.383E+02	.48	1.70	.48	.00
15.08	.00	.00	26.3	.380E+02	.48	1.71	.48	.00
15.21	.00	.00	26.6	.376E+02	.48	1.73	.48	.00
15.35	.00	.00	26.8	.373E+02	.48	1.74	.48	.00
15.48	.00	.00	27.0	.370E+02	.48	1.75	.48	.00
15.61	.00	.00	27.3	.367E+02	.49	1.76	.49	.00
15.75	.00	.00	27.5	.363E+02	.49	1.77	.49	.00
15.88	.00	.00	27.8	.360E+02	.49	1.79	.49	.00
16.01	.00	.00	28.0	.357E+02	.49	1.80	.49	.00
16.15	.00	.00	28.3	.354E+02	.49	1.81	.49	.00
16.28	.00	.00	28.5	.351E+02	.49	1.82	.49	.00
16.41	.00	.00	28.8	.348E+02	.49	1.83	.49	.00
16.55	.00	.00	29.0	.345E+02	.49	1.85	.49	.00

Cumulative travel time = 25. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .489E-02 m^2/s
Horizontal diffusivity (initial value) = .122E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
16.55	.00	.00	29.0	.345E+02	.49	1.85	.49	.00
26.94	.00	.00	33.6	.298E+02	.50	2.10	.50	.00
37.34	.00	.00	37.2	.269E+02	.50	2.32	.50	.00
47.73	.00	.00	40.5	.247E+02	.50	2.53	.50	.00
58.13	.00	.00	43.5	.230E+02	.50	2.72	.50	.00
68.52	.00	.00	46.4	.216E+02	.50	2.90	.50	.00
78.92	.00	.00	49.1	.204E+02	.50	3.07	.50	.00
89.31	.00	.00	51.6	.194E+02	.50	3.23	.50	.00
99.71	.00	.00	54.0	.185E+02	.50	3.38	.50	.00
110.11	.00	.00	56.3	.177E+02	.50	3.52	.50	.00
120.50	.00	.00	58.6	.171E+02	.50	3.66	.50	.00
130.90	.00	.00	60.7	.165E+02	.50	3.79	.50	.00

141.29	.00	.00	62.8	.159E+02	.50	3.92	.50	.00
151.69	.00	.00	64.8	.154E+02	.50	4.05	.50	.00
162.08	.00	.00	66.7	.150E+02	.50	4.17	.50	.00
172.48	.00	.00	68.6	.146E+02	.50	4.29	.50	.00
182.87	.00	.00	70.5	.142E+02	.50	4.40	.50	.00
193.27	.00	.00	72.3	.138E+02	.50	4.52	.50	.00
203.66	.00	.00	74.0	.135E+02	.50	4.63	.50	.00
214.06	.00	.00	75.7	.132E+02	.50	4.73	.50	.00
224.45	.00	.00	77.4	.129E+02	.50	4.84	.50	.00
234.85	.00	.00	79.0	.127E+02	.50	4.94	.50	.00
245.24	.00	.00	80.6	.124E+02	.50	5.04	.50	.00
255.64	.00	.00	82.2	.122E+02	.50	5.14	.50	.00
266.03	.00	.00	83.7	.119E+02	.50	5.23	.50	.00
276.43	.00	.00	85.3	.117E+02	.50	5.33	.50	.00
286.82	.00	.00	86.7	.115E+02	.50	5.42	.50	.00
297.22	.00	.00	88.2	.113E+02	.50	5.51	.50	.00
307.61	.00	.00	89.6	.112E+02	.50	5.60	.50	.00
318.01	.00	.00	91.1	.110E+02	.50	5.69	.50	.00
328.41	.00	.00	92.5	.108E+02	.50	5.78	.50	.00
338.80	.00	.00	93.8	.107E+02	.50	5.86	.50	.00
349.20	.00	.00	95.2	.105E+02	.50	5.95	.50	.00
359.59	.00	.00	96.5	.104E+02	.50	6.03	.50	.00
369.99	.00	.00	97.8	.102E+02	.50	6.11	.50	.00
380.38	.00	.00	99.1	.101E+02	.50	6.20	.50	.00
390.78	.00	.00	100.4	.996E+01	.50	6.28	.50	.00
401.17	.00	.00	101.7	.983E+01	.50	6.35	.50	.00
411.57	.00	.00	102.9	.972E+01	.50	6.43	.50	.00
421.96	.00	.00	104.2	.960E+01	.50	6.51	.50	.00
432.36	.00	.00	105.4	.949E+01	.50	6.59	.50	.00
442.75	.00	.00	106.6	.938E+01	.50	6.66	.50	.00
453.15	.00	.00	107.8	.928E+01	.50	6.74	.50	.00
463.54	.00	.00	109.0	.918E+01	.50	6.81	.50	.00
473.94	.00	.00	110.1	.908E+01	.50	6.88	.50	.00
484.33	.00	.00	111.3	.899E+01	.50	6.96	.50	.00
494.73	.00	.00	112.4	.889E+01	.50	7.03	.50	.00
505.12	.00	.00	113.6	.881E+01	.50	7.10	.50	.00
515.52	.00	.00	114.7	.872E+01	.50	7.17	.50	.00
525.91	.00	.00	115.8	.864E+01	.50	7.24	.50	.00
536.31	.00	.00	116.9	.855E+01	.50	7.31	.50	.00

Cumulative travel time = 1327. sec

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
536.31	7.31	.00	116.9	.855E+01	.50	14.61	.50	.00
545.58	7.31	.00	117.1	.854E+01	.50	14.64	.50	.00
554.86	7.31	.00	117.4	.852E+01	.50	14.67	.50	.00
564.13	7.31	.00	117.6	.850E+01	.50	14.70	.50	.00

MAC1-1X.CX1

573.40	7.31	.00	117.9	.848E+01	.50	14.73	.50	.00
582.68	7.31	.00	118.1	.847E+01	.50	14.76	.50	.00
591.95	7.31	.00	118.4	.845E+01	.50	14.79	.50	.00
601.23	7.31	.00	118.6	.843E+01	.50	14.82	.50	.00
610.50	7.31	.00	118.8	.841E+01	.50	14.85	.50	.00
619.77	7.31	.00	119.1	.840E+01	.50	14.88	.50	.00
629.05	7.31	.00	119.3	.838E+01	.50	14.91	.50	.00
638.32	7.31	.00	119.6	.836E+01	.50	14.94	.50	.00
647.60	7.31	.00	119.8	.835E+01	.50	14.97	.50	.00
656.87	7.31	.00	120.0	.833E+01	.50	15.00	.50	.00
666.14	7.31	.00	120.3	.831E+01	.50	15.03	.50	.00
675.42	7.31	.00	120.5	.830E+01	.50	15.06	.50	.00
684.69	7.31	.00	120.7	.828E+01	.50	15.09	.50	.00
693.96	7.31	.00	121.0	.827E+01	.50	15.12	.50	.00
703.24	7.31	.00	121.2	.825E+01	.50	15.15	.50	.00
712.51	7.31	.00	121.4	.823E+01	.50	15.18	.50	.00
721.79	7.31	.00	121.7	.822E+01	.50	15.21	.50	.00
731.06	7.31	.00	121.9	.820E+01	.50	15.24	.50	.00
740.33	7.31	.00	122.2	.819E+01	.50	15.27	.50	.00
749.61	7.31	.00	122.4	.817E+01	.50	15.30	.50	.00
758.88	7.31	.00	122.6	.816E+01	.50	15.33	.50	.00
768.15	7.31	.00	122.9	.814E+01	.50	15.36	.50	.00
777.43	7.31	.00	123.1	.812E+01	.50	15.38	.50	.00
786.70	7.31	.00	123.3	.811E+01	.50	15.41	.50	.00
795.98	7.31	.00	123.5	.809E+01	.50	15.44	.50	.00
805.25	7.31	.00	123.8	.808E+01	.50	15.47	.50	.00
814.52	7.31	.00	124.0	.806E+01	.50	15.50	.50	.00
823.80	7.31	.00	124.2	.805E+01	.50	15.53	.50	.00
833.07	7.31	.00	124.5	.803E+01	.50	15.56	.50	.00
842.35	7.31	.00	124.7	.802E+01	.50	15.59	.50	.00
851.62	7.31	.00	124.9	.800E+01	.50	15.61	.50	.00
860.89	7.31	.00	125.2	.799E+01	.50	15.64	.50	.00
870.17	7.31	.00	125.4	.798E+01	.50	15.67	.50	.00
879.44	7.31	.00	125.6	.796E+01	.50	15.70	.50	.00
888.71	7.31	.00	125.8	.795E+01	.50	15.73	.50	.00
897.99	7.31	.00	126.1	.793E+01	.50	15.76	.50	.00
907.26	7.31	.00	126.3	.792E+01	.50	15.78	.50	.00
916.54	7.31	.00	126.5	.790E+01	.50	15.81	.50	.00
925.81	7.31	.00	126.7	.789E+01	.50	15.84	.50	.00
935.08	7.31	.00	127.0	.788E+01	.50	15.87	.50	.00
944.36	7.31	.00	127.2	.786E+01	.50	15.90	.50	.00
953.63	7.31	.00	127.4	.785E+01	.50	15.93	.50	.00
962.90	7.31	.00	127.6	.783E+01	.50	15.95	.50	.00
972.18	7.31	.00	127.9	.782E+01	.50	15.98	.50	.00
981.45	7.31	.00	128.1	.781E+01	.50	16.01	.50	.00
990.73	7.31	.00	128.3	.779E+01	.50	16.04	.50	.00
1000.00	7.31	.00	128.5	.778E+01	.50	16.06	.50	.00

Cumulative travel time = 2488. sec

MAC1-1X.CX1

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

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MAC2-1N.CX1

CORMIX1 PREDICTION FILE:
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CORNELL MIXING ZONE EXPERT SYSTEM
Subsystem CORMIX1: Subsystem version:
Submerged Single Port Discharges CORMIX_v.3.20_____September_1996

CASE DESCRIPTION
Site name/label: Mach^Big^Muddy^River
Design case: Case^2^-^Port^1^Normal^Flow
FILE NAME: cormix\sim\Mac2-1N .cx1
Time of Fortran run: 11/08/16--09:43:12

ENVIRONMENT PARAMETERS (metric units)
Bounded section
BS = 16.61 AS = 8.33 QA = 3.30 ICHREG= 2
HA = .50 HD = .50
UA = .396 F = .121 USTAR = .4872E-01
UW = 2.000 UWSTAR= .2198E-02
Uniform density environment
STRCND= U RHOAM = 998.4901

DISCHARGE PARAMETERS (metric units)
BANK = LEFT DISTB = 5.23
D0 = .076 A0 = .005 H0 = .10
THETA = 15.00 SIGMA = .00
U0 = 1.413 Q0 = .006 = .6441E-02
RHO0 = 1013.3900 DRHO0 =-.1490E+02 GP0 =-.1463E+00
C0 = .1000E+04 CUNITS= ppm
IPOLL = 1 KS = .0000E+00 KD = .0000E+00

FLUX VARIABLES (metric units)
Q0 = .6441E-02 M0 = .9099E-02 J0 =-.9427E-03 SIGNJ0= -1.0
Associated length scales (meters)
LQ = .07 LM = .96 Lm = .24 Lb = .02
Lmp = 99999.00 Lbp = 99999.00

NON-DIMENSIONAL PARAMETERS
FR0 = 13.37 R = 3.56

FLOW CLASSIFICATION
1111111111111111111111111111111111111111
1 Flow class (CORMIX1) = NH4 1
1 Applicable layer depth HS = .50 1
1111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
C0 = .1000E+04 CUNITS= ppm

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         5.23 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z        S        C        B
      .00      .00      .10     1.0  .100E+04     .04

END OF MOD101: DISCHARGE MODULE
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet/plume transition motion in strong crossflow.

 Zone of flow establishment:            THETAE=     13.67  SIGMAE=       .00
  LE    =       .29  XE    =       .28  YE    =       .00  ZE    =       .17

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .10     1.0  .100E+04     .04
      .28      .00      .17     1.0  .100E+04     .04
      .34      .00      .18     1.1  .919E+03     .04
      .40      .00      .20     1.3  .793E+03     .05
      .47      .00      .21     1.4  .698E+03     .05
      .53      .00      .22     1.6  .626E+03     .06
      .59      .00      .23     1.8  .566E+03     .06
      .65      .00      .23     1.9  .521E+03     .07
      .72      .00      .24     2.1  .483E+03     .07
      .78      .00      .25     2.2  .452E+03     .07
      .84      .00      .25     2.4  .425E+03     .08
      .91      .00      .26     2.5  .402E+03     .08
      .97      .00      .26     2.6  .382E+03     .08
     1.03      .00      .27     2.7  .366E+03     .08
     1.09      .00      .27     2.8  .351E+03     .09
```

1.16	.00	.27	3.0	.338E+03	.09
1.22	.00	.27	3.1	.326E+03	.09
1.28	.00	.28	3.2	.316E+03	.09
1.35	.00	.28	3.3	.308E+03	.09
1.41	.00	.28	3.3	.300E+03	.09
1.47	.00	.28	3.4	.293E+03	.10

Maximum jet height has been reached.

1.54	.00	.28	3.5	.286E+03	.10
1.60	.00	.28	3.6	.280E+03	.10
1.66	.00	.28	3.7	.273E+03	.10
1.73	.00	.28	3.7	.267E+03	.10
1.79	.00	.27	3.8	.260E+03	.10
1.85	.00	.27	3.9	.254E+03	.10
1.91	.00	.27	4.0	.247E+03	.11
1.98	.00	.27	4.2	.241E+03	.11
2.04	.00	.26	4.3	.234E+03	.11
2.10	.00	.26	4.4	.228E+03	.11
2.17	.00	.26	4.5	.222E+03	.11
2.23	.00	.25	4.6	.216E+03	.12
2.29	.00	.25	4.8	.210E+03	.12
2.36	.00	.25	4.9	.204E+03	.12
2.42	.00	.24	5.0	.199E+03	.12
2.48	.00	.24	5.2	.193E+03	.12
2.54	.00	.23	5.3	.188E+03	.13
2.61	.00	.23	5.5	.183E+03	.13
2.67	.00	.22	5.6	.178E+03	.13
2.73	.00	.22	5.8	.173E+03	.13
2.80	.00	.21	5.9	.168E+03	.13
2.86	.00	.21	6.1	.164E+03	.14
2.92	.00	.20	6.3	.159E+03	.14
2.98	.00	.20	6.4	.155E+03	.14
3.05	.00	.19	6.6	.151E+03	.14
3.11	.00	.19	6.8	.147E+03	.14
3.17	.00	.18	7.0	.143E+03	.15
3.24	.00	.17	7.2	.140E+03	.15
3.30	.00	.17	7.3	.136E+03	.15
3.36	.00	.16	7.5	.133E+03	.15
3.43	.00	.15	7.7	.129E+03	.15

Cumulative travel time = 4. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

Control volume inflow:

X	Y	Z	S	C	B
3.43	.00	.15	7.7	.129E+03	.15

MAC2-1N.CX1

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
3.27	.00	.00	7.7	.129E+03	.00	.00	.00	.00
3.32	.00	.00	7.7	.129E+03	.21	.10	.21	.00
3.36	.00	.00	7.7	.129E+03	.24	.15	.24	.00
3.41	.00	.00	7.7	.129E+03	.27	.18	.27	.00
3.46	.00	.00	7.9	.126E+03	.29	.21	.29	.00
3.50	.00	.00	8.9	.112E+03	.30	.23	.30	.00
3.55	.00	.00	10.3	.972E+02	.31	.25	.31	.00
3.60	.00	.00	11.5	.868E+02	.32	.27	.32	.00
3.64	.00	.00	12.4	.808E+02	.32	.29	.32	.00
3.69	.00	.00	12.8	.779E+02	.33	.31	.33	.00
3.74	.00	.00	13.1	.761E+02	.33	.33	.33	.00

Cumulative travel time = 5. sec

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

** End of NEAR-FIELD REGION (NFR) **

BEGIN MOD141: BUOYANT AMBIENT SPREADING

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
3.74	.00	.00	13.1	.761E+02	.33	.33	.33	.00
3.77	.00	.00	13.2	.757E+02	.32	.33	.32	.00
3.81	.00	.00	13.3	.754E+02	.32	.33	.32	.00
3.84	.00	.00	13.3	.750E+02	.32	.34	.32	.00
3.88	.00	.00	13.4	.746E+02	.32	.34	.32	.00
3.92	.00	.00	13.5	.743E+02	.32	.35	.32	.00
3.95	.00	.00	13.5	.739E+02	.31	.35	.31	.00
3.99	.00	.00	13.6	.735E+02	.31	.35	.31	.00
4.02	.00	.00	13.7	.732E+02	.31	.36	.31	.00

4.06	.00	.00	13.7	.728E+02	.31	.36	.31	.00
4.10	.00	.00	13.8	.724E+02	.31	.36	.31	.00
4.13	.00	.00	13.9	.721E+02	.31	.37	.31	.00
4.17	.00	.00	13.9	.717E+02	.30	.37	.30	.00
4.21	.00	.00	14.0	.714E+02	.30	.38	.30	.00
4.24	.00	.00	14.1	.710E+02	.30	.38	.30	.00
4.28	.00	.00	14.2	.707E+02	.30	.38	.30	.00
4.31	.00	.00	14.2	.703E+02	.30	.39	.30	.00
4.35	.00	.00	14.3	.700E+02	.30	.39	.30	.00
4.39	.00	.00	14.4	.696E+02	.30	.39	.30	.00
4.42	.00	.00	14.4	.693E+02	.30	.40	.30	.00
4.46	.00	.00	14.5	.689E+02	.29	.40	.29	.00
4.50	.00	.00	14.6	.686E+02	.29	.40	.29	.00
4.53	.00	.00	14.7	.683E+02	.29	.41	.29	.00
4.57	.00	.00	14.7	.679E+02	.29	.41	.29	.00
4.60	.00	.00	14.8	.676E+02	.29	.41	.29	.00
4.64	.00	.00	14.9	.672E+02	.29	.42	.29	.00
4.68	.00	.00	14.9	.669E+02	.29	.42	.29	.00
4.71	.00	.00	15.0	.666E+02	.29	.42	.29	.00
4.75	.00	.00	15.1	.662E+02	.29	.43	.29	.00
4.79	.00	.00	15.2	.659E+02	.29	.43	.29	.00
4.82	.00	.00	15.3	.656E+02	.29	.43	.29	.00
4.86	.00	.00	15.3	.652E+02	.28	.44	.28	.00
4.89	.00	.00	15.4	.649E+02	.28	.44	.28	.00
4.93	.00	.00	15.5	.646E+02	.28	.44	.28	.00
4.97	.00	.00	15.6	.643E+02	.28	.45	.28	.00
5.00	.00	.00	15.6	.639E+02	.28	.45	.28	.00
5.04	.00	.00	15.7	.636E+02	.28	.45	.28	.00
5.07	.00	.00	15.8	.633E+02	.28	.46	.28	.00
5.11	.00	.00	15.9	.629E+02	.28	.46	.28	.00
5.15	.00	.00	16.0	.626E+02	.28	.46	.28	.00
5.18	.00	.00	16.1	.623E+02	.28	.47	.28	.00
5.22	.00	.00	16.1	.620E+02	.28	.47	.28	.00
5.26	.00	.00	16.2	.617E+02	.28	.47	.28	.00
5.29	.00	.00	16.3	.613E+02	.28	.48	.28	.00
5.33	.00	.00	16.4	.610E+02	.28	.48	.28	.00
5.36	.00	.00	16.5	.607E+02	.28	.48	.28	.00
5.40	.00	.00	16.6	.604E+02	.28	.49	.28	.00
5.44	.00	.00	16.6	.601E+02	.28	.49	.28	.00
5.47	.00	.00	16.7	.598E+02	.28	.49	.28	.00
5.51	.00	.00	16.8	.594E+02	.28	.50	.28	.00
5.55	.00	.00	16.9	.591E+02	.27	.50	.27	.00

Cumulative travel time = 10. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

MAC2-1N.CX1

Vertical diffusivity (initial value) = .489E-02 m^2/s
Horizontal diffusivity (initial value) = .122E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
5.55	.00	.00	16.9	.591E+02	.27	.50	.27	.00
11.15	.00	.00	45.5	.220E+02	.42	.89	.42	.00

Plume interacts with SURFACE.
The passive diffusion plume becomes VERTICALLY FULLY MIXED within this prediction interval.

16.76	.00	.00	71.2	.140E+02	.50	1.16	.50	.00
22.37	.00	.00	84.5	.118E+02	.50	1.37	.50	.00
27.97	.00	.00	95.9	.104E+02	.50	1.56	.50	.00
33.58	.00	.00	106.1	.942E+01	.50	1.72	.50	.00
39.19	.00	.00	115.4	.866E+01	.50	1.87	.50	.00
44.79	.00	.00	124.1	.806E+01	.50	2.01	.50	.00
50.40	.00	.00	132.1	.757E+01	.50	2.14	.50	.00
56.01	.00	.00	139.7	.716E+01	.50	2.26	.50	.00
61.61	.00	.00	146.9	.681E+01	.50	2.38	.50	.00
67.22	.00	.00	153.8	.650E+01	.50	2.49	.50	.00
72.83	.00	.00	160.3	.624E+01	.50	2.60	.50	.00
78.43	.00	.00	166.6	.600E+01	.50	2.70	.50	.00
84.04	.00	.00	172.7	.579E+01	.50	2.80	.50	.00
89.65	.00	.00	178.6	.560E+01	.50	2.89	.50	.00
95.25	.00	.00	184.3	.543E+01	.50	2.99	.50	.00
100.86	.00	.00	189.8	.527E+01	.50	3.08	.50	.00
106.47	.00	.00	195.1	.512E+01	.50	3.16	.50	.00
112.07	.00	.00	200.4	.499E+01	.50	3.25	.50	.00
117.68	.00	.00	205.4	.487E+01	.50	3.33	.50	.00
123.29	.00	.00	210.4	.475E+01	.50	3.41	.50	.00
128.89	.00	.00	215.2	.465E+01	.50	3.49	.50	.00
134.50	.00	.00	220.0	.455E+01	.50	3.57	.50	.00
140.11	.00	.00	224.6	.445E+01	.50	3.64	.50	.00
145.71	.00	.00	229.2	.436E+01	.50	3.72	.50	.00
151.32	.00	.00	233.6	.428E+01	.50	3.79	.50	.00
156.93	.00	.00	238.0	.420E+01	.50	3.86	.50	.00
162.54	.00	.00	242.3	.413E+01	.50	3.93	.50	.00

MAC2-1N.CX1

168.14	.00	.00	246.5	.406E+01	.50	4.00	.50	.00
173.75	.00	.00	250.7	.399E+01	.50	4.06	.50	.00
179.36	.00	.00	254.7	.393E+01	.50	4.13	.50	.00
184.96	.00	.00	258.8	.386E+01	.50	4.19	.50	.00
190.57	.00	.00	262.7	.381E+01	.50	4.26	.50	.00
196.18	.00	.00	266.6	.375E+01	.50	4.32	.50	.00
201.78	.00	.00	270.4	.370E+01	.50	4.38	.50	.00
207.39	.00	.00	274.2	.365E+01	.50	4.45	.50	.00
213.00	.00	.00	278.0	.360E+01	.50	4.51	.50	.00
218.60	.00	.00	281.7	.355E+01	.50	4.57	.50	.00
224.21	.00	.00	285.3	.351E+01	.50	4.62	.50	.00
229.82	.00	.00	288.9	.346E+01	.50	4.68	.50	.00
235.42	.00	.00	292.4	.342E+01	.50	4.74	.50	.00
241.03	.00	.00	295.9	.338E+01	.50	4.80	.50	.00
246.64	.00	.00	299.4	.334E+01	.50	4.85	.50	.00
252.24	.00	.00	302.8	.330E+01	.50	4.91	.50	.00
257.85	.00	.00	306.2	.327E+01	.50	4.96	.50	.00
263.46	.00	.00	309.6	.323E+01	.50	5.02	.50	.00
269.06	.00	.00	312.9	.320E+01	.50	5.07	.50	.00
274.67	.00	.00	316.2	.316E+01	.50	5.13	.50	.00
280.28	.00	.00	319.4	.313E+01	.50	5.18	.50	.00
285.88	.00	.00	322.6	.310E+01	.50	5.23	.50	.00

Cumulative travel time = 716. sec

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
285.88	5.23	.00	322.6	.310E+01	.50	10.46	.50	.00
300.17	5.23	.00	324.6	.308E+01	.50	10.53	.50	.00
314.45	5.23	.00	326.7	.306E+01	.50	10.59	.50	.00
328.73	5.23	.00	328.7	.304E+01	.50	10.66	.50	.00
343.01	5.23	.00	330.7	.302E+01	.50	10.72	.50	.00
357.30	5.23	.00	332.6	.301E+01	.50	10.78	.50	.00
371.58	5.23	.00	334.6	.299E+01	.50	10.85	.50	.00
385.86	5.23	.00	336.6	.297E+01	.50	10.91	.50	.00
400.14	5.23	.00	338.5	.295E+01	.50	10.98	.50	.00
414.43	5.23	.00	340.4	.294E+01	.50	11.04	.50	.00
428.71	5.23	.00	342.4	.292E+01	.50	11.10	.50	.00
442.99	5.23	.00	344.3	.290E+01	.50	11.16	.50	.00
457.27	5.23	.00	346.2	.289E+01	.50	11.22	.50	.00
471.55	5.23	.00	348.1	.287E+01	.50	11.29	.50	.00
485.84	5.23	.00	350.0	.286E+01	.50	11.35	.50	.00
500.12	5.23	.00	351.8	.284E+01	.50	11.41	.50	.00
514.40	5.23	.00	353.7	.283E+01	.50	11.47	.50	.00
528.68	5.23	.00	355.5	.281E+01	.50	11.53	.50	.00
542.97	5.23	.00	357.4	.280E+01	.50	11.59	.50	.00
557.25	5.23	.00	359.2	.278E+01	.50	11.65	.50	.00
571.53	5.23	.00	361.0	.277E+01	.50	11.71	.50	.00

585.81	5.23	.00	362.9	.276E+01	.50	11.76	.50	.00
600.10	5.23	.00	364.7	.274E+01	.50	11.82	.50	.00
614.38	5.23	.00	366.5	.273E+01	.50	11.88	.50	.00
628.66	5.23	.00	368.2	.272E+01	.50	11.94	.50	.00
642.94	5.23	.00	370.0	.270E+01	.50	12.00	.50	.00
657.22	5.23	.00	371.8	.269E+01	.50	12.05	.50	.00
671.51	5.23	.00	373.6	.268E+01	.50	12.11	.50	.00
685.79	5.23	.00	375.3	.266E+01	.50	12.17	.50	.00
700.07	5.23	.00	377.1	.265E+01	.50	12.23	.50	.00
714.35	5.23	.00	378.8	.264E+01	.50	12.28	.50	.00
728.64	5.23	.00	380.5	.263E+01	.50	12.34	.50	.00
742.92	5.23	.00	382.2	.262E+01	.50	12.39	.50	.00
757.20	5.23	.00	384.0	.260E+01	.50	12.45	.50	.00
771.48	5.23	.00	385.7	.259E+01	.50	12.50	.50	.00
785.77	5.23	.00	387.4	.258E+01	.50	12.56	.50	.00
800.05	5.23	.00	389.1	.257E+01	.50	12.61	.50	.00
814.33	5.23	.00	390.7	.256E+01	.50	12.67	.50	.00
828.61	5.23	.00	392.4	.255E+01	.50	12.72	.50	.00
842.89	5.23	.00	394.1	.254E+01	.50	12.78	.50	.00
857.18	5.23	.00	395.8	.253E+01	.50	12.83	.50	.00
871.46	5.23	.00	397.4	.252E+01	.50	12.89	.50	.00
885.74	5.23	.00	399.1	.251E+01	.50	12.94	.50	.00
900.02	5.23	.00	400.7	.250E+01	.50	12.99	.50	.00
914.31	5.23	.00	402.3	.249E+01	.50	13.04	.50	.00
928.59	5.23	.00	404.0	.248E+01	.50	13.10	.50	.00
942.87	5.23	.00	405.6	.247E+01	.50	13.15	.50	.00
957.15	5.23	.00	407.2	.246E+01	.50	13.20	.50	.00
971.43	5.23	.00	408.8	.245E+01	.50	13.25	.50	.00
985.72	5.23	.00	410.4	.244E+01	.50	13.31	.50	.00
1000.00	5.23	.00	412.0	.243E+01	.50	13.36	.50	.00

Cumulative travel time = 2515. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

11111111111111111111111111111111111111111111111111111111111111111111111111111

MAC2-1X.CX1

CORMIX1 PREDICTION FILE:
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CORNELL MIXING ZONE EXPERT SYSTEM

Subsystem CORMIX1: Subsystem version:
Submerged Single Port Discharges CORMIX_v.3.20_____September_1996

CASE DESCRIPTION
Site name/label: Mach^Big^Muddy^River
Design case: Case^2^-^Port^1^Maximum^Flow
FILE NAME: cormix\sim\Mac2-1X .cx1
Time of Fortran run: 11/08/16--14:57:39

ENVIRONMENT PARAMETERS (metric units)
Bounded section
BS = 33.47 AS = 38.66 QA = 11.08 ICHREG= 2
HA = 1.16 HD = 1.16
UA = .287 F = .092 USTAR = .3066E-01
UW = 2.000 UWSTAR= .2198E-02
Uniform density environment
STRCND= U RHOAM = 998.4901

DISCHARGE PARAMETERS (metric units)
BANK = LEFT DISTB = 7.31
D0 = .076 A0 = .005 H0 = .15
THETA = 15.00 SIGMA = .00
U0 = 5.487 Q0 = .025 = .2502E-01
RHO0 = 1013.3900 DRHO0 =-.1490E+02 GP0 =-.1463E+00
C0 = .1000E+04 CUNITS= ppm
IPOLL = 1 KS = .0000E+00 KD = .0000E+00

FLUX VARIABLES (metric units)
Q0 = .2502E-01 M0 = .1373E+00 J0 =-.3662E-02 SIGNJ0= -1.0
Associated length scales (meters)
LQ = .07 LM = 3.73 Lm = 1.29 Lb = .16
Lmp = 99999.00 Lbp = 99999.00

NON-DIMENSIONAL PARAMETERS
FR0 = 51.95 R = 19.15

FLOW CLASSIFICATION
1111111111111111111111111111111111111111
1 Flow class (CORMIX1) = NH5 1
1 Applicable layer depth HS = 1.16 1
1111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
C0 = .1000E+04 CUNITS= ppm

```
 NTOX  =  0
 NSTD  =  0
 REGMZ =  0
 XINT  =   1000.00  XMAX  =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         7.31 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

 COANDA ATTACHMENT immediately following the discharge.

       X        Y        Z        S        C        B
      .00      .00      .00     1.0  .100E+04     .05

END OF MOD101: DISCHARGE MODULE
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Bottom-attached jet motion.

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
          Half wall jet, attached to bottom.
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .00     1.0  .100E+04     .04
      .70      .00      .00     1.8  .565E+03     .11
     1.41      .00      .00     2.9  .344E+03     .16
     2.11      .00      .00     4.0  .249E+03     .22
     2.82      .00      .00     5.1  .195E+03     .26
     3.52      .00      .00     6.2  .162E+03     .31
     4.23      .00      .00     7.2  .138E+03     .35
     4.94      .00      .00     8.3  .121E+03     .39
     5.65      .00      .00     9.3  .107E+03     .42
     6.35      .00      .00    10.3  .970E+02     .45
     7.06      .00      .00    11.3  .886E+02     .48
     7.76      .00      .00    12.3  .816E+02     .51
     8.47      .00      .00    13.2  .758E+02     .54
     9.17      .00      .00    14.1  .707E+02     .57
     9.89      .00      .00    15.1  .663E+02     .59
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10.59	.00	.00	16.0	.626E+02	.62
11.30	.00	.00	16.9	.592E+02	.64
12.00	.00	.00	17.8	.563E+02	.66
12.71	.00	.00	18.6	.536E+02	.69
13.41	.00	.00	19.5	.513E+02	.71
14.12	.00	.00	20.4	.491E+02	.73
14.83	.00	.00	21.2	.471E+02	.75
15.54	.00	.00	22.1	.453E+02	.77
16.24	.00	.00	22.9	.437E+02	.78
16.95	.00	.00	23.7	.422E+02	.80
17.65	.00	.00	24.5	.408E+02	.82
18.36	.00	.00	25.3	.395E+02	.84
19.06	.00	.00	26.1	.383E+02	.85
19.78	.00	.00	26.9	.371E+02	.87
20.48	.00	.00	27.7	.361E+02	.89
21.19	.00	.00	28.5	.351E+02	.90
21.89	.00	.00	29.2	.342E+02	.92
22.60	.00	.00	30.0	.333E+02	.93
23.30	.00	.00	30.8	.325E+02	.94
24.01	.00	.00	31.5	.317E+02	.96
24.72	.00	.00	32.3	.310E+02	.97
25.43	.00	.00	33.0	.303E+02	.99
26.13	.00	.00	33.7	.296E+02	1.00
26.84	.00	.00	34.5	.290E+02	1.01
27.54	.00	.00	35.2	.284E+02	1.03
28.24	.00	.00	35.9	.278E+02	1.04
28.95	.00	.00	36.6	.273E+02	1.05
29.67	.00	.00	37.3	.268E+02	1.06
30.37	.00	.00	38.0	.263E+02	1.08
31.07	.00	.00	38.7	.258E+02	1.09
31.78	.00	.00	39.4	.254E+02	1.10
32.48	.00	.00	40.1	.249E+02	1.11
33.19	.00	.00	40.8	.245E+02	1.12
33.89	.00	.00	41.5	.241E+02	1.13
34.61	.00	.00	42.2	.237E+02	1.14
35.31	.00	.00	42.9	.233E+02	1.16

Cumulative travel time = 56. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
35.31	.00	.00	42.9	.233E+02	1.16

Profile definitions:

MAC2-1X.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
34.16	.00	.00	42.9	.233E+02	.00	.00	.00	.00
34.39	.00	.00	42.9	.233E+02	1.16	.22	1.16	.00
34.62	.00	.00	42.9	.233E+02	1.16	.30	1.16	.00
34.85	.00	.00	42.9	.233E+02	1.16	.37	1.16	.00
35.08	.00	.00	42.9	.233E+02	1.16	.43	1.16	.00
35.31	.00	.00	42.9	.233E+02	1.16	.48	1.16	.00
35.55	.00	.00	45.4	.220E+02	1.16	.53	1.16	.00
35.78	.00	.00	51.0	.196E+02	1.16	.57	1.16	.00
36.01	.00	.00	55.9	.179E+02	1.16	.61	1.16	.00
36.24	.00	.00	58.7	.170E+02	1.16	.65	1.16	.00
36.47	.00	.00	60.0	.167E+02	1.16	.68	1.16	.00

Cumulative travel time = 60. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.32 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC2-1X.CX1

Profile definitions:
  BV = top-hat thickness, measured vertically
  BH = top-hat half-width, measured horizontally in Y-direction
  ZU = upper plume boundary (Z-coordinate)
  ZL = lower plume boundary (Z-coordinate)
  S = hydrodynamic average (bulk) dilution
  C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
36.47	.00	.00	60.0	.167E+02	1.16	2.26	1.16	.00
37.33	.00	.00	61.1	.164E+02	1.12	2.37	1.12	.00
38.19	.00	.00	62.2	.161E+02	1.09	2.48	1.09	.00
39.04	.00	.00	63.3	.158E+02	1.07	2.59	1.07	.00
39.90	.00	.00	64.5	.155E+02	1.04	2.69	1.04	.00
40.76	.00	.00	65.6	.152E+02	1.02	2.79	1.02	.00
41.62	.00	.00	66.8	.150E+02	1.01	2.89	1.01	.00
42.48	.00	.00	67.9	.147E+02	.99	2.99	.99	.00
43.34	.00	.00	69.1	.145E+02	.98	3.09	.98	.00
44.19	.00	.00	70.4	.142E+02	.96	3.18	.96	.00
45.05	.00	.00	71.6	.140E+02	.95	3.28	.95	.00
45.91	.00	.00	72.9	.137E+02	.94	3.37	.94	.00
46.77	.00	.00	74.2	.135E+02	.93	3.46	.93	.00
47.63	.00	.00	75.6	.132E+02	.93	3.55	.93	.00
48.49	.00	.00	77.0	.130E+02	.92	3.64	.92	.00
49.34	.00	.00	78.4	.127E+02	.92	3.73	.92	.00
50.20	.00	.00	79.9	.125E+02	.91	3.81	.91	.00
51.06	.00	.00	81.4	.123E+02	.91	3.90	.91	.00
51.92	.00	.00	83.0	.121E+02	.91	3.98	.91	.00
52.78	.00	.00	84.6	.118E+02	.91	4.07	.91	.00
53.64	.00	.00	86.2	.116E+02	.90	4.15	.90	.00
54.49	.00	.00	87.9	.114E+02	.90	4.23	.90	.00
55.35	.00	.00	89.6	.112E+02	.90	4.32	.90	.00
56.21	.00	.00	91.4	.109E+02	.91	4.40	.91	.00
57.07	.00	.00	93.2	.107E+02	.91	4.48	.91	.00
57.93	.00	.00	95.1	.105E+02	.91	4.56	.91	.00
58.78	.00	.00	97.0	.103E+02	.91	4.63	.91	.00
59.64	.00	.00	99.0	.101E+02	.92	4.71	.92	.00
60.50	.00	.00	101.0	.990E+01	.92	4.79	.92	.00
61.36	.00	.00	103.1	.970E+01	.92	4.87	.92	.00
62.22	.00	.00	105.2	.951E+01	.93	4.94	.93	.00
63.08	.00	.00	107.4	.931E+01	.93	5.02	.93	.00
63.93	.00	.00	109.6	.913E+01	.94	5.09	.94	.00
64.79	.00	.00	111.9	.894E+01	.94	5.17	.94	.00
65.65	.00	.00	114.2	.876E+01	.95	5.24	.95	.00
66.51	.00	.00	116.6	.858E+01	.96	5.31	.96	.00
67.37	.00	.00	119.0	.840E+01	.96	5.39	.96	.00

68.23	.00	.00	121.5	.823E+01	.97	5.46	.97	.00
69.08	.00	.00	124.1	.806E+01	.98	5.53	.98	.00
69.94	.00	.00	126.7	.789E+01	.99	5.60	.99	.00
70.80	.00	.00	129.4	.773E+01	.99	5.67	.99	.00
71.66	.00	.00	132.1	.757E+01	1.00	5.74	1.00	.00
72.52	.00	.00	134.9	.741E+01	1.01	5.81	1.01	.00
73.38	.00	.00	137.8	.726E+01	1.02	5.88	1.02	.00
74.23	.00	.00	140.7	.711E+01	1.03	5.95	1.03	.00
75.09	.00	.00	143.6	.696E+01	1.04	6.02	1.04	.00
75.95	.00	.00	146.7	.682E+01	1.05	6.09	1.05	.00
76.81	.00	.00	149.8	.668E+01	1.06	6.16	1.06	.00
77.67	.00	.00	152.9	.654E+01	1.07	6.23	1.07	.00
78.53	.00	.00	156.1	.641E+01	1.08	6.29	1.08	.00
79.38	.00	.00	159.4	.627E+01	1.09	6.36	1.09	.00

Cumulative travel time = 210. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .709E-02 m^2/s
Horizontal diffusivity (initial value) = .177E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
79.38	.00	.00	159.4	.627E+01	1.09	6.36	1.09	.00
80.72	.00	.00	163.2	.613E+01	1.11	6.38	1.11	.00
82.05	.00	.00	167.1	.598E+01	1.14	6.40	1.14	.00
83.38	.00	.00	170.3	.587E+01	1.16	6.42	1.16	.00
84.72	.00	.00	170.8	.586E+01	1.16	6.44	1.16	.00
86.05	.00	.00	171.3	.584E+01	1.16	6.46	1.16	.00
87.38	.00	.00	171.9	.582E+01	1.16	6.48	1.16	.00
88.72	.00	.00	172.4	.580E+01	1.16	6.50	1.16	.00
90.05	.00	.00	172.9	.578E+01	1.16	6.52	1.16	.00
91.38	.00	.00	173.4	.577E+01	1.16	6.54	1.16	.00
92.72	.00	.00	174.0	.575E+01	1.16	6.56	1.16	.00
94.05	.00	.00	174.5	.573E+01	1.16	6.58	1.16	.00

95.38	.00	.00	175.0	.571E+01	1.16	6.60	1.16	.00
96.72	.00	.00	175.5	.570E+01	1.16	6.62	1.16	.00
98.05	.00	.00	176.0	.568E+01	1.16	6.64	1.16	.00
99.38	.00	.00	176.5	.566E+01	1.16	6.66	1.16	.00
100.72	.00	.00	177.1	.565E+01	1.16	6.68	1.16	.00
102.05	.00	.00	177.6	.563E+01	1.16	6.70	1.16	.00
103.38	.00	.00	178.1	.562E+01	1.16	6.72	1.16	.00
104.71	.00	.00	178.6	.560E+01	1.16	6.74	1.16	.00
106.05	.00	.00	179.1	.558E+01	1.16	6.75	1.16	.00
107.38	.00	.00	179.6	.557E+01	1.16	6.77	1.16	.00
108.71	.00	.00	180.1	.555E+01	1.16	6.79	1.16	.00
110.05	.00	.00	180.6	.554E+01	1.16	6.81	1.16	.00
111.38	.00	.00	181.1	.552E+01	1.16	6.83	1.16	.00
112.71	.00	.00	181.6	.551E+01	1.16	6.85	1.16	.00
114.05	.00	.00	182.1	.549E+01	1.16	6.87	1.16	.00
115.38	.00	.00	182.6	.548E+01	1.16	6.89	1.16	.00
116.71	.00	.00	183.1	.546E+01	1.16	6.91	1.16	.00
118.05	.00	.00	183.6	.545E+01	1.16	6.92	1.16	.00
119.38	.00	.00	184.1	.543E+01	1.16	6.94	1.16	.00
120.71	.00	.00	184.6	.542E+01	1.16	6.96	1.16	.00
122.05	.00	.00	185.1	.540E+01	1.16	6.98	1.16	.00
123.38	.00	.00	185.6	.539E+01	1.16	7.00	1.16	.00
124.71	.00	.00	186.1	.537E+01	1.16	7.02	1.16	.00
126.05	.00	.00	186.6	.536E+01	1.16	7.04	1.16	.00
127.38	.00	.00	187.0	.535E+01	1.16	7.05	1.16	.00
128.71	.00	.00	187.5	.533E+01	1.16	7.07	1.16	.00
130.05	.00	.00	188.0	.532E+01	1.16	7.09	1.16	.00
131.38	.00	.00	188.5	.531E+01	1.16	7.11	1.16	.00
132.71	.00	.00	189.0	.529E+01	1.16	7.13	1.16	.00
134.05	.00	.00	189.5	.528E+01	1.16	7.14	1.16	.00
135.38	.00	.00	189.9	.527E+01	1.16	7.16	1.16	.00
136.71	.00	.00	190.4	.525E+01	1.16	7.18	1.16	.00
138.05	.00	.00	190.9	.524E+01	1.16	7.20	1.16	.00
139.38	.00	.00	191.4	.523E+01	1.16	7.22	1.16	.00
140.71	.00	.00	191.8	.521E+01	1.16	7.23	1.16	.00
142.05	.00	.00	192.3	.520E+01	1.16	7.25	1.16	.00
143.38	.00	.00	192.8	.519E+01	1.16	7.27	1.16	.00
144.71	.00	.00	193.2	.517E+01	1.16	7.29	1.16	.00
146.04	.00	.00	193.7	.516E+01	1.16	7.31	1.16	.00

Cumulative travel time = 442. sec

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
146.04	7.31	.00	193.7	.516E+01	1.16	14.61	1.16	.00
163.12	7.31	.00	195.2	.512E+01	1.16	14.72	1.16	.00
180.20	7.31	.00	196.7	.508E+01	1.16	14.84	1.16	.00
197.28	7.31	.00	198.2	.505E+01	1.16	14.95	1.16	.00

MAC2-1X.CX1

214.36	7.31	.00	199.6	.501E+01	1.16	15.06	1.16	.00
231.44	7.31	.00	201.1	.497E+01	1.16	15.17	1.16	.00
248.52	7.31	.00	202.5	.494E+01	1.16	15.28	1.16	.00
265.60	7.31	.00	204.0	.490E+01	1.16	15.38	1.16	.00
282.68	7.31	.00	205.4	.487E+01	1.16	15.49	1.16	.00
299.76	7.31	.00	206.8	.484E+01	1.16	15.60	1.16	.00
316.84	7.31	.00	208.2	.480E+01	1.16	15.70	1.16	.00
333.92	7.31	.00	209.6	.477E+01	1.16	15.81	1.16	.00
350.99	7.31	.00	211.0	.474E+01	1.16	15.91	1.16	.00
368.07	7.31	.00	212.3	.471E+01	1.16	16.02	1.16	.00
385.15	7.31	.00	213.7	.468E+01	1.16	16.12	1.16	.00
402.23	7.31	.00	215.1	.465E+01	1.16	16.22	1.16	.00
419.31	7.31	.00	216.4	.462E+01	1.16	16.32	1.16	.00
436.39	7.31	.00	217.8	.459E+01	1.16	16.42	1.16	.00
453.47	7.31	.00	219.1	.456E+01	1.16	16.53	1.16	.00
470.55	7.31	.00	220.4	.454E+01	1.16	16.63	1.16	.00
487.63	7.31	.00	221.7	.451E+01	1.16	16.72	1.16	.00
504.71	7.31	.00	223.0	.448E+01	1.16	16.82	1.16	.00
521.79	7.31	.00	224.3	.446E+01	1.16	16.92	1.16	.00
538.86	7.31	.00	225.6	.443E+01	1.16	17.02	1.16	.00
555.94	7.31	.00	226.9	.441E+01	1.16	17.12	1.16	.00
573.02	7.31	.00	228.2	.438E+01	1.16	17.21	1.16	.00
590.10	7.31	.00	229.5	.436E+01	1.16	17.31	1.16	.00
607.18	7.31	.00	230.7	.433E+01	1.16	17.40	1.16	.00
624.26	7.31	.00	232.0	.431E+01	1.16	17.50	1.16	.00
641.34	7.31	.00	233.2	.429E+01	1.16	17.59	1.16	.00
658.42	7.31	.00	234.5	.426E+01	1.16	17.69	1.16	.00
675.50	7.31	.00	235.7	.424E+01	1.16	17.78	1.16	.00
692.58	7.31	.00	237.0	.422E+01	1.16	17.87	1.16	.00
709.66	7.31	.00	238.2	.420E+01	1.16	17.96	1.16	.00
726.73	7.31	.00	239.4	.418E+01	1.16	18.06	1.16	.00
743.81	7.31	.00	240.6	.416E+01	1.16	18.15	1.16	.00
760.89	7.31	.00	241.8	.414E+01	1.16	18.24	1.16	.00
777.97	7.31	.00	243.0	.412E+01	1.16	18.33	1.16	.00
795.05	7.31	.00	244.2	.409E+01	1.16	18.42	1.16	.00
812.13	7.31	.00	245.4	.408E+01	1.16	18.51	1.16	.00
829.21	7.31	.00	246.6	.406E+01	1.16	18.60	1.16	.00
846.29	7.31	.00	247.8	.404E+01	1.16	18.69	1.16	.00
863.37	7.31	.00	248.9	.402E+01	1.16	18.78	1.16	.00
880.45	7.31	.00	250.1	.400E+01	1.16	18.86	1.16	.00
897.53	7.31	.00	251.3	.398E+01	1.16	18.95	1.16	.00
914.60	7.31	.00	252.4	.396E+01	1.16	19.04	1.16	.00
931.68	7.31	.00	253.6	.394E+01	1.16	19.13	1.16	.00
948.76	7.31	.00	254.7	.393E+01	1.16	19.21	1.16	.00
965.84	7.31	.00	255.8	.391E+01	1.16	19.30	1.16	.00
982.92	7.31	.00	257.0	.389E+01	1.16	19.38	1.16	.00
1000.00	7.31	.00	258.1	.387E+01	1.16	19.47	1.16	.00

Cumulative travel time = 3416. sec

MAC2-1X.CX1

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

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MAC3-1N.CX1

CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111

CORNELL MIXING ZONE EXPERT SYSTEM

Subsystem CORMIX1: Subsystem version:
Submerged Single Port Discharges CORMIX_v.3.20_____September_1996

CASE DESCRIPTION
Site name/label: Mach^Big^Muddy^River
Design case: Case^3^-^Port^1^Normal^Flow
FILE NAME: cormix\sim\Mac3-1N .cx1
Time of Fortran run: 11/08/16--09:45:12

ENVIRONMENT PARAMETERS (metric units)
Bounded section
BS = 33.47 AS = 38.66 QA = 11.08 ICHREG= 2
HA = 1.16 HD = 1.16
UA = .287 F = .092 USTAR = .3066E-01
UW = 2.000 UWSTAR= .2198E-02
Uniform density environment
STRCND= U RHOAM = 998.4901

DISCHARGE PARAMETERS (metric units)
BANK = LEFT DISTB = 5.23
D0 = .076 A0 = .005 H0 = .10
THETA = 15.00 SIGMA = .00
U0 = 1.413 Q0 = .006 = .6441E-02
RHO0 = 1013.3900 DRHO0 =-.1490E+02 GP0 =-.1463E+00
C0 = .1000E+04 CUNITS= ppm
IPOLL = 1 KS = .0000E+00 KD = .0000E+00

FLUX VARIABLES (metric units)
Q0 = .6441E-02 M0 = .9099E-02 J0 =-.9427E-03 SIGNJ0= -1.0
Associated length scales (meters)
LQ = .07 LM = .96 Lm = .33 Lb = .04
Lmp = 99999.00 Lbp = 99999.00

NON-DIMENSIONAL PARAMETERS
FR0 = 13.37 R = 4.93

FLOW CLASSIFICATION
1111111111111111111111111111111111111111
1 Flow class (CORMIX1) = NH4 1
1 Applicable layer depth HS = 1.16 1
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MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
C0 = .1000E+04 CUNITS= ppm

MAC3-1N.CX1

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         5.23 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z        S        C        B
      .00      .00      .10     1.0  .100E+04     .04

END OF MOD101: DISCHARGE MODULE
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet/plume transition motion in strong crossflow.

 Zone of flow establishment:            THETAE=     14.04  SIGMAE=       .00
  LE    =       .32  XE    =       .31  YE    =       .00  ZE    =       .18

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .10     1.0  .100E+04     .04
      .31      .00      .18     1.0  .100E+04     .04
      .36      .00      .19     1.0  .961E+03     .04
      .41      .00      .20     1.2  .842E+03     .05
      .46      .00      .21     1.3  .750E+03     .05
      .52      .00      .22     1.5  .672E+03     .06
      .57      .00      .23     1.6  .613E+03     .06
      .62      .00      .24     1.8  .564E+03     .07
      .68      .00      .25     1.9  .521E+03     .07
      .73      .00      .25     2.1  .487E+03     .07
      .78      .00      .26     2.2  .457E+03     .08
      .84      .00      .27     2.3  .432E+03     .08
      .89      .00      .27     2.4  .408E+03     .08
      .95      .00      .28     2.6  .389E+03     .09
     1.00      .00      .28     2.7  .372E+03     .09
```

1.06	.00	.28	2.8	.356E+03	.09
1.11	.00	.29	2.9	.343E+03	.09
1.16	.00	.29	3.0	.331E+03	.10
1.22	.00	.29	3.1	.321E+03	.10
1.27	.00	.29	3.2	.311E+03	.10
1.33	.00	.29	3.3	.302E+03	.10
1.38	.00	.29	3.4	.294E+03	.10
1.44	.00	.29	3.5	.287E+03	.11

Maximum jet height has been reached.

1.49	.00	.29	3.6	.281E+03	.11
1.54	.00	.29	3.6	.274E+03	.11
1.60	.00	.29	3.7	.268E+03	.11
1.65	.00	.29	3.8	.261E+03	.11
1.70	.00	.29	3.9	.255E+03	.12
1.76	.00	.29	4.0	.248E+03	.12
1.81	.00	.29	4.1	.242E+03	.12
1.87	.00	.28	4.2	.236E+03	.12
1.92	.00	.28	4.4	.229E+03	.12
1.97	.00	.28	4.5	.224E+03	.13
2.03	.00	.27	4.6	.217E+03	.13
2.08	.00	.27	4.7	.212E+03	.13
2.14	.00	.26	4.9	.206E+03	.13
2.19	.00	.26	5.0	.200E+03	.13
2.25	.00	.26	5.1	.195E+03	.14
2.30	.00	.25	5.3	.190E+03	.14
2.35	.00	.25	5.4	.185E+03	.14
2.41	.00	.24	5.6	.180E+03	.14
2.46	.00	.24	5.7	.175E+03	.15
2.51	.00	.23	5.9	.170E+03	.15
2.57	.00	.22	6.0	.166E+03	.15
2.62	.00	.22	6.2	.161E+03	.15
2.68	.00	.21	6.4	.157E+03	.16
2.73	.00	.21	6.5	.153E+03	.16
2.79	.00	.20	6.7	.149E+03	.16
2.84	.00	.19	6.9	.145E+03	.16
2.89	.00	.19	7.1	.142E+03	.17
2.95	.00	.18	7.2	.138E+03	.17
3.00	.00	.17	7.4	.135E+03	.17

Cumulative travel time = 4. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

Control volume inflow:

X	Y	Z	S	C	B
3.00	.00	.17	7.4	.135E+03	.17

MAC3-1N.CX1

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
2.83	.00	.00	7.4	.135E+03	.00	.00	.00	.00
2.88	.00	.00	7.4	.135E+03	.24	.12	.24	.00
2.93	.00	.00	7.4	.135E+03	.28	.17	.28	.00
2.98	.00	.00	7.4	.135E+03	.31	.21	.31	.00
3.03	.00	.00	7.6	.131E+03	.33	.24	.33	.00
3.09	.00	.00	8.6	.117E+03	.35	.27	.35	.00
3.14	.00	.00	9.9	.101E+03	.36	.29	.36	.00
3.19	.00	.00	11.1	.903E+02	.37	.32	.37	.00
3.24	.00	.00	11.9	.841E+02	.37	.34	.37	.00
3.29	.00	.00	12.3	.811E+02	.38	.36	.38	.00
3.34	.00	.00	12.6	.792E+02	.38	.38	.38	.00

Cumulative travel time = 5. sec

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

** End of NEAR-FIELD REGION (NFR) **

BEGIN MOD141: BUOYANT AMBIENT SPREADING

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
3.34	.00	.00	12.6	.792E+02	.38	.38	.38	.00
3.63	.00	.00	13.0	.767E+02	.35	.42	.35	.00
3.92	.00	.00	13.4	.744E+02	.32	.47	.32	.00
4.21	.00	.00	13.8	.724E+02	.31	.51	.31	.00
4.49	.00	.00	14.2	.705E+02	.29	.55	.29	.00
4.78	.00	.00	14.5	.688E+02	.28	.58	.28	.00
5.07	.00	.00	14.9	.671E+02	.27	.62	.27	.00
5.36	.00	.00	15.3	.656E+02	.26	.66	.26	.00
5.65	.00	.00	15.6	.640E+02	.25	.69	.25	.00

5.94	.00	.00	16.0	.625E+02	.25	.73	.25	.00
6.22	.00	.00	16.4	.611E+02	.24	.76	.24	.00
6.51	.00	.00	16.8	.596E+02	.24	.79	.24	.00
6.80	.00	.00	17.2	.582E+02	.23	.83	.23	.00
7.09	.00	.00	17.6	.569E+02	.23	.86	.23	.00
7.38	.00	.00	18.0	.555E+02	.23	.89	.23	.00
7.66	.00	.00	18.5	.542E+02	.23	.92	.23	.00
7.95	.00	.00	18.9	.528E+02	.22	.95	.22	.00
8.24	.00	.00	19.4	.515E+02	.22	.98	.22	.00
8.53	.00	.00	19.9	.502E+02	.22	1.01	.22	.00
8.82	.00	.00	20.4	.490E+02	.22	1.03	.22	.00
9.11	.00	.00	21.0	.477E+02	.22	1.06	.22	.00
9.39	.00	.00	21.5	.465E+02	.22	1.09	.22	.00
9.68	.00	.00	22.1	.453E+02	.22	1.12	.22	.00
9.97	.00	.00	22.7	.441E+02	.22	1.14	.22	.00
10.26	.00	.00	23.3	.429E+02	.22	1.17	.22	.00
10.55	.00	.00	23.9	.418E+02	.22	1.20	.22	.00
10.83	.00	.00	24.6	.406E+02	.23	1.22	.23	.00
11.12	.00	.00	25.3	.395E+02	.23	1.25	.23	.00
11.41	.00	.00	26.0	.385E+02	.23	1.28	.23	.00
11.70	.00	.00	26.7	.374E+02	.23	1.30	.23	.00
11.99	.00	.00	27.5	.364E+02	.23	1.33	.23	.00
12.28	.00	.00	28.2	.354E+02	.24	1.35	.24	.00
12.56	.00	.00	29.0	.344E+02	.24	1.38	.24	.00
12.85	.00	.00	29.9	.335E+02	.24	1.40	.24	.00
13.14	.00	.00	30.7	.326E+02	.24	1.42	.24	.00
13.43	.00	.00	31.6	.317E+02	.25	1.45	.25	.00
13.72	.00	.00	32.5	.308E+02	.25	1.47	.25	.00
14.00	.00	.00	33.4	.299E+02	.25	1.50	.25	.00
14.29	.00	.00	34.4	.291E+02	.25	1.52	.25	.00
14.58	.00	.00	35.4	.283E+02	.26	1.54	.26	.00
14.87	.00	.00	36.4	.275E+02	.26	1.57	.26	.00
15.16	.00	.00	37.4	.267E+02	.26	1.59	.26	.00
15.45	.00	.00	38.4	.260E+02	.27	1.61	.27	.00
15.73	.00	.00	39.5	.253E+02	.27	1.63	.27	.00
16.02	.00	.00	40.6	.246E+02	.28	1.66	.28	.00
16.31	.00	.00	41.8	.239E+02	.28	1.68	.28	.00
16.60	.00	.00	43.0	.233E+02	.28	1.70	.28	.00
16.89	.00	.00	44.1	.227E+02	.29	1.72	.29	.00
17.17	.00	.00	45.4	.220E+02	.29	1.74	.29	.00
17.46	.00	.00	46.6	.214E+02	.30	1.77	.30	.00
17.75	.00	.00	47.9	.209E+02	.30	1.79	.30	.00

Cumulative travel time = 56. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

MAC3-1N.CX1

Vertical diffusivity (initial value) = .709E-02 m^2/s
Horizontal diffusivity (initial value) = .177E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
17.75	.00	.00	47.9	.209E+02	.30	1.79	.30	.00
20.24	.00	.00	53.7	.186E+02	.31	1.92	.31	.00
22.73	.00	.00	60.1	.166E+02	.33	2.04	.33	.00
25.22	.00	.00	67.1	.149E+02	.35	2.16	.35	.00
27.71	.00	.00	74.9	.134E+02	.37	2.26	.37	.00
30.19	.00	.00	83.6	.120E+02	.40	2.37	.40	.00
32.68	.00	.00	93.5	.107E+02	.43	2.47	.43	.00
35.17	.00	.00	104.6	.956E+01	.46	2.56	.46	.00
37.66	.00	.00	117.2	.853E+01	.50	2.66	.50	.00
40.15	.00	.00	131.3	.761E+01	.54	2.75	.54	.00
42.64	.00	.00	147.0	.680E+01	.58	2.83	.58	.00
45.13	.00	.00	164.3	.609E+01	.63	2.92	.63	.00
47.62	.00	.00	183.0	.546E+01	.69	3.00	.69	.00
50.10	.00	.00	203.2	.492E+01	.74	3.08	.74	.00
52.59	.00	.00	224.6	.445E+01	.80	3.16	.80	.00
55.08	.00	.00	247.1	.405E+01	.86	3.23	.86	.00
57.57	.00	.00	270.4	.370E+01	.92	3.31	.92	.00
60.06	.00	.00	294.5	.340E+01	.98	3.38	.98	.00
62.55	.00	.00	319.3	.313E+01	1.04	3.45	1.04	.00
65.04	.00	.00	344.5	.290E+01	1.10	3.52	1.10	.00

Plume interacts with SURFACE.
The passive diffusion plume becomes VERTICALLY FULLY MIXED within this prediction interval.

67.52	.00	.00	368.5	.271E+01	1.16	3.59	1.16	.00
70.01	.00	.00	375.4	.266E+01	1.16	3.65	1.16	.00
72.50	.00	.00	382.1	.262E+01	1.16	3.72	1.16	.00
74.99	.00	.00	388.7	.257E+01	1.16	3.78	1.16	.00
77.48	.00	.00	395.2	.253E+01	1.16	3.85	1.16	.00
79.97	.00	.00	401.6	.249E+01	1.16	3.91	1.16	.00
82.46	.00	.00	407.9	.245E+01	1.16	3.97	1.16	.00
84.94	.00	.00	414.1	.241E+01	1.16	4.03	1.16	.00
87.43	.00	.00	420.3	.238E+01	1.16	4.09	1.16	.00

MAC3-1N.CX1

89.92	.00	.00	426.3	.235E+01	1.16	4.15	1.16	.00
92.41	.00	.00	432.2	.231E+01	1.16	4.21	1.16	.00
94.90	.00	.00	438.1	.228E+01	1.16	4.26	1.16	.00
97.39	.00	.00	443.9	.225E+01	1.16	4.32	1.16	.00
99.88	.00	.00	449.6	.222E+01	1.16	4.37	1.16	.00
102.37	.00	.00	455.2	.220E+01	1.16	4.43	1.16	.00
104.85	.00	.00	460.8	.217E+01	1.16	4.48	1.16	.00
107.34	.00	.00	466.3	.214E+01	1.16	4.54	1.16	.00
109.83	.00	.00	471.7	.212E+01	1.16	4.59	1.16	.00
112.32	.00	.00	477.1	.210E+01	1.16	4.64	1.16	.00
114.81	.00	.00	482.4	.207E+01	1.16	4.69	1.16	.00
117.30	.00	.00	487.7	.205E+01	1.16	4.75	1.16	.00
119.79	.00	.00	492.9	.203E+01	1.16	4.80	1.16	.00
122.27	.00	.00	498.1	.201E+01	1.16	4.85	1.16	.00
124.76	.00	.00	503.1	.199E+01	1.16	4.90	1.16	.00
127.25	.00	.00	508.2	.197E+01	1.16	4.95	1.16	.00
129.74	.00	.00	513.2	.195E+01	1.16	4.99	1.16	.00
132.23	.00	.00	518.1	.193E+01	1.16	5.04	1.16	.00
134.72	.00	.00	523.0	.191E+01	1.16	5.09	1.16	.00
137.21	.00	.00	527.9	.189E+01	1.16	5.14	1.16	.00
139.70	.00	.00	532.7	.188E+01	1.16	5.18	1.16	.00
142.18	.00	.00	537.5	.186E+01	1.16	5.23	1.16	.00

Cumulative travel time = 490. sec

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
142.18	5.23	.00	537.5	.186E+01	1.16	10.46	1.16	.00
159.34	5.23	.00	545.6	.183E+01	1.16	10.62	1.16	.00
176.50	5.23	.00	553.6	.181E+01	1.16	10.77	1.16	.00
193.65	5.23	.00	561.5	.178E+01	1.16	10.93	1.16	.00
210.81	5.23	.00	569.3	.176E+01	1.16	11.08	1.16	.00
227.97	5.23	.00	576.9	.173E+01	1.16	11.23	1.16	.00
245.12	5.23	.00	584.5	.171E+01	1.16	11.38	1.16	.00
262.28	5.23	.00	592.0	.169E+01	1.16	11.52	1.16	.00
279.43	5.23	.00	599.4	.167E+01	1.16	11.66	1.16	.00
296.59	5.23	.00	606.6	.165E+01	1.16	11.81	1.16	.00
313.75	5.23	.00	613.9	.163E+01	1.16	11.95	1.16	.00
330.90	5.23	.00	621.0	.161E+01	1.16	12.09	1.16	.00
348.06	5.23	.00	628.0	.159E+01	1.16	12.22	1.16	.00
365.22	5.23	.00	635.0	.157E+01	1.16	12.36	1.16	.00
382.37	5.23	.00	641.9	.156E+01	1.16	12.49	1.16	.00
399.53	5.23	.00	648.7	.154E+01	1.16	12.62	1.16	.00
416.68	5.23	.00	655.4	.153E+01	1.16	12.76	1.16	.00
433.84	5.23	.00	662.1	.151E+01	1.16	12.89	1.16	.00
451.00	5.23	.00	668.7	.150E+01	1.16	13.01	1.16	.00
468.15	5.23	.00	675.2	.148E+01	1.16	13.14	1.16	.00
485.31	5.23	.00	681.7	.147E+01	1.16	13.27	1.16	.00

502.47	5.23	.00	688.1	.145E+01	1.16	13.39	1.16	.00
519.62	5.23	.00	694.5	.144E+01	1.16	13.52	1.16	.00
536.78	5.23	.00	700.8	.143E+01	1.16	13.64	1.16	.00
553.94	5.23	.00	707.1	.141E+01	1.16	13.76	1.16	.00
571.09	5.23	.00	713.2	.140E+01	1.16	13.88	1.16	.00
588.25	5.23	.00	719.4	.139E+01	1.16	14.00	1.16	.00
605.40	5.23	.00	725.5	.138E+01	1.16	14.12	1.16	.00
622.56	5.23	.00	731.5	.137E+01	1.16	14.24	1.16	.00
639.72	5.23	.00	737.5	.136E+01	1.16	14.35	1.16	.00
656.87	5.23	.00	743.4	.135E+01	1.16	14.47	1.16	.00
674.03	5.23	.00	749.3	.133E+01	1.16	14.58	1.16	.00
691.19	5.23	.00	755.2	.132E+01	1.16	14.70	1.16	.00
708.34	5.23	.00	761.0	.131E+01	1.16	14.81	1.16	.00
725.50	5.23	.00	766.7	.130E+01	1.16	14.92	1.16	.00
742.65	5.23	.00	772.4	.129E+01	1.16	15.03	1.16	.00
759.81	5.23	.00	778.1	.129E+01	1.16	15.14	1.16	.00
776.97	5.23	.00	783.7	.128E+01	1.16	15.25	1.16	.00
794.12	5.23	.00	789.3	.127E+01	1.16	15.36	1.16	.00
811.28	5.23	.00	794.9	.126E+01	1.16	15.47	1.16	.00
828.44	5.23	.00	800.4	.125E+01	1.16	15.58	1.16	.00
845.59	5.23	.00	805.9	.124E+01	1.16	15.68	1.16	.00
862.75	5.23	.00	811.3	.123E+01	1.16	15.79	1.16	.00
879.91	5.23	.00	816.7	.122E+01	1.16	15.89	1.16	.00
897.06	5.23	.00	822.1	.122E+01	1.16	16.00	1.16	.00
914.22	5.23	.00	827.4	.121E+01	1.16	16.10	1.16	.00
931.37	5.23	.00	832.7	.120E+01	1.16	16.21	1.16	.00
948.53	5.23	.00	838.0	.119E+01	1.16	16.31	1.16	.00
965.69	5.23	.00	843.2	.119E+01	1.16	16.41	1.16	.00
982.84	5.23	.00	848.4	.118E+01	1.16	16.51	1.16	.00
1000.00	5.23	.00	853.6	.117E+01	1.16	16.61	1.16	.00

Cumulative travel time = 3482. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

11111111111111111111111111111111111111111111111111111111111111111111111111111

MAC3-1X.CX1

CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111

CORNELL MIXING ZONE EXPERT SYSTEM

Subsystem CORMIX1: Subsystem version:
Submerged Single Port Discharges CORMIX_v.3.20_____September_1996

CASE DESCRIPTION
Site name/label: Mach^Big^Muddy^River
Design case: Case^3^-^Port^1^Maximum^Flow
FILE NAME: cormix\sim\Mac3-1X .cx1
Time of Fortran run: 11/08/16--14:58:57

ENVIRONMENT PARAMETERS (metric units)
Bounded section
BS = 43.24 AS = 58.13 QA = 16.65 ICHREG= 2
HA = 1.34 HD = 1.34
UA = .287 F = .087 USTAR = .2989E-01
UW = 2.000 UWSTAR= .2198E-02
Uniform density environment
STRCND= U RHOAM = 998.4901

DISCHARGE PARAMETERS (metric units)
BANK = LEFT DISTB = 7.31
D0 = .076 A0 = .005 H0 = .15
THETA = 15.00 SIGMA = .00
U0 = 5.487 Q0 = .025 = .2502E-01
RHO0 = 1013.3900 DRHO0 =-.1490E+02 GP0 =-.1463E+00
C0 = .1000E+04 CUNITS= ppm
IPOLL = 1 KS = .0000E+00 KD = .0000E+00

FLUX VARIABLES (metric units)
Q0 = .2502E-01 M0 = .1373E+00 J0 =-.3662E-02 SIGNJ0= -1.0
Associated length scales (meters)
LQ = .07 LM = 3.73 Lm = 1.29 Lb = .16
Lmp = 99999.00 Lbp = 99999.00

NON-DIMENSIONAL PARAMETERS
FR0 = 51.95 R = 19.15

FLOW CLASSIFICATION
1111111111111111111111111111111111111111
1 Flow class (CORMIX1) = NH5 1
1 Applicable layer depth HS = 1.34 1
1111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
C0 = .1000E+04 CUNITS= ppm

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         7.31 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

 COANDA ATTACHMENT immediately following the discharge.

       X        Y        Z        S        C        B
      .00      .00      .00     1.0  .100E+04     .05

END OF MOD101: DISCHARGE MODULE
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Bottom-attached jet motion.

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
            Half wall jet, attached to bottom.
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .00     1.0  .100E+04     .04
      .98      .00      .00     2.2  .449E+03     .13
     1.97      .00      .00     3.8  .264E+03     .21
     2.95      .00      .00     5.3  .188E+03     .27
     3.94      .00      .00     6.8  .147E+03     .33
     4.93      .00      .00     8.3  .121E+03     .38
     5.91      .00      .00     9.7  .103E+03     .43
     6.89      .00      .00    11.1  .904E+02     .48
     7.89      .00      .00    12.4  .805E+02     .52
     8.87      .00      .00    13.7  .728E+02     .56
     9.85      .00      .00    15.0  .665E+02     .59
    10.84      .00      .00    16.3  .614E+02     .63
    11.83      .00      .00    17.6  .570E+02     .66
    12.82      .00      .00    18.8  .532E+02     .69
    13.80      .00      .00    20.0  .500E+02     .72
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14.78	.00	.00	21.2	.472E+02	.74
15.78	.00	.00	22.3	.447E+02	.77
16.76	.00	.00	23.5	.426E+02	.80
17.74	.00	.00	24.6	.406E+02	.82
18.73	.00	.00	25.7	.388E+02	.85
19.72	.00	.00	26.9	.372E+02	.87
20.70	.00	.00	28.0	.358E+02	.89
21.69	.00	.00	29.0	.345E+02	.91
22.68	.00	.00	30.1	.332E+02	.93
23.67	.00	.00	31.2	.321E+02	.95
24.65	.00	.00	32.2	.311E+02	.97
25.63	.00	.00	33.2	.301E+02	.99
26.63	.00	.00	34.3	.292E+02	1.01
27.61	.00	.00	35.3	.284E+02	1.03
28.59	.00	.00	36.3	.276E+02	1.05
29.58	.00	.00	37.3	.268E+02	1.06
30.57	.00	.00	38.2	.261E+02	1.08
31.56	.00	.00	39.2	.255E+02	1.10
32.54	.00	.00	40.2	.249E+02	1.11
33.52	.00	.00	41.1	.243E+02	1.13
34.52	.00	.00	42.1	.238E+02	1.14
35.50	.00	.00	43.0	.232E+02	1.16
36.48	.00	.00	44.0	.227E+02	1.17
37.47	.00	.00	44.9	.223E+02	1.19
38.46	.00	.00	45.8	.218E+02	1.20
39.44	.00	.00	46.7	.214E+02	1.22
40.43	.00	.00	47.6	.210E+02	1.23
41.42	.00	.00	48.6	.206E+02	1.24
42.41	.00	.00	49.4	.202E+02	1.26
43.39	.00	.00	50.3	.199E+02	1.27
44.37	.00	.00	51.2	.195E+02	1.28
45.37	.00	.00	52.1	.192E+02	1.30
46.35	.00	.00	53.0	.189E+02	1.31
47.33	.00	.00	53.8	.186E+02	1.32
48.32	.00	.00	54.7	.183E+02	1.33
49.31	.00	.00	55.5	.180E+02	1.34

Cumulative travel time = 88. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
49.31	.00	.00	55.5	.180E+02	1.34

Profile definitions:

MAC3-1X.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
47.97	.00	.00	55.5	.180E+02	.00	.00	.00	.00
48.24	.00	.00	55.5	.180E+02	1.34	.24	1.34	.00
48.50	.00	.00	55.5	.180E+02	1.34	.35	1.34	.00
48.77	.00	.00	55.5	.180E+02	1.34	.42	1.34	.00
49.04	.00	.00	55.5	.180E+02	1.34	.49	1.34	.00
49.31	.00	.00	55.5	.180E+02	1.34	.55	1.34	.00
49.58	.00	.00	58.8	.170E+02	1.34	.60	1.34	.00
49.85	.00	.00	66.1	.151E+02	1.34	.65	1.34	.00
50.12	.00	.00	72.5	.138E+02	1.34	.69	1.34	.00
50.39	.00	.00	76.1	.131E+02	1.34	.73	1.34	.00
50.66	.00	.00	77.8	.129E+02	1.34	.77	1.34	.00

Cumulative travel time = 94. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.26 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC3-1X.CX1

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
50.66	.00	.00	77.8	.129E+02	1.34	2.52	1.34	.00
51.72	.00	.00	79.3	.126E+02	1.30	2.65	1.30	.00
52.79	.00	.00	80.9	.124E+02	1.27	2.78	1.27	.00
53.86	.00	.00	82.4	.121E+02	1.24	2.90	1.24	.00
54.93	.00	.00	84.0	.119E+02	1.21	3.03	1.21	.00
56.00	.00	.00	85.6	.117E+02	1.19	3.15	1.19	.00
57.06	.00	.00	87.2	.115E+02	1.17	3.26	1.17	.00
58.13	.00	.00	88.9	.112E+02	1.15	3.38	1.15	.00
59.20	.00	.00	90.6	.110E+02	1.13	3.49	1.13	.00
60.27	.00	.00	92.4	.108E+02	1.12	3.60	1.12	.00
61.34	.00	.00	94.2	.106E+02	1.11	3.71	1.11	.00
62.41	.00	.00	96.0	.104E+02	1.10	3.82	1.10	.00
63.47	.00	.00	97.9	.102E+02	1.09	3.93	1.09	.00
64.54	.00	.00	99.9	.100E+02	1.08	4.03	1.08	.00
65.61	.00	.00	101.9	.981E+01	1.07	4.14	1.07	.00
66.68	.00	.00	104.0	.962E+01	1.07	4.24	1.07	.00
67.75	.00	.00	106.1	.942E+01	1.07	4.34	1.07	.00
68.81	.00	.00	108.3	.923E+01	1.06	4.44	1.06	.00
69.88	.00	.00	110.6	.904E+01	1.06	4.54	1.06	.00
70.95	.00	.00	112.9	.885E+01	1.06	4.64	1.06	.00
72.02	.00	.00	115.3	.867E+01	1.06	4.74	1.06	.00
73.09	.00	.00	117.8	.849E+01	1.06	4.83	1.06	.00
74.16	.00	.00	120.3	.831E+01	1.06	4.93	1.06	.00
75.22	.00	.00	123.0	.813E+01	1.07	5.02	1.07	.00
76.29	.00	.00	125.6	.796E+01	1.07	5.11	1.07	.00
77.36	.00	.00	128.4	.779E+01	1.08	5.21	1.08	.00
78.43	.00	.00	131.2	.762E+01	1.08	5.30	1.08	.00
79.50	.00	.00	134.2	.745E+01	1.09	5.39	1.09	.00
80.56	.00	.00	137.2	.729E+01	1.09	5.48	1.09	.00
81.63	.00	.00	140.2	.713E+01	1.10	5.57	1.10	.00
82.70	.00	.00	143.4	.697E+01	1.11	5.66	1.11	.00
83.77	.00	.00	146.6	.682E+01	1.11	5.74	1.11	.00
84.84	.00	.00	149.9	.667E+01	1.12	5.83	1.12	.00
85.91	.00	.00	153.3	.652E+01	1.13	5.92	1.13	.00
86.97	.00	.00	156.8	.638E+01	1.14	6.00	1.14	.00
88.04	.00	.00	160.4	.623E+01	1.15	6.09	1.15	.00
89.11	.00	.00	164.1	.610E+01	1.16	6.17	1.16	.00

90.18	.00	.00	167.8	.596E+01	1.17	6.26	1.17	.00
91.25	.00	.00	171.6	.583E+01	1.18	6.34	1.18	.00
92.31	.00	.00	175.6	.570E+01	1.19	6.43	1.19	.00
93.38	.00	.00	179.6	.557E+01	1.20	6.51	1.20	.00
94.45	.00	.00	183.7	.544E+01	1.22	6.59	1.22	.00
95.52	.00	.00	187.9	.532E+01	1.23	6.67	1.23	.00
96.59	.00	.00	192.1	.520E+01	1.24	6.75	1.24	.00
97.66	.00	.00	196.5	.509E+01	1.25	6.83	1.25	.00
98.72	.00	.00	201.0	.498E+01	1.27	6.91	1.27	.00
99.79	.00	.00	205.5	.487E+01	1.28	6.99	1.28	.00
100.86	.00	.00	210.2	.476E+01	1.30	7.07	1.30	.00
101.93	.00	.00	215.0	.465E+01	1.31	7.15	1.31	.00
103.00	.00	.00	219.8	.455E+01	1.33	7.23	1.33	.00
104.06	.00	.00	224.7	.445E+01	1.34	7.31	1.34	.00

Cumulative travel time = 280. sec

Plume is ATTACHED to LEFT bank/shore.
Plume width is now determined from LEFT bank/shore.

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
104.06	7.31	.00	224.7	.445E+01	1.34	14.61	1.34	.00
104.07	7.31	.00	224.8	.445E+01	1.34	14.61	1.34	.00
104.07	7.31	.00	224.8	.445E+01	1.34	14.61	1.34	.00
104.08	7.31	.00	224.8	.445E+01	1.34	14.61	1.34	.00
104.08	7.31	.00	224.8	.445E+01	1.34	14.61	1.34	.00
104.08	7.31	.00	224.8	.445E+01	1.34	14.61	1.34	.00
104.09	7.31	.00	224.8	.445E+01	1.34	14.61	1.34	.00
104.09	7.31	.00	224.9	.445E+01	1.34	14.61	1.34	.00
104.09	7.31	.00	224.9	.445E+01	1.34	14.61	1.34	.00
104.10	7.31	.00	224.9	.445E+01	1.34	14.61	1.34	.00
104.10	7.31	.00	224.9	.445E+01	1.34	14.61	1.34	.00
104.10	7.31	.00	224.9	.445E+01	1.34	14.61	1.34	.00
104.11	7.31	.00	224.9	.445E+01	1.34	14.61	1.34	.00
104.11	7.31	.00	224.9	.445E+01	1.34	14.61	1.34	.00
104.11	7.31	.00	225.0	.445E+01	1.34	14.62	1.34	.00
104.12	7.31	.00	225.0	.444E+01	1.34	14.62	1.34	.00
104.12	7.31	.00	225.0	.444E+01	1.34	14.62	1.34	.00
104.12	7.31	.00	225.0	.444E+01	1.34	14.62	1.34	.00
104.13	7.31	.00	225.0	.444E+01	1.34	14.62	1.34	.00
104.13	7.31	.00	225.0	.444E+01	1.34	14.62	1.34	.00
104.13	7.31	.00	225.1	.444E+01	1.34	14.62	1.34	.00
104.14	7.31	.00	225.1	.444E+01	1.34	14.62	1.34	.00
104.14	7.31	.00	225.1	.444E+01	1.34	14.62	1.34	.00
104.15	7.31	.00	225.1	.444E+01	1.34	14.62	1.34	.00
104.15	7.31	.00	225.1	.444E+01	1.34	14.62	1.34	.00
104.15	7.31	.00	225.1	.444E+01	1.34	14.62	1.34	.00

104.16	7.31	.00	225.1	.444E+01	1.34	14.62	1.34	.00
104.16	7.31	.00	225.2	.444E+01	1.34	14.62	1.34	.00
104.16	7.31	.00	225.2	.444E+01	1.34	14.62	1.34	.00
104.17	7.31	.00	225.2	.444E+01	1.34	14.62	1.34	.00
104.17	7.31	.00	225.2	.444E+01	1.34	14.62	1.34	.00
104.17	7.31	.00	225.2	.444E+01	1.34	14.62	1.34	.00
104.18	7.31	.00	225.2	.444E+01	1.34	14.62	1.34	.00
104.18	7.31	.00	225.3	.444E+01	1.34	14.62	1.34	.00
104.18	7.31	.00	225.3	.444E+01	1.34	14.62	1.34	.00
104.19	7.31	.00	225.3	.444E+01	1.34	14.62	1.34	.00
104.19	7.31	.00	225.3	.444E+01	1.34	14.62	1.34	.00
104.19	7.31	.00	225.3	.444E+01	1.34	14.62	1.34	.00
104.20	7.31	.00	225.3	.444E+01	1.34	14.62	1.34	.00
104.20	7.31	.00	225.3	.444E+01	1.34	14.62	1.34	.00
104.20	7.31	.00	225.4	.444E+01	1.34	14.62	1.34	.00
104.21	7.31	.00	225.4	.444E+01	1.34	14.62	1.34	.00
104.21	7.31	.00	225.4	.444E+01	1.34	14.62	1.34	.00
104.22	7.31	.00	225.4	.444E+01	1.34	14.62	1.34	.00
104.22	7.31	.00	225.4	.444E+01	1.34	14.62	1.34	.00
104.22	7.31	.00	225.4	.444E+01	1.34	14.62	1.34	.00
104.23	7.31	.00	225.5	.444E+01	1.34	14.62	1.34	.00
104.23	7.31	.00	225.5	.444E+01	1.34	14.62	1.34	.00
104.23	7.31	.00	225.5	.443E+01	1.34	14.62	1.34	.00
104.24	7.31	.00	225.5	.443E+01	1.34	14.62	1.34	.00
104.24	7.31	.00	225.5	.443E+01	1.34	14.62	1.34	.00

Cumulative travel time = 280. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .804E-02 m^2/s
Horizontal diffusivity (initial value) = .201E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
104.24	7.31	.00	225.5	.443E+01	1.34	14.62	1.34	.00

MAC3-1X.CX1

122.15	7.31	.00	227.6	.439E+01	1.34	14.76	1.34	.00
140.07	7.31	.00	229.6	.435E+01	1.34	14.89	1.34	.00
157.99	7.31	.00	231.7	.432E+01	1.34	15.02	1.34	.00
175.90	7.31	.00	233.7	.428E+01	1.34	15.15	1.34	.00
193.82	7.31	.00	235.7	.424E+01	1.34	15.28	1.34	.00
211.73	7.31	.00	237.7	.421E+01	1.34	15.41	1.34	.00
229.65	7.31	.00	239.6	.417E+01	1.34	15.54	1.34	.00
247.56	7.31	.00	241.6	.414E+01	1.34	15.67	1.34	.00
265.48	7.31	.00	243.5	.411E+01	1.34	15.79	1.34	.00
283.39	7.31	.00	245.4	.407E+01	1.34	15.92	1.34	.00
301.31	7.31	.00	247.3	.404E+01	1.34	16.04	1.34	.00
319.22	7.31	.00	249.2	.401E+01	1.34	16.16	1.34	.00
337.14	7.31	.00	251.1	.398E+01	1.34	16.28	1.34	.00
355.05	7.31	.00	253.0	.395E+01	1.34	16.40	1.34	.00
372.97	7.31	.00	254.8	.392E+01	1.34	16.52	1.34	.00
390.88	7.31	.00	256.6	.390E+01	1.34	16.64	1.34	.00
408.80	7.31	.00	258.5	.387E+01	1.34	16.76	1.34	.00
426.71	7.31	.00	260.3	.384E+01	1.34	16.88	1.34	.00
444.63	7.31	.00	262.1	.382E+01	1.34	16.99	1.34	.00
462.54	7.31	.00	263.9	.379E+01	1.34	17.11	1.34	.00
480.46	7.31	.00	265.6	.376E+01	1.34	17.22	1.34	.00
498.37	7.31	.00	267.4	.374E+01	1.34	17.34	1.34	.00
516.29	7.31	.00	269.1	.372E+01	1.34	17.45	1.34	.00
534.20	7.31	.00	270.9	.369E+01	1.34	17.56	1.34	.00
552.12	7.31	.00	272.6	.367E+01	1.34	17.68	1.34	.00
570.04	7.31	.00	274.3	.365E+01	1.34	17.79	1.34	.00
587.95	7.31	.00	276.0	.362E+01	1.34	17.90	1.34	.00
605.87	7.31	.00	277.7	.360E+01	1.34	18.01	1.34	.00
623.78	7.31	.00	279.4	.358E+01	1.34	18.12	1.34	.00
641.70	7.31	.00	281.1	.356E+01	1.34	18.23	1.34	.00
659.61	7.31	.00	282.7	.354E+01	1.34	18.33	1.34	.00
677.53	7.31	.00	284.4	.352E+01	1.34	18.44	1.34	.00
695.44	7.31	.00	286.0	.350E+01	1.34	18.55	1.34	.00
713.36	7.31	.00	287.7	.348E+01	1.34	18.65	1.34	.00
731.27	7.31	.00	289.3	.346E+01	1.34	18.76	1.34	.00
749.19	7.31	.00	290.9	.344E+01	1.34	18.86	1.34	.00
767.10	7.31	.00	292.5	.342E+01	1.34	18.97	1.34	.00
785.02	7.31	.00	294.1	.340E+01	1.34	19.07	1.34	.00
802.93	7.31	.00	295.7	.338E+01	1.34	19.17	1.34	.00
820.85	7.31	.00	297.3	.336E+01	1.34	19.28	1.34	.00
838.76	7.31	.00	298.9	.335E+01	1.34	19.38	1.34	.00
856.68	7.31	.00	300.4	.333E+01	1.34	19.48	1.34	.00
874.59	7.31	.00	302.0	.331E+01	1.34	19.58	1.34	.00
892.51	7.31	.00	303.5	.329E+01	1.34	19.68	1.34	.00
910.42	7.31	.00	305.1	.328E+01	1.34	19.78	1.34	.00
928.34	7.31	.00	306.6	.326E+01	1.34	19.88	1.34	.00
946.25	7.31	.00	308.1	.325E+01	1.34	19.98	1.34	.00
964.17	7.31	.00	309.6	.323E+01	1.34	20.08	1.34	.00

982.09	7.31	.00	311.2	.321E+01	1.34	20.18	1.34	.00
1000.00	7.31	.00	312.7	.320E+01	1.34	20.27	1.34	.00

Cumulative travel time = 3402. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

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MAC3-3N.CX1

CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
CORNELL MIXING ZONE EXPERT SYSTEM

Subsystem CORMIX1: Subsystem version:
Submerged Single Port Discharges CORMIX_v.3.20_____September_1996

CASE DESCRIPTION
Site name/label: Mach^Big^Muddy^River
Design case: Case^3^-^Port^3^Normal^Flow
FILE NAME: cormix\sim\Mac3-3N .cx1
Time of Fortran run: 11/08/16--15:19:45

ENVIRONMENT PARAMETERS (metric units)
Bounded section
BS = 33.47 AS = 38.66 QA = 11.08 ICHREG= 2
HA = 1.16 HD = 1.16
UA = .287 F = .092 USTAR = .3066E-01
UW = 2.000 UWSTAR= .2198E-02
Uniform density environment
STRCND= U RHOAM = 998.4901

DISCHARGE PARAMETERS (metric units)
BANK = LEFT DISTB = 15.73
D0 = .102 A0 = .008 H0 = .15
THETA = 15.00 SIGMA = .00
U0 = 2.905 Q0 = .024 = .2355E-01
RHO0 = 1013.3900 DRHO0 =-.1490E+02 GP0 =-.1463E+00
C0 = .1000E+04 CUNITS= ppm
IPOLL = 1 KS = .0000E+00 KD = .0000E+00

FLUX VARIABLES (metric units)
Q0 = .2355E-01 M0 = .6841E-01 J0 =-.3446E-02 SIGNJ0= -1.0
Associated length scales (meters)
LQ = .09 LM = 2.28 Lm = .91 Lb = .15
Lmp = 99999.00 Lbp = 99999.00

NON-DIMENSIONAL PARAMETERS
FR0 = 23.82 R = 10.13

FLOW CLASSIFICATION
1111111111111111111111111111111111111111
1 Flow class (CORMIX1) = NH5 1
1 Applicable layer depth HS = 1.16 1
1111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
C0 = .1000E+04 CUNITS= ppm

```
 NTOX  =  0
 NSTD  =  0
 REGMZ =  0
 XINT  =   1000.00  XMAX  =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
        15.73 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

 COANDA ATTACHMENT immediately following the discharge.

       X        Y        Z        S        C        B
       .00      .00      .00     1.0  .100E+04     .07

END OF MOD101: DISCHARGE MODULE
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Bottom-attached jet motion.

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
            Half wall jet, attached to bottom.
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

        X        Y        Z        S        C        B
       .00      .00      .00     1.0  .100E+04     .05
      1.13      .00      .00     1.9  .514E+03     .14
      2.26      .00      .00     3.2  .311E+03     .22
      3.41      .00      .00     4.4  .225E+03     .28
      4.54      .00      .00     5.6  .178E+03     .33
      5.67      .00      .00     6.7  .148E+03     .38
      6.81      .00      .00     7.8  .128E+03     .42
      7.94      .00      .00     8.9  .113E+03     .45
      9.07      .00      .00     9.9  .101E+03     .49
     10.22      .00      .00    10.9  .917E+02     .52
     11.35      .00      .00    11.9  .842E+02     .55
     12.48      .00      .00    12.8  .779E+02     .58
     13.62      .00      .00    13.8  .726E+02     .60
     14.75      .00      .00    14.7  .681E+02     .63
     15.88      .00      .00    15.6  .642E+02     .65
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17.03	.00	.00	16.4	.608E+02	.68
18.16	.00	.00	17.3	.578E+02	.70
19.29	.00	.00	18.2	.551E+02	.72
20.43	.00	.00	19.0	.527E+02	.74
21.56	.00	.00	19.8	.505E+02	.76
22.69	.00	.00	20.6	.485E+02	.77
23.84	.00	.00	21.4	.467E+02	.79
24.97	.00	.00	22.2	.450E+02	.81
26.10	.00	.00	23.0	.435E+02	.83
27.24	.00	.00	23.8	.421E+02	.84
28.37	.00	.00	24.5	.408E+02	.86
29.51	.00	.00	25.3	.396E+02	.87
30.65	.00	.00	26.0	.384E+02	.89
31.78	.00	.00	26.7	.374E+02	.90
32.92	.00	.00	27.5	.364E+02	.92
34.05	.00	.00	28.2	.355E+02	.93
35.18	.00	.00	28.9	.346E+02	.94
36.32	.00	.00	29.6	.338E+02	.96
37.46	.00	.00	30.3	.330E+02	.97
38.59	.00	.00	31.0	.322E+02	.98
39.73	.00	.00	31.7	.315E+02	.99
40.86	.00	.00	32.4	.309E+02	1.01
41.99	.00	.00	33.1	.303E+02	1.02
43.13	.00	.00	33.7	.297E+02	1.03
44.27	.00	.00	34.4	.291E+02	1.04
45.40	.00	.00	35.0	.285E+02	1.05
46.54	.00	.00	35.7	.280E+02	1.06
47.67	.00	.00	36.4	.275E+02	1.07
48.80	.00	.00	37.0	.270E+02	1.09
49.94	.00	.00	37.6	.266E+02	1.10
51.08	.00	.00	38.3	.261E+02	1.11
52.21	.00	.00	38.9	.257E+02	1.12
53.35	.00	.00	39.5	.253E+02	1.13
54.48	.00	.00	40.2	.249E+02	1.14
55.62	.00	.00	40.8	.245E+02	1.15
56.75	.00	.00	41.4	.242E+02	1.16

Cumulative travel time = 119. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
56.75	.00	.00	41.4	.242E+02	1.16

Profile definitions:

MAC3-3N.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
55.60	.00	.00	41.4	.242E+02	.00	.00	.00	.00
55.83	.00	.00	41.4	.242E+02	1.16	.20	1.16	.00
56.06	.00	.00	41.4	.242E+02	1.16	.29	1.16	.00
56.29	.00	.00	41.4	.242E+02	1.16	.35	1.16	.00
56.52	.00	.00	41.4	.242E+02	1.16	.41	1.16	.00
56.75	.00	.00	41.4	.242E+02	1.16	.46	1.16	.00
56.99	.00	.00	43.8	.228E+02	1.16	.50	1.16	.00
57.22	.00	.00	49.2	.203E+02	1.16	.54	1.16	.00
57.45	.00	.00	54.0	.185E+02	1.16	.58	1.16	.00
57.68	.00	.00	56.7	.176E+02	1.16	.61	1.16	.00
57.91	.00	.00	57.9	.173E+02	1.16	.65	1.16	.00

Cumulative travel time = 124. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.19 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC3-3N.CX1

Profile definitions:
  BV = top-hat thickness, measured vertically
  BH = top-hat half-width, measured horizontally in Y-direction
  ZU = upper plume boundary (Z-coordinate)
  ZL = lower plume boundary (Z-coordinate)
  S = hydrodynamic average (bulk) dilution
  C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
57.91	.00	.00	57.9	.173E+02	1.16	2.06	1.16	.00
58.79	.00	.00	59.1	.169E+02	1.12	2.17	1.12	.00
59.67	.00	.00	60.3	.166E+02	1.08	2.29	1.08	.00
60.55	.00	.00	61.5	.163E+02	1.05	2.40	1.05	.00
61.43	.00	.00	62.6	.160E+02	1.03	2.50	1.03	.00
62.31	.00	.00	63.8	.157E+02	1.00	2.61	1.00	.00
63.19	.00	.00	65.0	.154E+02	.98	2.71	.98	.00
64.08	.00	.00	66.3	.151E+02	.97	2.81	.97	.00
64.96	.00	.00	67.5	.148E+02	.95	2.91	.95	.00
65.84	.00	.00	68.8	.145E+02	.94	3.01	.94	.00
66.72	.00	.00	70.1	.143E+02	.93	3.10	.93	.00
67.60	.00	.00	71.5	.140E+02	.92	3.20	.92	.00
68.48	.00	.00	72.9	.137E+02	.91	3.29	.91	.00
69.36	.00	.00	74.3	.135E+02	.90	3.38	.90	.00
70.24	.00	.00	75.8	.132E+02	.89	3.47	.89	.00
71.12	.00	.00	77.3	.129E+02	.89	3.56	.89	.00
72.00	.00	.00	78.8	.127E+02	.89	3.65	.89	.00
72.88	.00	.00	80.4	.124E+02	.88	3.74	.88	.00
73.76	.00	.00	82.1	.122E+02	.88	3.83	.88	.00
74.64	.00	.00	83.8	.119E+02	.88	3.91	.88	.00
75.53	.00	.00	85.5	.117E+02	.88	4.00	.88	.00
76.41	.00	.00	87.3	.115E+02	.88	4.08	.88	.00
77.29	.00	.00	89.2	.112E+02	.88	4.16	.88	.00
78.17	.00	.00	91.1	.110E+02	.88	4.24	.88	.00
79.05	.00	.00	93.0	.108E+02	.88	4.32	.88	.00
79.93	.00	.00	95.0	.105E+02	.88	4.40	.88	.00
80.81	.00	.00	97.1	.103E+02	.89	4.48	.89	.00
81.69	.00	.00	99.2	.101E+02	.89	4.56	.89	.00
82.57	.00	.00	101.4	.986E+01	.90	4.64	.90	.00
83.45	.00	.00	103.6	.965E+01	.90	4.72	.90	.00
84.33	.00	.00	105.9	.944E+01	.91	4.80	.91	.00
85.21	.00	.00	108.3	.924E+01	.91	4.87	.91	.00
86.10	.00	.00	110.7	.903E+01	.92	4.95	.92	.00
86.98	.00	.00	113.2	.884E+01	.92	5.02	.92	.00
87.86	.00	.00	115.7	.864E+01	.93	5.10	.93	.00
88.74	.00	.00	118.3	.845E+01	.94	5.17	.94	.00
89.62	.00	.00	121.0	.827E+01	.95	5.25	.95	.00

90.50	.00	.00	123.7	.808E+01	.95	5.32	.95	.00
91.38	.00	.00	126.5	.790E+01	.96	5.39	.96	.00
92.26	.00	.00	129.4	.773E+01	.97	5.46	.97	.00
93.14	.00	.00	132.3	.756E+01	.98	5.53	.98	.00
94.02	.00	.00	135.3	.739E+01	.99	5.61	.99	.00
94.90	.00	.00	138.4	.723E+01	1.00	5.68	1.00	.00
95.78	.00	.00	141.5	.707E+01	1.01	5.75	1.01	.00
96.66	.00	.00	144.7	.691E+01	1.02	5.82	1.02	.00
97.55	.00	.00	147.9	.676E+01	1.03	5.89	1.03	.00
98.43	.00	.00	151.3	.661E+01	1.04	5.95	1.04	.00
99.31	.00	.00	154.7	.646E+01	1.05	6.02	1.05	.00
100.19	.00	.00	158.2	.632E+01	1.06	6.09	1.06	.00
101.07	.00	.00	161.7	.618E+01	1.08	6.16	1.08	.00
101.95	.00	.00	165.3	.605E+01	1.09	6.23	1.09	.00

Cumulative travel time = 278. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .709E-02 m^2/s
Horizontal diffusivity (initial value) = .177E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
101.95	.00	.00	165.3	.605E+01	1.09	6.23	1.09	.00
119.91	.00	.00	183.1	.546E+01	1.16	6.50	1.16	.00
137.87	.00	.00	190.5	.525E+01	1.16	6.76	1.16	.00
155.83	.00	.00	197.6	.506E+01	1.16	7.01	1.16	.00
173.79	.00	.00	204.5	.489E+01	1.16	7.26	1.16	.00
191.75	.00	.00	211.1	.474E+01	1.16	7.49	1.16	.00
209.72	.00	.00	217.6	.460E+01	1.16	7.72	1.16	.00
227.68	.00	.00	223.8	.447E+01	1.16	7.95	1.16	.00
245.64	.00	.00	229.9	.435E+01	1.16	8.16	1.16	.00
263.60	.00	.00	235.8	.424E+01	1.16	8.37	1.16	.00
281.56	.00	.00	241.6	.414E+01	1.16	8.58	1.16	.00
299.52	.00	.00	247.3	.404E+01	1.16	8.78	1.16	.00

317.48	.00	.00	252.8	.396E+01	1.16	8.97	1.16	.00
335.44	.00	.00	258.2	.387E+01	1.16	9.17	1.16	.00
353.40	.00	.00	263.5	.380E+01	1.16	9.35	1.16	.00
371.36	.00	.00	268.7	.372E+01	1.16	9.54	1.16	.00
389.33	.00	.00	273.8	.365E+01	1.16	9.72	1.16	.00
407.29	.00	.00	278.8	.359E+01	1.16	9.90	1.16	.00
425.25	.00	.00	283.7	.352E+01	1.16	10.07	1.16	.00
443.21	.00	.00	288.5	.347E+01	1.16	10.24	1.16	.00
461.17	.00	.00	293.3	.341E+01	1.16	10.41	1.16	.00
479.13	.00	.00	297.9	.336E+01	1.16	10.58	1.16	.00
497.09	.00	.00	302.5	.331E+01	1.16	10.74	1.16	.00
515.05	.00	.00	307.1	.326E+01	1.16	10.90	1.16	.00
533.01	.00	.00	311.5	.321E+01	1.16	11.06	1.16	.00
550.97	.00	.00	315.9	.317E+01	1.16	11.22	1.16	.00
568.94	.00	.00	320.3	.312E+01	1.16	11.37	1.16	.00
586.90	.00	.00	324.6	.308E+01	1.16	11.52	1.16	.00
604.86	.00	.00	328.8	.304E+01	1.16	11.67	1.16	.00
622.82	.00	.00	333.0	.300E+01	1.16	11.82	1.16	.00
640.78	.00	.00	337.1	.297E+01	1.16	11.97	1.16	.00
658.74	.00	.00	341.2	.293E+01	1.16	12.11	1.16	.00
676.70	.00	.00	345.2	.290E+01	1.16	12.25	1.16	.00
694.66	.00	.00	349.2	.286E+01	1.16	12.40	1.16	.00
712.62	.00	.00	353.1	.283E+01	1.16	12.54	1.16	.00
730.58	.00	.00	357.0	.280E+01	1.16	12.67	1.16	.00
748.55	.00	.00	360.8	.277E+01	1.16	12.81	1.16	.00
766.51	.00	.00	364.6	.274E+01	1.16	12.95	1.16	.00
784.47	.00	.00	368.4	.271E+01	1.16	13.08	1.16	.00
802.43	.00	.00	372.1	.269E+01	1.16	13.21	1.16	.00
820.39	.00	.00	375.8	.266E+01	1.16	13.34	1.16	.00
838.35	.00	.00	379.5	.264E+01	1.16	13.47	1.16	.00
856.31	.00	.00	383.1	.261E+01	1.16	13.60	1.16	.00
874.27	.00	.00	386.7	.259E+01	1.16	13.73	1.16	.00
892.23	.00	.00	390.3	.256E+01	1.16	13.85	1.16	.00
910.19	.00	.00	393.8	.254E+01	1.16	13.98	1.16	.00
928.16	.00	.00	397.3	.252E+01	1.16	14.10	1.16	.00
946.12	.00	.00	400.7	.250E+01	1.16	14.23	1.16	.00
964.08	.00	.00	404.2	.247E+01	1.16	14.35	1.16	.00
982.04	.00	.00	407.6	.245E+01	1.16	14.47	1.16	.00
1000.00	.00	.00	410.9	.243E+01	1.16	14.59	1.16	.00

Cumulative travel time = 3406. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

MAC3-3N.CX1

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MAC3-3X.CX1

CORMIX1 PREDICTION FILE:
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CORNELL MIXING ZONE EXPERT SYSTEM

Subsystem CORMIX1: Subsystem version:
Submerged Single Port Discharges CORMIX_v.3.20_____September_1996

CASE DESCRIPTION
Site name/label: Mach^Big^Muddy^River
Design case: Case^3^-^Port^3^Maximum^Flow
FILE NAME: cormix\sim\Mac3-3X .cx1
Time of Fortran run: 11/09/16--09:06:50

ENVIRONMENT PARAMETERS (metric units)
Bounded section
BS = 43.24 AS = 58.13 QA = 16.65 ICHREG= 2
HA = 1.34 HD = 1.34
UA = .287 F = .087 USTAR = .2989E-01
UW = 2.000 UWSTAR= .2198E-02
Uniform density environment
STRCND= U RHOAM = 998.4901

DISCHARGE PARAMETERS (metric units)
BANK = LEFT DISTB = 20.62
D0 = .102 A0 = .008 H0 = .15
THETA = 15.00 SIGMA = .00
U0 = 5.487 Q0 = .044 = .4448E-01
RHO0 = 1013.3900 DRHO0 =-.1490E+02 GP0 =-.1463E+00
C0 = .1000E+04 CUNITS= ppm
IPOLL = 1 KS = .0000E+00 KD = .0000E+00

FLUX VARIABLES (metric units)
Q0 = .4448E-01 M0 = .2441E+00 J0 =-.6509E-02 SIGNJ0= -1.0
Associated length scales (meters)
LQ = .09 LM = 4.30 Lm = 1.72 Lb = .28
Lmp = 99999.00 Lbp = 99999.00

NON-DIMENSIONAL PARAMETERS
FR0 = 44.99 R = 19.15

FLOW CLASSIFICATION
1111111111111111111111111111111111111111
1 Flow class (CORMIX1) = NH5 1
1 Applicable layer depth HS = 1.34 1
1111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
C0 = .1000E+04 CUNITS= ppm

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
        20.62 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

 COANDA ATTACHMENT immediately following the discharge.

       X        Y        Z        S        C        B
       .00      .00      .00     1.0  .100E+04     .07

END OF MOD101: DISCHARGE MODULE
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Bottom-attached jet motion.

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
            Half wall jet, attached to bottom.
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
       .00      .00      .00     1.0  .100E+04     .05
       .70      .00      .00     1.5  .678E+03     .12
      1.41      .00      .00     2.3  .427E+03     .18
      2.12      .00      .00     3.2  .313E+03     .24
      2.82      .00      .00     4.0  .248E+03     .29
      3.54      .00      .00     4.9  .206E+03     .34
      4.25      .00      .00     5.7  .176E+03     .38
      4.95      .00      .00     6.5  .155E+03     .42
      5.66      .00      .00     7.3  .138E+03     .46
      6.37      .00      .00     8.1  .124E+03     .50
      7.09      .00      .00     8.8  .113E+03     .54
      7.78      .00      .00     9.6  .104E+03     .57
      8.50      .00      .00    10.3  .968E+02     .60
      9.21      .00      .00    11.1  .903E+02     .64
      9.91      .00      .00    11.8  .848E+02     .67
```

10.62	.00	.00	12.5	.799E+02	.69
11.33	.00	.00	13.2	.755E+02	.72
12.05	.00	.00	14.0	.717E+02	.75
12.75	.00	.00	14.6	.683E+02	.78
13.46	.00	.00	15.3	.652E+02	.80
14.17	.00	.00	16.0	.624E+02	.82
14.87	.00	.00	16.7	.599E+02	.85
15.58	.00	.00	17.4	.576E+02	.87
16.30	.00	.00	18.0	.554E+02	.89
17.01	.00	.00	18.7	.535E+02	.92
17.71	.00	.00	19.3	.517E+02	.94
18.42	.00	.00	20.0	.500E+02	.96
19.13	.00	.00	20.6	.484E+02	.98
19.83	.00	.00	21.3	.470E+02	1.00
20.54	.00	.00	21.9	.456E+02	1.02
21.26	.00	.00	22.5	.444E+02	1.03
21.97	.00	.00	23.2	.432E+02	1.05
22.67	.00	.00	23.8	.421E+02	1.07
23.38	.00	.00	24.4	.410E+02	1.09
24.09	.00	.00	25.0	.400E+02	1.11
24.79	.00	.00	25.6	.391E+02	1.12
25.51	.00	.00	26.2	.382E+02	1.14
26.22	.00	.00	26.8	.373E+02	1.16
26.93	.00	.00	27.4	.365E+02	1.17
27.63	.00	.00	28.0	.358E+02	1.19
28.34	.00	.00	28.6	.350E+02	1.20
29.05	.00	.00	29.1	.343E+02	1.22
29.75	.00	.00	29.7	.337E+02	1.23
30.47	.00	.00	30.3	.330E+02	1.25
31.18	.00	.00	30.9	.324E+02	1.26
31.89	.00	.00	31.4	.318E+02	1.28
32.59	.00	.00	32.0	.313E+02	1.29
33.30	.00	.00	32.5	.307E+02	1.30
34.02	.00	.00	33.1	.302E+02	1.32
34.71	.00	.00	33.6	.297E+02	1.33
35.43	.00	.00	34.2	.292E+02	1.34

Cumulative travel time = 50. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
35.43	.00	.00	34.2	.292E+02	1.34

Profile definitions:

MAC3-3X.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
34.08	.00	.00	34.2	.292E+02	.00	.00	.00	.00
34.35	.00	.00	34.2	.292E+02	1.34	.26	1.34	.00
34.62	.00	.00	34.2	.292E+02	1.34	.36	1.34	.00
34.89	.00	.00	34.2	.292E+02	1.34	.45	1.34	.00
35.16	.00	.00	34.2	.292E+02	1.34	.51	1.34	.00
35.43	.00	.00	34.2	.292E+02	1.34	.58	1.34	.00
35.70	.00	.00	36.2	.276E+02	1.34	.63	1.34	.00
35.97	.00	.00	40.7	.246E+02	1.34	.68	1.34	.00
36.23	.00	.00	44.6	.224E+02	1.34	.73	1.34	.00
36.50	.00	.00	46.8	.214E+02	1.34	.77	1.34	.00
36.77	.00	.00	47.9	.209E+02	1.34	.81	1.34	.00

Cumulative travel time = 55. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.39 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC3-3X.CX1

Profile definitions:
  BV = top-hat thickness, measured vertically
  BH = top-hat half-width, measured horizontally in Y-direction
  ZU = upper plume boundary (Z-coordinate)
  ZL = lower plume boundary (Z-coordinate)
  S = hydrodynamic average (bulk) dilution
  C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
36.77	.00	.00	47.9	.209E+02	1.34	2.76	1.34	.00
38.32	.00	.00	49.2	.203E+02	1.27	3.00	1.27	.00
39.86	.00	.00	50.5	.198E+02	1.21	3.22	1.21	.00
41.41	.00	.00	51.7	.193E+02	1.16	3.45	1.16	.00
42.95	.00	.00	53.0	.189E+02	1.12	3.66	1.12	.00
44.50	.00	.00	54.3	.184E+02	1.09	3.87	1.09	.00
46.05	.00	.00	55.6	.180E+02	1.06	4.07	1.06	.00
47.59	.00	.00	56.9	.176E+02	1.03	4.27	1.03	.00
49.14	.00	.00	58.3	.172E+02	1.01	4.46	1.01	.00
50.68	.00	.00	59.7	.168E+02	.99	4.65	.99	.00
52.23	.00	.00	61.1	.164E+02	.98	4.84	.98	.00
53.77	.00	.00	62.6	.160E+02	.97	5.02	.97	.00
55.32	.00	.00	64.1	.156E+02	.96	5.20	.96	.00
56.87	.00	.00	65.7	.152E+02	.95	5.38	.95	.00
58.41	.00	.00	67.4	.148E+02	.94	5.55	.94	.00
59.96	.00	.00	69.1	.145E+02	.94	5.72	.94	.00
61.50	.00	.00	70.9	.141E+02	.93	5.89	.93	.00
63.05	.00	.00	72.7	.138E+02	.93	6.05	.93	.00
64.59	.00	.00	74.6	.134E+02	.93	6.21	.93	.00
66.14	.00	.00	76.6	.131E+02	.93	6.38	.93	.00
67.68	.00	.00	78.7	.127E+02	.93	6.53	.93	.00
69.23	.00	.00	80.8	.124E+02	.93	6.69	.93	.00
70.78	.00	.00	83.0	.120E+02	.94	6.85	.94	.00
72.32	.00	.00	85.3	.117E+02	.94	7.00	.94	.00
73.87	.00	.00	87.6	.114E+02	.95	7.15	.95	.00
75.41	.00	.00	90.1	.111E+02	.95	7.30	.95	.00
76.96	.00	.00	92.6	.108E+02	.96	7.45	.96	.00
78.50	.00	.00	95.2	.105E+02	.97	7.60	.97	.00
80.05	.00	.00	97.8	.102E+02	.98	7.74	.98	.00
81.60	.00	.00	100.6	.994E+01	.99	7.89	.99	.00
83.14	.00	.00	103.5	.966E+01	1.00	8.03	1.00	.00
84.69	.00	.00	106.4	.940E+01	1.01	8.17	1.01	.00
86.23	.00	.00	109.4	.914E+01	1.02	8.31	1.02	.00
87.78	.00	.00	112.5	.889E+01	1.03	8.45	1.03	.00
89.32	.00	.00	115.8	.864E+01	1.04	8.59	1.04	.00
90.87	.00	.00	119.0	.840E+01	1.06	8.73	1.06	.00
92.41	.00	.00	122.4	.817E+01	1.07	8.87	1.07	.00

93.96	.00	.00	125.9	.794E+01	1.08	9.00	1.08	.00
95.51	.00	.00	129.5	.772E+01	1.10	9.14	1.10	.00
97.05	.00	.00	133.2	.751E+01	1.11	9.27	1.11	.00
98.60	.00	.00	136.9	.730E+01	1.13	9.40	1.13	.00
100.14	.00	.00	140.8	.710E+01	1.14	9.53	1.14	.00
101.69	.00	.00	144.8	.691E+01	1.16	9.66	1.16	.00
103.23	.00	.00	148.8	.672E+01	1.18	9.79	1.18	.00
104.78	.00	.00	153.0	.654E+01	1.19	9.92	1.19	.00
106.33	.00	.00	157.2	.636E+01	1.21	10.05	1.21	.00
107.87	.00	.00	161.6	.619E+01	1.23	10.18	1.23	.00
109.42	.00	.00	166.1	.602E+01	1.25	10.30	1.25	.00
110.96	.00	.00	170.6	.586E+01	1.27	10.43	1.27	.00
112.51	.00	.00	175.3	.570E+01	1.29	10.55	1.29	.00
114.05	.00	.00	180.1	.555E+01	1.31	10.68	1.31	.00

Cumulative travel time = 324. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .804E-02 m^2/s
Horizontal diffusivity (initial value) = .201E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
114.05	.00	.00	180.1	.555E+01	1.31	10.68	1.31	.00
131.77	.00	.00	188.5	.530E+01	1.34	10.86	1.34	.00
149.49	.00	.00	191.6	.522E+01	1.34	11.03	1.34	.00
167.21	.00	.00	194.7	.514E+01	1.34	11.21	1.34	.00
184.93	.00	.00	197.7	.506E+01	1.34	11.38	1.34	.00
202.65	.00	.00	200.6	.498E+01	1.34	11.55	1.34	.00
220.37	.00	.00	203.5	.491E+01	1.34	11.72	1.34	.00
238.09	.00	.00	206.4	.485E+01	1.34	11.88	1.34	.00
255.80	.00	.00	209.2	.478E+01	1.34	12.05	1.34	.00
273.52	.00	.00	212.0	.472E+01	1.34	12.21	1.34	.00
291.24	.00	.00	214.8	.466E+01	1.34	12.37	1.34	.00
308.96	.00	.00	217.5	.460E+01	1.34	12.52	1.34	.00

326.68	.00	.00	220.2	.454E+01	1.34	12.68	1.34	.00
344.40	.00	.00	222.8	.449E+01	1.34	12.83	1.34	.00
362.12	.00	.00	225.4	.444E+01	1.34	12.98	1.34	.00
379.84	.00	.00	228.0	.439E+01	1.34	13.13	1.34	.00
397.56	.00	.00	230.6	.434E+01	1.34	13.28	1.34	.00
415.27	.00	.00	233.1	.429E+01	1.34	13.42	1.34	.00
432.99	.00	.00	235.6	.424E+01	1.34	13.57	1.34	.00
450.71	.00	.00	238.1	.420E+01	1.34	13.71	1.34	.00
468.43	.00	.00	240.6	.416E+01	1.34	13.85	1.34	.00
486.15	.00	.00	243.0	.412E+01	1.34	13.99	1.34	.00
503.87	.00	.00	245.4	.408E+01	1.34	14.13	1.34	.00
521.59	.00	.00	247.8	.404E+01	1.34	14.27	1.34	.00
539.31	.00	.00	250.1	.400E+01	1.34	14.40	1.34	.00
557.03	.00	.00	252.5	.396E+01	1.34	14.54	1.34	.00
574.75	.00	.00	254.8	.392E+01	1.34	14.67	1.34	.00
592.46	.00	.00	257.1	.389E+01	1.34	14.80	1.34	.00
610.18	.00	.00	259.4	.386E+01	1.34	14.93	1.34	.00
627.90	.00	.00	261.6	.382E+01	1.34	15.06	1.34	.00
645.62	.00	.00	263.9	.379E+01	1.34	15.19	1.34	.00
663.34	.00	.00	266.1	.376E+01	1.34	15.32	1.34	.00
681.06	.00	.00	268.3	.373E+01	1.34	15.45	1.34	.00
698.78	.00	.00	270.5	.370E+01	1.34	15.57	1.34	.00
716.50	.00	.00	272.6	.367E+01	1.34	15.70	1.34	.00
734.22	.00	.00	274.8	.364E+01	1.34	15.82	1.34	.00
751.93	.00	.00	276.9	.361E+01	1.34	15.94	1.34	.00
769.65	.00	.00	279.0	.358E+01	1.34	16.07	1.34	.00
787.37	.00	.00	281.1	.356E+01	1.34	16.19	1.34	.00
805.09	.00	.00	283.2	.353E+01	1.34	16.31	1.34	.00
822.81	.00	.00	285.3	.351E+01	1.34	16.43	1.34	.00
840.53	.00	.00	287.3	.348E+01	1.34	16.54	1.34	.00
858.25	.00	.00	289.3	.346E+01	1.34	16.66	1.34	.00
875.97	.00	.00	291.4	.343E+01	1.34	16.78	1.34	.00
893.69	.00	.00	293.4	.341E+01	1.34	16.89	1.34	.00
911.41	.00	.00	295.4	.339E+01	1.34	17.01	1.34	.00
929.12	.00	.00	297.4	.336E+01	1.34	17.12	1.34	.00
946.84	.00	.00	299.3	.334E+01	1.34	17.24	1.34	.00
964.56	.00	.00	301.3	.332E+01	1.34	17.35	1.34	.00
982.28	.00	.00	303.2	.330E+01	1.34	17.46	1.34	.00
1000.00	.00	.00	305.2	.328E+01	1.34	17.57	1.34	.00

Cumulative travel time = 3408. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

MAC3-3X.CX1

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MAC4-1N.CX1

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CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111
                    CORNELL MIXING ZONE EXPERT SYSTEM
Subsystem CORMIX1:                                          Subsystem version:
 Submerged Single Port Discharges          CORMIX_v.3.20_____September_1996
------------------------------------------------------------------------------
------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:         Mach^Big^Muddy^River
 Design case:             Case^4^-^Port^1^Normal^Flow
 FILE NAME:               cormix\sim\Mac4-1N .cx1
 Time of Fortran run:     11/08/16--09:47:07

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     43.24  AS    =     58.13  QA    =     16.66  ICHREG= 2
 HA    =      1.34  HD    =      1.34
 UA    =       .287 F     =       .087 USTAR = .2989E-01
 UW    =      2.000 UWSTAR= .2198E-02
 Uniform density environment
 STRCND=  U         RHOAM =  998.4901

DISCHARGE PARAMETERS (metric units)
 BANK  =  LEFT      DISTB =      5.23
 D0    =       .076 A0    =       .005 H0    =       .10
 THETA =     15.00  SIGMA =       .00
 U0    =      1.413 Q0    =       .006       = .6441E-02
 RHO0  = 1013.3900  DRHO0 =-.1490E+02  GP0   =-.1463E+00
 C0    = .1000E+04  CUNITS=  ppm
 IPOLL =  1         KS    = .0000E+00  KD    = .0000E+00

FLUX VARIABLES (metric units)
 Q0    = .6441E-02  M0    = .9099E-02  J0    =-.9427E-03  SIGNJ0=     -1.0
 Associated length scales (meters)
 LQ    =       .07  LM    =       .96  Lm    =       .33  Lb    =       .04
                                       Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =     13.37  R     =      4.93

FLOW CLASSIFICATION
 11111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    NH4    1
 1  Applicable layer depth HS =     1.34  1
 11111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    = .1000E+04  CUNITS=  ppm
```

MAC4-1N.CX1

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 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         5.23 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z        S        C        B
      .00      .00      .10     1.0  .100E+04     .04

END OF MOD101: DISCHARGE MODULE
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet/plume transition motion in strong crossflow.

 Zone of flow establishment:              THETAE=     14.04  SIGMAE=       .00
  LE    =       .32  XE    =       .31  YE    =       .00  ZE    =       .18

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .10     1.0  .100E+04     .04
      .31      .00      .18     1.0  .100E+04     .04
      .36      .00      .19     1.0  .961E+03     .04
      .41      .00      .20     1.2  .842E+03     .05
      .46      .00      .21     1.3  .750E+03     .05
      .52      .00      .22     1.5  .672E+03     .06
      .57      .00      .23     1.6  .613E+03     .06
      .62      .00      .24     1.8  .564E+03     .07
      .68      .00      .25     1.9  .521E+03     .07
      .73      .00      .25     2.1  .487E+03     .07
      .78      .00      .26     2.2  .457E+03     .08
      .84      .00      .27     2.3  .432E+03     .08
      .89      .00      .27     2.4  .408E+03     .08
      .95      .00      .28     2.6  .389E+03     .09
     1.00      .00      .28     2.7  .372E+03     .09
```

1.06	.00	.28	2.8	.356E+03	.09
1.11	.00	.29	2.9	.343E+03	.09
1.16	.00	.29	3.0	.331E+03	.10
1.22	.00	.29	3.1	.321E+03	.10
1.27	.00	.29	3.2	.311E+03	.10
1.33	.00	.29	3.3	.302E+03	.10
1.38	.00	.29	3.4	.294E+03	.10
1.44	.00	.29	3.5	.287E+03	.11

Maximum jet height has been reached.

1.49	.00	.29	3.6	.281E+03	.11
1.54	.00	.29	3.6	.274E+03	.11
1.60	.00	.29	3.7	.268E+03	.11
1.65	.00	.29	3.8	.261E+03	.11
1.70	.00	.29	3.9	.255E+03	.12
1.76	.00	.29	4.0	.248E+03	.12
1.81	.00	.29	4.1	.242E+03	.12
1.87	.00	.28	4.2	.236E+03	.12
1.92	.00	.28	4.4	.229E+03	.12
1.97	.00	.28	4.5	.224E+03	.13
2.03	.00	.27	4.6	.217E+03	.13
2.08	.00	.27	4.7	.212E+03	.13
2.14	.00	.26	4.9	.206E+03	.13
2.19	.00	.26	5.0	.200E+03	.13
2.25	.00	.26	5.1	.195E+03	.14
2.30	.00	.25	5.3	.190E+03	.14
2.35	.00	.25	5.4	.185E+03	.14
2.41	.00	.24	5.6	.180E+03	.14
2.46	.00	.24	5.7	.175E+03	.15
2.51	.00	.23	5.9	.170E+03	.15
2.57	.00	.22	6.0	.166E+03	.15
2.62	.00	.22	6.2	.161E+03	.15
2.68	.00	.21	6.4	.157E+03	.16
2.73	.00	.21	6.5	.153E+03	.16
2.79	.00	.20	6.7	.149E+03	.16
2.84	.00	.19	6.9	.145E+03	.16
2.89	.00	.19	7.1	.142E+03	.17
2.95	.00	.18	7.2	.138E+03	.17
3.00	.00	.17	7.4	.135E+03	.17

Cumulative travel time = 4. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

Control volume inflow:

X	Y	Z	S	C	B
3.00	.00	.17	7.4	.135E+03	.17

MAC4-1N.CX1

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
2.83	.00	.00	7.4	.135E+03	.00	.00	.00	.00
2.88	.00	.00	7.4	.135E+03	.24	.12	.24	.00
2.93	.00	.00	7.4	.135E+03	.28	.17	.28	.00
2.98	.00	.00	7.4	.135E+03	.31	.21	.31	.00
3.03	.00	.00	7.6	.131E+03	.33	.24	.33	.00
3.09	.00	.00	8.6	.117E+03	.35	.27	.35	.00
3.14	.00	.00	9.9	.101E+03	.36	.29	.36	.00
3.19	.00	.00	11.1	.903E+02	.37	.32	.37	.00
3.24	.00	.00	11.9	.841E+02	.37	.34	.37	.00
3.29	.00	.00	12.3	.811E+02	.38	.36	.38	.00
3.34	.00	.00	12.6	.792E+02	.38	.38	.38	.00

Cumulative travel time = 5. sec

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

** End of NEAR-FIELD REGION (NFR) **

BEGIN MOD141: BUOYANT AMBIENT SPREADING

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
3.34	.00	.00	12.6	.792E+02	.38	.38	.38	.00
3.65	.00	.00	13.1	.765E+02	.34	.43	.34	.00
3.97	.00	.00	13.5	.741E+02	.32	.47	.32	.00
4.28	.00	.00	13.9	.720E+02	.30	.52	.30	.00
4.59	.00	.00	14.3	.701E+02	.29	.56	.29	.00
4.91	.00	.00	14.7	.682E+02	.27	.60	.27	.00
5.22	.00	.00	15.0	.665E+02	.26	.64	.26	.00
5.53	.00	.00	15.4	.649E+02	.26	.68	.26	.00
5.84	.00	.00	15.8	.633E+02	.25	.72	.25	.00

6.16	.00	.00	16.2	.618E+02	.24	.75	.24	.00
6.47	.00	.00	16.6	.603E+02	.24	.79	.24	.00
6.78	.00	.00	17.0	.588E+02	.23	.82	.23	.00
7.10	.00	.00	17.4	.573E+02	.23	.86	.23	.00
7.41	.00	.00	17.9	.559E+02	.23	.89	.23	.00
7.72	.00	.00	18.4	.545E+02	.22	.92	.22	.00
8.03	.00	.00	18.8	.531E+02	.22	.96	.22	.00
8.35	.00	.00	19.3	.517E+02	.22	.99	.22	.00
8.66	.00	.00	19.9	.504E+02	.22	1.02	.22	.00
8.97	.00	.00	20.4	.490E+02	.22	1.05	.22	.00
9.28	.00	.00	20.9	.477E+02	.22	1.08	.22	.00
9.60	.00	.00	21.5	.464E+02	.22	1.11	.22	.00
9.91	.00	.00	22.1	.452E+02	.22	1.14	.22	.00
10.22	.00	.00	22.8	.439E+02	.22	1.17	.22	.00
10.54	.00	.00	23.4	.427E+02	.22	1.20	.22	.00
10.85	.00	.00	24.1	.415E+02	.22	1.23	.22	.00
11.16	.00	.00	24.8	.404E+02	.22	1.25	.22	.00
11.47	.00	.00	25.5	.392E+02	.22	1.28	.22	.00
11.79	.00	.00	26.2	.381E+02	.23	1.31	.23	.00
12.10	.00	.00	27.0	.370E+02	.23	1.34	.23	.00
12.41	.00	.00	27.8	.360E+02	.23	1.36	.23	.00
12.73	.00	.00	28.6	.349E+02	.23	1.39	.23	.00
13.04	.00	.00	29.5	.339E+02	.23	1.42	.23	.00
13.35	.00	.00	30.4	.329E+02	.24	1.44	.24	.00
13.66	.00	.00	31.3	.320E+02	.24	1.47	.24	.00
13.98	.00	.00	32.2	.311E+02	.24	1.49	.24	.00
14.29	.00	.00	33.2	.302E+02	.25	1.52	.25	.00
14.60	.00	.00	34.2	.293E+02	.25	1.54	.25	.00
14.91	.00	.00	35.2	.284E+02	.25	1.57	.25	.00
15.23	.00	.00	36.2	.276E+02	.26	1.59	.26	.00
15.54	.00	.00	37.3	.268E+02	.26	1.62	.26	.00
15.85	.00	.00	38.4	.260E+02	.26	1.64	.26	.00
16.17	.00	.00	39.5	.253E+02	.27	1.67	.27	.00
16.48	.00	.00	40.7	.246E+02	.27	1.69	.27	.00
16.79	.00	.00	41.9	.239E+02	.27	1.72	.27	.00
17.10	.00	.00	43.1	.232E+02	.28	1.74	.28	.00
17.42	.00	.00	44.4	.225E+02	.28	1.76	.28	.00
17.73	.00	.00	45.7	.219E+02	.29	1.79	.29	.00
18.04	.00	.00	47.0	.213E+02	.29	1.81	.29	.00
18.36	.00	.00	48.4	.207E+02	.30	1.83	.30	.00
18.67	.00	.00	49.8	.201E+02	.30	1.86	.30	.00
18.98	.00	.00	51.2	.195E+02	.31	1.88	.31	.00

Cumulative travel time = 60. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

MAC4-1N.CX1

Vertical diffusivity (initial value) = .804E-02 m^2/s
Horizontal diffusivity (initial value) = .201E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
18.98	.00	.00	51.2	.195E+02	.31	1.88	.31	.00
21.14	.00	.00	56.1	.178E+02	.32	2.00	.32	.00
23.31	.00	.00	61.3	.163E+02	.33	2.12	.33	.00
25.47	.00	.00	66.9	.150E+02	.34	2.23	.34	.00
27.63	.00	.00	72.8	.137E+02	.35	2.33	.35	.00
29.79	.00	.00	79.1	.126E+02	.37	2.43	.37	.00
31.95	.00	.00	86.1	.116E+02	.38	2.53	.38	.00
34.12	.00	.00	93.6	.107E+02	.40	2.62	.40	.00
36.28	.00	.00	101.9	.981E+01	.42	2.71	.42	.00
38.44	.00	.00	111.1	.900E+01	.45	2.80	.45	.00
40.60	.00	.00	121.2	.825E+01	.47	2.88	.47	.00
42.77	.00	.00	132.3	.756E+01	.50	2.96	.50	.00
44.93	.00	.00	144.6	.692E+01	.53	3.04	.53	.00
47.09	.00	.00	158.0	.633E+01	.57	3.12	.57	.00
49.25	.00	.00	172.6	.579E+01	.61	3.19	.61	.00
51.41	.00	.00	188.6	.530E+01	.65	3.27	.65	.00
53.58	.00	.00	205.7	.486E+01	.69	3.34	.69	.00
55.74	.00	.00	224.1	.446E+01	.74	3.41	.74	.00
57.90	.00	.00	243.6	.411E+01	.79	3.48	.79	.00
60.06	.00	.00	264.1	.379E+01	.84	3.55	.84	.00
62.23	.00	.00	285.6	.350E+01	.89	3.61	.89	.00
64.39	.00	.00	307.9	.325E+01	.94	3.68	.94	.00
66.55	.00	.00	331.0	.302E+01	.99	3.74	.99	.00
68.71	.00	.00	354.7	.282E+01	1.05	3.81	1.05	.00
70.87	.00	.00	378.9	.264E+01	1.10	3.87	1.10	.00
73.04	.00	.00	403.5	.248E+01	1.15	3.93	1.15	.00
75.20	.00	.00	428.6	.233E+01	1.21	3.99	1.21	.00
77.36	.00	.00	453.9	.220E+01	1.26	4.05	1.26	.00
79.52	.00	.00	479.6	.209E+01	1.31	4.11	1.31	.00

Plume interacts with SURFACE.
The passive diffusion plume becomes VERTICALLY FULLY MIXED within this prediction interval.

81.68	.00	.00	498.2	.201E+01	1.34	4.16	1.34	.00
83.85	.00	.00	505.0	.198E+01	1.34	4.22	1.34	.00
86.01	.00	.00	511.7	.195E+01	1.34	4.28	1.34	.00
88.17	.00	.00	518.3	.193E+01	1.34	4.33	1.34	.00
90.33	.00	.00	524.8	.191E+01	1.34	4.39	1.34	.00
92.50	.00	.00	531.3	.188E+01	1.34	4.44	1.34	.00
94.66	.00	.00	537.6	.186E+01	1.34	4.50	1.34	.00
96.82	.00	.00	543.9	.184E+01	1.34	4.55	1.34	.00
98.98	.00	.00	550.2	.182E+01	1.34	4.60	1.34	.00
101.14	.00	.00	556.3	.180E+01	1.34	4.65	1.34	.00
103.31	.00	.00	562.4	.178E+01	1.34	4.70	1.34	.00
105.47	.00	.00	568.5	.176E+01	1.34	4.75	1.34	.00
107.63	.00	.00	574.4	.174E+01	1.34	4.80	1.34	.00
109.79	.00	.00	580.3	.172E+01	1.34	4.85	1.34	.00
111.96	.00	.00	586.2	.171E+01	1.34	4.90	1.34	.00
114.12	.00	.00	592.0	.169E+01	1.34	4.95	1.34	.00
116.28	.00	.00	597.7	.167E+01	1.34	5.00	1.34	.00
118.44	.00	.00	603.4	.166E+01	1.34	5.04	1.34	.00
120.60	.00	.00	609.0	.164E+01	1.34	5.09	1.34	.00
122.77	.00	.00	614.6	.163E+01	1.34	5.14	1.34	.00
124.93	.00	.00	620.1	.161E+01	1.34	5.18	1.34	.00
127.09	.00	.00	625.5	.160E+01	1.34	5.23	1.34	.00

Cumulative travel time = 437. sec

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
127.09	5.23	.00	625.5	.160E+01	1.34	10.46	1.34	.00
144.55	5.23	.00	636.5	.157E+01	1.34	10.64	1.34	.00
162.01	5.23	.00	647.2	.155E+01	1.34	10.82	1.34	.00
179.47	5.23	.00	657.7	.152E+01	1.34	11.00	1.34	.00
196.92	5.23	.00	668.1	.150E+01	1.34	11.17	1.34	.00
214.38	5.23	.00	678.3	.147E+01	1.34	11.34	1.34	.00
231.84	5.23	.00	688.4	.145E+01	1.34	11.51	1.34	.00
249.30	5.23	.00	698.3	.143E+01	1.34	11.68	1.34	.00
266.76	5.23	.00	708.1	.141E+01	1.34	11.84	1.34	.00
284.21	5.23	.00	717.7	.139E+01	1.34	12.00	1.34	.00
301.67	5.23	.00	727.3	.138E+01	1.34	12.16	1.34	.00
319.13	5.23	.00	736.7	.136E+01	1.34	12.32	1.34	.00
336.59	5.23	.00	745.9	.134E+01	1.34	12.47	1.34	.00
354.05	5.23	.00	755.1	.132E+01	1.34	12.63	1.34	.00
371.51	5.23	.00	764.2	.131E+01	1.34	12.78	1.34	.00
388.96	5.23	.00	773.1	.129E+01	1.34	12.93	1.34	.00
406.42	5.23	.00	782.0	.128E+01	1.34	13.08	1.34	.00
423.88	5.23	.00	790.7	.126E+01	1.34	13.22	1.34	.00
441.34	5.23	.00	799.4	.125E+01	1.34	13.37	1.34	.00
458.80	5.23	.00	807.9	.124E+01	1.34	13.51	1.34	.00
476.25	5.23	.00	816.4	.122E+01	1.34	13.65	1.34	.00

493.71	5.23	.00	824.8	.121E+01	1.34	13.79	1.34	.00
511.17	5.23	.00	833.1	.120E+01	1.34	13.93	1.34	.00
528.63	5.23	.00	841.3	.119E+01	1.34	14.07	1.34	.00
546.09	5.23	.00	849.4	.118E+01	1.34	14.20	1.34	.00
563.55	5.23	.00	857.5	.117E+01	1.34	14.34	1.34	.00
581.00	5.23	.00	865.5	.116E+01	1.34	14.47	1.34	.00
598.46	5.23	.00	873.4	.114E+01	1.34	14.60	1.34	.00
615.92	5.23	.00	881.2	.113E+01	1.34	14.74	1.34	.00
633.38	5.23	.00	889.0	.112E+01	1.34	14.87	1.34	.00
650.84	5.23	.00	896.7	.112E+01	1.34	14.99	1.34	.00
668.29	5.23	.00	904.4	.111E+01	1.34	15.12	1.34	.00
685.75	5.23	.00	911.9	.110E+01	1.34	15.25	1.34	.00
703.21	5.23	.00	919.4	.109E+01	1.34	15.37	1.34	.00
720.67	5.23	.00	926.9	.108E+01	1.34	15.50	1.34	.00
738.13	5.23	.00	934.3	.107E+01	1.34	15.62	1.34	.00
755.59	5.23	.00	941.6	.106E+01	1.34	15.75	1.34	.00
773.04	5.23	.00	948.9	.105E+01	1.34	15.87	1.34	.00
790.50	5.23	.00	956.1	.105E+01	1.34	15.99	1.34	.00
807.96	5.23	.00	963.3	.104E+01	1.34	16.11	1.34	.00
825.42	5.23	.00	970.4	.103E+01	1.34	16.23	1.34	.00
842.88	5.23	.00	977.5	.102E+01	1.34	16.34	1.34	.00
860.33	5.23	.00	984.5	.102E+01	1.34	16.46	1.34	.00
877.79	5.23	.00	991.5	.101E+01	1.34	16.58	1.34	.00
895.25	5.23	.00	998.4	.100E+01	1.34	16.69	1.34	.00
912.71	5.23	.00	1005.2	.995E+00	1.34	16.81	1.34	.00
930.17	5.23	.00	1012.1	.988E+00	1.34	16.92	1.34	.00
947.63	5.23	.00	1018.8	.982E+00	1.34	17.04	1.34	.00
965.08	5.23	.00	1025.6	.975E+00	1.34	17.15	1.34	.00
982.54	5.23	.00	1032.2	.969E+00	1.34	17.26	1.34	.00
1000.00	5.23	.00	1038.9	.963E+00	1.34	17.37	1.34	.00

Cumulative travel time = 3483. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

11111111111111111111111111111111111111111111111111111111111111111111111111111111

MAC4-1X.CX1

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CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111111
                    CORNELL MIXING ZONE EXPERT SYSTEM
Subsystem CORMIX1:                                          Subsystem version:
 Submerged Single Port Discharges          CORMIX_v.3.20_____September_1996
------------------------------------------------------------------------------
------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:         Mach^Big^Muddy^River
 Design case:             Case^4^-^Port^1^Maximum^Flow
 FILE NAME:               cormix\sim\Mac4-1X .cx1
 Time of Fortran run:     11/08/16--15:00:22

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     56.85  AS    =     93.39  QA    =     33.02  ICHREG= 2
 HA    =      1.64  HD    =      1.64
 UA    =       .354 F     =       .081 USTAR = .3568E-01
 UW    =     2.000 UWSTAR= .2198E-02
 Uniform density environment
 STRCND=  U         RHOAM =  998.4901

DISCHARGE PARAMETERS (metric units)
 BANK  =  LEFT      DISTB =      7.31
 D0    =       .076 A0    =       .005 H0    =       .15
 THETA =     15.00  SIGMA =       .00
 U0    =      5.487 Q0    =       .025       = .2502E-01
 RHO0  = 1013.3900  DRHO0 =-.1490E+02  GP0   =-.1463E+00
 C0    = .1000E+04  CUNITS=  ppm
 IPOLL =  1         KS    = .0000E+00  KD    = .0000E+00

FLUX VARIABLES (metric units)
 Q0    = .2502E-01  M0    = .1373E+00  J0    =-.3662E-02  SIGNJ0=    -1.0
 Associated length scales (meters)
 LQ    =       .07  LM    =      3.73  Lm    =      1.05  Lb    =       .08
                                        Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =     51.95  R     =     15.51

FLOW CLASSIFICATION
 111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    NH4    1
 1  Applicable layer depth HS =     1.64  1
 111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    = .1000E+04  CUNITS=  ppm
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 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         7.31 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z        S        C        B
      .00      .00      .15      1.0  .100E+04     .04

END OF MOD101: DISCHARGE MODULE
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet/plume transition motion in strong crossflow.

 Zone of flow establishment:            THETAE=     14.69  SIGMAE=       .00
  LE    =       .36  XE    =       .35  YE    =       .00  ZE    =       .24

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .15      1.0  .100E+04     .04
      .35      .00      .24      1.0  .100E+04     .04
      .56      .00      .30      1.4  .690E+03     .06
      .79      .00      .35      2.1  .483E+03     .09
     1.01      .00      .40      2.7  .369E+03     .11
     1.24      .00      .44      3.4  .298E+03     .13
     1.46      .00      .49      4.0  .249E+03     .15
     1.69      .00      .52      4.7  .214E+03     .17
     1.92      .00      .56      5.3  .187E+03     .19
     2.15      .00      .59      6.0  .167E+03     .21
     2.38      .00      .62      6.6  .151E+03     .22
     2.61      .00      .65      7.3  .138E+03     .24
     2.83      .00      .67      7.9  .127E+03     .25
     3.05      .00      .69      8.5  .118E+03     .27
     3.28      .00      .71      9.1  .110E+03     .28
```

3.51	.00	.73	9.7	.103E+03	.29
3.74	.00	.75	10.2	.976E+02	.30
3.97	.00	.77	10.8	.926E+02	.32
4.20	.00	.78	11.3	.882E+02	.33
4.43	.00	.79	11.9	.843E+02	.34
4.66	.00	.80	12.4	.808E+02	.35
4.89	.00	.81	12.9	.777E+02	.36
5.12	.00	.82	13.3	.749E+02	.37
5.35	.00	.82	13.8	.724E+02	.37
5.59	.00	.83	14.2	.702E+02	.38
5.81	.00	.83	14.7	.682E+02	.39
6.04	.00	.83	15.1	.664E+02	.40
6.27	.00	.83	15.5	.647E+02	.40

Maximum jet height has been reached.

6.50	.00	.83	15.8	.631E+02	.41
6.73	.00	.83	16.2	.616E+02	.42
6.96	.00	.83	16.6	.601E+02	.42
7.19	.00	.83	17.0	.587E+02	.43
7.42	.00	.82	17.5	.572E+02	.44
7.65	.00	.82	17.9	.558E+02	.44
7.88	.00	.81	18.4	.545E+02	.45
8.11	.00	.81	18.8	.531E+02	.46
8.34	.00	.80	19.3	.518E+02	.47
8.56	.00	.79	19.8	.506E+02	.47
8.79	.00	.78	20.3	.493E+02	.48
9.02	.00	.77	20.8	.481E+02	.49
9.25	.00	.76	21.3	.469E+02	.50
9.48	.00	.74	21.9	.457E+02	.50
9.71	.00	.73	22.4	.446E+02	.51
9.94	.00	.72	23.0	.435E+02	.52
10.17	.00	.70	23.6	.424E+02	.53
10.40	.00	.69	24.2	.413E+02	.54
10.63	.00	.67	24.8	.403E+02	.54
10.86	.00	.66	25.4	.393E+02	.55
11.09	.00	.64	26.1	.384E+02	.56
11.31	.00	.62	26.7	.375E+02	.57
11.54	.00	.60	27.3	.366E+02	.58
11.77	.00	.59	28.0	.357E+02	.59

Cumulative travel time = 13. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

Control volume inflow:

X	Y	Z	S	C	B
11.77	.00	.59	28.0	.357E+02	.59

MAC4-1X.CX1

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
11.19	.00	.00	28.0	.357E+02	.00	.00	.00	.00
11.36	.00	.00	28.0	.357E+02	.82	.41	.82	.00
11.54	.00	.00	28.0	.357E+02	.97	.58	.97	.00
11.71	.00	.00	28.0	.357E+02	1.07	.71	1.07	.00
11.89	.00	.00	28.8	.348E+02	1.14	.82	1.14	.00
12.06	.00	.00	32.3	.309E+02	1.19	.92	1.19	.00
12.24	.00	.00	37.3	.268E+02	1.23	1.01	1.23	.00
12.41	.00	.00	41.7	.240E+02	1.26	1.09	1.26	.00
12.59	.00	.00	44.8	.223E+02	1.28	1.16	1.28	.00
12.77	.00	.00	46.5	.215E+02	1.29	1.23	1.29	.00
12.94	.00	.00	47.6	.210E+02	1.30	1.30	1.30	.00

Cumulative travel time = 17. sec

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

** End of NEAR-FIELD REGION (NFR) **

BEGIN MOD141: BUOYANT AMBIENT SPREADING

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
12.94	.00	.00	47.6	.210E+02	1.30	1.30	1.30	.00
13.60	.00	.00	48.5	.206E+02	1.24	1.38	1.24	.00
14.26	.00	.00	49.4	.202E+02	1.20	1.46	1.20	.00
14.92	.00	.00	50.3	.199E+02	1.16	1.54	1.16	.00
15.57	.00	.00	51.2	.195E+02	1.12	1.61	1.12	.00
16.23	.00	.00	52.0	.192E+02	1.09	1.69	1.09	.00
16.89	.00	.00	52.9	.189E+02	1.06	1.76	1.06	.00
17.55	.00	.00	53.8	.186E+02	1.04	1.83	1.04	.00
18.21	.00	.00	54.6	.183E+02	1.02	1.90	1.02	.00

18.86	.00	.00	55.5	.180E+02	1.00	1.97	1.00	.00
19.52	.00	.00	56.4	.177E+02	.98	2.03	.98	.00
20.18	.00	.00	57.3	.174E+02	.97	2.10	.97	.00
20.84	.00	.00	58.2	.172E+02	.95	2.16	.95	.00
21.50	.00	.00	59.2	.169E+02	.94	2.23	.94	.00
22.15	.00	.00	60.1	.166E+02	.93	2.29	.93	.00
22.81	.00	.00	61.1	.164E+02	.92	2.35	.92	.00
23.47	.00	.00	62.1	.161E+02	.91	2.41	.91	.00
24.13	.00	.00	63.1	.158E+02	.90	2.47	.90	.00
24.79	.00	.00	64.2	.156E+02	.90	2.53	.90	.00
25.45	.00	.00	65.2	.153E+02	.89	2.59	.89	.00
26.10	.00	.00	66.3	.151E+02	.89	2.65	.89	.00
26.76	.00	.00	67.5	.148E+02	.88	2.71	.88	.00
27.42	.00	.00	68.6	.146E+02	.88	2.77	.88	.00
28.08	.00	.00	69.8	.143E+02	.88	2.82	.88	.00
28.74	.00	.00	71.0	.141E+02	.87	2.88	.87	.00
29.39	.00	.00	72.2	.138E+02	.87	2.93	.87	.00
30.05	.00	.00	73.5	.136E+02	.87	2.99	.87	.00
30.71	.00	.00	74.8	.134E+02	.87	3.04	.87	.00
31.37	.00	.00	76.1	.131E+02	.87	3.10	.87	.00
32.03	.00	.00	77.5	.129E+02	.87	3.15	.87	.00
32.68	.00	.00	78.9	.127E+02	.87	3.20	.87	.00
33.34	.00	.00	80.3	.124E+02	.87	3.26	.87	.00
34.00	.00	.00	81.8	.122E+02	.87	3.31	.87	.00
34.66	.00	.00	83.3	.120E+02	.88	3.36	.88	.00
35.32	.00	.00	84.8	.118E+02	.88	3.41	.88	.00
35.97	.00	.00	86.4	.116E+02	.88	3.46	.88	.00
36.63	.00	.00	88.0	.114E+02	.89	3.51	.89	.00
37.29	.00	.00	89.7	.112E+02	.89	3.56	.89	.00
37.95	.00	.00	91.3	.109E+02	.89	3.61	.89	.00
38.61	.00	.00	93.1	.107E+02	.90	3.66	.90	.00
39.27	.00	.00	94.8	.105E+02	.90	3.71	.90	.00
39.92	.00	.00	96.6	.103E+02	.91	3.76	.91	.00
40.58	.00	.00	98.5	.102E+02	.91	3.81	.91	.00
41.24	.00	.00	100.3	.997E+01	.92	3.86	.92	.00
41.90	.00	.00	102.2	.978E+01	.93	3.91	.93	.00
42.56	.00	.00	104.2	.960E+01	.93	3.95	.93	.00
43.21	.00	.00	106.2	.942E+01	.94	4.00	.94	.00
43.87	.00	.00	108.2	.924E+01	.95	4.05	.95	.00
44.53	.00	.00	110.3	.907E+01	.95	4.09	.95	.00
45.19	.00	.00	112.4	.890E+01	.96	4.14	.96	.00
45.85	.00	.00	114.6	.873E+01	.97	4.19	.97	.00

Cumulative travel time = 110. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

MAC4-1X.CX1

Vertical diffusivity (initial value) = .117E-01 m^2/s
Horizontal diffusivity (initial value) = .293E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
45.85	.00	.00	114.6	.873E+01	.97	4.19	.97	.00
48.60	.00	.00	121.6	.823E+01	1.01	4.27	1.01	.00
51.35	.00	.00	128.9	.776E+01	1.05	4.35	1.05	.00
54.11	.00	.00	136.6	.732E+01	1.09	4.44	1.09	.00
56.86	.00	.00	144.6	.691E+01	1.13	4.52	1.13	.00
59.62	.00	.00	153.0	.653E+01	1.18	4.60	1.18	.00
62.37	.00	.00	161.7	.618E+01	1.22	4.67	1.22	.00
65.12	.00	.00	170.8	.586E+01	1.27	4.75	1.27	.00
67.88	.00	.00	180.1	.555E+01	1.32	4.82	1.32	.00
70.63	.00	.00	189.7	.527E+01	1.37	4.90	1.37	.00
73.39	.00	.00	199.6	.501E+01	1.42	4.97	1.42	.00
76.14	.00	.00	209.8	.477E+01	1.47	5.04	1.47	.00
78.89	.00	.00	220.1	.454E+01	1.52	5.11	1.52	.00
81.65	.00	.00	230.7	.433E+01	1.58	5.18	1.58	.00
84.40	.00	.00	241.5	.414E+01	1.63	5.25	1.63	.00

Plume interacts with SURFACE.
The passive diffusion plume becomes VERTICALLY FULLY MIXED within this prediction interval.

87.15	.00	.00	247.0	.405E+01	1.64	5.32	1.64	.00
89.91	.00	.00	250.1	.400E+01	1.64	5.39	1.64	.00
92.66	.00	.00	253.1	.395E+01	1.64	5.45	1.64	.00
95.42	.00	.00	256.2	.390E+01	1.64	5.52	1.64	.00
98.17	.00	.00	259.2	.386E+01	1.64	5.58	1.64	.00
100.92	.00	.00	262.1	.381E+01	1.64	5.65	1.64	.00
103.68	.00	.00	265.1	.377E+01	1.64	5.71	1.64	.00
106.43	.00	.00	268.0	.373E+01	1.64	5.77	1.64	.00
109.19	.00	.00	270.8	.369E+01	1.64	5.83	1.64	.00
111.94	.00	.00	273.7	.365E+01	1.64	5.89	1.64	.00
114.69	.00	.00	276.5	.362E+01	1.64	5.95	1.64	.00
117.45	.00	.00	279.3	.358E+01	1.64	6.01	1.64	.00
120.20	.00	.00	282.0	.355E+01	1.64	6.07	1.64	.00
122.96	.00	.00	284.8	.351E+01	1.64	6.13	1.64	.00

125.71	.00	.00	287.5	.348E+01	1.64	6.19	1.64	.00
128.46	.00	.00	290.1	.345E+01	1.64	6.25	1.64	.00
131.22	.00	.00	292.8	.342E+01	1.64	6.31	1.64	.00
133.97	.00	.00	295.4	.339E+01	1.64	6.36	1.64	.00
136.73	.00	.00	298.0	.336E+01	1.64	6.42	1.64	.00
139.48	.00	.00	300.6	.333E+01	1.64	6.47	1.64	.00
142.23	.00	.00	303.2	.330E+01	1.64	6.53	1.64	.00
144.99	.00	.00	305.7	.327E+01	1.64	6.58	1.64	.00
147.74	.00	.00	308.2	.324E+01	1.64	6.64	1.64	.00
150.50	.00	.00	310.7	.322E+01	1.64	6.69	1.64	.00
153.25	.00	.00	313.2	.319E+01	1.64	6.74	1.64	.00
156.00	.00	.00	315.7	.317E+01	1.64	6.80	1.64	.00
158.76	.00	.00	318.1	.314E+01	1.64	6.85	1.64	.00
161.51	.00	.00	320.5	.312E+01	1.64	6.90	1.64	.00
164.26	.00	.00	322.9	.310E+01	1.64	6.95	1.64	.00
167.02	.00	.00	325.3	.307E+01	1.64	7.01	1.64	.00
169.77	.00	.00	327.7	.305E+01	1.64	7.06	1.64	.00
172.53	.00	.00	330.0	.303E+01	1.64	7.11	1.64	.00
175.28	.00	.00	332.4	.301E+01	1.64	7.16	1.64	.00
178.03	.00	.00	334.7	.299E+01	1.64	7.21	1.64	.00
180.79	.00	.00	337.0	.297E+01	1.64	7.26	1.64	.00
183.54	.00	.00	339.3	.295E+01	1.64	7.31	1.64	.00

Cumulative travel time = 499. sec

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
183.54	7.31	.00	339.3	.295E+01	1.64	14.61	1.64	.00
199.87	7.31	.00	342.6	.292E+01	1.64	14.76	1.64	.00
216.20	7.31	.00	345.9	.289E+01	1.64	14.90	1.64	.00
232.53	7.31	.00	349.2	.286E+01	1.64	15.04	1.64	.00
248.86	7.31	.00	352.5	.284E+01	1.64	15.18	1.64	.00
265.19	7.31	.00	355.7	.281E+01	1.64	15.32	1.64	.00
281.52	7.31	.00	359.0	.279E+01	1.64	15.46	1.64	.00
297.85	7.31	.00	362.1	.276E+01	1.64	15.60	1.64	.00
314.18	7.31	.00	365.3	.274E+01	1.64	15.73	1.64	.00
330.50	7.31	.00	368.4	.271E+01	1.64	15.87	1.64	.00
346.83	7.31	.00	371.5	.269E+01	1.64	16.00	1.64	.00
363.16	7.31	.00	374.6	.267E+01	1.64	16.13	1.64	.00
379.49	7.31	.00	377.6	.265E+01	1.64	16.26	1.64	.00
395.82	7.31	.00	380.6	.263E+01	1.64	16.39	1.64	.00
412.15	7.31	.00	383.6	.261E+01	1.64	16.52	1.64	.00
428.48	7.31	.00	386.6	.259E+01	1.64	16.65	1.64	.00
444.81	7.31	.00	389.6	.257E+01	1.64	16.78	1.64	.00
461.14	7.31	.00	392.5	.255E+01	1.64	16.90	1.64	.00
477.47	7.31	.00	395.4	.253E+01	1.64	17.03	1.64	.00
493.80	7.31	.00	398.3	.251E+01	1.64	17.15	1.64	.00
510.13	7.31	.00	401.2	.249E+01	1.64	17.28	1.64	.00

MAC4-1X.CX1

526.45	7.31	.00	404.0	.248E+01	1.64	17.40	1.64	.00
542.78	7.31	.00	406.8	.246E+01	1.64	17.52	1.64	.00
559.11	7.31	.00	409.6	.244E+01	1.64	17.64	1.64	.00
575.44	7.31	.00	412.4	.242E+01	1.64	17.76	1.64	.00
591.77	7.31	.00	415.2	.241E+01	1.64	17.88	1.64	.00
608.10	7.31	.00	417.9	.239E+01	1.64	18.00	1.64	.00
624.43	7.31	.00	420.7	.238E+01	1.64	18.12	1.64	.00
640.76	7.31	.00	423.4	.236E+01	1.64	18.24	1.64	.00
657.09	7.31	.00	426.1	.235E+01	1.64	18.35	1.64	.00
673.42	7.31	.00	428.8	.233E+01	1.64	18.47	1.64	.00
689.75	7.31	.00	431.4	.232E+01	1.64	18.58	1.64	.00
706.08	7.31	.00	434.1	.230E+01	1.64	18.70	1.64	.00
722.40	7.31	.00	436.7	.229E+01	1.64	18.81	1.64	.00
738.73	7.31	.00	439.3	.228E+01	1.64	18.92	1.64	.00
755.06	7.31	.00	441.9	.226E+01	1.64	19.03	1.64	.00
771.39	7.31	.00	444.5	.225E+01	1.64	19.14	1.64	.00
787.72	7.31	.00	447.1	.224E+01	1.64	19.26	1.64	.00
804.05	7.31	.00	449.6	.222E+01	1.64	19.37	1.64	.00
820.38	7.31	.00	452.2	.221E+01	1.64	19.48	1.64	.00
836.71	7.31	.00	454.7	.220E+01	1.64	19.58	1.64	.00
853.04	7.31	.00	457.2	.219E+01	1.64	19.69	1.64	.00
869.37	7.31	.00	459.7	.218E+01	1.64	19.80	1.64	.00
885.70	7.31	.00	462.2	.216E+01	1.64	19.91	1.64	.00
902.03	7.31	.00	464.7	.215E+01	1.64	20.01	1.64	.00
918.35	7.31	.00	467.1	.214E+01	1.64	20.12	1.64	.00
934.68	7.31	.00	469.6	.213E+01	1.64	20.22	1.64	.00
951.01	7.31	.00	472.0	.212E+01	1.64	20.33	1.64	.00
967.34	7.31	.00	474.4	.211E+01	1.64	20.43	1.64	.00
983.67	7.31	.00	476.8	.210E+01	1.64	20.54	1.64	.00
1000.00	7.31	.00	479.2	.209E+01	1.64	20.64	1.64	.00

Cumulative travel time = 2806. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

11111111111111111111111111111111111111111111111111111111111111111111111111111111

MAC4-3N.CX1

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CORMIX1 PRESCRIPTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111
                    CORNELL MIXING ZONE EXPERT SYSTEM
Subsystem CORMIX1:                                          Subsystem version:
 Submerged Single Port Discharges           CORMIX_v.3.20_____September_1996
------------------------------------------------------------------------------
------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:         Mach^Big^Muddy^River
 Design case:             Case^4^-^Port^3^Normal^Flow
 FILE NAME:               cormix\sim\Mac4-3N .cx1
 Time of Fortran run:     11/09/16--09:00:39

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     43.24  AS    =     58.13  QA    =     16.65  ICHREG= 2
 HA    =      1.34  HD    =      1.34
 UA    =      .287  F     =       .087 USTAR = .2989E-01
 UW    =     2.000 UWSTAR= .2198E-02
 Uniform density environment
 STRCND=  U         RHOAM =  998.4901

DISCHARGE PARAMETERS (metric units)
 BANK  =  LEFT      DISTB =     15.73
 D0    =      .102 A0    =      .008 H0    =       .15
 THETA =    15.00  SIGMA =       .00
 U0    =     2.905 Q0    =       .024       = .2355E-01
 RHO0  = 1013.3900  DRHO0 =-.1490E+02  GP0   =-.1463E+00
 C0    = .1000E+04  CUNITS=  ppm
 IPOLL =  1         KS    = .0000E+00  KD    = .0000E+00

FLUX VARIABLES (metric units)
 Q0    = .2355E-01  M0    = .6841E-01  J0    =-.3446E-02  SIGNJ0=     -1.0
 Associated length scales (meters)
 LQ    =      .09  LM    =      2.28  Lm    =       .91  Lb    =       .15
                                      Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =     23.82  R     =     10.13

FLOW CLASSIFICATION
 11111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    NH5    1
 1  Applicable layer depth HS =     1.34  1
 11111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    = .1000E+04  CUNITS=  ppm
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 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
        15.73 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

 COANDA ATTACHMENT immediately following the discharge.

       X        Y        Z        S        C        B
      .00      .00      .00      1.0  .100E+04     .07

END OF MOD101: DISCHARGE MODULE
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Bottom-attached jet motion.

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
            Half wall jet, attached to bottom.
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .00      1.0  .100E+04     .05
     1.65      .00      .00      2.5  .394E+03     .18
     3.30      .00      .00      4.3  .231E+03     .27
     4.96      .00      .00      6.0  .166E+03     .35
     6.61      .00      .00      7.6  .131E+03     .41
     8.26      .00      .00      9.2  .109E+03     .46
     9.91      .00      .00     10.6  .939E+02     .51
    11.57      .00      .00     12.1  .829E+02     .56
    13.23      .00      .00     13.4  .744E+02     .60
    14.88      .00      .00     14.8  .677E+02     .63
    16.53      .00      .00     16.1  .622E+02     .67
    18.19      .00      .00     17.3  .577E+02     .70
    19.84      .00      .00     18.6  .539E+02     .73
    21.49      .00      .00     19.8  .506E+02     .75
    23.14      .00      .00     20.9  .478E+02     .78
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24.80	.00	.00	22.1	.453E+02	.81
26.46	.00	.00	23.2	.430E+02	.83
28.11	.00	.00	24.3	.411E+02	.85
29.76	.00	.00	25.4	.393E+02	.88
31.41	.00	.00	26.5	.377E+02	.90
33.07	.00	.00	27.6	.363E+02	.92
34.73	.00	.00	28.6	.349E+02	.94
36.38	.00	.00	29.7	.337E+02	.96
38.03	.00	.00	30.7	.326E+02	.98
39.68	.00	.00	31.7	.316E+02	.99
41.34	.00	.00	32.7	.306E+02	1.01
42.99	.00	.00	33.6	.297E+02	1.03
44.64	.00	.00	34.6	.289E+02	1.05
46.30	.00	.00	35.6	.281E+02	1.06
47.96	.00	.00	36.5	.274E+02	1.08
49.61	.00	.00	37.5	.267E+02	1.09
51.26	.00	.00	38.4	.261E+02	1.11
52.91	.00	.00	39.3	.254E+02	1.12
54.57	.00	.00	40.2	.249E+02	1.14
56.23	.00	.00	41.1	.243E+02	1.15
57.88	.00	.00	42.0	.238E+02	1.16
59.53	.00	.00	42.9	.233E+02	1.18
61.18	.00	.00	43.8	.229E+02	1.19
62.84	.00	.00	44.6	.224E+02	1.20
64.49	.00	.00	45.5	.220E+02	1.22
66.14	.00	.00	46.3	.216E+02	1.23
67.79	.00	.00	47.2	.212E+02	1.24
69.45	.00	.00	48.0	.208E+02	1.25
71.11	.00	.00	48.9	.205E+02	1.27
72.76	.00	.00	49.7	.201E+02	1.28
74.41	.00	.00	50.5	.198E+02	1.29
76.07	.00	.00	51.4	.195E+02	1.30
77.72	.00	.00	52.2	.192E+02	1.31
79.37	.00	.00	53.0	.189E+02	1.32
81.02	.00	.00	53.8	.186E+02	1.33
82.67	.00	.00	54.6	.183E+02	1.34

Cumulative travel time = 191. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
82.67	.00	.00	54.6	.183E+02	1.34

Profile definitions:

MAC4-3N.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
81.33	.00	.00	54.6	.183E+02	.00	.00	.00	.00
81.60	.00	.00	54.6	.183E+02	1.34	.23	1.34	.00
81.87	.00	.00	54.6	.183E+02	1.34	.33	1.34	.00
82.14	.00	.00	54.6	.183E+02	1.34	.40	1.34	.00
82.41	.00	.00	54.6	.183E+02	1.34	.47	1.34	.00
82.67	.00	.00	54.6	.183E+02	1.34	.52	1.34	.00
82.94	.00	.00	57.8	.173E+02	1.34	.57	1.34	.00
83.21	.00	.00	64.9	.154E+02	1.34	.62	1.34	.00
83.48	.00	.00	71.2	.140E+02	1.34	.66	1.34	.00
83.75	.00	.00	74.7	.134E+02	1.34	.70	1.34	.00
84.02	.00	.00	76.4	.131E+02	1.34	.74	1.34	.00

Cumulative travel time = 197. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.16 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC4-3N.CX1

Profile definitions:
  BV = top-hat thickness, measured vertically
  BH = top-hat half-width, measured horizontally in Y-direction
  ZU = upper plume boundary (Z-coordinate)
  ZL = lower plume boundary (Z-coordinate)
  S = hydrodynamic average (bulk) dilution
  C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
84.02	.00	.00	76.4	.131E+02	1.34	2.33	1.34	.00
85.08	.00	.00	78.0	.128E+02	1.30	2.46	1.30	.00
86.14	.00	.00	79.6	.126E+02	1.26	2.59	1.26	.00
87.20	.00	.00	81.2	.123E+02	1.23	2.71	1.23	.00
88.26	.00	.00	82.8	.121E+02	1.20	2.84	1.20	.00
89.32	.00	.00	84.4	.118E+02	1.17	2.96	1.17	.00
90.38	.00	.00	86.1	.116E+02	1.15	3.07	1.15	.00
91.45	.00	.00	87.8	.114E+02	1.13	3.19	1.13	.00
92.51	.00	.00	89.5	.112E+02	1.11	3.30	1.11	.00
93.57	.00	.00	91.3	.110E+02	1.10	3.41	1.10	.00
94.63	.00	.00	93.1	.107E+02	1.09	3.52	1.09	.00
95.69	.00	.00	95.0	.105E+02	1.08	3.63	1.08	.00
96.75	.00	.00	96.9	.103E+02	1.07	3.73	1.07	.00
97.81	.00	.00	98.9	.101E+02	1.06	3.83	1.06	.00
98.87	.00	.00	101.0	.990E+01	1.05	3.94	1.05	.00
99.93	.00	.00	103.1	.970E+01	1.05	4.04	1.05	.00
100.99	.00	.00	105.3	.950E+01	1.04	4.14	1.04	.00
102.06	.00	.00	107.5	.930E+01	1.04	4.24	1.04	.00
103.12	.00	.00	109.8	.910E+01	1.04	4.34	1.04	.00
104.18	.00	.00	112.2	.891E+01	1.04	4.43	1.04	.00
105.24	.00	.00	114.7	.872E+01	1.04	4.53	1.04	.00
106.30	.00	.00	117.2	.853E+01	1.04	4.62	1.04	.00
107.36	.00	.00	119.8	.835E+01	1.04	4.72	1.04	.00
108.42	.00	.00	122.5	.816E+01	1.05	4.81	1.05	.00
109.48	.00	.00	125.3	.798E+01	1.05	4.90	1.05	.00
110.54	.00	.00	128.1	.781E+01	1.05	4.99	1.05	.00
111.60	.00	.00	131.0	.763E+01	1.06	5.08	1.06	.00
112.66	.00	.00	134.0	.746E+01	1.06	5.17	1.06	.00
113.73	.00	.00	137.1	.729E+01	1.07	5.26	1.07	.00
114.79	.00	.00	140.3	.713E+01	1.08	5.35	1.08	.00
115.85	.00	.00	143.6	.697E+01	1.08	5.43	1.08	.00
116.91	.00	.00	146.9	.681E+01	1.09	5.52	1.09	.00
117.97	.00	.00	150.3	.665E+01	1.10	5.61	1.10	.00
119.03	.00	.00	153.8	.650E+01	1.11	5.69	1.11	.00
120.09	.00	.00	157.5	.635E+01	1.12	5.78	1.12	.00
121.15	.00	.00	161.2	.621E+01	1.13	5.86	1.13	.00
122.21	.00	.00	164.9	.606E+01	1.14	5.94	1.14	.00

123.27	.00	.00	168.8	.592E+01	1.15	6.03	1.15	.00
124.34	.00	.00	172.8	.579E+01	1.16	6.11	1.16	.00
125.40	.00	.00	176.9	.565E+01	1.17	6.19	1.17	.00
126.46	.00	.00	181.0	.552E+01	1.18	6.27	1.18	.00
127.52	.00	.00	185.3	.540E+01	1.20	6.35	1.20	.00
128.58	.00	.00	189.7	.527E+01	1.21	6.43	1.21	.00
129.64	.00	.00	194.1	.515E+01	1.22	6.51	1.22	.00
130.70	.00	.00	198.7	.503E+01	1.24	6.59	1.24	.00
131.76	.00	.00	203.3	.492E+01	1.25	6.67	1.25	.00
132.82	.00	.00	208.1	.481E+01	1.27	6.75	1.27	.00
133.88	.00	.00	212.9	.470E+01	1.28	6.82	1.28	.00
134.94	.00	.00	217.9	.459E+01	1.30	6.90	1.30	.00
136.01	.00	.00	222.9	.449E+01	1.31	6.98	1.31	.00
137.07	.00	.00	228.1	.438E+01	1.33	7.05	1.33	.00

Cumulative travel time = 382. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .804E-02 m^2/s
Horizontal diffusivity (initial value) = .201E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
137.07	.00	.00	228.1	.438E+01	1.33	7.05	1.33	.00
154.33	.00	.00	239.8	.417E+01	1.34	7.32	1.34	.00
171.58	.00	.00	248.1	.403E+01	1.34	7.57	1.34	.00
188.84	.00	.00	256.2	.390E+01	1.34	7.82	1.34	.00
206.10	.00	.00	264.0	.379E+01	1.34	8.06	1.34	.00
223.36	.00	.00	271.7	.368E+01	1.34	8.29	1.34	.00
240.62	.00	.00	279.1	.358E+01	1.34	8.52	1.34	.00
257.88	.00	.00	286.3	.349E+01	1.34	8.74	1.34	.00
275.14	.00	.00	293.3	.341E+01	1.34	8.95	1.34	.00
292.39	.00	.00	300.2	.333E+01	1.34	9.16	1.34	.00
309.65	.00	.00	306.9	.326E+01	1.34	9.37	1.34	.00
326.91	.00	.00	313.5	.319E+01	1.34	9.57	1.34	.00

344.17	.00	.00	319.9	.313E+01	1.34	9.77	1.34	.00
361.43	.00	.00	326.2	.307E+01	1.34	9.96	1.34	.00
378.69	.00	.00	332.4	.301E+01	1.34	10.15	1.34	.00
395.95	.00	.00	338.5	.295E+01	1.34	10.33	1.34	.00
413.21	.00	.00	344.5	.290E+01	1.34	10.51	1.34	.00
430.46	.00	.00	350.3	.285E+01	1.34	10.69	1.34	.00
447.72	.00	.00	356.1	.281E+01	1.34	10.87	1.34	.00
464.98	.00	.00	361.8	.276E+01	1.34	11.04	1.34	.00
482.24	.00	.00	367.4	.272E+01	1.34	11.21	1.34	.00
499.50	.00	.00	372.9	.268E+01	1.34	11.38	1.34	.00
516.76	.00	.00	378.3	.264E+01	1.34	11.55	1.34	.00
534.02	.00	.00	383.7	.261E+01	1.34	11.71	1.34	.00
551.27	.00	.00	388.9	.257E+01	1.34	11.87	1.34	.00
568.53	.00	.00	394.1	.254E+01	1.34	12.03	1.34	.00
585.79	.00	.00	399.3	.250E+01	1.34	12.19	1.34	.00
603.05	.00	.00	404.4	.247E+01	1.34	12.34	1.34	.00
620.31	.00	.00	409.4	.244E+01	1.34	12.50	1.34	.00
637.57	.00	.00	414.3	.241E+01	1.34	12.65	1.34	.00
654.83	.00	.00	419.2	.239E+01	1.34	12.80	1.34	.00
672.09	.00	.00	424.0	.236E+01	1.34	12.94	1.34	.00
689.34	.00	.00	428.8	.233E+01	1.34	13.09	1.34	.00
706.60	.00	.00	433.6	.231E+01	1.34	13.23	1.34	.00
723.86	.00	.00	438.2	.228E+01	1.34	13.38	1.34	.00
741.12	.00	.00	442.9	.226E+01	1.34	13.52	1.34	.00
758.38	.00	.00	447.4	.223E+01	1.34	13.66	1.34	.00
775.64	.00	.00	452.0	.221E+01	1.34	13.80	1.34	.00
792.90	.00	.00	456.5	.219E+01	1.34	13.93	1.34	.00
810.15	.00	.00	460.9	.217E+01	1.34	14.07	1.34	.00
827.41	.00	.00	465.3	.215E+01	1.34	14.20	1.34	.00
844.67	.00	.00	469.7	.213E+01	1.34	14.34	1.34	.00
861.93	.00	.00	474.0	.211E+01	1.34	14.47	1.34	.00
879.19	.00	.00	478.3	.209E+01	1.34	14.60	1.34	.00
896.45	.00	.00	482.5	.207E+01	1.34	14.73	1.34	.00
913.71	.00	.00	486.7	.205E+01	1.34	14.86	1.34	.00
930.97	.00	.00	490.9	.204E+01	1.34	14.98	1.34	.00
948.22	.00	.00	495.0	.202E+01	1.34	15.11	1.34	.00
965.48	.00	.00	499.1	.200E+01	1.34	15.24	1.34	.00
982.74	.00	.00	503.2	.199E+01	1.34	15.36	1.34	.00
1000.00	.00	.00	507.2	.197E+01	1.34	15.48	1.34	.00

Cumulative travel time = 3389. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

MAC4-3N.CX1

1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111

MAC4-3X.CX1

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CORMIX1 PRESCRIPTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111
                    CORNELL MIXING ZONE EXPERT SYSTEM
Subsystem CORMIX1:                                          Subsystem version:
 Submerged Single Port Discharges           CORMIX_v.3.20_____September_1996
------------------------------------------------------------------------------
------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:         Mach^Big^Muddy^River
 Design case:             Case^4^-^Port^4^Maximum^Flow
 FILE NAME:               cormix\sim\Mac4-3X .cx1
 Time of Fortran run:     11/09/16--09:08:19

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     56.85  AS    =     93.39  QA    =     33.02  ICHREG= 2
 HA    =      1.64  HD    =      1.64
 UA    =       .354 F     =       .081 USTAR = .3568E-01
 UW    =     2.000 UWSTAR= .2198E-02
 Uniform density environment
 STRCND=  U         RHOAM =  998.4907

DISCHARGE PARAMETERS (metric units)
 BANK  =  LEFT      DISTB =     20.62
 D0    =       .102 A0    =       .008 H0    =       .15
 THETA =     15.00  SIGMA =       .00
 U0    =      5.487 Q0    =       .044       = .4448E-01
 RHO0  = 1013.3900  DRHO0 =-.1490E+02  GP0   =-.1463E+00
 C0    = .1000E+04  CUNITS=  ppm
 IPOLL =  1         KS    = .0000E+00  KD    = .0000E+00

FLUX VARIABLES (metric units)
 Q0    = .4448E-01  M0    = .2441E+00  J0    =-.6509E-02  SIGNJ0=     -1.0
 Associated length scales (meters)
 LQ    =       .09  LM    =      4.30  Lm    =      1.40  Lb    =       .15
                                        Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =     44.99  R     =     15.51

FLOW CLASSIFICATION
 11111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    NH5    1
 1  Applicable layer depth HS =     1.64  1
 11111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    = .1000E+04  CUNITS=  ppm
```

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
        20.62 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

 COANDA ATTACHMENT immediately following the discharge.

       X        Y        Z        S        C        B
       .00      .00      .00     1.0  .100E+04     .07

END OF MOD101: DISCHARGE MODULE
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Bottom-attached jet motion.

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
            Half wall jet, attached to bottom.
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
       .00      .00      .00     1.0  .100E+04     .05
      1.43      .00      .00     2.3  .427E+03     .18
      2.85      .00      .00     4.0  .250E+03     .28
      4.28      .00      .00     5.6  .178E+03     .36
      5.70      .00      .00     7.2  .140E+03     .44
      7.13      .00      .00     8.7  .115E+03     .50
      8.55      .00      .00    10.1  .988E+02     .56
      9.98      .00      .00    11.5  .867E+02     .62
     11.40      .00      .00    12.9  .775E+02     .67
     12.83      .00      .00    14.3  .702E+02     .71
     14.25      .00      .00    15.6  .643E+02     .76
     15.68      .00      .00    16.8  .594E+02     .80
     17.10      .00      .00    18.1  .552E+02     .84
     18.53      .00      .00    19.3  .517E+02     .87
     19.95      .00      .00    20.5  .487E+02     .91
```

21.38	.00	.00	21.7	.460E+02	.94
22.80	.00	.00	22.9	.437E+02	.97
24.23	.00	.00	24.1	.416E+02	1.00
25.65	.00	.00	25.2	.397E+02	1.03
27.08	.00	.00	26.3	.380E+02	1.06
28.50	.00	.00	27.4	.365E+02	1.08
29.93	.00	.00	28.5	.351E+02	1.11
31.35	.00	.00	29.6	.338E+02	1.14
32.78	.00	.00	30.6	.326E+02	1.16
34.20	.00	.00	31.7	.316E+02	1.18
35.63	.00	.00	32.7	.306E+02	1.21
37.05	.00	.00	33.7	.296E+02	1.23
38.48	.00	.00	34.8	.288E+02	1.25
39.90	.00	.00	35.8	.280E+02	1.27
41.34	.00	.00	36.8	.272E+02	1.29
42.76	.00	.00	37.7	.265E+02	1.31
44.19	.00	.00	38.7	.258E+02	1.33
45.61	.00	.00	39.7	.252E+02	1.35
47.04	.00	.00	40.6	.246E+02	1.37
48.46	.00	.00	41.6	.240E+02	1.39
49.89	.00	.00	42.5	.235E+02	1.41
51.31	.00	.00	43.5	.230E+02	1.42
52.74	.00	.00	44.4	.225E+02	1.44
54.16	.00	.00	45.3	.221E+02	1.46
55.59	.00	.00	46.2	.216E+02	1.48
57.01	.00	.00	47.1	.212E+02	1.49
58.44	.00	.00	48.0	.208E+02	1.51
59.87	.00	.00	48.9	.205E+02	1.52
61.29	.00	.00	49.8	.201E+02	1.54
62.72	.00	.00	50.6	.197E+02	1.56
64.14	.00	.00	51.5	.194E+02	1.57
65.57	.00	.00	52.4	.191E+02	1.59
66.99	.00	.00	53.2	.188E+02	1.60
68.42	.00	.00	54.1	.185E+02	1.61
69.84	.00	.00	54.9	.182E+02	1.63
71.27	.00	.00	55.8	.179E+02	1.64

Cumulative travel time = 114. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
71.27	.00	.00	55.8	.179E+02	1.64

Profile definitions:

MAC4-3X.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
69.62	.00	.00	55.8	.179E+02	.00	.00	.00	.00
69.95	.00	.00	55.8	.179E+02	1.64	.29	1.64	.00
70.28	.00	.00	55.8	.179E+02	1.64	.42	1.64	.00
70.61	.00	.00	55.8	.179E+02	1.64	.51	1.64	.00
70.94	.00	.00	55.8	.179E+02	1.64	.59	1.64	.00
71.27	.00	.00	55.8	.179E+02	1.64	.66	1.64	.00
71.59	.00	.00	59.1	.169E+02	1.64	.72	1.64	.00
71.92	.00	.00	66.3	.151E+02	1.64	.78	1.64	.00
72.25	.00	.00	72.8	.137E+02	1.64	.83	1.64	.00
72.58	.00	.00	76.4	.131E+02	1.64	.88	1.64	.00
72.91	.00	.00	78.1	.128E+02	1.64	.93	1.64	.00

Cumulative travel time = 119. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.22 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC4-3X.CX1

Profile definitions:
  BV = top-hat thickness, measured vertically
  BH = top-hat half-width, measured horizontally in Y-direction
  ZU = upper plume boundary (Z-coordinate)
  ZL = lower plume boundary (Z-coordinate)
  S = hydrodynamic average (bulk) dilution
  C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
72.91	.00	.00	78.1	.128E+02	1.64	2.99	1.64	.00
74.03	.00	.00	79.4	.126E+02	1.60	3.11	1.60	.00
75.16	.00	.00	80.8	.124E+02	1.57	3.23	1.57	.00
76.28	.00	.00	82.1	.122E+02	1.54	3.35	1.54	.00
77.41	.00	.00	83.5	.120E+02	1.51	3.47	1.51	.00
78.53	.00	.00	84.9	.118E+02	1.49	3.58	1.49	.00
79.66	.00	.00	86.3	.116E+02	1.47	3.69	1.47	.00
80.79	.00	.00	87.8	.114E+02	1.45	3.80	1.45	.00
81.91	.00	.00	89.3	.112E+02	1.43	3.91	1.43	.00
83.04	.00	.00	90.8	.110E+02	1.42	4.02	1.42	.00
84.16	.00	.00	92.4	.108E+02	1.41	4.13	1.41	.00
85.29	.00	.00	93.9	.106E+02	1.39	4.23	1.39	.00
86.41	.00	.00	95.6	.105E+02	1.38	4.34	1.38	.00
87.54	.00	.00	97.3	.103E+02	1.38	4.44	1.38	.00
88.66	.00	.00	99.0	.101E+02	1.37	4.54	1.37	.00
89.79	.00	.00	100.7	.993E+01	1.36	4.64	1.36	.00
90.91	.00	.00	102.5	.975E+01	1.36	4.74	1.36	.00
92.04	.00	.00	104.4	.958E+01	1.35	4.84	1.35	.00
93.16	.00	.00	106.3	.941E+01	1.35	4.94	1.35	.00
94.29	.00	.00	108.2	.924E+01	1.35	5.03	1.35	.00
95.41	.00	.00	110.2	.907E+01	1.35	5.13	1.35	.00
96.54	.00	.00	112.3	.891E+01	1.35	5.22	1.35	.00
97.66	.00	.00	114.4	.874E+01	1.35	5.32	1.35	.00
98.79	.00	.00	116.6	.858E+01	1.35	5.41	1.35	.00
99.92	.00	.00	118.8	.842E+01	1.36	5.50	1.36	.00
101.04	.00	.00	121.0	.826E+01	1.36	5.59	1.36	.00
102.17	.00	.00	123.4	.811E+01	1.36	5.68	1.36	.00
103.29	.00	.00	125.7	.795E+01	1.37	5.77	1.37	.00
104.42	.00	.00	128.2	.780E+01	1.37	5.86	1.37	.00
105.54	.00	.00	130.7	.765E+01	1.38	5.95	1.38	.00
106.67	.00	.00	133.2	.751E+01	1.39	6.04	1.39	.00
107.79	.00	.00	135.8	.736E+01	1.39	6.13	1.39	.00
108.92	.00	.00	138.5	.722E+01	1.40	6.21	1.40	.00
110.04	.00	.00	141.2	.708E+01	1.41	6.30	1.41	.00
111.17	.00	.00	144.0	.694E+01	1.42	6.39	1.42	.00
112.29	.00	.00	146.9	.681E+01	1.43	6.47	1.43	.00
113.42	.00	.00	149.8	.667E+01	1.44	6.55	1.44	.00

114.54	.00	.00	152.8	.654E+01	1.45	6.64	1.45	.00
115.67	.00	.00	155.9	.642E+01	1.46	6.72	1.46	.00
116.79	.00	.00	159.0	.629E+01	1.47	6.80	1.47	.00
117.92	.00	.00	162.2	.617E+01	1.48	6.89	1.48	.00
119.05	.00	.00	165.4	.605E+01	1.49	6.97	1.49	.00
120.17	.00	.00	168.7	.593E+01	1.50	7.05	1.50	.00
121.30	.00	.00	172.1	.581E+01	1.52	7.13	1.52	.00
122.42	.00	.00	175.5	.570E+01	1.53	7.21	1.53	.00
123.55	.00	.00	179.1	.558E+01	1.54	7.29	1.54	.00
124.67	.00	.00	182.6	.547E+01	1.56	7.37	1.56	.00
125.80	.00	.00	186.3	.537E+01	1.57	7.45	1.57	.00
126.92	.00	.00	190.0	.526E+01	1.59	7.53	1.59	.00
128.05	.00	.00	193.8	.516E+01	1.60	7.61	1.60	.00
129.17	.00	.00	197.7	.506E+01	1.62	7.68	1.62	.00

Cumulative travel time = 278. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .117E-01 m^2/s
Horizontal diffusivity (initial value) = .293E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
129.17	.00	.00	197.7	.506E+01	1.62	7.68	1.62	.00
146.59	.00	.00	208.5	.480E+01	1.64	7.97	1.64	.00
164.01	.00	.00	215.8	.463E+01	1.64	8.25	1.64	.00
181.42	.00	.00	222.9	.449E+01	1.64	8.52	1.64	.00
198.84	.00	.00	229.8	.435E+01	1.64	8.78	1.64	.00
216.26	.00	.00	236.4	.423E+01	1.64	9.04	1.64	.00
233.67	.00	.00	242.9	.412E+01	1.64	9.29	1.64	.00
251.09	.00	.00	249.2	.401E+01	1.64	9.53	1.64	.00
268.51	.00	.00	255.3	.392E+01	1.64	9.76	1.64	.00
285.92	.00	.00	261.3	.383E+01	1.64	9.99	1.64	.00
303.34	.00	.00	267.2	.374E+01	1.64	10.21	1.64	.00
320.75	.00	.00	272.9	.366E+01	1.64	10.43	1.64	.00

338.17	.00	.00	278.5	.359E+01	1.64	10.65	1.64	.00
355.59	.00	.00	284.1	.352E+01	1.64	10.86	1.64	.00
373.00	.00	.00	289.5	.345E+01	1.64	11.07	1.64	.00
390.42	.00	.00	294.8	.339E+01	1.64	11.27	1.64	.00
407.84	.00	.00	300.0	.333E+01	1.64	11.47	1.64	.00
425.25	.00	.00	305.1	.328E+01	1.64	11.66	1.64	.00
442.67	.00	.00	310.1	.322E+01	1.64	11.86	1.64	.00
460.09	.00	.00	315.1	.317E+01	1.64	12.05	1.64	.00
477.50	.00	.00	320.0	.313E+01	1.64	12.23	1.64	.00
494.92	.00	.00	324.8	.308E+01	1.64	12.42	1.64	.00
512.34	.00	.00	329.5	.303E+01	1.64	12.60	1.64	.00
529.75	.00	.00	334.2	.299E+01	1.64	12.78	1.64	.00
547.17	.00	.00	338.8	.295E+01	1.64	12.95	1.64	.00
564.59	.00	.00	343.3	.291E+01	1.64	13.13	1.64	.00
582.00	.00	.00	347.8	.287E+01	1.64	13.30	1.64	.00
599.42	.00	.00	352.3	.284E+01	1.64	13.47	1.64	.00
616.84	.00	.00	356.6	.280E+01	1.64	13.63	1.64	.00
634.25	.00	.00	361.0	.277E+01	1.64	13.80	1.64	.00
651.67	.00	.00	365.2	.274E+01	1.64	13.96	1.64	.00
669.09	.00	.00	369.4	.271E+01	1.64	14.12	1.64	.00
686.50	.00	.00	373.6	.268E+01	1.64	14.28	1.64	.00
703.92	.00	.00	377.7	.265E+01	1.64	14.44	1.64	.00
721.34	.00	.00	381.8	.262E+01	1.64	14.60	1.64	.00
738.75	.00	.00	385.9	.259E+01	1.64	14.75	1.64	.00
756.17	.00	.00	389.9	.257E+01	1.64	14.90	1.64	.00
773.59	.00	.00	393.8	.254E+01	1.64	15.06	1.64	.00
791.00	.00	.00	397.7	.251E+01	1.64	15.21	1.64	.00
808.42	.00	.00	401.6	.249E+01	1.64	15.35	1.64	.00
825.84	.00	.00	405.4	.247E+01	1.64	15.50	1.64	.00
843.25	.00	.00	409.3	.244E+01	1.64	15.65	1.64	.00
860.67	.00	.00	413.0	.242E+01	1.64	15.79	1.64	.00
878.08	.00	.00	416.8	.240E+01	1.64	15.93	1.64	.00
895.50	.00	.00	420.5	.238E+01	1.64	16.08	1.64	.00
912.92	.00	.00	424.1	.236E+01	1.64	16.22	1.64	.00
930.33	.00	.00	427.8	.234E+01	1.64	16.35	1.64	.00
947.75	.00	.00	431.4	.232E+01	1.64	16.49	1.64	.00
965.17	.00	.00	435.0	.230E+01	1.64	16.63	1.64	.00
982.58	.00	.00	438.5	.228E+01	1.64	16.76	1.64	.00
1000.00	.00	.00	442.0	.226E+01	1.64	16.90	1.64	.00

Cumulative travel time = 2738. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

MAC4-3X.CX1

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MAC4-4N.CX1

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CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111
                    CORNELL MIXING ZONE EXPERT SYSTEM
Subsystem CORMIX1:                                          Subsystem version:
 Submerged Single Port Discharges          CORMIX_v.3.20_____September_1996
------------------------------------------------------------------------------
------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:        Mach^Big^Muddy^River
 Design case:            Case^4^-^Port^4^Normal^Flow
 FILE NAME:              cormix\sim\Mac4-4N .cx1
 Time of Fortran run:    11/09/16--09:57:08

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     43.24  AS    =     58.13  QA    =     16.65  ICHREG= 2
 HA    =      1.34  HD    =      1.34
 UA    =       .287 F     =       .087 USTAR = .2989E-01
 UW    =      2.000 UWSTAR= .2198E-02
 Uniform density environment
 STRCND=  U         RHOAM =  998.4901

DISCHARGE PARAMETERS (metric units)
 BANK  =  LEFT      DISTB =     20.62
 D0    =       .152 A0    =       .018 H0    =       .15
 THETA =     15.00  SIGMA =       .00
 U0    =      2.665 Q0    =       .049       = .4861E-01
 RHO0  = 1013.3900  DRHO0 =-.1490E+02  GP0   =-.1463E+00
 C0    = .1000E+04  CUNITS=  ppm
 IPOLL =  1         KS    = .0000E+00  KD    = .0000E+00

FLUX VARIABLES (metric units)
 Q0    = .4861E-01  M0    = .1295E+00  J0    =-.7114E-02  SIGNJ0=     -1.0
 Associated length scales (meters)
 LQ    =       .14  LM    =      2.56  Lm    =      1.26  Lb    =       .30
                                        Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =     17.84  R     =      9.30

FLOW CLASSIFICATION
 1111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    NH5    1
 1  Applicable layer depth HS =     1.34  1
 1111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    = .1000E+04  CUNITS=  ppm
```

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
        20.62 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

 COANDA ATTACHMENT immediately following the discharge.

       X        Y        Z        S        C        B
       .00      .00      .00     1.0  .100E+04     .11

END OF MOD101: DISCHARGE MODULE
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Bottom-attached jet motion.

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
            Half wall jet, attached to bottom.
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
       .00      .00      .00     1.0  .100E+04     .08
      1.06      .00      .00     1.4  .694E+03     .17
      2.11      .00      .00     2.2  .446E+03     .24
      3.17      .00      .00     3.0  .331E+03     .31
      4.22      .00      .00     3.8  .265E+03     .36
      5.28      .00      .00     4.5  .222E+03     .41
      6.33      .00      .00     5.2  .191E+03     .46
      7.39      .00      .00     5.9  .169E+03     .50
      8.44      .00      .00     6.6  .151E+03     .54
      9.50      .00      .00     7.3  .138E+03     .58
     10.55      .00      .00     7.9  .126E+03     .61
     11.61      .00      .00     8.6  .117E+03     .65
     12.66      .00      .00     9.2  .109E+03     .68
     13.72      .00      .00     9.8  .102E+03     .71
     14.77      .00      .00    10.4  .962E+02     .74
```

15.83	.00	.00	11.0	.910E+02	.76
16.88	.00	.00	11.6	.864E+02	.79
17.94	.00	.00	12.2	.823E+02	.81
18.99	.00	.00	12.7	.786E+02	.84
20.05	.00	.00	13.3	.753E+02	.86
21.11	.00	.00	13.8	.723E+02	.88
22.16	.00	.00	14.4	.695E+02	.90
23.22	.00	.00	14.9	.670E+02	.92
24.27	.00	.00	15.5	.647E+02	.94
25.33	.00	.00	16.0	.626E+02	.96
26.38	.00	.00	16.5	.606E+02	.98
27.44	.00	.00	17.0	.587E+02	1.00
28.49	.00	.00	17.5	.570E+02	1.02
29.55	.00	.00	18.0	.554E+02	1.04
30.60	.00	.00	18.5	.539E+02	1.05
31.66	.00	.00	19.0	.525E+02	1.07
32.71	.00	.00	19.5	.512E+02	1.09
33.77	.00	.00	20.0	.500E+02	1.10
34.82	.00	.00	20.5	.488E+02	1.12
35.88	.00	.00	21.0	.477E+02	1.13
36.93	.00	.00	21.5	.466E+02	1.15
37.99	.00	.00	21.9	.456E+02	1.16
39.04	.00	.00	22.4	.447E+02	1.18
40.10	.00	.00	22.9	.438E+02	1.19
41.15	.00	.00	23.3	.429E+02	1.21
42.21	.00	.00	23.8	.421E+02	1.22
43.27	.00	.00	24.2	.413E+02	1.23
44.32	.00	.00	24.7	.405E+02	1.25
45.38	.00	.00	25.1	.398E+02	1.26
46.43	.00	.00	25.6	.391E+02	1.27
47.49	.00	.00	26.0	.385E+02	1.28
48.54	.00	.00	26.4	.378E+02	1.30
49.60	.00	.00	26.9	.372E+02	1.31
50.65	.00	.00	27.3	.366E+02	1.32
51.71	.00	.00	27.7	.361E+02	1.33
52.76	.00	.00	28.2	.355E+02	1.34

Cumulative travel time = 99. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
52.76	.00	.00	28.2	.355E+02	1.34

Profile definitions:

MAC4-4N.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
51.42	.00	.00	28.2	.355E+02	.00	.00	.00	.00
51.69	.00	.00	28.2	.355E+02	1.34	.24	1.34	.00
51.96	.00	.00	28.2	.355E+02	1.34	.34	1.34	.00
52.22	.00	.00	28.2	.355E+02	1.34	.42	1.34	.00
52.49	.00	.00	28.2	.355E+02	1.34	.49	1.34	.00
52.76	.00	.00	28.2	.355E+02	1.34	.54	1.34	.00
53.03	.00	.00	29.8	.335E+02	1.34	.59	1.34	.00
53.30	.00	.00	33.5	.299E+02	1.34	.64	1.34	.00
53.57	.00	.00	36.8	.272E+02	1.34	.69	1.34	.00
53.84	.00	.00	38.6	.259E+02	1.34	.73	1.34	.00
54.11	.00	.00	39.4	.254E+02	1.34	.77	1.34	.00

Cumulative travel time = 105. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.23 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC4-4N.CX1

Profile definitions:
  BV = top-hat thickness, measured vertically
  BH = top-hat half-width, measured horizontally in Y-direction
  ZU = upper plume boundary (Z-coordinate)
  ZL = lower plume boundary (Z-coordinate)
  S = hydrodynamic average (bulk) dilution
  C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
54.11	.00	.00	39.4	.254E+02	1.34	2.48	1.34	.00
55.88	.00	.00	40.8	.245E+02	1.24	2.78	1.24	.00
57.65	.00	.00	42.1	.237E+02	1.16	3.06	1.16	.00
59.43	.00	.00	43.4	.230E+02	1.10	3.33	1.10	.00
61.20	.00	.00	44.7	.224E+02	1.05	3.60	1.05	.00
62.97	.00	.00	46.0	.218E+02	1.01	3.85	1.01	.00
64.75	.00	.00	47.2	.212E+02	.98	4.09	.98	.00
66.52	.00	.00	48.6	.206E+02	.95	4.33	.95	.00
68.29	.00	.00	49.9	.200E+02	.93	4.56	.93	.00
70.07	.00	.00	51.3	.195E+02	.91	4.78	.91	.00
71.84	.00	.00	52.8	.190E+02	.89	5.00	.89	.00
73.61	.00	.00	54.3	.184E+02	.88	5.21	.88	.00
75.39	.00	.00	55.8	.179E+02	.87	5.42	.87	.00
77.16	.00	.00	57.5	.174E+02	.86	5.63	.86	.00
78.93	.00	.00	59.2	.169E+02	.86	5.83	.86	.00
80.70	.00	.00	61.0	.164E+02	.85	6.03	.85	.00
82.48	.00	.00	62.8	.159E+02	.85	6.23	.85	.00
84.25	.00	.00	64.8	.154E+02	.85	6.42	.85	.00
86.02	.00	.00	66.8	.150E+02	.85	6.61	.85	.00
87.80	.00	.00	68.9	.145E+02	.86	6.80	.86	.00
89.57	.00	.00	71.1	.141E+02	.86	6.98	.86	.00
91.34	.00	.00	73.3	.136E+02	.87	7.16	.87	.00
93.12	.00	.00	75.7	.132E+02	.87	7.34	.87	.00
94.89	.00	.00	78.2	.128E+02	.88	7.52	.88	.00
96.66	.00	.00	80.7	.124E+02	.89	7.70	.89	.00
98.44	.00	.00	83.4	.120E+02	.90	7.87	.90	.00
100.21	.00	.00	86.1	.116E+02	.91	8.04	.91	.00
101.98	.00	.00	89.0	.112E+02	.92	8.21	.92	.00
103.76	.00	.00	92.0	.109E+02	.93	8.38	.93	.00
105.53	.00	.00	95.0	.105E+02	.94	8.55	.94	.00
107.30	.00	.00	98.2	.102E+02	.95	8.71	.95	.00
109.08	.00	.00	101.4	.986E+01	.97	8.87	.97	.00
110.85	.00	.00	104.8	.954E+01	.98	9.04	.98	.00
112.62	.00	.00	108.3	.923E+01	1.00	9.20	1.00	.00
114.40	.00	.00	111.9	.894E+01	1.01	9.35	1.01	.00
116.17	.00	.00	115.6	.865E+01	1.03	9.51	1.03	.00
117.94	.00	.00	119.4	.837E+01	1.04	9.67	1.04	.00

119.72	.00	.00	123.3	.811E+01	1.06	9.82	1.06	.00
121.49	.00	.00	127.4	.785E+01	1.08	9.98	1.08	.00
123.26	.00	.00	131.5	.760E+01	1.10	10.13	1.10	.00
125.03	.00	.00	135.8	.736E+01	1.12	10.28	1.12	.00
126.81	.00	.00	140.2	.713E+01	1.14	10.43	1.14	.00
128.58	.00	.00	144.7	.691E+01	1.16	10.58	1.16	.00
130.35	.00	.00	149.3	.670E+01	1.18	10.73	1.18	.00
132.13	.00	.00	154.1	.649E+01	1.20	10.88	1.20	.00
133.90	.00	.00	159.0	.629E+01	1.22	11.02	1.22	.00
135.67	.00	.00	164.0	.610E+01	1.24	11.17	1.24	.00
137.45	.00	.00	169.1	.591E+01	1.26	11.31	1.26	.00
139.22	.00	.00	174.3	.574E+01	1.29	11.46	1.29	.00
140.99	.00	.00	179.7	.557E+01	1.31	11.60	1.31	.00
142.77	.00	.00	185.2	.540E+01	1.33	11.74	1.33	.00

Cumulative travel time = 414. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .804E-02 m^2/s
Horizontal diffusivity (initial value) = .201E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
142.77	.00	.00	185.2	.540E+01	1.33	11.74	1.33	.00
159.91	.00	.00	189.1	.529E+01	1.34	11.90	1.34	.00
177.06	.00	.00	191.6	.522E+01	1.34	12.06	1.34	.00
194.20	.00	.00	194.1	.515E+01	1.34	12.21	1.34	.00
211.35	.00	.00	196.6	.509E+01	1.34	12.37	1.34	.00
228.49	.00	.00	199.0	.503E+01	1.34	12.52	1.34	.00
245.63	.00	.00	201.3	.497E+01	1.34	12.67	1.34	.00
262.78	.00	.00	203.7	.491E+01	1.34	12.81	1.34	.00
279.92	.00	.00	206.0	.485E+01	1.34	12.96	1.34	.00
297.07	.00	.00	208.3	.480E+01	1.34	13.11	1.34	.00
314.21	.00	.00	210.6	.475E+01	1.34	13.25	1.34	.00
331.36	.00	.00	212.8	.470E+01	1.34	13.39	1.34	.00

348.50	.00	.00	215.1	.465E+01	1.34	13.53	1.34	.00
365.65	.00	.00	217.3	.460E+01	1.34	13.67	1.34	.00
382.79	.00	.00	219.4	.456E+01	1.34	13.81	1.34	.00
399.94	.00	.00	221.6	.451E+01	1.34	13.94	1.34	.00
417.08	.00	.00	223.7	.447E+01	1.34	14.08	1.34	.00
434.23	.00	.00	225.9	.443E+01	1.34	14.21	1.34	.00
451.37	.00	.00	228.0	.439E+01	1.34	14.34	1.34	.00
468.52	.00	.00	230.0	.435E+01	1.34	14.47	1.34	.00
485.66	.00	.00	232.1	.431E+01	1.34	14.60	1.34	.00
502.80	.00	.00	234.1	.427E+01	1.34	14.73	1.34	.00
519.95	.00	.00	236.2	.423E+01	1.34	14.86	1.34	.00
537.09	.00	.00	238.2	.420E+01	1.34	14.98	1.34	.00
554.24	.00	.00	240.2	.416E+01	1.34	15.11	1.34	.00
571.38	.00	.00	242.1	.413E+01	1.34	15.23	1.34	.00
588.53	.00	.00	244.1	.410E+01	1.34	15.36	1.34	.00
605.67	.00	.00	246.0	.406E+01	1.34	15.48	1.34	.00
622.82	.00	.00	248.0	.403E+01	1.34	15.60	1.34	.00
639.96	.00	.00	249.9	.400E+01	1.34	15.72	1.34	.00
657.11	.00	.00	251.8	.397E+01	1.34	15.84	1.34	.00
674.25	.00	.00	253.7	.394E+01	1.34	15.96	1.34	.00
691.40	.00	.00	255.5	.391E+01	1.34	16.08	1.34	.00
708.54	.00	.00	257.4	.389E+01	1.34	16.19	1.34	.00
725.68	.00	.00	259.2	.386E+01	1.34	16.31	1.34	.00
742.83	.00	.00	261.1	.383E+01	1.34	16.42	1.34	.00
759.97	.00	.00	262.9	.380E+01	1.34	16.54	1.34	.00
777.12	.00	.00	264.7	.378E+01	1.34	16.65	1.34	.00
794.26	.00	.00	266.5	.375E+01	1.34	16.76	1.34	.00
811.41	.00	.00	268.2	.373E+01	1.34	16.88	1.34	.00
828.55	.00	.00	270.0	.370E+01	1.34	16.99	1.34	.00
845.70	.00	.00	271.8	.368E+01	1.34	17.10	1.34	.00
862.84	.00	.00	273.5	.366E+01	1.34	17.21	1.34	.00
879.99	.00	.00	275.3	.363E+01	1.34	17.32	1.34	.00
897.13	.00	.00	277.0	.361E+01	1.34	17.43	1.34	.00
914.28	.00	.00	278.7	.359E+01	1.34	17.53	1.34	.00
931.42	.00	.00	280.4	.357E+01	1.34	17.64	1.34	.00
948.57	.00	.00	282.1	.354E+01	1.34	17.75	1.34	.00
965.71	.00	.00	283.8	.352E+01	1.34	17.85	1.34	.00
982.85	.00	.00	285.4	.350E+01	1.34	17.96	1.34	.00
1000.00	.00	.00	287.1	.348E+01	1.34	18.06	1.34	.00

Cumulative travel time = 3397. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

MAC4-4N.CX1

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MAC4-4X.CX1

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CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111
                    CORNELL MIXING ZONE EXPERT SYSTEM
Subsystem CORMIX1:                                          Subsystem version:
 Submerged Single Port Discharges          CORMIX_v.3.20_____September_1996
------------------------------------------------------------------------------
------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:         Mach^Big^Muddy^River
 Design case:             Case^4^-^Port^4^Maximum^Flow
 FILE NAME:               cormix\sim\Mac4-4X .cx1
 Time of Fortran run:     11/09/16--10:18:49

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     56.85  AS    =     93.39  QA    =     33.02  ICHREG= 2
 HA    =      1.64  HD    =      1.64
 UA    =       .354 F     =       .081 USTAR = .3568E-01
 UW    =     2.000 UWSTAR= .2198E-02
 Uniform density environment
 STRCND=  U         RHOAM =  998.4907

DISCHARGE PARAMETERS (metric units)
 BANK  =  LEFT      DISTB =     27.42
 D0    =       .152 A0    =       .018 H0    =       .15
 THETA =     15.00  SIGMA =       .00
 U0    =      5.487 Q0    =       .100       = .1001E+00
 RHO0  = 1013.3900  DRHO0 =-.1490E+02  GP0   =-.1463E+00
 C0    = .1000E+04  CUNITS=  ppm
 IPOLL =  1         KS    = .0000E+00  KD    = .0000E+00

FLUX VARIABLES (metric units)
 Q0    = .1001E+00  M0    = .5491E+00  J0    =-.1465E-01  SIGNJ0=    -1.0
 Associated length scales (meters)
 LQ    =       .14  LM    =      5.27  Lm    =      2.10  Lb    =       .33
                                        Lmp   =  99999.00  Lbp   =  99999.00


NON-DIMENSIONAL PARAMETERS
 FR0   =     36.73  R     =     15.51

FLOW CLASSIFICATION
 1111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    NH5    1
 1  Applicable layer depth HS =     1.64  1
 1111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    = .1000E+04  CUNITS=  ppm
```

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
        27.42 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

 COANDA ATTACHMENT immediately following the discharge.

       X        Y        Z        S        C        B
      .00      .00      .00      1.0  .100E+04     .11

END OF MOD101: DISCHARGE MODULE
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Bottom-attached jet motion.

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
            Half wall jet, attached to bottom.
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .00      1.0  .100E+04     .08
      .87      .00      .00      1.3  .757E+03     .16
     1.74      .00      .00      2.0  .495E+03     .23
     2.61      .00      .00      2.7  .369E+03     .30
     3.48      .00      .00      3.4  .295E+03     .36
     4.35      .00      .00      4.1  .246E+03     .42
     5.24      .00      .00      4.7  .211E+03     .48
     6.11      .00      .00      5.4  .186E+03     .53
     6.98      .00      .00      6.0  .166E+03     .58
     7.85      .00      .00      6.7  .150E+03     .62
     8.72      .00      .00      7.3  .137E+03     .67
     9.61      .00      .00      7.9  .126E+03     .71
    10.48      .00      .00      8.5  .117E+03     .75
    11.35      .00      .00      9.1  .110E+03     .78
    12.22      .00      .00      9.7  .103E+03     .82
```

13.09	.00	.00	10.3	.971E+02	.86
13.98	.00	.00	10.9	.919E+02	.89
14.85	.00	.00	11.5	.873E+02	.92
15.72	.00	.00	12.0	.832E+02	.95
16.59	.00	.00	12.6	.795E+02	.98
17.46	.00	.00	13.1	.761E+02	1.01
18.35	.00	.00	13.7	.730E+02	1.04
19.22	.00	.00	14.2	.702E+02	1.07
20.09	.00	.00	14.8	.677E+02	1.10
20.96	.00	.00	15.3	.653E+02	1.12
21.83	.00	.00	15.8	.631E+02	1.15
22.72	.00	.00	16.4	.611E+02	1.17
23.59	.00	.00	16.9	.592E+02	1.20
24.46	.00	.00	17.4	.575E+02	1.22
25.33	.00	.00	17.9	.558E+02	1.24
26.20	.00	.00	18.4	.543E+02	1.27
27.09	.00	.00	18.9	.528E+02	1.29
27.96	.00	.00	19.4	.515E+02	1.31
28.83	.00	.00	19.9	.502E+02	1.33
29.70	.00	.00	20.4	.490E+02	1.35
30.57	.00	.00	20.9	.478E+02	1.37
31.46	.00	.00	21.4	.467E+02	1.39
32.33	.00	.00	21.9	.457E+02	1.41
33.20	.00	.00	22.4	.447E+02	1.43
34.07	.00	.00	22.8	.438E+02	1.45
34.94	.00	.00	23.3	.429E+02	1.47
35.82	.00	.00	23.8	.421E+02	1.49
36.70	.00	.00	24.2	.412E+02	1.51
37.57	.00	.00	24.7	.405E+02	1.53
38.44	.00	.00	25.2	.397E+02	1.54
39.31	.00	.00	25.6	.390E+02	1.56
40.19	.00	.00	26.1	.383E+02	1.58
41.07	.00	.00	26.5	.377E+02	1.59
41.94	.00	.00	27.0	.370E+02	1.61
42.81	.00	.00	27.4	.364E+02	1.63
43.68	.00	.00	27.9	.359E+02	1.64

Cumulative travel time = 51. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
43.68	.00	.00	27.9	.359E+02	1.64

Profile definitions:

MAC4-4X.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
42.04	.00	.00	27.9	.359E+02	.00	.00	.00	.00
42.37	.00	.00	27.9	.359E+02	1.64	.31	1.64	.00
42.70	.00	.00	27.9	.359E+02	1.64	.44	1.64	.00
43.03	.00	.00	27.9	.359E+02	1.64	.54	1.64	.00
43.36	.00	.00	27.9	.359E+02	1.64	.63	1.64	.00
43.68	.00	.00	27.9	.359E+02	1.64	.70	1.64	.00
44.01	.00	.00	29.5	.339E+02	1.64	.77	1.64	.00
44.34	.00	.00	33.2	.302E+02	1.64	.83	1.64	.00
44.67	.00	.00	36.4	.275E+02	1.64	.89	1.64	.00
45.00	.00	.00	38.2	.262E+02	1.64	.94	1.64	.00
45.33	.00	.00	39.0	.256E+02	1.64	.99	1.64	.00

Cumulative travel time = 56. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.38 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC4-4X.CX1

Profile definitions:
  BV = top-hat thickness, measured vertically
  BH = top-hat half-width, measured horizontally in Y-direction
  ZU = upper plume boundary (Z-coordinate)
  ZL = lower plume boundary (Z-coordinate)
  S = hydrodynamic average (bulk) dilution
  C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
45.33	.00	.00	39.0	.256E+02	1.64	3.35	1.64	.00
47.42	.00	.00	40.2	.249E+02	1.54	3.67	1.54	.00
49.52	.00	.00	41.3	.242E+02	1.47	3.98	1.47	.00
51.62	.00	.00	42.4	.236E+02	1.40	4.27	1.40	.00
53.71	.00	.00	43.6	.230E+02	1.35	4.56	1.35	.00
55.81	.00	.00	44.7	.224E+02	1.30	4.84	1.30	.00
57.90	.00	.00	45.8	.218E+02	1.27	5.11	1.27	.00
60.00	.00	.00	47.0	.213E+02	1.23	5.37	1.23	.00
62.09	.00	.00	48.2	.208E+02	1.21	5.62	1.21	.00
64.19	.00	.00	49.4	.202E+02	1.19	5.87	1.19	.00
66.29	.00	.00	50.7	.197E+02	1.17	6.12	1.17	.00
68.38	.00	.00	52.0	.192E+02	1.15	6.36	1.15	.00
70.48	.00	.00	53.4	.187E+02	1.14	6.59	1.14	.00
72.57	.00	.00	54.8	.183E+02	1.13	6.82	1.13	.00
74.67	.00	.00	56.3	.178E+02	1.13	7.05	1.13	.00
76.77	.00	.00	57.8	.173E+02	1.12	7.28	1.12	.00
78.86	.00	.00	59.4	.168E+02	1.12	7.50	1.12	.00
80.96	.00	.00	61.1	.164E+02	1.12	7.71	1.12	.00
83.05	.00	.00	62.8	.159E+02	1.12	7.93	1.12	.00
85.15	.00	.00	64.6	.155E+02	1.12	8.14	1.12	.00
87.25	.00	.00	66.4	.151E+02	1.12	8.35	1.12	.00
89.34	.00	.00	68.4	.146E+02	1.13	8.55	1.13	.00
91.44	.00	.00	70.4	.142E+02	1.13	8.76	1.13	.00
93.53	.00	.00	72.4	.138E+02	1.14	8.96	1.14	.00
95.63	.00	.00	74.6	.134E+02	1.15	9.16	1.15	.00
97.72	.00	.00	76.8	.130E+02	1.16	9.35	1.16	.00
99.82	.00	.00	79.1	.126E+02	1.17	9.55	1.17	.00
101.92	.00	.00	81.5	.123E+02	1.18	9.74	1.18	.00
104.01	.00	.00	83.9	.119E+02	1.19	9.93	1.19	.00
106.11	.00	.00	86.5	.116E+02	1.21	10.12	1.21	.00
108.20	.00	.00	89.1	.112E+02	1.22	10.31	1.22	.00
110.30	.00	.00	91.8	.109E+02	1.23	10.50	1.23	.00
112.40	.00	.00	94.6	.106E+02	1.25	10.68	1.25	.00
114.49	.00	.00	97.4	.103E+02	1.27	10.86	1.27	.00
116.59	.00	.00	100.4	.996E+01	1.28	11.04	1.28	.00
118.68	.00	.00	103.4	.967E+01	1.30	11.22	1.30	.00
120.78	.00	.00	106.6	.938E+01	1.32	11.40	1.32	.00

122.88	.00	.00	109.8	.911E+01	1.34	11.58	1.34	.00
124.97	.00	.00	113.1	.884E+01	1.36	11.75	1.36	.00
127.07	.00	.00	116.5	.859E+01	1.38	11.93	1.38	.00
129.16	.00	.00	120.0	.834E+01	1.40	12.10	1.40	.00
131.26	.00	.00	123.5	.809E+01	1.42	12.27	1.42	.00
133.36	.00	.00	127.2	.786E+01	1.44	12.44	1.44	.00
135.45	.00	.00	131.0	.763E+01	1.47	12.61	1.47	.00
137.55	.00	.00	134.8	.742E+01	1.49	12.78	1.49	.00
139.64	.00	.00	138.8	.720E+01	1.51	12.94	1.51	.00
141.74	.00	.00	142.9	.700E+01	1.54	13.11	1.54	.00
143.83	.00	.00	147.0	.680E+01	1.56	13.28	1.56	.00
145.93	.00	.00	151.2	.661E+01	1.59	13.44	1.59	.00
148.03	.00	.00	155.6	.643E+01	1.61	13.60	1.61	.00
150.12	.00	.00	160.0	.625E+01	1.64	13.76	1.64	.00

Cumulative travel time = 351. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .117E-01 m^2/s
Horizontal diffusivity (initial value) = .293E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
150.12	.00	.00	160.0	.625E+01	1.64	13.76	1.64	.00
167.12	.00	.00	162.1	.617E+01	1.64	13.92	1.64	.00
184.12	.00	.00	164.0	.610E+01	1.64	14.08	1.64	.00
201.11	.00	.00	165.8	.603E+01	1.64	14.24	1.64	.00
218.11	.00	.00	167.6	.597E+01	1.64	14.39	1.64	.00
235.11	.00	.00	169.4	.590E+01	1.64	14.54	1.64	.00
252.11	.00	.00	171.1	.584E+01	1.64	14.69	1.64	.00
269.11	.00	.00	172.9	.579E+01	1.64	14.84	1.64	.00
286.10	.00	.00	174.6	.573E+01	1.64	14.99	1.64	.00
303.10	.00	.00	176.3	.567E+01	1.64	15.14	1.64	.00
320.10	.00	.00	178.0	.562E+01	1.64	15.28	1.64	.00
337.10	.00	.00	179.6	.557E+01	1.64	15.43	1.64	.00

354.09	.00	.00	181.3	.552E+01	1.64	15.57	1.64	.00
371.09	.00	.00	182.9	.547E+01	1.64	15.71	1.64	.00
388.09	.00	.00	184.6	.542E+01	1.64	15.85	1.64	.00
405.09	.00	.00	186.2	.537E+01	1.64	15.99	1.64	.00
422.08	.00	.00	187.8	.533E+01	1.64	16.13	1.64	.00
439.08	.00	.00	189.4	.528E+01	1.64	16.26	1.64	.00
456.08	.00	.00	191.0	.524E+01	1.64	16.40	1.64	.00
473.08	.00	.00	192.5	.519E+01	1.64	16.53	1.64	.00
490.07	.00	.00	194.1	.515E+01	1.64	16.67	1.64	.00
507.07	.00	.00	195.6	.511E+01	1.64	16.80	1.64	.00
524.07	.00	.00	197.1	.507E+01	1.64	16.93	1.64	.00
541.07	.00	.00	198.6	.503E+01	1.64	17.06	1.64	.00
558.06	.00	.00	200.1	.500E+01	1.64	17.19	1.64	.00
575.06	.00	.00	201.6	.496E+01	1.64	17.32	1.64	.00
592.06	.00	.00	203.1	.492E+01	1.64	17.44	1.64	.00
609.06	.00	.00	204.6	.489E+01	1.64	17.57	1.64	.00
626.05	.00	.00	206.0	.485E+01	1.64	17.69	1.64	.00
643.05	.00	.00	207.5	.482E+01	1.64	17.82	1.64	.00
660.05	.00	.00	208.9	.479E+01	1.64	17.94	1.64	.00
677.05	.00	.00	210.3	.475E+01	1.64	18.06	1.64	.00
694.04	.00	.00	211.8	.472E+01	1.64	18.19	1.64	.00
711.04	.00	.00	213.2	.469E+01	1.64	18.31	1.64	.00
728.04	.00	.00	214.6	.466E+01	1.64	18.43	1.64	.00
745.04	.00	.00	216.0	.463E+01	1.64	18.55	1.64	.00
762.03	.00	.00	217.3	.460E+01	1.64	18.66	1.64	.00
779.03	.00	.00	218.7	.457E+01	1.64	18.78	1.64	.00
796.03	.00	.00	220.1	.454E+01	1.64	18.90	1.64	.00
813.03	.00	.00	221.4	.452E+01	1.64	19.02	1.64	.00
830.02	.00	.00	222.8	.449E+01	1.64	19.13	1.64	.00
847.02	.00	.00	224.1	.446E+01	1.64	19.25	1.64	.00
864.02	.00	.00	225.5	.444E+01	1.64	19.36	1.64	.00
881.02	.00	.00	226.8	.441E+01	1.64	19.48	1.64	.00
898.01	.00	.00	228.1	.438E+01	1.64	19.59	1.64	.00
915.01	.00	.00	229.4	.436E+01	1.64	19.70	1.64	.00
932.01	.00	.00	230.7	.433E+01	1.64	19.81	1.64	.00
949.01	.00	.00	232.0	.431E+01	1.64	19.92	1.64	.00
966.01	.00	.00	233.3	.429E+01	1.64	20.03	1.64	.00
983.00	.00	.00	234.6	.426E+01	1.64	20.14	1.64	.00
1000.00	.00	.00	235.8	.424E+01	1.64	20.25	1.64	.00

Cumulative travel time = 2747. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

MAC4-4X.CX1

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MAC5-1N.CX1

CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111111

CORNELL MIXING ZONE EXPERT SYSTEM

Subsystem CORMIX1: Subsystem version:
Submerged Single Port Discharges CORMIX_v.3.20_____September_1996

CASE DESCRIPTION
Site name/label: Mach^Big^Muddy^River
Design case: Case^5^-^Port^1^Normal^Flow
FILE NAME: cormix\sim\Mac5-1N .cx1
Time of Fortran run: 11/08/16--09:48:39

ENVIRONMENT PARAMETERS (metric units)
Bounded section
BS = 56.85 AS = 93.39 QA = 33.02 ICHREG= 2
HA = 1.64 HD = 1.64
UA = .354 F = .081 USTAR = .3568E-01
UW = 2.000 UWSTAR= .2198E-02
Uniform density environment
STRCND= U RHOAM = 998.4901

DISCHARGE PARAMETERS (metric units)
BANK = LEFT DISTB = 5.23
D0 = .076 A0 = .005 H0 = .10
THETA = 15.00 SIGMA = .00
U0 = 1.413 Q0 = .006 = .6441E-02
RHO0 = 1013.3900 DRHO0 =-.1490E+02 GP0 =-.1463E+00
C0 = .1000E+04 CUNITS= ppm
IPOLL = 1 KS = .0000E+00 KD = .0000E+00

FLUX VARIABLES (metric units)
Q0 = .6441E-02 M0 = .9099E-02 J0 =-.9427E-03 SIGNJ0= -1.0
Associated length scales (meters)
LQ = .07 LM = .96 Lm = .27 Lb = .02
Lmp = 99999.00 Lbp = 99999.00

NON-DIMENSIONAL PARAMETERS
FR0 = 13.37 R = 3.99

FLOW CLASSIFICATION
11111111111111111111111111111111111111111
1 Flow class (CORMIX1) = NH4 1
1 Applicable layer depth HS = 1.64 1
11111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
C0 = .1000E+04 CUNITS= ppm

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         5.23 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z        S        C        B
      .00      .00      .10     1.0  .100E+04     .04

END OF MOD101: DISCHARGE MODULE
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet/plume transition motion in strong crossflow.

 Zone of flow establishment:            THETAE=     13.81  SIGMAE=       .00
  LE    =       .30  XE    =       .29  YE    =       .00  ZE    =       .17

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .10     1.0  .100E+04     .04
      .29      .00      .17     1.0  .100E+04     .04
      .35      .00      .19     1.1  .934E+03     .04
      .41      .00      .20     1.2  .809E+03     .05
      .47      .00      .21     1.4  .715E+03     .05
      .52      .00      .22     1.6  .642E+03     .06
      .58      .00      .23     1.7  .583E+03     .06
      .64      .00      .24     1.9  .536E+03     .07
      .70      .00      .24     2.0  .495E+03     .07
      .76      .00      .25     2.2  .462E+03     .07
      .82      .00      .26     2.3  .434E+03     .08
      .88      .00      .26     2.4  .411E+03     .08
      .94      .00      .27     2.6  .390E+03     .08
     1.00      .00      .27     2.7  .373E+03     .08
     1.06      .00      .27     2.8  .357E+03     .09
```

1.12	.00	.28	2.9	.343E+03	.09
1.18	.00	.28	3.0	.331E+03	.09
1.24	.00	.28	3.1	.320E+03	.09
1.30	.00	.28	3.2	.311E+03	.10
1.36	.00	.28	3.3	.302E+03	.10
1.42	.00	.28	3.4	.295E+03	.10
1.48	.00	.28	3.5	.288E+03	.10

Maximum jet height has been reached.

1.54	.00	.28	3.6	.281E+03	.10
1.60	.00	.28	3.6	.275E+03	.10
1.66	.00	.28	3.7	.268E+03	.10
1.72	.00	.28	3.8	.262E+03	.11
1.77	.00	.28	3.9	.255E+03	.11
1.83	.00	.28	4.0	.249E+03	.11
1.89	.00	.28	4.1	.243E+03	.11
1.96	.00	.27	4.2	.236E+03	.11
2.01	.00	.27	4.4	.230E+03	.12
2.07	.00	.27	4.5	.224E+03	.12
2.13	.00	.26	4.6	.218E+03	.12
2.19	.00	.26	4.7	.212E+03	.12
2.25	.00	.26	4.9	.206E+03	.12
2.31	.00	.25	5.0	.201E+03	.13
2.37	.00	.25	5.1	.195E+03	.13
2.43	.00	.24	5.3	.190E+03	.13
2.49	.00	.24	5.4	.184E+03	.13
2.55	.00	.23	5.6	.180E+03	.13
2.61	.00	.23	5.7	.175E+03	.14
2.67	.00	.22	5.9	.170E+03	.14
2.73	.00	.22	6.0	.165E+03	.14
2.79	.00	.21	6.2	.161E+03	.14
2.85	.00	.20	6.4	.157E+03	.14
2.91	.00	.20	6.6	.153E+03	.15
2.97	.00	.19	6.7	.149E+03	.15
3.03	.00	.19	6.9	.145E+03	.15
3.08	.00	.18	7.1	.141E+03	.15
3.14	.00	.17	7.3	.138E+03	.16
3.21	.00	.17	7.5	.134E+03	.16
3.26	.00	.16	7.7	.131E+03	.16

Cumulative travel time = 4. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

Control volume inflow:

X	Y	Z	S	C	B
3.26	.00	.16	7.7	.131E+03	.16

MAC5-1N.CX1

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
3.10	.00	.00	7.7	.131E+03	.00	.00	.00	.00
3.15	.00	.00	7.7	.131E+03	.22	.11	.22	.00
3.20	.00	.00	7.7	.131E+03	.26	.15	.26	.00
3.25	.00	.00	7.7	.131E+03	.28	.19	.28	.00
3.30	.00	.00	7.9	.127E+03	.30	.22	.30	.00
3.34	.00	.00	8.8	.113E+03	.32	.24	.32	.00
3.39	.00	.00	10.2	.982E+02	.33	.27	.33	.00
3.44	.00	.00	11.4	.877E+02	.33	.29	.33	.00
3.49	.00	.00	12.3	.816E+02	.34	.31	.34	.00
3.54	.00	.00	12.7	.787E+02	.34	.33	.34	.00
3.59	.00	.00	13.0	.769E+02	.34	.34	.34	.00

Cumulative travel time = 5. sec

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

** End of NEAR-FIELD REGION (NFR) **

BEGIN MOD141: BUOYANT AMBIENT SPREADING

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
3.59	.00	.00	13.0	.769E+02	.34	.34	.34	.00
3.76	.00	.00	13.3	.754E+02	.33	.37	.33	.00
3.94	.00	.00	13.5	.740E+02	.32	.39	.32	.00
4.11	.00	.00	13.7	.727E+02	.31	.41	.31	.00
4.29	.00	.00	14.0	.715E+02	.30	.43	.30	.00
4.47	.00	.00	14.2	.703E+02	.29	.45	.29	.00
4.64	.00	.00	14.5	.691E+02	.28	.47	.28	.00
4.82	.00	.00	14.7	.680E+02	.28	.48	.28	.00
5.00	.00	.00	15.0	.669E+02	.27	.50	.27	.00

5.17	.00	.00	15.2	.658E+02	.27	.52	.27	.00
5.35	.00	.00	15.4	.648E+02	.26	.54	.26	.00
5.52	.00	.00	15.7	.637E+02	.26	.56	.26	.00
5.70	.00	.00	16.0	.627E+02	.25	.57	.25	.00
5.88	.00	.00	16.2	.617E+02	.25	.59	.25	.00
6.05	.00	.00	16.5	.607E+02	.25	.61	.25	.00
6.23	.00	.00	16.8	.597E+02	.25	.62	.25	.00
6.40	.00	.00	17.0	.587E+02	.24	.64	.24	.00
6.58	.00	.00	17.3	.577E+02	.24	.65	.24	.00
6.76	.00	.00	17.6	.568E+02	.24	.67	.24	.00
6.93	.00	.00	17.9	.558E+02	.24	.69	.24	.00
7.11	.00	.00	18.2	.549E+02	.24	.70	.24	.00
7.29	.00	.00	18.5	.540E+02	.24	.72	.24	.00
7.46	.00	.00	18.9	.530E+02	.23	.73	.23	.00
7.64	.00	.00	19.2	.521E+02	.23	.75	.23	.00
7.81	.00	.00	19.5	.512E+02	.23	.76	.23	.00
7.99	.00	.00	19.9	.503E+02	.23	.78	.23	.00
8.17	.00	.00	20.2	.494E+02	.23	.79	.23	.00
8.34	.00	.00	20.6	.486E+02	.23	.81	.23	.00
8.52	.00	.00	21.0	.477E+02	.23	.82	.23	.00
8.70	.00	.00	21.4	.468E+02	.23	.83	.23	.00
8.87	.00	.00	21.7	.460E+02	.23	.85	.23	.00
9.05	.00	.00	22.1	.452E+02	.23	.86	.23	.00
9.22	.00	.00	22.6	.443E+02	.23	.88	.23	.00
9.40	.00	.00	23.0	.435E+02	.24	.89	.24	.00
9.58	.00	.00	23.4	.427E+02	.24	.90	.24	.00
9.75	.00	.00	23.9	.419E+02	.24	.92	.24	.00
9.93	.00	.00	24.3	.411E+02	.24	.93	.24	.00
10.10	.00	.00	24.8	.404E+02	.24	.94	.24	.00
10.28	.00	.00	25.2	.396E+02	.24	.96	.24	.00
10.46	.00	.00	25.7	.389E+02	.24	.97	.24	.00
10.63	.00	.00	26.2	.381E+02	.24	.98	.24	.00
10.81	.00	.00	26.7	.374E+02	.24	.99	.24	.00
10.99	.00	.00	27.2	.367E+02	.25	1.01	.25	.00
11.16	.00	.00	27.8	.360E+02	.25	1.02	.25	.00
11.34	.00	.00	28.3	.353E+02	.25	1.03	.25	.00
11.51	.00	.00	28.9	.346E+02	.25	1.05	.25	.00
11.69	.00	.00	29.4	.340E+02	.25	1.06	.25	.00
11.87	.00	.00	30.0	.333E+02	.26	1.07	.26	.00
12.04	.00	.00	30.6	.327E+02	.26	1.08	.26	.00
12.22	.00	.00	31.2	.321E+02	.26	1.10	.26	.00
12.39	.00	.00	31.8	.315E+02	.26	1.11	.26	.00

Cumulative travel time = 30. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

MAC5-1N.CX1

Vertical diffusivity (initial value) = .117E-01 m^2/s
Horizontal diffusivity (initial value) = .293E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
12.39	.00	.00	31.8	.315E+02	.26	1.11	.26	.00
14.40	.00	.00	38.7	.259E+02	.27	1.32	.27	.00
16.41	.00	.00	45.1	.222E+02	.27	1.51	.27	.00
18.41	.00	.00	51.4	.194E+02	.28	1.67	.28	.00
20.42	.00	.00	57.9	.173E+02	.29	1.82	.29	.00
22.43	.00	.00	64.7	.155E+02	.30	1.96	.30	.00
24.43	.00	.00	71.9	.139E+02	.31	2.09	.31	.00
26.44	.00	.00	79.7	.126E+02	.33	2.21	.33	.00
28.44	.00	.00	88.3	.113E+02	.35	2.33	.35	.00
30.45	.00	.00	97.8	.102E+02	.37	2.44	.37	.00
32.46	.00	.00	108.4	.923E+01	.39	2.54	.39	.00
34.46	.00	.00	120.3	.831E+01	.42	2.64	.42	.00
36.47	.00	.00	133.8	.747E+01	.45	2.74	.45	.00
38.47	.00	.00	149.0	.671E+01	.48	2.83	.48	.00
40.48	.00	.00	166.1	.602E+01	.52	2.92	.52	.00
42.49	.00	.00	185.1	.540E+01	.56	3.01	.56	.00
44.49	.00	.00	206.3	.485E+01	.61	3.10	.61	.00
46.50	.00	.00	229.5	.436E+01	.66	3.18	.66	.00
48.51	.00	.00	254.7	.393E+01	.71	3.26	.71	.00
50.51	.00	.00	281.8	.355E+01	.77	3.34	.77	.00
52.52	.00	.00	310.4	.322E+01	.83	3.42	.83	.00
54.52	.00	.00	340.6	.294E+01	.89	3.49	.89	.00
56.53	.00	.00	371.9	.269E+01	.95	3.57	.95	.00
58.54	.00	.00	404.2	.247E+01	1.01	3.64	1.01	.00
60.54	.00	.00	437.4	.229E+01	1.07	3.71	1.07	.00
62.55	.00	.00	471.2	.212E+01	1.14	3.78	1.14	.00
64.55	.00	.00	505.6	.198E+01	1.20	3.85	1.20	.00
66.56	.00	.00	540.4	.185E+01	1.26	3.92	1.26	.00
68.57	.00	.00	575.6	.174E+01	1.32	3.98	1.32	.00
70.57	.00	.00	611.0	.164E+01	1.38	4.05	1.38	.00
72.58	.00	.00	646.6	.155E+01	1.43	4.11	1.43	.00
74.59	.00	.00	682.5	.147E+01	1.49	4.17	1.49	.00

76.59	.00	.00	718.4	.139E+01	1.54	4.24	1.54	.00
78.60	.00	.00	754.5	.133E+01	1.60	4.30	1.60	.00

Plume interacts with SURFACE.
The passive diffusion plume becomes VERTICALLY FULLY MIXED within this prediction interval.

80.60	.00	.00	786.0	.127E+01	1.64	4.36	1.64	.00
82.61	.00	.00	796.7	.126E+01	1.64	4.42	1.64	.00
84.62	.00	.00	807.3	.124E+01	1.64	4.48	1.64	.00
86.62	.00	.00	817.8	.122E+01	1.64	4.53	1.64	.00
88.63	.00	.00	828.1	.121E+01	1.64	4.59	1.64	.00
90.63	.00	.00	838.3	.119E+01	1.64	4.65	1.64	.00
92.64	.00	.00	848.4	.118E+01	1.64	4.70	1.64	.00
94.65	.00	.00	858.4	.117E+01	1.64	4.76	1.64	.00
96.65	.00	.00	868.2	.115E+01	1.64	4.81	1.64	.00
98.66	.00	.00	877.9	.114E+01	1.64	4.87	1.64	.00
100.67	.00	.00	887.6	.113E+01	1.64	4.92	1.64	.00
102.67	.00	.00	897.1	.111E+01	1.64	4.97	1.64	.00
104.68	.00	.00	906.5	.110E+01	1.64	5.03	1.64	.00
106.68	.00	.00	915.8	.109E+01	1.64	5.08	1.64	.00
108.69	.00	.00	925.1	.108E+01	1.64	5.13	1.64	.00
110.70	.00	.00	934.2	.107E+01	1.64	5.18	1.64	.00
112.70	.00	.00	943.3	.106E+01	1.64	5.23	1.64	.00

Cumulative travel time = 314. sec

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
112.70	5.23	.00	943.3	.106E+01	1.64	10.46	1.64	.00
130.45	5.23	.00	963.0	.104E+01	1.64	10.68	1.64	.00
148.19	5.23	.00	982.3	.102E+01	1.64	10.89	1.64	.00
165.94	5.23	.00	1001.3	.999E+00	1.64	11.10	1.64	.00
183.69	5.23	.00	1019.9	.981E+00	1.64	11.31	1.64	.00
201.43	5.23	.00	1038.1	.963E+00	1.64	11.51	1.64	.00
219.18	5.23	.00	1056.1	.947E+00	1.64	11.71	1.64	.00
236.92	5.23	.00	1073.7	.931E+00	1.64	11.91	1.64	.00
254.67	5.23	.00	1091.1	.917E+00	1.64	12.10	1.64	.00
272.42	5.23	.00	1108.2	.902E+00	1.64	12.29	1.64	.00
290.16	5.23	.00	1125.0	.889E+00	1.64	12.48	1.64	.00
307.91	5.23	.00	1141.6	.876E+00	1.64	12.66	1.64	.00
325.65	5.23	.00	1157.9	.864E+00	1.64	12.84	1.64	.00
343.40	5.23	.00	1174.1	.852E+00	1.64	13.02	1.64	.00
361.15	5.23	.00	1190.0	.840E+00	1.64	13.20	1.64	.00
378.89	5.23	.00	1205.6	.829E+00	1.64	13.37	1.64	.00
396.64	5.23	.00	1221.1	.819E+00	1.64	13.54	1.64	.00
414.38	5.23	.00	1236.4	.809E+00	1.64	13.71	1.64	.00
432.13	5.23	.00	1251.5	.799E+00	1.64	13.88	1.64	.00
449.88	5.23	.00	1266.5	.790E+00	1.64	14.04	1.64	.00
467.62	5.23	.00	1281.2	.781E+00	1.64	14.21	1.64	.00

485.37	5.23	.00	1295.8	.772E+00	1.64	14.37	1.64	.00
503.11	5.23	.00	1310.2	.763E+00	1.64	14.53	1.64	.00
520.86	5.23	.00	1324.5	.755E+00	1.64	14.69	1.64	.00
538.61	5.23	.00	1338.6	.747E+00	1.64	14.84	1.64	.00
556.35	5.23	.00	1352.6	.739E+00	1.64	15.00	1.64	.00
574.10	5.23	.00	1366.4	.732E+00	1.64	15.15	1.64	.00
591.84	5.23	.00	1380.1	.725E+00	1.64	15.30	1.64	.00
609.59	5.23	.00	1393.6	.718E+00	1.64	15.45	1.64	.00
627.33	5.23	.00	1407.1	.711E+00	1.64	15.60	1.64	.00
645.08	5.23	.00	1420.4	.704E+00	1.64	15.75	1.64	.00
662.83	5.23	.00	1433.5	.698E+00	1.64	15.90	1.64	.00
680.57	5.23	.00	1446.6	.691E+00	1.64	16.04	1.64	.00
698.32	5.23	.00	1459.5	.685E+00	1.64	16.18	1.64	.00
716.06	5.23	.00	1472.3	.679E+00	1.64	16.33	1.64	.00
733.81	5.23	.00	1485.0	.673E+00	1.64	16.47	1.64	.00
751.56	5.23	.00	1497.6	.668E+00	1.64	16.61	1.64	.00
769.30	5.23	.00	1510.1	.662E+00	1.64	16.75	1.64	.00
787.05	5.23	.00	1522.5	.657E+00	1.64	16.88	1.64	.00
804.79	5.23	.00	1534.8	.652E+00	1.64	17.02	1.64	.00
822.54	5.23	.00	1547.0	.646E+00	1.64	17.16	1.64	.00
840.29	5.23	.00	1559.1	.641E+00	1.64	17.29	1.64	.00
858.03	5.23	.00	1571.1	.636E+00	1.64	17.42	1.64	.00
875.78	5.23	.00	1583.1	.632E+00	1.64	17.55	1.64	.00
893.52	5.23	.00	1594.9	.627E+00	1.64	17.69	1.64	.00
911.27	5.23	.00	1606.6	.622E+00	1.64	17.82	1.64	.00
929.02	5.23	.00	1618.3	.618E+00	1.64	17.95	1.64	.00
946.76	5.23	.00	1629.9	.614E+00	1.64	18.07	1.64	.00
964.51	5.23	.00	1641.3	.609E+00	1.64	18.20	1.64	.00
982.25	5.23	.00	1652.8	.605E+00	1.64	18.33	1.64	.00
1000.00	5.23	.00	1664.1	.601E+00	1.64	18.45	1.64	.00

Cumulative travel time = 2823. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

11111111111111111111111111111111111111111111111111111111111111111111111111111

MAC5-1X.CX1

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CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111
                    CORNELL MIXING ZONE EXPERT SYSTEM
Subsystem CORMIX1:                                          Subsystem version:
 Submerged Single Port Discharges           CORMIX_v.3.20_____September_1996
------------------------------------------------------------------------------
------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:        Mach^Big^Muddy^River
 Design case:            Case^5^-^Port^1^Maximum^Flow
 FILE NAME:              cormix\sim\Mac5-1X .cx1
 Time of Fortran run:    11/08/16--15:06:03

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =    113.20  AS    =    186.78  QA    =     51.24  ICHREG= 2
 HA    =      1.65  HD    =      1.65
 UA    =      .274  F     =      .081 USTAR = .2766E-01
 UW    =     2.000 UWSTAR= .2198E-02
 Uniform density environment
 STRCND=  U         RHOAM =  998.4901

DISCHARGE PARAMETERS (metric units)
 BANK  =  LEFT      DISTB =      7.31
 D0    =      .076 A0    =      .005 H0    =       .15
 THETA =    15.00  SIGMA =      .00
 U0    =     5.487 Q0    =      .025       = .2502E-01
 RHO0  = 1013.3900  DRHO0 =-.1490E+02  GP0   =-.1463E+00
 C0    = .1000E+04  CUNITS=  ppm
 IPOLL =  1         KS    = .0000E+00  KD    = .0000E+00

FLUX VARIABLES (metric units)
 Q0    = .2502E-01  M0    = .1373E+00  J0    =-.3662E-02  SIGNJ0=     -1.0
 Associated length scales (meters)
 LQ    =      .07  LM    =     3.73  Lm    =     1.35  Lb    =       .18
                                    Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =     51.95  R     =     20.00

FLOW CLASSIFICATION
 1111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    NH5    1
 1  Applicable layer depth HS =     1.65  1
 1111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    = .1000E+04  CUNITS=  ppm
```

NTOX = 0
NSTD = 0
REGMZ = 0
XINT = 1000.00 XMAX = 1000.00

X-Y-Z COORDINATE SYSTEM:
ORIGIN is located at the bottom and below the center of the port:
7.31 m from the LEFT bank/shore.
X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module

BEGIN MOD101: DISCHARGE MODULE

COANDA ATTACHMENT immediately following the discharge.

X	Y	Z	S	C	B
.00	.00	.00	1.0	.100E+04	.05

END OF MOD101: DISCHARGE MODULE

BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

Bottom-attached jet motion.

Profile definitions:
B = Gaussian 1/e (37%) half-width, normal to trajectory
Half wall jet, attached to bottom.
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

X	Y	Z	S	C	B
.00	.00	.00	1.0	.100E+04	.04
1.49	.00	.00	3.0	.329E+03	.17
2.98	.00	.00	5.4	.185E+03	.28
4.48	.00	.00	7.7	.131E+03	.37
5.97	.00	.00	9.8	.102E+03	.44
7.47	.00	.00	11.9	.839E+02	.51
8.97	.00	.00	14.0	.717E+02	.57
10.45	.00	.00	15.9	.629E+02	.62
11.95	.00	.00	17.8	.561E+02	.67
13.45	.00	.00	19.7	.508E+02	.72
14.94	.00	.00	21.5	.465E+02	.76
16.44	.00	.00	23.3	.429E+02	.80
17.94	.00	.00	25.1	.399E+02	.84
19.42	.00	.00	26.8	.374E+02	.88
20.92	.00	.00	28.4	.352E+02	.91

22.42	.00	.00	30.1	.332E+02	.95
23.91	.00	.00	31.7	.315E+02	.98
25.41	.00	.00	33.3	.300E+02	1.01
26.91	.00	.00	34.9	.287E+02	1.04
28.39	.00	.00	36.4	.275E+02	1.07
29.89	.00	.00	37.9	.264E+02	1.09
31.39	.00	.00	39.4	.253E+02	1.12
32.88	.00	.00	40.9	.244E+02	1.14
34.37	.00	.00	42.4	.236E+02	1.17
35.87	.00	.00	43.8	.228E+02	1.19
37.36	.00	.00	45.3	.221E+02	1.21
38.86	.00	.00	46.7	.214E+02	1.24
40.36	.00	.00	48.1	.208E+02	1.26
41.84	.00	.00	49.5	.202E+02	1.28
43.34	.00	.00	50.8	.197E+02	1.30
44.84	.00	.00	52.2	.192E+02	1.32
46.33	.00	.00	53.5	.187E+02	1.34
47.83	.00	.00	54.9	.182E+02	1.36
49.33	.00	.00	56.2	.178E+02	1.38
50.81	.00	.00	57.5	.174E+02	1.40
52.31	.00	.00	58.8	.170E+02	1.41
53.81	.00	.00	60.1	.166E+02	1.43
55.30	.00	.00	61.4	.163E+02	1.45
56.80	.00	.00	62.6	.160E+02	1.47
58.29	.00	.00	63.9	.157E+02	1.48
59.78	.00	.00	65.1	.154E+02	1.50
61.28	.00	.00	66.4	.151E+02	1.52
62.78	.00	.00	67.6	.148E+02	1.53
64.26	.00	.00	68.8	.145E+02	1.55
65.76	.00	.00	70.0	.143E+02	1.56
67.26	.00	.00	71.2	.140E+02	1.58
68.75	.00	.00	72.4	.138E+02	1.59
70.25	.00	.00	73.6	.136E+02	1.61
71.75	.00	.00	74.8	.134E+02	1.62
73.23	.00	.00	75.9	.132E+02	1.64
74.73	.00	.00	77.1	.130E+02	1.65

Cumulative travel time = 157. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
74.73	.00	.00	77.1	.130E+02	1.65

Profile definitions:

MAC5-1X.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
73.08	.00	.00	77.1	.130E+02	.00	.00	.00	.00
73.41	.00	.00	77.1	.130E+02	1.65	.29	1.65	.00
73.74	.00	.00	77.1	.130E+02	1.65	.42	1.65	.00
74.07	.00	.00	77.1	.130E+02	1.65	.51	1.65	.00
74.40	.00	.00	77.1	.130E+02	1.65	.59	1.65	.00
74.73	.00	.00	77.1	.130E+02	1.65	.66	1.65	.00
75.06	.00	.00	81.6	.122E+02	1.65	.72	1.65	.00
75.39	.00	.00	91.7	.109E+02	1.65	.78	1.65	.00
75.72	.00	.00	100.6	.994E+01	1.65	.83	1.65	.00
76.05	.00	.00	105.5	.948E+01	1.65	.88	1.65	.00
76.38	.00	.00	107.9	.927E+01	1.65	.93	1.65	.00

Cumulative travel time = 164. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.21 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC5-1X.CX1

Profile definitions:
  BV = top-hat thickness, measured vertically
  BH = top-hat half-width, measured horizontally in Y-direction
  ZU = upper plume boundary (Z-coordinate)
  ZL = lower plume boundary (Z-coordinate)
  S = hydrodynamic average (bulk) dilution
  C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
76.38	.00	.00	107.9	.927E+01	1.65	2.98	1.65	.00
77.31	.00	.00	109.4	.914E+01	1.61	3.09	1.61	.00
78.24	.00	.00	110.9	.902E+01	1.58	3.20	1.58	.00
79.16	.00	.00	112.4	.890E+01	1.55	3.31	1.55	.00
80.09	.00	.00	113.9	.878E+01	1.52	3.42	1.52	.00
81.02	.00	.00	115.4	.866E+01	1.49	3.52	1.49	.00
81.94	.00	.00	117.0	.855E+01	1.47	3.62	1.47	.00
82.87	.00	.00	118.5	.844E+01	1.45	3.73	1.45	.00
83.80	.00	.00	120.1	.833E+01	1.43	3.83	1.43	.00
84.73	.00	.00	121.7	.822E+01	1.41	3.93	1.41	.00
85.65	.00	.00	123.3	.811E+01	1.40	4.02	1.40	.00
86.58	.00	.00	124.9	.801E+01	1.38	4.12	1.38	.00
87.51	.00	.00	126.6	.790E+01	1.37	4.22	1.37	.00
88.43	.00	.00	128.3	.780E+01	1.36	4.31	1.36	.00
89.36	.00	.00	130.0	.769E+01	1.35	4.40	1.35	.00
90.29	.00	.00	131.7	.759E+01	1.34	4.50	1.34	.00
91.21	.00	.00	133.5	.749E+01	1.33	4.59	1.33	.00
92.14	.00	.00	135.3	.739E+01	1.32	4.68	1.32	.00
93.07	.00	.00	137.2	.729E+01	1.31	4.77	1.31	.00
94.00	.00	.00	139.1	.719E+01	1.31	4.86	1.31	.00
94.92	.00	.00	141.0	.709E+01	1.30	4.94	1.30	.00
95.85	.00	.00	143.0	.699E+01	1.30	5.03	1.30	.00
96.78	.00	.00	145.0	.690E+01	1.29	5.12	1.29	.00
97.70	.00	.00	147.0	.680E+01	1.29	5.20	1.29	.00
98.63	.00	.00	149.1	.671E+01	1.29	5.29	1.29	.00
99.56	.00	.00	151.3	.661E+01	1.28	5.37	1.28	.00
100.49	.00	.00	153.4	.652E+01	1.28	5.46	1.28	.00
101.41	.00	.00	155.7	.642E+01	1.28	5.54	1.28	.00
102.34	.00	.00	157.9	.633E+01	1.28	5.62	1.28	.00
103.27	.00	.00	160.2	.624E+01	1.28	5.70	1.28	.00
104.19	.00	.00	162.6	.615E+01	1.28	5.79	1.28	.00
105.12	.00	.00	165.0	.606E+01	1.28	5.87	1.28	.00
106.05	.00	.00	167.5	.597E+01	1.28	5.95	1.28	.00
106.97	.00	.00	170.0	.588E+01	1.29	6.03	1.29	.00
107.90	.00	.00	172.5	.580E+01	1.29	6.10	1.29	.00
108.83	.00	.00	175.1	.571E+01	1.29	6.18	1.29	.00
109.76	.00	.00	177.8	.563E+01	1.29	6.26	1.29	.00

MAC5-1X.CX1

110.68	.00	.00	180.5	.554E+01	1.30	6.34	1.30	.00
111.61	.00	.00	183.2	.546E+01	1.30	6.42	1.30	.00
112.54	.00	.00	186.0	.538E+01	1.31	6.49	1.31	.00
113.46	.00	.00	188.9	.529E+01	1.31	6.57	1.31	.00
114.39	.00	.00	191.8	.521E+01	1.32	6.64	1.32	.00
115.32	.00	.00	194.8	.513E+01	1.32	6.72	1.32	.00
116.24	.00	.00	197.8	.506E+01	1.33	6.80	1.33	.00
117.17	.00	.00	200.9	.498E+01	1.33	6.87	1.33	.00
118.10	.00	.00	204.0	.490E+01	1.34	6.94	1.34	.00
119.03	.00	.00	207.2	.483E+01	1.35	7.02	1.35	.00
119.95	.00	.00	210.4	.475E+01	1.35	7.09	1.35	.00
120.88	.00	.00	213.7	.468E+01	1.36	7.16	1.36	.00
121.81	.00	.00	217.1	.461E+01	1.37	7.24	1.37	.00
122.73	.00	.00	220.5	.454E+01	1.37	7.31	1.37	.00

Cumulative travel time = 333. sec

Plume is ATTACHED to LEFT bank/shore.
Plume width is now determined from LEFT bank/shore.

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
122.73	7.31	.00	220.5	.454E+01	1.37	14.61	1.37	.00
123.12	7.31	.00	221.8	.451E+01	1.38	14.64	1.38	.00
123.51	7.31	.00	223.1	.448E+01	1.39	14.67	1.39	.00
123.91	7.31	.00	224.5	.445E+01	1.39	14.70	1.39	.00
124.30	7.31	.00	225.8	.443E+01	1.40	14.73	1.40	.00
124.69	7.31	.00	227.2	.440E+01	1.40	14.76	1.40	.00
125.08	7.31	.00	228.6	.438E+01	1.41	14.79	1.41	.00
125.47	7.31	.00	229.9	.435E+01	1.41	14.82	1.41	.00
125.86	7.31	.00	231.3	.432E+01	1.42	14.85	1.42	.00
126.25	7.31	.00	232.7	.430E+01	1.42	14.88	1.42	.00
126.64	7.31	.00	234.1	.427E+01	1.43	14.91	1.43	.00
127.03	7.31	.00	235.5	.425E+01	1.44	14.94	1.44	.00
127.42	7.31	.00	236.8	.422E+01	1.44	14.97	1.44	.00
127.81	7.31	.00	238.3	.420E+01	1.45	15.00	1.45	.00
128.20	7.31	.00	239.7	.417E+01	1.45	15.03	1.45	.00
128.59	7.31	.00	241.1	.415E+01	1.46	15.06	1.46	.00
128.98	7.31	.00	242.5	.412E+01	1.46	15.09	1.46	.00
129.37	7.31	.00	243.9	.410E+01	1.47	15.12	1.47	.00
129.76	7.31	.00	245.3	.408E+01	1.48	15.15	1.48	.00
130.15	7.31	.00	246.8	.405E+01	1.48	15.18	1.48	.00
130.54	7.31	.00	248.2	.403E+01	1.49	15.21	1.49	.00
130.93	7.31	.00	249.7	.401E+01	1.49	15.24	1.49	.00
131.32	7.31	.00	251.1	.398E+01	1.50	15.27	1.50	.00
131.71	7.31	.00	252.6	.396E+01	1.50	15.30	1.50	.00
132.10	7.31	.00	254.0	.394E+01	1.51	15.33	1.51	.00
132.50	7.31	.00	255.5	.391E+01	1.52	15.36	1.52	.00

132.89	7.31	.00	257.0	.389E+01	1.52	15.39	1.52	.00
133.28	7.31	.00	258.4	.387E+01	1.53	15.42	1.53	.00
133.67	7.31	.00	259.9	.385E+01	1.53	15.45	1.53	.00
134.06	7.31	.00	261.4	.383E+01	1.54	15.48	1.54	.00
134.45	7.31	.00	262.9	.380E+01	1.55	15.51	1.55	.00
134.84	7.31	.00	264.4	.378E+01	1.55	15.54	1.55	.00
135.23	7.31	.00	265.9	.376E+01	1.56	15.57	1.56	.00
135.62	7.31	.00	267.4	.374E+01	1.56	15.59	1.56	.00
136.01	7.31	.00	268.9	.372E+01	1.57	15.62	1.57	.00
136.40	7.31	.00	270.5	.370E+01	1.57	15.65	1.57	.00
136.79	7.31	.00	272.0	.368E+01	1.58	15.68	1.58	.00
137.18	7.31	.00	273.5	.366E+01	1.59	15.71	1.59	.00
137.57	7.31	.00	275.1	.364E+01	1.59	15.74	1.59	.00
137.96	7.31	.00	276.6	.362E+01	1.60	15.77	1.60	.00
138.35	7.31	.00	278.2	.360E+01	1.60	15.80	1.60	.00
138.74	7.31	.00	279.7	.358E+01	1.61	15.83	1.61	.00
139.13	7.31	.00	281.3	.356E+01	1.62	15.86	1.62	.00
139.52	7.31	.00	282.8	.354E+01	1.62	15.89	1.62	.00
139.91	7.31	.00	284.4	.352E+01	1.63	15.92	1.63	.00
140.30	7.31	.00	286.0	.350E+01	1.63	15.94	1.63	.00
140.69	7.31	.00	287.6	.348E+01	1.64	15.97	1.64	.00
141.08	7.31	.00	289.2	.346E+01	1.65	16.00	1.65	.00
141.48	7.31	.00	290.8	.344E+01	1.65	16.03	1.65	.00
141.87	7.31	.00	292.4	.342E+01	1.65	16.06	1.65	.00
142.26	7.31	.00	294.0	.340E+01	1.65	16.09	1.65	.00

Cumulative travel time = 404. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .913E-02 m^2/s
Horizontal diffusivity (initial value) = .228E-01 m^2/s

The passive diffusion plume is VERTICALLY FULLY MIXED at beginning of region.

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 2 (bank attached):

MAC5-1X.CX1

X	Y	Z	S	C	BV	BH	ZU	ZL
142.26	7.31	.00	294.0	.340E+01	1.65	16.09	1.65	.00
159.41	7.31	.00	296.5	.337E+01	1.65	16.23	1.65	.00
176.57	7.31	.00	299.0	.334E+01	1.65	16.37	1.65	.00
193.72	7.31	.00	301.5	.332E+01	1.65	16.50	1.65	.00
210.88	7.31	.00	304.0	.329E+01	1.65	16.64	1.65	.00
228.03	7.31	.00	306.4	.326E+01	1.65	16.77	1.65	.00
245.19	7.31	.00	308.9	.324E+01	1.65	16.90	1.65	.00
262.34	7.31	.00	311.3	.321E+01	1.65	17.04	1.65	.00
279.50	7.31	.00	313.7	.319E+01	1.65	17.17	1.65	.00
296.65	7.31	.00	316.1	.316E+01	1.65	17.30	1.65	.00
313.80	7.31	.00	318.4	.314E+01	1.65	17.43	1.65	.00
330.96	7.31	.00	320.8	.312E+01	1.65	17.56	1.65	.00
348.11	7.31	.00	323.1	.310E+01	1.65	17.68	1.65	.00
365.27	7.31	.00	325.4	.307E+01	1.65	17.81	1.65	.00
382.42	7.31	.00	327.7	.305E+01	1.65	17.93	1.65	.00
399.58	7.31	.00	330.0	.303E+01	1.65	18.06	1.65	.00
416.73	7.31	.00	332.2	.301E+01	1.65	18.18	1.65	.00
433.89	7.31	.00	334.5	.299E+01	1.65	18.31	1.65	.00
451.04	7.31	.00	336.7	.297E+01	1.65	18.43	1.65	.00
468.20	7.31	.00	338.9	.295E+01	1.65	18.55	1.65	.00
485.35	7.31	.00	341.1	.293E+01	1.65	18.67	1.65	.00
502.51	7.31	.00	343.3	.291E+01	1.65	18.79	1.65	.00
519.66	7.31	.00	345.5	.289E+01	1.65	18.91	1.65	.00
536.82	7.31	.00	347.6	.288E+01	1.65	19.03	1.65	.00
553.97	7.31	.00	349.8	.286E+01	1.65	19.14	1.65	.00
571.13	7.31	.00	351.9	.284E+01	1.65	19.26	1.65	.00
588.28	7.31	.00	354.0	.282E+01	1.65	19.38	1.65	.00
605.44	7.31	.00	356.1	.281E+01	1.65	19.49	1.65	.00
622.59	7.31	.00	358.2	.279E+01	1.65	19.61	1.65	.00
639.75	7.31	.00	360.3	.278E+01	1.65	19.72	1.65	.00
656.90	7.31	.00	362.4	.276E+01	1.65	19.83	1.65	.00
674.06	7.31	.00	364.4	.274E+01	1.65	19.95	1.65	.00
691.21	7.31	.00	366.5	.273E+01	1.65	20.06	1.65	.00
708.37	7.31	.00	368.5	.271E+01	1.65	20.17	1.65	.00
725.52	7.31	.00	370.6	.270E+01	1.65	20.28	1.65	.00
742.68	7.31	.00	372.6	.268E+01	1.65	20.39	1.65	.00
759.83	7.31	.00	374.6	.267E+01	1.65	20.50	1.65	.00
776.99	7.31	.00	376.6	.266E+01	1.65	20.61	1.65	.00
794.14	7.31	.00	378.5	.264E+01	1.65	20.72	1.65	.00
811.30	7.31	.00	380.5	.263E+01	1.65	20.83	1.65	.00
828.45	7.31	.00	382.5	.261E+01	1.65	20.93	1.65	.00
845.61	7.31	.00	384.4	.260E+01	1.65	21.04	1.65	.00
862.76	7.31	.00	386.4	.259E+01	1.65	21.15	1.65	.00
879.92	7.31	.00	388.3	.258E+01	1.65	21.25	1.65	.00
897.07	7.31	.00	390.2	.256E+01	1.65	21.36	1.65	.00
914.23	7.31	.00	392.1	.255E+01	1.65	21.46	1.65	.00
931.38	7.31	.00	394.0	.254E+01	1.65	21.57	1.65	.00

MAC5-1X.CX1

948.54	7.31	.00	395.9	.253E+01	1.65	21.67	1.65	.00
965.69	7.31	.00	397.8	.251E+01	1.65	21.77	1.65	.00
982.85	7.31	.00	399.7	.250E+01	1.65	21.88	1.65	.00
1000.00	7.31	.00	401.6	.249E+01	1.65	21.98	1.65	.00

Cumulative travel time = 3530. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

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MAC5-3N.CX1

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CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111
                    CORNELL MIXING ZONE EXPERT SYSTEM
Subsystem CORMIX1:                                        Subsystem version:
 Submerged Single Port Discharges          CORMIX_v.3.20_____September_1996
------------------------------------------------------------------------------
------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:        Mach^Big^Muddy^River
 Design case:            Case^5^-^Port^3^Normal^Flow
 FILE NAME:              cormix\sim\Mac5-3N .cx1
 Time of Fortran run:    11/09/16--09:02:15

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     56.85  AS    =     93.39  QA    =     33.02  ICHREG= 2
 HA    =      1.64  HD    =      1.64
 UA    =       .354 F     =       .081 USTAR = .3568E-01
 UW    =     2.000 UWSTAR= .2198E-02
 Uniform density environment
 STRCND=  U         RHOAM =  998.4901

DISCHARGE PARAMETERS (metric units)
 BANK  =  LEFT      DISTB =     15.73
 D0    =       .102 A0    =       .008 H0    =       .15
 THETA =     15.00  SIGMA =       .00
 U0    =     2.905 Q0    =       .024       = .2355E-01
 RHO0  = 1013.3900  DRHO0 =-.1490E+02  GP0   =-.1463E+00
 C0    = .1000E+04  CUNITS=  ppm
 IPOLL =  1         KS    = .0000E+00 KD    = .0000E+00

FLUX VARIABLES (metric units)
 Q0    = .2355E-01  M0    = .6841E-01  J0    =-.3446E-02  SIGNJ0=     -1.0
 Associated length scales (meters)
 LQ    =       .09  LM    =      2.28  Lm    =       .74  Lb    =       .08
                                        Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =     23.82  R     =      8.21

FLOW CLASSIFICATION
 11111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    NH4    1
 1  Applicable layer depth HS =     1.64  1
 11111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    = .1000E+04  CUNITS=  ppm
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MAC5-3N.CX1

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 NTOX  =  0
 NSTD  =  0
 REGMZ =  0
 XINT  =   1000.00  XMAX  =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
        15.73 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z        S        C        B
      .00      .00      .15      1.0  .100E+04     .05

END OF MOD101: DISCHARGE MODULE
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet/plume transition motion in strong crossflow.

 Zone of flow establishment:            THETAE=     14.42  SIGMAE=       .00
  LE    =       .46  XE    =       .44  YE    =       .00  ZE    =       .27

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .15      1.0  .100E+04     .05
      .44      .00      .27      1.0  .100E+04     .05
      .56      .00      .30      1.1  .884E+03     .06
      .69      .00      .33      1.4  .713E+03     .08
      .82      .00      .36      1.7  .596E+03     .09
      .95      .00      .38      2.0  .511E+03     .10
     1.08      .00      .41      2.2  .448E+03     .11
     1.22      .00      .43      2.5  .398E+03     .12
     1.35      .00      .45      2.8  .359E+03     .13
     1.48      .00      .47      3.1  .327E+03     .14
     1.61      .00      .48      3.3  .301E+03     .15
     1.74      .00      .50      3.6  .279E+03     .16
     1.88      .00      .51      3.8  .260E+03     .17
     2.01      .00      .53      4.1  .244E+03     .18
     2.14      .00      .54      4.3  .230E+03     .19
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2.27	.00	.55	4.6	.218E+03	.20
2.41	.00	.56	4.8	.208E+03	.20
2.54	.00	.56	5.0	.198E+03	.21
2.67	.00	.57	5.3	.190E+03	.21
2.81	.00	.58	5.5	.183E+03	.22
2.94	.00	.58	5.7	.176E+03	.23
3.07	.00	.59	5.9	.170E+03	.23
3.21	.00	.59	6.1	.165E+03	.24
3.34	.00	.59	6.2	.160E+03	.24
3.47	.00	.59	6.4	.156E+03	.25
3.60	.00	.60	6.6	.152E+03	.25

Maximum jet height has been reached.

3.74	.00	.59	6.7	.148E+03	.25
3.87	.00	.59	6.9	.145E+03	.26
4.00	.00	.59	7.1	.141E+03	.26
4.14	.00	.59	7.3	.138E+03	.27
4.27	.00	.59	7.5	.134E+03	.27
4.40	.00	.58	7.7	.131E+03	.28
4.54	.00	.58	7.9	.127E+03	.28
4.67	.00	.57	8.1	.124E+03	.29
4.80	.00	.57	8.3	.121E+03	.29
4.94	.00	.56	8.5	.118E+03	.30
5.07	.00	.55	8.7	.115E+03	.30
5.20	.00	.54	9.0	.112E+03	.31
5.33	.00	.54	9.2	.109E+03	.31
5.47	.00	.53	9.4	.106E+03	.32
5.60	.00	.52	9.7	.103E+03	.32
5.73	.00	.51	9.9	.101E+03	.33
5.87	.00	.50	10.2	.979E+02	.33
6.00	.00	.49	10.5	.954E+02	.34
6.13	.00	.47	10.8	.929E+02	.34
6.26	.00	.46	11.0	.905E+02	.35
6.40	.00	.45	11.3	.882E+02	.35
6.53	.00	.44	11.6	.859E+02	.36
6.66	.00	.42	11.9	.838E+02	.37
6.79	.00	.41	12.2	.817E+02	.37
6.93	.00	.40	12.6	.796E+02	.38
7.06	.00	.38	12.9	.777E+02	.38

Cumulative travel time = 8. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

Control volume inflow:

X	Y	Z	S	C	B
7.06	.00	.38	12.9	.777E+02	.38

MAC5-3N.CX1

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
6.68	.00	.00	12.9	.777E+02	.00	.00	.00	.00
6.79	.00	.00	12.9	.777E+02	.54	.27	.54	.00
6.91	.00	.00	12.9	.777E+02	.64	.38	.64	.00
7.02	.00	.00	12.9	.777E+02	.70	.47	.70	.00
7.13	.00	.00	13.2	.756E+02	.75	.54	.75	.00
7.25	.00	.00	14.9	.673E+02	.78	.60	.78	.00
7.36	.00	.00	17.1	.584E+02	.81	.66	.81	.00
7.48	.00	.00	19.2	.521E+02	.83	.71	.83	.00
7.59	.00	.00	20.6	.485E+02	.84	.76	.84	.00
7.71	.00	.00	21.4	.468E+02	.85	.81	.85	.00
7.82	.00	.00	21.9	.457E+02	.85	.85	.85	.00

Cumulative travel time = 10. sec

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

** End of NEAR-FIELD REGION (NFR) **

BEGIN MOD141: BUOYANT AMBIENT SPREADING

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
7.82	.00	.00	21.9	.457E+02	.85	.85	.85	.00
8.51	.00	.00	22.6	.443E+02	.79	.95	.79	.00
9.19	.00	.00	23.3	.430E+02	.74	1.05	.74	.00
9.88	.00	.00	23.9	.418E+02	.70	1.14	.70	.00
10.56	.00	.00	24.5	.408E+02	.67	1.23	.67	.00
11.25	.00	.00	25.2	.398E+02	.64	1.31	.64	.00
11.93	.00	.00	25.8	.388E+02	.61	1.40	.61	.00
12.62	.00	.00	26.4	.379E+02	.60	1.48	.60	.00
13.30	.00	.00	27.0	.370E+02	.58	1.55	.58	.00

13.99	.00	.00	27.7	.362E+02	.57	1.63	.57	.00
14.68	.00	.00	28.3	.353E+02	.55	1.70	.55	.00
15.36	.00	.00	29.0	.345E+02	.54	1.77	.54	.00
16.05	.00	.00	29.7	.337E+02	.54	1.85	.54	.00
16.73	.00	.00	30.4	.329E+02	.53	1.92	.53	.00
17.42	.00	.00	31.1	.321E+02	.52	1.98	.52	.00
18.10	.00	.00	31.9	.313E+02	.52	2.05	.52	.00
18.79	.00	.00	32.7	.306E+02	.51	2.12	.51	.00
19.47	.00	.00	33.5	.298E+02	.51	2.18	.51	.00
20.16	.00	.00	34.4	.291E+02	.51	2.25	.51	.00
20.84	.00	.00	35.3	.283E+02	.51	2.31	.51	.00
21.53	.00	.00	36.2	.276E+02	.51	2.37	.51	.00
22.21	.00	.00	37.2	.269E+02	.51	2.43	.51	.00
22.90	.00	.00	38.2	.262E+02	.51	2.49	.51	.00
23.58	.00	.00	39.2	.255E+02	.51	2.55	.51	.00
24.27	.00	.00	40.3	.248E+02	.51	2.61	.51	.00
24.95	.00	.00	41.4	.242E+02	.52	2.67	.52	.00
25.64	.00	.00	42.5	.235E+02	.52	2.73	.52	.00
26.32	.00	.00	43.7	.229E+02	.52	2.79	.52	.00
27.01	.00	.00	44.9	.223E+02	.53	2.84	.53	.00
27.69	.00	.00	46.1	.217E+02	.53	2.90	.53	.00
28.38	.00	.00	47.4	.211E+02	.53	2.96	.53	.00
29.06	.00	.00	48.8	.205E+02	.54	3.01	.54	.00
29.75	.00	.00	50.1	.199E+02	.54	3.07	.54	.00
30.43	.00	.00	51.6	.194E+02	.55	3.12	.55	.00
31.12	.00	.00	53.0	.189E+02	.56	3.17	.56	.00
31.80	.00	.00	54.5	.183E+02	.56	3.23	.56	.00
32.49	.00	.00	56.1	.178E+02	.57	3.28	.57	.00
33.17	.00	.00	57.7	.173E+02	.58	3.33	.58	.00
33.86	.00	.00	59.3	.169E+02	.58	3.39	.58	.00
34.54	.00	.00	61.0	.164E+02	.59	3.44	.59	.00
35.23	.00	.00	62.7	.160E+02	.60	3.49	.60	.00
35.91	.00	.00	64.5	.155E+02	.61	3.54	.61	.00
36.60	.00	.00	66.3	.151E+02	.61	3.59	.61	.00
37.28	.00	.00	68.1	.147E+02	.62	3.64	.62	.00
37.97	.00	.00	70.1	.143E+02	.63	3.69	.63	.00
38.65	.00	.00	72.0	.139E+02	.64	3.74	.64	.00
39.34	.00	.00	74.0	.135E+02	.65	3.79	.65	.00
40.02	.00	.00	76.1	.131E+02	.66	3.84	.66	.00
40.71	.00	.00	78.2	.128E+02	.67	3.89	.67	.00
41.40	.00	.00	80.3	.124E+02	.68	3.93	.68	.00
42.08	.00	.00	82.5	.121E+02	.69	3.98	.69	.00

Cumulative travel time = 107. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

MAC5-3N.CX1

Vertical diffusivity (initial value) = .117E-01 m^2/s
Horizontal diffusivity (initial value) = .293E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
42.08	.00	.00	82.5	.121E+02	.69	3.98	.69	.00
59.87	.00	.00	123.4	.810E+01	.91	4.53	.91	.00
77.66	.00	.00	181.8	.550E+01	1.21	5.01	1.21	.00
95.45	.00	.00	254.5	.393E+01	1.55	5.45	1.55	.00

Plume interacts with SURFACE.
The passive diffusion plume becomes VERTICALLY FULLY MIXED within this prediction interval.

113.24	.00	.00	289.3	.346E+01	1.64	5.86	1.64	.00
131.04	.00	.00	308.2	.325E+01	1.64	6.25	1.64	.00
148.83	.00	.00	325.9	.307E+01	1.64	6.61	1.64	.00
166.62	.00	.00	342.8	.292E+01	1.64	6.95	1.64	.00
184.41	.00	.00	358.9	.279E+01	1.64	7.27	1.64	.00
202.20	.00	.00	374.2	.267E+01	1.64	7.59	1.64	.00
219.99	.00	.00	389.0	.257E+01	1.64	7.88	1.64	.00
237.78	.00	.00	403.2	.248E+01	1.64	8.17	1.64	.00
255.57	.00	.00	417.0	.240E+01	1.64	8.45	1.64	.00
273.36	.00	.00	430.3	.232E+01	1.64	8.72	1.64	.00
291.15	.00	.00	443.2	.226E+01	1.64	8.98	1.64	.00
308.95	.00	.00	455.7	.219E+01	1.64	9.24	1.64	.00
326.74	.00	.00	467.9	.214E+01	1.64	9.48	1.64	.00
344.53	.00	.00	479.8	.208E+01	1.64	9.73	1.64	.00
362.32	.00	.00	491.4	.203E+01	1.64	9.96	1.64	.00
380.11	.00	.00	502.8	.199E+01	1.64	10.19	1.64	.00
397.90	.00	.00	513.9	.195E+01	1.64	10.42	1.64	.00
415.69	.00	.00	524.7	.191E+01	1.64	10.64	1.64	.00
433.48	.00	.00	535.4	.187E+01	1.64	10.85	1.64	.00
451.27	.00	.00	545.8	.183E+01	1.64	11.06	1.64	.00
469.07	.00	.00	556.0	.180E+01	1.64	11.27	1.64	.00
486.86	.00	.00	566.1	.177E+01	1.64	11.47	1.64	.00
504.65	.00	.00	575.9	.174E+01	1.64	11.67	1.64	.00
522.44	.00	.00	585.6	.171E+01	1.64	11.87	1.64	.00
540.23	.00	.00	595.2	.168E+01	1.64	12.06	1.64	.00

MAC5-3N.CX1

558.02	.00	.00	604.6	.165E+01	1.64	12.25	1.64	.00
575.81	.00	.00	613.8	.163E+01	1.64	12.44	1.64	.00
593.60	.00	.00	622.9	.161E+01	1.64	12.63	1.64	.00
611.39	.00	.00	631.9	.158E+01	1.64	12.81	1.64	.00
629.18	.00	.00	640.8	.156E+01	1.64	12.99	1.64	.00
646.98	.00	.00	649.5	.154E+01	1.64	13.17	1.64	.00
664.77	.00	.00	658.1	.152E+01	1.64	13.34	1.64	.00
682.56	.00	.00	666.7	.150E+01	1.64	13.51	1.64	.00
700.35	.00	.00	675.1	.148E+01	1.64	13.68	1.64	.00
718.14	.00	.00	683.4	.146E+01	1.64	13.85	1.64	.00
735.93	.00	.00	691.6	.145E+01	1.64	14.02	1.64	.00
753.72	.00	.00	699.7	.143E+01	1.64	14.18	1.64	.00
771.51	.00	.00	707.7	.141E+01	1.64	14.34	1.64	.00
789.30	.00	.00	715.6	.140E+01	1.64	14.50	1.64	.00
807.09	.00	.00	723.4	.138E+01	1.64	14.66	1.64	.00
824.89	.00	.00	731.2	.137E+01	1.64	14.82	1.64	.00
842.68	.00	.00	738.8	.135E+01	1.64	14.98	1.64	.00
860.47	.00	.00	746.4	.134E+01	1.64	15.13	1.64	.00
878.26	.00	.00	753.9	.133E+01	1.64	15.28	1.64	.00
896.05	.00	.00	761.4	.131E+01	1.64	15.43	1.64	.00
913.84	.00	.00	768.8	.130E+01	1.64	15.58	1.64	.00
931.63	.00	.00	776.1	.129E+01	1.64	15.73	1.64	.00

Cumulative travel time = 2621. sec

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
931.63	15.73	.00	776.1	.129E+01	1.64	31.46	1.64	.00
933.00	15.73	.00	776.2	.129E+01	1.64	31.47	1.64	.00
934.37	15.73	.00	776.3	.129E+01	1.64	31.47	1.64	.00
935.73	15.73	.00	776.5	.129E+01	1.64	31.48	1.64	.00
937.10	15.73	.00	776.6	.129E+01	1.64	31.48	1.64	.00
938.47	15.73	.00	776.7	.129E+01	1.64	31.49	1.64	.00
939.84	15.73	.00	776.9	.129E+01	1.64	31.49	1.64	.00
941.20	15.73	.00	777.0	.129E+01	1.64	31.50	1.64	.00
942.57	15.73	.00	777.2	.129E+01	1.64	31.51	1.64	.00
943.94	15.73	.00	777.3	.129E+01	1.64	31.51	1.64	.00
945.31	15.73	.00	777.4	.129E+01	1.64	31.52	1.64	.00
946.67	15.73	.00	777.6	.129E+01	1.64	31.52	1.64	.00
948.04	15.73	.00	777.7	.129E+01	1.64	31.53	1.64	.00
949.41	15.73	.00	777.9	.129E+01	1.64	31.53	1.64	.00
950.78	15.73	.00	778.0	.129E+01	1.64	31.54	1.64	.00
952.14	15.73	.00	778.1	.129E+01	1.64	31.54	1.64	.00
953.51	15.73	.00	778.3	.128E+01	1.64	31.55	1.64	.00
954.88	15.73	.00	778.4	.128E+01	1.64	31.56	1.64	.00
956.24	15.73	.00	778.6	.128E+01	1.64	31.56	1.64	.00
957.61	15.73	.00	778.7	.128E+01	1.64	31.57	1.64	.00
958.98	15.73	.00	778.8	.128E+01	1.64	31.57	1.64	.00

960.35	15.73	.00	779.0	.128E+01	1.64	31.58	1.64	.00
961.71	15.73	.00	779.1	.128E+01	1.64	31.58	1.64	.00
963.08	15.73	.00	779.3	.128E+01	1.64	31.59	1.64	.00
964.45	15.73	.00	779.4	.128E+01	1.64	31.60	1.64	.00
965.82	15.73	.00	779.5	.128E+01	1.64	31.60	1.64	.00
967.18	15.73	.00	779.7	.128E+01	1.64	31.61	1.64	.00
968.55	15.73	.00	779.8	.128E+01	1.64	31.61	1.64	.00
969.92	15.73	.00	779.9	.128E+01	1.64	31.62	1.64	.00
971.29	15.73	.00	780.1	.128E+01	1.64	31.62	1.64	.00
972.65	15.73	.00	780.2	.128E+01	1.64	31.63	1.64	.00
974.02	15.73	.00	780.4	.128E+01	1.64	31.63	1.64	.00
975.39	15.73	.00	780.5	.128E+01	1.64	31.64	1.64	.00
976.76	15.73	.00	780.6	.128E+01	1.64	31.65	1.64	.00
978.12	15.73	.00	780.8	.128E+01	1.64	31.65	1.64	.00
979.49	15.73	.00	780.9	.128E+01	1.64	31.66	1.64	.00
980.86	15.73	.00	781.1	.128E+01	1.64	31.66	1.64	.00
982.22	15.73	.00	781.2	.128E+01	1.64	31.67	1.64	.00
983.59	15.73	.00	781.3	.128E+01	1.64	31.67	1.64	.00
984.96	15.73	.00	781.5	.128E+01	1.64	31.68	1.64	.00
986.33	15.73	.00	781.6	.128E+01	1.64	31.69	1.64	.00
987.69	15.73	.00	781.8	.128E+01	1.64	31.69	1.64	.00
989.06	15.73	.00	781.9	.128E+01	1.64	31.70	1.64	.00
990.43	15.73	.00	782.0	.128E+01	1.64	31.70	1.64	.00
991.80	15.73	.00	782.2	.128E+01	1.64	31.71	1.64	.00
993.16	15.73	.00	782.3	.128E+01	1.64	31.71	1.64	.00
994.53	15.73	.00	782.4	.128E+01	1.64	31.72	1.64	.00
995.90	15.73	.00	782.6	.128E+01	1.64	31.72	1.64	.00
997.27	15.73	.00	782.7	.128E+01	1.64	31.73	1.64	.00
998.63	15.73	.00	782.9	.128E+01	1.64	31.74	1.64	.00
1000.00	15.73	.00	783.0	.128E+01	1.64	31.74	1.64	.00

Cumulative travel time = 2814. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File
11111111111111111111111111111111111111111111111111111111111111111111111111111111

MAC5-3X.CX1

CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111

CORNELL MIXING ZONE EXPERT SYSTEM

Subsystem CORMIX1: Subsystem version:
Submerged Single Port Discharges CORMIX_v.3.20_____September_1996

CASE DESCRIPTION
Site name/label: Mach^Big^Muddy^River
Design case: Case^4^-^Port^3^Maximum^Flow
FILE NAME: cormix\sim\Mac5-3X .cx1
Time of Fortran run: 11/09/16--09:10:18

ENVIRONMENT PARAMETERS (metric units)
Bounded section
BS = 113.20 AS = 186.91 QA = 51.27 ICHREG= 2
HA = 1.65 HD = 1.65
UA = .274 F = .081 USTAR = .2766E-01
UW = 2.000 UWSTAR= .2198E-02
Uniform density environment
STRCND= U RHOAM = 998.4901

DISCHARGE PARAMETERS (metric units)
BANK = LEFT DISTB = 20.62
D0 = .102 A0 = .008 H0 = .15
THETA = 15.00 SIGMA = .00
U0 = 5.487 Q0 = .044 = .4448E-01
RHO0 = 1013.3900 DRHO0 =-.1490E+02 GP0 =-.1463E+00
C0 = .1000E+04 CUNITS= ppm
IPOLL = 1 KS = .0000E+00 KD = .0000E+00

FLUX VARIABLES (metric units)
Q0 = .4448E-01 M0 = .2441E+00 J0 =-.6509E-02 SIGNJ0= -1.0
Associated length scales (meters)
LQ = .09 LM = 4.30 Lm = 1.80 Lb = .32
Lmp = 99999.00 Lbp = 99999.00

NON-DIMENSIONAL PARAMETERS
FR0 = 44.99 R = 20.00

FLOW CLASSIFICATION
1111111111111111111111111111111111111111
1 Flow class (CORMIX1) = NH5 1
1 Applicable layer depth HS = 1.65 1
1111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
C0 = .1000E+04 CUNITS= ppm

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX  =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
        20.62 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

 COANDA ATTACHMENT immediately following the discharge.

       X        Y        Z        S        C        B
      .00      .00      .00     1.0  .100E+04     .07

END OF MOD101: DISCHARGE MODULE
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Bottom-attached jet motion.

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
         Half wall jet, attached to bottom.
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .00     1.0  .100E+04     .05
     1.02      .00      .00     1.9  .533E+03     .15
     2.06      .00      .00     3.1  .319E+03     .24
     3.10      .00      .00     4.4  .229E+03     .31
     4.14      .00      .00     5.6  .179E+03     .38
     5.18      .00      .00     6.8  .148E+03     .44
     6.22      .00      .00     7.9  .126E+03     .50
     7.26      .00      .00     9.1  .110E+03     .55
     8.31      .00      .00    10.2  .982E+02     .61
     9.35      .00      .00    11.3  .887E+02     .65
    10.39      .00      .00    12.4  .810E+02     .70
    11.43      .00      .00    13.4  .746E+02     .74
    12.47      .00      .00    14.5  .692E+02     .78
    13.51      .00      .00    15.5  .646E+02     .82
    14.55      .00      .00    16.5  .606E+02     .85
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15.59	.00	.00	17.5	.572E+02	.89
16.63	.00	.00	18.5	.541E+02	.92
17.67	.00	.00	19.5	.514E+02	.95
18.71	.00	.00	20.4	.490E+02	.98
19.73	.00	.00	21.3	.469E+02	1.01
20.77	.00	.00	22.3	.449E+02	1.04
21.81	.00	.00	23.2	.431E+02	1.07
22.85	.00	.00	24.1	.415E+02	1.10
23.89	.00	.00	25.0	.400E+02	1.12
24.93	.00	.00	25.9	.386E+02	1.15
25.97	.00	.00	26.8	.373E+02	1.17
27.01	.00	.00	27.7	.361E+02	1.20
28.05	.00	.00	28.6	.350E+02	1.22
29.09	.00	.00	29.4	.340E+02	1.25
30.13	.00	.00	30.3	.330E+02	1.27
31.17	.00	.00	31.1	.321E+02	1.29
32.21	.00	.00	32.0	.313E+02	1.31
33.25	.00	.00	32.8	.305E+02	1.33
34.29	.00	.00	33.6	.297E+02	1.35
35.33	.00	.00	34.4	.290E+02	1.37
36.37	.00	.00	35.3	.284E+02	1.39
37.41	.00	.00	36.1	.277E+02	1.41
38.44	.00	.00	36.9	.271E+02	1.43
39.48	.00	.00	37.7	.266E+02	1.45
40.52	.00	.00	38.4	.260E+02	1.47
41.56	.00	.00	39.2	.255E+02	1.49
42.60	.00	.00	40.0	.250E+02	1.50
43.64	.00	.00	40.8	.245E+02	1.52
44.68	.00	.00	41.5	.241E+02	1.54
45.72	.00	.00	42.3	.236E+02	1.56
46.76	.00	.00	43.1	.232E+02	1.57
47.80	.00	.00	43.8	.228E+02	1.59
48.84	.00	.00	44.6	.224E+02	1.60
49.88	.00	.00	45.3	.221E+02	1.62
50.92	.00	.00	46.1	.217E+02	1.64
51.96	.00	.00	46.8	.214E+02	1.65

Cumulative travel time = 88. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
51.96	.00	.00	46.8	.214E+02	1.65

Profile definitions:

MAC5-3X.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
50.31	.00	.00	46.8	.214E+02	.00	.00	.00	.00
50.64	.00	.00	46.8	.214E+02	1.65	.31	1.65	.00
50.97	.00	.00	46.8	.214E+02	1.65	.43	1.65	.00
51.30	.00	.00	46.8	.214E+02	1.65	.53	1.65	.00
51.63	.00	.00	46.8	.214E+02	1.65	.61	1.65	.00
51.96	.00	.00	46.8	.214E+02	1.65	.69	1.65	.00
52.29	.00	.00	49.5	.202E+02	1.65	.75	1.65	.00
52.62	.00	.00	55.6	.180E+02	1.65	.81	1.65	.00
52.95	.00	.00	61.1	.164E+02	1.65	.87	1.65	.00
53.28	.00	.00	64.0	.156E+02	1.65	.92	1.65	.00
53.61	.00	.00	65.5	.153E+02	1.65	.97	1.65	.00

Cumulative travel time = 95. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.31 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC5-3X.CX1

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
53.61	.00	.00	65.5	.153E+02	1.65	3.21	1.65	.00
55.66	.00	.00	67.5	.148E+02	1.55	3.53	1.55	.00
57.70	.00	.00	69.4	.144E+02	1.47	3.83	1.47	.00
59.75	.00	.00	71.2	.140E+02	1.40	4.11	1.40	.00
61.80	.00	.00	73.1	.137E+02	1.35	4.39	1.35	.00
63.85	.00	.00	75.0	.133E+02	1.30	4.66	1.30	.00
65.89	.00	.00	76.9	.130E+02	1.27	4.92	1.27	.00
67.94	.00	.00	78.8	.127E+02	1.23	5.18	1.23	.00
69.99	.00	.00	80.9	.124E+02	1.21	5.43	1.21	.00
72.03	.00	.00	82.9	.121E+02	1.18	5.67	1.18	.00
74.08	.00	.00	85.0	.118E+02	1.17	5.91	1.17	.00
76.13	.00	.00	87.3	.115E+02	1.15	6.14	1.15	.00
78.17	.00	.00	89.5	.112E+02	1.14	6.37	1.14	.00
80.22	.00	.00	91.9	.109E+02	1.13	6.60	1.13	.00
82.27	.00	.00	94.4	.106E+02	1.12	6.82	1.12	.00
84.31	.00	.00	97.0	.103E+02	1.12	7.03	1.12	.00
86.36	.00	.00	99.6	.100E+02	1.11	7.25	1.11	.00
88.41	.00	.00	102.4	.977E+01	1.11	7.46	1.11	.00
90.45	.00	.00	105.3	.950E+01	1.11	7.67	1.11	.00
92.50	.00	.00	108.3	.924E+01	1.11	7.87	1.11	.00
94.55	.00	.00	111.4	.898E+01	1.12	8.08	1.12	.00
96.60	.00	.00	114.6	.873E+01	1.12	8.28	1.12	.00
98.64	.00	.00	117.9	.848E+01	1.13	8.47	1.13	.00
100.69	.00	.00	121.4	.824E+01	1.13	8.67	1.13	.00
102.74	.00	.00	125.0	.800E+01	1.14	8.86	1.14	.00
104.78	.00	.00	128.7	.777E+01	1.15	9.05	1.15	.00
106.83	.00	.00	132.6	.754E+01	1.16	9.24	1.16	.00
108.88	.00	.00	136.5	.732E+01	1.17	9.43	1.17	.00
110.92	.00	.00	140.6	.711E+01	1.18	9.62	1.18	.00
112.97	.00	.00	144.9	.690E+01	1.20	9.80	1.20	.00
115.02	.00	.00	149.3	.670E+01	1.21	9.98	1.21	.00
117.06	.00	.00	153.8	.650E+01	1.23	10.16	1.23	.00
119.11	.00	.00	158.4	.631E+01	1.24	10.34	1.24	.00
121.16	.00	.00	163.2	.613E+01	1.26	10.52	1.26	.00
123.20	.00	.00	168.2	.595E+01	1.27	10.69	1.27	.00
125.25	.00	.00	173.3	.577E+01	1.29	10.87	1.29	.00
127.30	.00	.00	178.5	.560E+01	1.31	11.04	1.31	.00

129.34	.00	.00	183.9	.544E+01	1.33	11.21	1.33	.00
131.39	.00	.00	189.4	.528E+01	1.35	11.38	1.35	.00
133.44	.00	.00	195.1	.513E+01	1.37	11.55	1.37	.00
135.49	.00	.00	201.0	.498E+01	1.39	11.72	1.39	.00
137.53	.00	.00	206.9	.483E+01	1.41	11.89	1.41	.00
139.58	.00	.00	213.1	.469E+01	1.43	12.05	1.43	.00
141.63	.00	.00	219.4	.456E+01	1.45	12.22	1.45	.00
143.67	.00	.00	225.9	.443E+01	1.48	12.38	1.48	.00
145.72	.00	.00	232.5	.430E+01	1.50	12.54	1.50	.00
147.77	.00	.00	239.3	.418E+01	1.53	12.70	1.53	.00
149.81	.00	.00	246.2	.406E+01	1.55	12.86	1.55	.00
151.86	.00	.00	253.3	.395E+01	1.58	13.02	1.58	.00
153.91	.00	.00	260.6	.384E+01	1.60	13.18	1.60	.00
155.95	.00	.00	268.0	.373E+01	1.63	13.34	1.63	.00

Cumulative travel time = 467. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .914E-02 m^2/s
Horizontal diffusivity (initial value) = .228E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
155.95	.00	.00	268.0	.373E+01	1.63	13.34	1.63	.00
172.83	.00	.00	275.2	.363E+01	1.65	13.50	1.65	.00
189.72	.00	.00	278.5	.359E+01	1.65	13.66	1.65	.00
206.60	.00	.00	281.8	.355E+01	1.65	13.83	1.65	.00
223.48	.00	.00	285.0	.351E+01	1.65	13.98	1.65	.00
240.36	.00	.00	288.2	.347E+01	1.65	14.14	1.65	.00
257.24	.00	.00	291.4	.343E+01	1.65	14.30	1.65	.00
274.12	.00	.00	294.5	.340E+01	1.65	14.45	1.65	.00
291.00	.00	.00	297.6	.336E+01	1.65	14.60	1.65	.00
307.88	.00	.00	300.7	.333E+01	1.65	14.75	1.65	.00
324.76	.00	.00	303.7	.329E+01	1.65	14.90	1.65	.00
341.64	.00	.00	306.7	.326E+01	1.65	15.05	1.65	.00

358.52	.00	.00	309.7	.323E+01	1.65	15.19	1.65	.00
375.41	.00	.00	312.6	.320E+01	1.65	15.34	1.65	.00
392.29	.00	.00	315.5	.317E+01	1.65	15.48	1.65	.00
409.17	.00	.00	318.4	.314E+01	1.65	15.62	1.65	.00
426.05	.00	.00	321.3	.311E+01	1.65	15.76	1.65	.00
442.93	.00	.00	324.1	.309E+01	1.65	15.90	1.65	.00
459.81	.00	.00	327.0	.306E+01	1.65	16.04	1.65	.00
476.69	.00	.00	329.7	.303E+01	1.65	16.18	1.65	.00
493.57	.00	.00	332.5	.301E+01	1.65	16.31	1.65	.00
510.45	.00	.00	335.3	.298E+01	1.65	16.45	1.65	.00
527.33	.00	.00	338.0	.296E+01	1.65	16.58	1.65	.00
544.21	.00	.00	340.7	.294E+01	1.65	16.72	1.65	.00
561.10	.00	.00	343.4	.291E+01	1.65	16.85	1.65	.00
577.98	.00	.00	346.0	.289E+01	1.65	16.98	1.65	.00
594.86	.00	.00	348.7	.287E+01	1.65	17.11	1.65	.00
611.74	.00	.00	351.3	.285E+01	1.65	17.24	1.65	.00
628.62	.00	.00	353.9	.283E+01	1.65	17.36	1.65	.00
645.50	.00	.00	356.5	.281E+01	1.65	17.49	1.65	.00
662.38	.00	.00	359.0	.279E+01	1.65	17.61	1.65	.00
679.26	.00	.00	361.6	.277E+01	1.65	17.74	1.65	.00
696.14	.00	.00	364.1	.275E+01	1.65	17.86	1.65	.00
713.02	.00	.00	366.6	.273E+01	1.65	17.99	1.65	.00
729.90	.00	.00	369.1	.271E+01	1.65	18.11	1.65	.00
746.79	.00	.00	371.6	.269E+01	1.65	18.23	1.65	.00
763.67	.00	.00	374.0	.267E+01	1.65	18.35	1.65	.00
780.55	.00	.00	376.5	.266E+01	1.65	18.47	1.65	.00
797.43	.00	.00	378.9	.264E+01	1.65	18.59	1.65	.00
814.31	.00	.00	381.3	.262E+01	1.65	18.71	1.65	.00
831.19	.00	.00	383.7	.261E+01	1.65	18.83	1.65	.00
848.07	.00	.00	386.1	.259E+01	1.65	18.94	1.65	.00
864.95	.00	.00	388.5	.257E+01	1.65	19.06	1.65	.00
881.83	.00	.00	390.8	.256E+01	1.65	19.17	1.65	.00
898.71	.00	.00	393.1	.254E+01	1.65	19.29	1.65	.00
915.60	.00	.00	395.5	.253E+01	1.65	19.40	1.65	.00
932.48	.00	.00	397.8	.251E+01	1.65	19.52	1.65	.00
949.36	.00	.00	400.1	.250E+01	1.65	19.63	1.65	.00
966.24	.00	.00	402.4	.249E+01	1.65	19.74	1.65	.00
983.12	.00	.00	404.6	.247E+01	1.65	19.85	1.65	.00
1000.00	.00	.00	406.9	.246E+01	1.65	19.96	1.65	.00

Cumulative travel time = 3542. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

MAC5-3X.CX1

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MAC5-4N.CX1

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CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111
                    CORNELL MIXING ZONE EXPERT SYSTEM
Subsystem CORMIX1:                                          Subsystem version:
 Submerged Single Port Discharges          CORMIX_v.3.20_____September_1996
------------------------------------------------------------------------------
------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:         Mach^Big^Muddy^River
 Design case:             Case^5^-^Port^4^Normal^Flow
 FILE NAME:               cormix\sim\Mac5-4N .cx1
 Time of Fortran run:     11/09/16--09:58:49

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     56.85 AS    =     93.39  QA    =     33.02  ICHREG= 2
 HA    =      1.64 HD    =      1.64
 UA    =       .354 F     =       .081 USTAR = .3568E-01
 UW    =     2.000 UWSTAR= .2198E-02
 Uniform density environment
 STRCND=  U         RHOAM =  998.4907

DISCHARGE PARAMETERS (metric units)
 BANK  =  LEFT      DISTB =     20.62
 D0    =       .152 A0    =       .018 H0    =       .15
 THETA =     15.00  SIGMA =       .00
 U0    =      2.665 Q0    =       .049       = .4861E-01
 RHO0  = 1013.3900  DRHO0 =-.1490E+02  GP0   =-.1463E+00
 C0    = .1000E+04  CUNITS=  ppm
 IPOLL =  1         KS    = .0000E+00  KD    = .0000E+00

FLUX VARIABLES (metric units)
 Q0    = .4861E-01  M0    = .1295E+00  J0    =-.7113E-02  SIGNJ0=     -1.0
 Associated length scales (meters)
 LQ    =       .14  LM    =      2.56  Lm    =      1.02  Lb    =       .16
                                        Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =     17.84  R     =      7.53

FLOW CLASSIFICATION
 11111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    NH4    1
 1  Applicable layer depth HS =     1.64  1
 11111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    = .1000E+04  CUNITS=  ppm
```

MAC5-4N.CX1

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
        20.62 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z        S        C        B
       .00      .00      .15     1.0  .100E+04     .08

END OF MOD101: DISCHARGE MODULE
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet/plume transition motion in strong crossflow.

 Zone of flow establishment:            THETAE=     14.37  SIGMAE=        .00
  LE    =        .68  XE    =        .66  YE    =        .00  ZE    =        .32

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
       .00      .00      .15     1.0  .100E+04     .08
       .66      .00      .32     1.0  .100E+04     .08
       .77      .00      .35     1.0  .958E+03     .09
       .90      .00      .38     1.2  .818E+03     .10
      1.03      .00      .41     1.4  .713E+03     .12
      1.16      .00      .44     1.6  .631E+03     .13
      1.29      .00      .46     1.8  .566E+03     .14
      1.41      .00      .49     1.9  .518E+03     .15
      1.54      .00      .51     2.1  .473E+03     .16
      1.67      .00      .53     2.3  .437E+03     .17
      1.80      .00      .55     2.5  .405E+03     .18
      1.93      .00      .56     2.6  .379E+03     .19
      2.07      .00      .58     2.8  .356E+03     .20
      2.19      .00      .59     3.0  .337E+03     .21
      2.32      .00      .61     3.1  .319E+03     .22
```

2.45	.00	.62	3.3	.304E+03	.23
2.58	.00	.63	3.4	.290E+03	.23
2.71	.00	.64	3.6	.278E+03	.24
2.85	.00	.65	3.8	.267E+03	.25
2.97	.00	.65	3.9	.257E+03	.25
3.10	.00	.66	4.0	.248E+03	.26
3.23	.00	.67	4.2	.240E+03	.27
3.37	.00	.67	4.3	.233E+03	.27
3.50	.00	.67	4.4	.226E+03	.28
3.62	.00	.68	4.5	.221E+03	.28
3.75	.00	.68	4.7	.215E+03	.29
3.88	.00	.68	4.8	.210E+03	.29

Maximum jet height has been reached.

4.02	.00	.68	4.9	.205E+03	.30
4.15	.00	.68	5.0	.200E+03	.30
4.28	.00	.67	5.1	.195E+03	.31
4.40	.00	.67	5.2	.191E+03	.31
4.54	.00	.67	5.4	.186E+03	.32
4.67	.00	.66	5.5	.182E+03	.32
4.80	.00	.66	5.6	.177E+03	.33
4.93	.00	.65	5.8	.173E+03	.34
5.06	.00	.64	5.9	.169E+03	.34
5.19	.00	.63	6.1	.165E+03	.35
5.32	.00	.63	6.2	.161E+03	.35
5.45	.00	.62	6.4	.157E+03	.36
5.58	.00	.61	6.6	.153E+03	.36
5.71	.00	.60	6.7	.149E+03	.37
5.84	.00	.58	6.9	.145E+03	.38
5.97	.00	.57	7.1	.142E+03	.38
6.10	.00	.56	7.3	.138E+03	.39
6.23	.00	.55	7.4	.134E+03	.40
6.36	.00	.53	7.6	.131E+03	.40
6.49	.00	.52	7.8	.128E+03	.41
6.62	.00	.51	8.0	.125E+03	.41
6.75	.00	.49	8.2	.122E+03	.42
6.88	.00	.47	8.4	.119E+03	.43
7.01	.00	.46	8.6	.116E+03	.44
7.14	.00	.44	8.8	.113E+03	.44

Cumulative travel time = 7. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

Control volume inflow:

X	Y	Z	S	C	B
7.14	.00	.44	8.8	.113E+03	.44

MAC5-4N.CX1

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
6.70	.00	.00	8.8	.113E+03	.00	.00	.00	.00
6.83	.00	.00	8.8	.113E+03	.64	.32	.64	.00
6.96	.00	.00	8.8	.113E+03	.76	.45	.76	.00
7.10	.00	.00	8.8	.113E+03	.83	.56	.83	.00
7.23	.00	.00	9.1	.110E+03	.89	.64	.89	.00
7.36	.00	.00	10.2	.979E+02	.93	.72	.93	.00
7.49	.00	.00	11.8	.849E+02	.96	.79	.96	.00
7.63	.00	.00	13.2	.758E+02	.99	.85	.99	.00
7.76	.00	.00	14.2	.706E+02	1.00	.91	1.00	.00
7.89	.00	.00	14.7	.680E+02	1.01	.96	1.01	.00
8.02	.00	.00	15.0	.665E+02	1.02	1.02	1.02	.00

Cumulative travel time = 9. sec

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

** End of NEAR-FIELD REGION (NFR) **

BEGIN MOD141: BUOYANT AMBIENT SPREADING

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
8.02	.00	.00	15.0	.665E+02	1.02	1.02	1.02	.00
9.56	.00	.00	16.1	.621E+02	.85	1.30	.85	.00
11.09	.00	.00	17.0	.589E+02	.75	1.56	.75	.00
12.62	.00	.00	17.8	.563E+02	.68	1.80	.68	.00
14.15	.00	.00	18.5	.539E+02	.63	2.02	.63	.00
15.68	.00	.00	19.3	.518E+02	.60	2.23	.60	.00
17.22	.00	.00	20.1	.498E+02	.57	2.43	.57	.00
18.75	.00	.00	20.9	.479E+02	.55	2.62	.55	.00
20.28	.00	.00	21.7	.460E+02	.53	2.81	.53	.00

21.81	.00	.00	22.6	.442E+02	.52	2.99	.52	.00
23.35	.00	.00	23.6	.424E+02	.51	3.16	.51	.00
24.88	.00	.00	24.6	.407E+02	.51	3.33	.51	.00
26.41	.00	.00	25.7	.390E+02	.50	3.50	.50	.00
27.94	.00	.00	26.8	.373E+02	.50	3.66	.50	.00
29.47	.00	.00	28.0	.357E+02	.50	3.82	.50	.00
31.01	.00	.00	29.3	.342E+02	.51	3.97	.51	.00
32.54	.00	.00	30.6	.326E+02	.51	4.12	.51	.00
34.07	.00	.00	32.1	.312E+02	.52	4.27	.52	.00
35.60	.00	.00	33.6	.298E+02	.52	4.42	.52	.00
37.13	.00	.00	35.2	.284E+02	.53	4.57	.53	.00
38.67	.00	.00	36.9	.271E+02	.54	4.71	.54	.00
40.20	.00	.00	38.6	.259E+02	.55	4.85	.55	.00
41.73	.00	.00	40.5	.247E+02	.56	4.99	.56	.00
43.26	.00	.00	42.4	.236E+02	.57	5.12	.57	.00
44.80	.00	.00	44.5	.225E+02	.58	5.26	.58	.00
46.33	.00	.00	46.6	.214E+02	.59	5.39	.59	.00
47.86	.00	.00	48.9	.205E+02	.61	5.52	.61	.00
49.39	.00	.00	51.2	.195E+02	.62	5.65	.62	.00
50.92	.00	.00	53.6	.186E+02	.64	5.78	.64	.00
52.46	.00	.00	56.2	.178E+02	.65	5.90	.65	.00
53.99	.00	.00	58.8	.170E+02	.67	6.03	.67	.00
55.52	.00	.00	61.5	.163E+02	.69	6.15	.69	.00
57.05	.00	.00	64.4	.155E+02	.71	6.28	.71	.00
58.58	.00	.00	67.3	.149E+02	.72	6.40	.72	.00
60.12	.00	.00	70.4	.142E+02	.74	6.52	.74	.00
61.65	.00	.00	73.5	.136E+02	.76	6.64	.76	.00
63.18	.00	.00	76.8	.130E+02	.78	6.75	.78	.00
64.71	.00	.00	80.2	.125E+02	.80	6.87	.80	.00
66.24	.00	.00	83.6	.120E+02	.82	6.99	.82	.00
67.78	.00	.00	87.2	.115E+02	.84	7.10	.84	.00
69.31	.00	.00	91.0	.110E+02	.87	7.22	.87	.00
70.84	.00	.00	94.8	.105E+02	.89	7.33	.89	.00
72.37	.00	.00	98.7	.101E+02	.91	7.44	.91	.00
73.91	.00	.00	102.8	.973E+01	.94	7.56	.94	.00
75.44	.00	.00	107.0	.935E+01	.96	7.67	.96	.00
76.97	.00	.00	111.3	.899E+01	.98	7.78	.98	.00
78.50	.00	.00	115.7	.865E+01	1.01	7.89	1.01	.00
80.03	.00	.00	120.2	.832E+01	1.03	7.99	1.03	.00
81.57	.00	.00	124.9	.801E+01	1.06	8.10	1.06	.00
83.10	.00	.00	129.6	.771E+01	1.09	8.21	1.09	.00
84.63	.00	.00	134.5	.743E+01	1.11	8.32	1.11	.00

Cumulative travel time = 225. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

MAC5-4N.CX1

Vertical diffusivity (initial value) = .117E-01 m^2/s
Horizontal diffusivity (initial value) = .293E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
84.63	.00	.00	134.5	.743E+01	1.11	8.32	1.11	.00
102.94	.00	.00	176.6	.566E+01	1.41	8.60	1.41	.00

Plume interacts with SURFACE.
The passive diffusion plume becomes VERTICALLY FULLY MIXED within this prediction interval.

121.24	.00	.00	212.0	.472E+01	1.64	8.87	1.64	.00
139.55	.00	.00	218.3	.458E+01	1.64	9.13	1.64	.00
157.86	.00	.00	224.5	.445E+01	1.64	9.39	1.64	.00
176.17	.00	.00	230.5	.434E+01	1.64	9.64	1.64	.00
194.47	.00	.00	236.3	.423E+01	1.64	9.89	1.64	.00
212.78	.00	.00	242.0	.413E+01	1.64	10.12	1.64	.00
231.09	.00	.00	247.5	.404E+01	1.64	10.36	1.64	.00
249.40	.00	.00	253.0	.395E+01	1.64	10.58	1.64	.00
267.70	.00	.00	258.3	.387E+01	1.64	10.81	1.64	.00
286.01	.00	.00	263.5	.380E+01	1.64	11.02	1.64	.00
304.32	.00	.00	268.6	.372E+01	1.64	11.24	1.64	.00
322.63	.00	.00	273.6	.365E+01	1.64	11.45	1.64	.00
340.93	.00	.00	278.6	.359E+01	1.64	11.65	1.64	.00
359.24	.00	.00	283.4	.353E+01	1.64	11.86	1.64	.00
377.55	.00	.00	288.2	.347E+01	1.64	12.06	1.64	.00
395.86	.00	.00	292.8	.341E+01	1.64	12.25	1.64	.00
414.16	.00	.00	297.5	.336E+01	1.64	12.44	1.64	.00
432.47	.00	.00	302.0	.331E+01	1.64	12.63	1.64	.00
450.78	.00	.00	306.5	.326E+01	1.64	12.82	1.64	.00
469.09	.00	.00	310.9	.322E+01	1.64	13.01	1.64	.00
487.39	.00	.00	315.2	.317E+01	1.64	13.19	1.64	.00
505.70	.00	.00	319.5	.313E+01	1.64	13.37	1.64	.00
524.01	.00	.00	323.7	.309E+01	1.64	13.54	1.64	.00
542.32	.00	.00	327.9	.305E+01	1.64	13.72	1.64	.00
560.62	.00	.00	332.0	.301E+01	1.64	13.89	1.64	.00
578.93	.00	.00	336.1	.298E+01	1.64	14.06	1.64	.00
597.24	.00	.00	340.1	.294E+01	1.64	14.23	1.64	.00

MAC5-4N.CX1

615.54	.00	.00	344.1	.291E+01	1.64	14.40	1.64	.00
633.85	.00	.00	348.0	.287E+01	1.64	14.56	1.64	.00
652.16	.00	.00	351.9	.284E+01	1.64	14.72	1.64	.00
670.47	.00	.00	355.8	.281E+01	1.64	14.88	1.64	.00
688.77	.00	.00	359.6	.278E+01	1.64	15.04	1.64	.00
707.08	.00	.00	363.3	.275E+01	1.64	15.20	1.64	.00
725.39	.00	.00	367.1	.272E+01	1.64	15.36	1.64	.00
743.70	.00	.00	370.7	.270E+01	1.64	15.51	1.64	.00
762.00	.00	.00	374.4	.267E+01	1.64	15.66	1.64	.00
780.31	.00	.00	378.0	.265E+01	1.64	15.82	1.64	.00
798.62	.00	.00	381.6	.262E+01	1.64	15.97	1.64	.00
816.93	.00	.00	385.1	.260E+01	1.64	16.11	1.64	.00
835.23	.00	.00	388.7	.257E+01	1.64	16.26	1.64	.00
853.54	.00	.00	392.1	.255E+01	1.64	16.41	1.64	.00
871.85	.00	.00	395.6	.253E+01	1.64	16.55	1.64	.00
890.16	.00	.00	399.0	.251E+01	1.64	16.69	1.64	.00
908.46	.00	.00	402.4	.248E+01	1.64	16.84	1.64	.00
926.77	.00	.00	405.8	.246E+01	1.64	16.98	1.64	.00
945.08	.00	.00	409.1	.244E+01	1.64	17.12	1.64	.00
963.38	.00	.00	412.4	.242E+01	1.64	17.26	1.64	.00
981.69	.00	.00	415.7	.241E+01	1.64	17.39	1.64	.00
1000.00	.00	.00	419.0	.239E+01	1.64	17.53	1.64	.00

Cumulative travel time = 2810. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

11111111111111111111111111111111111111111111111111111111111111111111111111111111

MAC5-4N.CX1

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CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111111
                    CORNELL MIXING ZONE EXPERT SYSTEM
Subsystem CORMIX1:                                          Subsystem version:
 Submerged Single Port Discharges          CORMIX_v.3.20_____September_1996
------------------------------------------------------------------------------
------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:         Mach^Big^Muddy^River
 Design case:             Case^5^-^Port^4^Normal^Flow
 FILE NAME:               cormix\sim\Mac5-4N .cx1
 Time of Fortran run:     11/09/16--09:58:49

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     56.85  AS    =     93.39  QA    =     33.02  ICHREG= 2
 HA    =      1.64  HD    =      1.64
 UA    =       .354 F     =       .081 USTAR = .3568E-01
 UW    =     2.000 UWSTAR= .2198E-02
 Uniform density environment
 STRCND=  U         RHOAM = 998.4907

DISCHARGE PARAMETERS (metric units)
 BANK  =  LEFT      DISTB =     20.62
 D0    =       .152 A0    =       .018 H0    =       .15
 THETA =     15.00  SIGMA =       .00
 U0    =      2.665 Q0    =       .049       = .4861E-01
 RHO0  = 1013.3900  DRHO0 =-.1490E+02  GP0   =-.1463E+00
 C0    = .1000E+04  CUNITS=  ppm
 IPOLL =  1         KS    = .0000E+00  KD    = .0000E+00

FLUX VARIABLES (metric units)
 Q0    = .4861E-01  M0    = .1295E+00  J0    =-.7113E-02  SIGNJ0=     -1.0
 Associated length scales (meters)
 LQ    =       .14  LM    =      2.56  Lm    =      1.02  Lb    =       .16
                                        Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =     17.84  R     =      7.53

FLOW CLASSIFICATION
 11111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    NH4    1
 1  Applicable layer depth HS =     1.64  1
 11111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    = .1000E+04  CUNITS=  ppm
```

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
        20.62 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z        S        C        B
      .00      .00      .15      1.0  .100E+04     .08

END OF MOD101: DISCHARGE MODULE
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet/plume transition motion in strong crossflow.

 Zone of flow establishment:            THETAE=     14.37  SIGMAE=       .00
  LE    =       .68  XE    =       .66  YE    =       .00  ZE    =       .32

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .15      1.0  .100E+04     .08
      .66      .00      .32      1.0  .100E+04     .08
      .77      .00      .35      1.0  .958E+03     .09
      .90      .00      .38      1.2  .818E+03     .10
     1.03      .00      .41      1.4  .713E+03     .12
     1.16      .00      .44      1.6  .631E+03     .13
     1.29      .00      .46      1.8  .566E+03     .14
     1.41      .00      .49      1.9  .518E+03     .15
     1.54      .00      .51      2.1  .473E+03     .16
     1.67      .00      .53      2.3  .437E+03     .17
     1.80      .00      .55      2.5  .405E+03     .18
     1.93      .00      .56      2.6  .379E+03     .19
     2.07      .00      .58      2.8  .356E+03     .20
     2.19      .00      .59      3.0  .337E+03     .21
     2.32      .00      .61      3.1  .319E+03     .22
```

2.45	.00	.62	3.3	.304E+03	.23
2.58	.00	.63	3.4	.290E+03	.23
2.71	.00	.64	3.6	.278E+03	.24
2.85	.00	.65	3.8	.267E+03	.25
2.97	.00	.65	3.9	.257E+03	.25
3.10	.00	.66	4.0	.248E+03	.26
3.23	.00	.67	4.2	.240E+03	.27
3.37	.00	.67	4.3	.233E+03	.27
3.50	.00	.67	4.4	.226E+03	.28
3.62	.00	.68	4.5	.221E+03	.28
3.75	.00	.68	4.7	.215E+03	.29
3.88	.00	.68	4.8	.210E+03	.29

Maximum jet height has been reached.

4.02	.00	.68	4.9	.205E+03	.30
4.15	.00	.68	5.0	.200E+03	.30
4.28	.00	.67	5.1	.195E+03	.31
4.40	.00	.67	5.2	.191E+03	.31
4.54	.00	.67	5.4	.186E+03	.32
4.67	.00	.66	5.5	.182E+03	.32
4.80	.00	.66	5.6	.177E+03	.33
4.93	.00	.65	5.8	.173E+03	.34
5.06	.00	.64	5.9	.169E+03	.34
5.19	.00	.63	6.1	.165E+03	.35
5.32	.00	.63	6.2	.161E+03	.35
5.45	.00	.62	6.4	.157E+03	.36
5.58	.00	.61	6.6	.153E+03	.36
5.71	.00	.60	6.7	.149E+03	.37
5.84	.00	.58	6.9	.145E+03	.38
5.97	.00	.57	7.1	.142E+03	.38
6.10	.00	.56	7.3	.138E+03	.39
6.23	.00	.55	7.4	.134E+03	.40
6.36	.00	.53	7.6	.131E+03	.40
6.49	.00	.52	7.8	.128E+03	.41
6.62	.00	.51	8.0	.125E+03	.41
6.75	.00	.49	8.2	.122E+03	.42
6.88	.00	.47	8.4	.119E+03	.43
7.01	.00	.46	8.6	.116E+03	.44
7.14	.00	.44	8.8	.113E+03	.44

Cumulative travel time = 7. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

Control volume inflow:

X	Y	Z	S	C	B
7.14	.00	.44	8.8	.113E+03	.44

MAC5-4N.CX1

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
6.70	.00	.00	8.8	.113E+03	.00	.00	.00	.00
6.83	.00	.00	8.8	.113E+03	.64	.32	.64	.00
6.96	.00	.00	8.8	.113E+03	.76	.45	.76	.00
7.10	.00	.00	8.8	.113E+03	.83	.56	.83	.00
7.23	.00	.00	9.1	.110E+03	.89	.64	.89	.00
7.36	.00	.00	10.2	.979E+02	.93	.72	.93	.00
7.49	.00	.00	11.8	.849E+02	.96	.79	.96	.00
7.63	.00	.00	13.2	.758E+02	.99	.85	.99	.00
7.76	.00	.00	14.2	.706E+02	1.00	.91	1.00	.00
7.89	.00	.00	14.7	.680E+02	1.01	.96	1.01	.00
8.02	.00	.00	15.0	.665E+02	1.02	1.02	1.02	.00

Cumulative travel time = 9. sec

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

** End of NEAR-FIELD REGION (NFR) **

BEGIN MOD141: BUOYANT AMBIENT SPREADING

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
8.02	.00	.00	15.0	.665E+02	1.02	1.02	1.02	.00
9.56	.00	.00	16.1	.621E+02	.85	1.30	.85	.00
11.09	.00	.00	17.0	.589E+02	.75	1.56	.75	.00
12.62	.00	.00	17.8	.563E+02	.68	1.80	.68	.00
14.15	.00	.00	18.5	.539E+02	.63	2.02	.63	.00
15.68	.00	.00	19.3	.518E+02	.60	2.23	.60	.00
17.22	.00	.00	20.1	.498E+02	.57	2.43	.57	.00
18.75	.00	.00	20.9	.479E+02	.55	2.62	.55	.00
20.28	.00	.00	21.7	.460E+02	.53	2.81	.53	.00

21.81	.00	.00	22.6	.442E+02	.52	2.99	.52	.00
23.35	.00	.00	23.6	.424E+02	.51	3.16	.51	.00
24.88	.00	.00	24.6	.407E+02	.51	3.33	.51	.00
26.41	.00	.00	25.7	.390E+02	.50	3.50	.50	.00
27.94	.00	.00	26.8	.373E+02	.50	3.66	.50	.00
29.47	.00	.00	28.0	.357E+02	.50	3.82	.50	.00
31.01	.00	.00	29.3	.342E+02	.51	3.97	.51	.00
32.54	.00	.00	30.6	.326E+02	.51	4.12	.51	.00
34.07	.00	.00	32.1	.312E+02	.52	4.27	.52	.00
35.60	.00	.00	33.6	.298E+02	.52	4.42	.52	.00
37.13	.00	.00	35.2	.284E+02	.53	4.57	.53	.00
38.67	.00	.00	36.9	.271E+02	.54	4.71	.54	.00
40.20	.00	.00	38.6	.259E+02	.55	4.85	.55	.00
41.73	.00	.00	40.5	.247E+02	.56	4.99	.56	.00
43.26	.00	.00	42.4	.236E+02	.57	5.12	.57	.00
44.80	.00	.00	44.5	.225E+02	.58	5.26	.58	.00
46.33	.00	.00	46.6	.214E+02	.59	5.39	.59	.00
47.86	.00	.00	48.9	.205E+02	.61	5.52	.61	.00
49.39	.00	.00	51.2	.195E+02	.62	5.65	.62	.00
50.92	.00	.00	53.6	.186E+02	.64	5.78	.64	.00
52.46	.00	.00	56.2	.178E+02	.65	5.90	.65	.00
53.99	.00	.00	58.8	.170E+02	.67	6.03	.67	.00
55.52	.00	.00	61.5	.163E+02	.69	6.15	.69	.00
57.05	.00	.00	64.4	.155E+02	.71	6.28	.71	.00
58.58	.00	.00	67.3	.149E+02	.72	6.40	.72	.00
60.12	.00	.00	70.4	.142E+02	.74	6.52	.74	.00
61.65	.00	.00	73.5	.136E+02	.76	6.64	.76	.00
63.18	.00	.00	76.8	.130E+02	.78	6.75	.78	.00
64.71	.00	.00	80.2	.125E+02	.80	6.87	.80	.00
66.24	.00	.00	83.6	.120E+02	.82	6.99	.82	.00
67.78	.00	.00	87.2	.115E+02	.84	7.10	.84	.00
69.31	.00	.00	91.0	.110E+02	.87	7.22	.87	.00
70.84	.00	.00	94.8	.105E+02	.89	7.33	.89	.00
72.37	.00	.00	98.7	.101E+02	.91	7.44	.91	.00
73.91	.00	.00	102.8	.973E+01	.94	7.56	.94	.00
75.44	.00	.00	107.0	.935E+01	.96	7.67	.96	.00
76.97	.00	.00	111.3	.899E+01	.98	7.78	.98	.00
78.50	.00	.00	115.7	.865E+01	1.01	7.89	1.01	.00
80.03	.00	.00	120.2	.832E+01	1.03	7.99	1.03	.00
81.57	.00	.00	124.9	.801E+01	1.06	8.10	1.06	.00
83.10	.00	.00	129.6	.771E+01	1.09	8.21	1.09	.00
84.63	.00	.00	134.5	.743E+01	1.11	8.32	1.11	.00

Cumulative travel time = 225. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

MAC5-4N.CX1

Vertical diffusivity (initial value) = .117E-01 m^2/s
Horizontal diffusivity (initial value) = .293E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
84.63	.00	.00	134.5	.743E+01	1.11	8.32	1.11	.00
102.94	.00	.00	176.6	.566E+01	1.41	8.60	1.41	.00

Plume interacts with SURFACE.
The passive diffusion plume becomes VERTICALLY FULLY MIXED within this prediction interval.

121.24	.00	.00	212.0	.472E+01	1.64	8.87	1.64	.00
139.55	.00	.00	218.3	.458E+01	1.64	9.13	1.64	.00
157.86	.00	.00	224.5	.445E+01	1.64	9.39	1.64	.00
176.17	.00	.00	230.5	.434E+01	1.64	9.64	1.64	.00
194.47	.00	.00	236.3	.423E+01	1.64	9.89	1.64	.00
212.78	.00	.00	242.0	.413E+01	1.64	10.12	1.64	.00
231.09	.00	.00	247.5	.404E+01	1.64	10.36	1.64	.00
249.40	.00	.00	253.0	.395E+01	1.64	10.58	1.64	.00
267.70	.00	.00	258.3	.387E+01	1.64	10.81	1.64	.00
286.01	.00	.00	263.5	.380E+01	1.64	11.02	1.64	.00
304.32	.00	.00	268.6	.372E+01	1.64	11.24	1.64	.00
322.63	.00	.00	273.6	.365E+01	1.64	11.45	1.64	.00
340.93	.00	.00	278.6	.359E+01	1.64	11.65	1.64	.00
359.24	.00	.00	283.4	.353E+01	1.64	11.86	1.64	.00
377.55	.00	.00	288.2	.347E+01	1.64	12.06	1.64	.00
395.86	.00	.00	292.8	.341E+01	1.64	12.25	1.64	.00
414.16	.00	.00	297.5	.336E+01	1.64	12.44	1.64	.00
432.47	.00	.00	302.0	.331E+01	1.64	12.63	1.64	.00
450.78	.00	.00	306.5	.326E+01	1.64	12.82	1.64	.00
469.09	.00	.00	310.9	.322E+01	1.64	13.01	1.64	.00
487.39	.00	.00	315.2	.317E+01	1.64	13.19	1.64	.00
505.70	.00	.00	319.5	.313E+01	1.64	13.37	1.64	.00
524.01	.00	.00	323.7	.309E+01	1.64	13.54	1.64	.00
542.32	.00	.00	327.9	.305E+01	1.64	13.72	1.64	.00
560.62	.00	.00	332.0	.301E+01	1.64	13.89	1.64	.00
578.93	.00	.00	336.1	.298E+01	1.64	14.06	1.64	.00
597.24	.00	.00	340.1	.294E+01	1.64	14.23	1.64	.00

MAC5-4N.CX1

615.54	.00	.00	344.1	.291E+01	1.64	14.40	1.64	.00
633.85	.00	.00	348.0	.287E+01	1.64	14.56	1.64	.00
652.16	.00	.00	351.9	.284E+01	1.64	14.72	1.64	.00
670.47	.00	.00	355.8	.281E+01	1.64	14.88	1.64	.00
688.77	.00	.00	359.6	.278E+01	1.64	15.04	1.64	.00
707.08	.00	.00	363.3	.275E+01	1.64	15.20	1.64	.00
725.39	.00	.00	367.1	.272E+01	1.64	15.36	1.64	.00
743.70	.00	.00	370.7	.270E+01	1.64	15.51	1.64	.00
762.00	.00	.00	374.4	.267E+01	1.64	15.66	1.64	.00
780.31	.00	.00	378.0	.265E+01	1.64	15.82	1.64	.00
798.62	.00	.00	381.6	.262E+01	1.64	15.97	1.64	.00
816.93	.00	.00	385.1	.260E+01	1.64	16.11	1.64	.00
835.23	.00	.00	388.7	.257E+01	1.64	16.26	1.64	.00
853.54	.00	.00	392.1	.255E+01	1.64	16.41	1.64	.00
871.85	.00	.00	395.6	.253E+01	1.64	16.55	1.64	.00
890.16	.00	.00	399.0	.251E+01	1.64	16.69	1.64	.00
908.46	.00	.00	402.4	.248E+01	1.64	16.84	1.64	.00
926.77	.00	.00	405.8	.246E+01	1.64	16.98	1.64	.00
945.08	.00	.00	409.1	.244E+01	1.64	17.12	1.64	.00
963.38	.00	.00	412.4	.242E+01	1.64	17.26	1.64	.00
981.69	.00	.00	415.7	.241E+01	1.64	17.39	1.64	.00
1000.00	.00	.00	419.0	.239E+01	1.64	17.53	1.64	.00

Cumulative travel time = 2810. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

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MAC5-5N.CX1

CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111

CORNELL MIXING ZONE EXPERT SYSTEM

Subsystem CORMIX1: Subsystem version:
Submerged Single Port Discharges CORMIX_v.3.20_____September_1996

CASE DESCRIPTION
Site name/label: Mach^Big^Muddy^River
Design case: Case^5^-^Port^5^Normal^Flow
FILE NAME: cormix\sim\Mac5-5N .cx1
Time of Fortran run: 11/09/16--10:22:52

ENVIRONMENT PARAMETERS (metric units)
Bounded section
BS = 56.85 AS = 93.39 QA = 33.02 ICHREG= 2
HA = 1.64 HD = 1.64
UA = .354 F = .081 USTAR = .3568E-01
UW = 2.000 UWSTAR= .2198E-02
Uniform density environment
STRCND= U RHOAM = 998.4907

DISCHARGE PARAMETERS (metric units)
BANK = LEFT DISTB = 27.42
D0 = .203 A0 = .032 H0 = .15
THETA = 15.00 SIGMA = .00
U0 = 2.866 Q0 = .093 = .9294E-01
RHO0 = 1013.3900 DRHO0 =-.1490E+02 GP0 =-.1463E+00
C0 = .1000E+04 CUNITS= ppm
IPOLL = 1 KS = .0000E+00 KD = .0000E+00

FLUX VARIABLES (metric units)
Q0 = .9294E-01 M0 = .2664E+00 J0 =-.1360E-01 SIGNJ0= -1.0
Associated length scales (meters)
LQ = .18 LM = 3.18 Lm = 1.46 Lb = .31
Lmp = 99999.00 Lbp = 99999.00

NON-DIMENSIONAL PARAMETERS
FR0 = 16.62 R = 8.10

FLOW CLASSIFICATION
1111111111111111111111111111111111111111
1 Flow class (CORMIX1) = NH5 1
1 Applicable layer depth HS = 1.64 1
1111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
C0 = .1000E+04 CUNITS= ppm

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
   ORIGIN is located at the bottom and below the center of the port:
       27.42 m  from the LEFT  bank/shore.
   X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

 COANDA ATTACHMENT immediately following the discharge.

       X        Y        Z        S        C        B
      .00      .00      .00      1.0  .100E+04     .14

END OF MOD101: DISCHARGE MODULE
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Bottom-attached jet motion.

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
            Half wall jet, attached to bottom.
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .00      1.0  .100E+04     .10
     1.39      .00      .00      1.4  .705E+03     .22
     2.77      .00      .00      2.2  .456E+03     .31
     4.17      .00      .00      3.0  .339E+03     .39
     5.56      .00      .00      3.7  .272E+03     .46
     6.96      .00      .00      4.4  .228E+03     .52
     8.35      .00      .00      5.1  .197E+03     .58
     9.75      .00      .00      5.7  .174E+03     .63
    11.14      .00      .00      6.4  .157E+03     .68
    12.54      .00      .00      7.0  .142E+03     .72
    13.92      .00      .00      7.6  .131E+03     .77
    15.33      .00      .00      8.2  .121E+03     .81
    16.71      .00      .00      8.8  .113E+03     .84
    18.11      .00      .00      9.4  .106E+03     .88
    19.50      .00      .00     10.0  .100E+03     .91
```

20.90	.00	.00	10.6	.947E+02	.95
22.29	.00	.00	11.1	.900E+02	.98
23.67	.00	.00	11.7	.858E+02	1.01
25.08	.00	.00	12.2	.820E+02	1.03
26.46	.00	.00	12.7	.785E+02	1.06
27.86	.00	.00	13.3	.754E+02	1.09
29.25	.00	.00	13.8	.726E+02	1.11
30.65	.00	.00	14.3	.700E+02	1.14
32.04	.00	.00	14.8	.676E+02	1.16
33.44	.00	.00	15.3	.654E+02	1.19
34.83	.00	.00	15.8	.634E+02	1.21
36.23	.00	.00	16.3	.615E+02	1.23
37.61	.00	.00	16.7	.597E+02	1.25
39.01	.00	.00	17.2	.580E+02	1.27
40.40	.00	.00	17.7	.565E+02	1.29
41.80	.00	.00	18.2	.550E+02	1.31
43.19	.00	.00	18.6	.537E+02	1.33
44.59	.00	.00	19.1	.524E+02	1.35
45.98	.00	.00	19.5	.512E+02	1.37
47.36	.00	.00	20.0	.500E+02	1.39
48.76	.00	.00	20.4	.489E+02	1.41
50.15	.00	.00	20.9	.479E+02	1.43
51.55	.00	.00	21.3	.469E+02	1.44
52.94	.00	.00	21.8	.460E+02	1.46
54.34	.00	.00	22.2	.451E+02	1.48
55.73	.00	.00	22.6	.442E+02	1.49
57.13	.00	.00	23.1	.434E+02	1.51
58.51	.00	.00	23.5	.426E+02	1.52
59.92	.00	.00	23.9	.418E+02	1.54
61.30	.00	.00	24.3	.411E+02	1.56
62.70	.00	.00	24.7	.404E+02	1.57
64.09	.00	.00	25.1	.398E+02	1.59
65.49	.00	.00	25.6	.391E+02	1.60
66.88	.00	.00	26.0	.385E+02	1.61
68.28	.00	.00	26.4	.379E+02	1.63
69.67	.00	.00	26.8	.374E+02	1.64

Cumulative travel time = 111. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
69.67	.00	.00	26.8	.374E+02	1.64

Profile definitions:

MAC5-5N.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
68.02	.00	.00	26.8	.374E+02	.00	.00	.00	.00
68.35	.00	.00	26.8	.374E+02	1.64	.29	1.64	.00
68.68	.00	.00	26.8	.374E+02	1.64	.42	1.64	.00
69.01	.00	.00	26.8	.374E+02	1.64	.51	1.64	.00
69.34	.00	.00	26.8	.374E+02	1.64	.59	1.64	.00
69.67	.00	.00	26.8	.374E+02	1.64	.66	1.64	.00
69.99	.00	.00	28.3	.353E+02	1.64	.72	1.64	.00
70.32	.00	.00	31.8	.314E+02	1.64	.78	1.64	.00
70.65	.00	.00	34.9	.286E+02	1.64	.83	1.64	.00
70.98	.00	.00	36.6	.273E+02	1.64	.88	1.64	.00
71.31	.00	.00	37.5	.267E+02	1.64	.93	1.64	.00

Cumulative travel time = 117. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.22 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC5-5N.CX1

Profile definitions:
  BV = top-hat thickness, measured vertically
  BH = top-hat half-width, measured horizontally in Y-direction
  ZU = upper plume boundary (Z-coordinate)
  ZL = lower plume boundary (Z-coordinate)
  S = hydrodynamic average (bulk) dilution
  C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
71.31	.00	.00	37.5	.267E+02	1.64	2.99	1.64	.00
73.39	.00	.00	38.7	.258E+02	1.53	3.31	1.53	.00
75.47	.00	.00	39.9	.251E+02	1.44	3.62	1.44	.00
77.55	.00	.00	41.0	.244E+02	1.37	3.92	1.37	.00
79.62	.00	.00	42.1	.237E+02	1.31	4.20	1.31	.00
81.70	.00	.00	43.3	.231E+02	1.27	4.48	1.27	.00
83.78	.00	.00	44.4	.225E+02	1.23	4.74	1.23	.00
85.86	.00	.00	45.6	.219E+02	1.19	5.00	1.19	.00
87.94	.00	.00	46.8	.214E+02	1.17	5.26	1.17	.00
90.02	.00	.00	48.1	.208E+02	1.14	5.50	1.14	.00
92.10	.00	.00	49.4	.203E+02	1.13	5.74	1.13	.00
94.18	.00	.00	50.7	.197E+02	1.11	5.98	1.11	.00
96.25	.00	.00	52.1	.192E+02	1.10	6.21	1.10	.00
98.33	.00	.00	53.6	.187E+02	1.09	6.44	1.09	.00
100.41	.00	.00	55.1	.182E+02	1.08	6.66	1.08	.00
102.49	.00	.00	56.6	.177E+02	1.08	6.88	1.08	.00
104.57	.00	.00	58.3	.172E+02	1.08	7.10	1.08	.00
106.65	.00	.00	60.0	.167E+02	1.07	7.31	1.07	.00
108.73	.00	.00	61.8	.162E+02	1.08	7.53	1.08	.00
110.81	.00	.00	63.6	.157E+02	1.08	7.73	1.08	.00
112.89	.00	.00	65.5	.153E+02	1.08	7.94	1.08	.00
114.96	.00	.00	67.5	.148E+02	1.09	8.14	1.09	.00
117.04	.00	.00	69.6	.144E+02	1.09	8.34	1.09	.00
119.12	.00	.00	71.8	.139E+02	1.10	8.54	1.10	.00
121.20	.00	.00	74.0	.135E+02	1.11	8.73	1.11	.00
123.28	.00	.00	76.3	.131E+02	1.12	8.92	1.12	.00
125.36	.00	.00	78.7	.127E+02	1.13	9.11	1.13	.00
127.44	.00	.00	81.2	.123E+02	1.14	9.30	1.14	.00
129.52	.00	.00	83.7	.119E+02	1.16	9.49	1.16	.00
131.59	.00	.00	86.4	.116E+02	1.17	9.67	1.17	.00
133.67	.00	.00	89.1	.112E+02	1.18	9.86	1.18	.00
135.75	.00	.00	92.0	.109E+02	1.20	10.04	1.20	.00
137.83	.00	.00	94.9	.105E+02	1.22	10.22	1.22	.00
139.91	.00	.00	97.9	.102E+02	1.23	10.40	1.23	.00
141.99	.00	.00	101.0	.990E+01	1.25	10.57	1.25	.00
144.07	.00	.00	104.2	.960E+01	1.27	10.75	1.27	.00
146.15	.00	.00	107.5	.930E+01	1.29	10.92	1.29	.00

148.23	.00	.00	110.9	.902E+01	1.31	11.10	1.31	.00
150.30	.00	.00	114.3	.875E+01	1.33	11.27	1.33	.00
152.38	.00	.00	117.9	.848E+01	1.35	11.44	1.35	.00
154.46	.00	.00	121.6	.822E+01	1.37	11.61	1.37	.00
156.54	.00	.00	125.4	.798E+01	1.40	11.77	1.40	.00
158.62	.00	.00	129.3	.774E+01	1.42	11.94	1.42	.00
160.70	.00	.00	133.2	.751E+01	1.44	12.10	1.44	.00
162.78	.00	.00	137.3	.728E+01	1.47	12.27	1.47	.00
164.86	.00	.00	141.5	.707E+01	1.49	12.43	1.49	.00
166.93	.00	.00	145.8	.686E+01	1.52	12.59	1.52	.00
169.01	.00	.00	150.2	.666E+01	1.54	12.75	1.54	.00
171.09	.00	.00	154.7	.647E+01	1.57	12.91	1.57	.00
173.17	.00	.00	159.3	.628E+01	1.60	13.07	1.60	.00
175.25	.00	.00	164.0	.610E+01	1.62	13.23	1.62	.00

Cumulative travel time = 410. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .117E-01 m^2/s
Horizontal diffusivity (initial value) = .293E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
175.25	.00	.00	164.0	.610E+01	1.62	13.23	1.62	.00
191.74	.00	.00	167.9	.596E+01	1.64	13.39	1.64	.00
208.24	.00	.00	169.9	.589E+01	1.64	13.55	1.64	.00
224.73	.00	.00	171.8	.582E+01	1.64	13.71	1.64	.00
241.23	.00	.00	173.8	.575E+01	1.64	13.86	1.64	.00
257.72	.00	.00	175.7	.569E+01	1.64	14.02	1.64	.00
274.22	.00	.00	177.6	.563E+01	1.64	14.17	1.64	.00
290.71	.00	.00	179.5	.557E+01	1.64	14.32	1.64	.00
307.21	.00	.00	181.4	.551E+01	1.64	14.47	1.64	.00
323.70	.00	.00	183.2	.546E+01	1.64	14.62	1.64	.00
340.20	.00	.00	185.1	.540E+01	1.64	14.76	1.64	.00
356.69	.00	.00	186.9	.535E+01	1.64	14.91	1.64	.00

373.19	.00	.00	188.7	.530E+01	1.64	15.05	1.64	.00
389.68	.00	.00	190.4	.525E+01	1.64	15.19	1.64	.00
406.18	.00	.00	192.2	.520E+01	1.64	15.33	1.64	.00
422.67	.00	.00	193.9	.516E+01	1.64	15.47	1.64	.00
439.17	.00	.00	195.7	.511E+01	1.64	15.61	1.64	.00
455.66	.00	.00	197.4	.507E+01	1.64	15.74	1.64	.00
472.16	.00	.00	199.1	.502E+01	1.64	15.88	1.64	.00
488.65	.00	.00	200.8	.498E+01	1.64	16.01	1.64	.00
505.15	.00	.00	202.4	.494E+01	1.64	16.15	1.64	.00
521.64	.00	.00	204.1	.490E+01	1.64	16.28	1.64	.00
538.14	.00	.00	205.7	.486E+01	1.64	16.41	1.64	.00
554.63	.00	.00	207.4	.482E+01	1.64	16.54	1.64	.00
571.13	.00	.00	209.0	.479E+01	1.64	16.67	1.64	.00
587.62	.00	.00	210.6	.475E+01	1.64	16.80	1.64	.00
604.12	.00	.00	212.2	.471E+01	1.64	16.93	1.64	.00
620.61	.00	.00	213.8	.468E+01	1.64	17.05	1.64	.00
637.11	.00	.00	215.3	.464E+01	1.64	17.18	1.64	.00
653.60	.00	.00	216.9	.461E+01	1.64	17.30	1.64	.00
670.10	.00	.00	218.4	.458E+01	1.64	17.42	1.64	.00
686.59	.00	.00	220.0	.455E+01	1.64	17.55	1.64	.00
703.09	.00	.00	221.5	.451E+01	1.64	17.67	1.64	.00
719.58	.00	.00	223.0	.448E+01	1.64	17.79	1.64	.00
736.08	.00	.00	224.5	.445E+01	1.64	17.91	1.64	.00
752.57	.00	.00	226.0	.442E+01	1.64	18.03	1.64	.00
769.07	.00	.00	227.5	.440E+01	1.64	18.15	1.64	.00
785.56	.00	.00	229.0	.437E+01	1.64	18.26	1.64	.00
802.06	.00	.00	230.4	.434E+01	1.64	18.38	1.64	.00
818.55	.00	.00	231.9	.431E+01	1.64	18.50	1.64	.00
835.05	.00	.00	233.3	.429E+01	1.64	18.61	1.64	.00
851.54	.00	.00	234.8	.426E+01	1.64	18.73	1.64	.00
868.04	.00	.00	236.2	.423E+01	1.64	18.84	1.64	.00
884.53	.00	.00	237.6	.421E+01	1.64	18.96	1.64	.00
901.03	.00	.00	239.0	.418E+01	1.64	19.07	1.64	.00
917.52	.00	.00	240.4	.416E+01	1.64	19.18	1.64	.00
934.02	.00	.00	241.8	.413E+01	1.64	19.29	1.64	.00
950.51	.00	.00	243.2	.411E+01	1.64	19.40	1.64	.00
967.01	.00	.00	244.6	.409E+01	1.64	19.51	1.64	.00
983.50	.00	.00	246.0	.407E+01	1.64	19.62	1.64	.00
1000.00	.00	.00	247.4	.404E+01	1.64	19.73	1.64	.00

Cumulative travel time = 2736. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

MAC5-5N.CX1

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MAC5-5X.CX1

CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
CORNELL MIXING ZONE EXPERT SYSTEM
Subsystem CORMIX1: Subsystem version:
Submerged Single Port Discharges CORMIX_v.3.20_____September_1996

CASE DESCRIPTION
Site name/label: Mach^Big^Muddy^River
Design case: Case^5^-^Port^5^Maximum^Flow
FILE NAME: cormix\sim\Mac5-5X .cx1
Time of Fortran run: 11/09/16--10:26:14

ENVIRONMENT PARAMETERS (metric units)
Bounded section
BS = 113.20 AS = 186.91 QA = 51.27 ICHREG= 2
HA = 1.65 HD = 1.65
UA = .274 F = .081 USTAR = .2766E-01
UW = 2.000 UWSTAR= .2198E-02
Uniform density environment
STRCND= U RHOAM = 998.4907

DISCHARGE PARAMETERS (metric units)
BANK = LEFT DISTB = 55.60
D0 = .203 A0 = .032 H0 = .15
THETA = 15.00 SIGMA = .00
U0 = 5.487 Q0 = .178 = .1779E+00
RHO0 = 1013.3900 DRHO0 =-.1490E+02 GP0 =-.1463E+00
C0 = .1000E+04 CUNITS= ppm
IPOLL = 1 KS = .0000E+00 KD = .0000E+00

FLUX VARIABLES (metric units)
Q0 = .1779E+00 M0 = .9762E+00 J0 =-.2604E-01 SIGNJ0= -1.0
Associated length scales (meters)
LQ = .18 LM = 6.09 Lm = 3.60 Lb = 1.26
Lmp = 99999.00 Lbp = 99999.00

NON-DIMENSIONAL PARAMETERS
FR0 = 31.81 R = 20.00

FLOW CLASSIFICATION
1111111111111111111111111111111111111111
1 Flow class (CORMIX1) = . NH5 1
1 Applicable layer depth HS = 1.65 1
1111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
C0 = .1000E+04 CUNITS= ppm

```
 NTOX   =  0
 NSTD   =  0
 REGMZ  =  0
 XINT   =   1000.00  XMAX   =   1000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
        55.60 m  from the LEFT  bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 50 display intervals per module
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

 COANDA ATTACHMENT immediately following the discharge.

       X        Y        Z        S        C        B
      .00      .00      .00     1.0  .100E+04     .14

END OF MOD101: DISCHARGE MODULE
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Bottom-attached jet motion.

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
            Half wall jet, attached to bottom.
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)

       X        Y        Z        S        C        B
      .00      .00      .00     1.0  .100E+04     .10
      .54      .00      .00     1.0  .100E+04     .16
     1.09      .00      .00     1.3  .781E+03     .21
     1.65      .00      .00     1.6  .615E+03     .26
     2.20      .00      .00     2.0  .511E+03     .31
     2.74      .00      .00     2.3  .437E+03     .36
     3.30      .00      .00     2.6  .380E+03     .40
     3.85      .00      .00     3.0  .338E+03     .45
     4.41      .00      .00     3.3  .304E+03     .49
     4.95      .00      .00     3.6  .276E+03     .53
     5.50      .00      .00     3.9  .254E+03     .57
     6.06      .00      .00     4.3  .234E+03     .61
     6.60      .00      .00     4.6  .218E+03     .65
     7.17      .00      .00     4.9  .203E+03     .69
     7.71      .00      .00     5.2  .191E+03     .72
```

8.26	.00	.00	5.6	.180E+03	.76
8.82	.00	.00	5.9	.170E+03	.79
9.36	.00	.00	6.2	.162E+03	.83
9.92	.00	.00	6.5	.154E+03	.86
10.47	.00	.00	6.8	.147E+03	.89
11.01	.00	.00	7.1	.141E+03	.92
11.57	.00	.00	7.4	.135E+03	.95
12.12	.00	.00	7.7	.129E+03	.98
12.66	.00	.00	8.0	.124E+03	1.01
13.23	.00	.00	8.3	.120E+03	1.04
13.77	.00	.00	8.6	.116E+03	1.07
14.33	.00	.00	8.9	.112E+03	1.10
14.88	.00	.00	9.2	.108E+03	1.13
15.42	.00	.00	9.5	.105E+03	1.15
15.98	.00	.00	9.8	.102E+03	1.18
16.53	.00	.00	10.1	.988E+02	1.21
17.09	.00	.00	10.4	.959E+02	1.23
17.63	.00	.00	10.7	.934E+02	1.26
18.18	.00	.00	11.0	.909E+02	1.28
18.74	.00	.00	11.3	.886E+02	1.31
19.28	.00	.00	11.6	.864E+02	1.33
19.85	.00	.00	11.9	.843E+02	1.35
20.39	.00	.00	12.1	.823E+02	1.38
20.94	.00	.00	12.4	.805E+02	1.40
21.50	.00	.00	12.7	.786E+02	1.42
22.04	.00	.00	13.0	.770E+02	1.44
22.59	.00	.00	13.3	.754E+02	1.47
23.15	.00	.00	13.6	.738E+02	1.49
23.69	.00	.00	13.8	.723E+02	1.51
24.25	.00	.00	14.1	.709E+02	1.53
24.80	.00	.00	14.4	.695E+02	1.55
25.34	.00	.00	14.7	.682E+02	1.57
25.91	.00	.00	14.9	.670E+02	1.59
26.45	.00	.00	15.2	.658E+02	1.61
27.01	.00	.00	15.5	.646E+02	1.63
27.56	.00	.00	15.7	.635E+02	1.65

Cumulative travel time = 24. sec

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

Control volume inflow:

X	Y	Z	S	C	B
27.56	.00	.00	15.7	.635E+02	1.65

Profile definitions:

MAC5-5X.CX1

BV = layer depth (vertically mixed)
BH = top-hat half-width, in horizontal plane normal to trajectory
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

X	Y	Z	S	C	BV	BH	ZU	ZL
25.91	.00	.00	15.7	.635E+02	.00	.00	.00	.00
26.24	.00	.00	15.7	.635E+02	1.65	.35	1.65	.00
26.57	.00	.00	15.7	.635E+02	1.65	.50	1.65	.00
26.90	.00	.00	15.7	.635E+02	1.65	.61	1.65	.00
27.23	.00	.00	15.7	.635E+02	1.65	.71	1.65	.00
27.56	.00	.00	15.7	.635E+02	1.65	.79	1.65	.00
27.89	.00	.00	16.7	.600E+02	1.65	.87	1.65	.00
28.22	.00	.00	18.7	.534E+02	1.65	.94	1.65	.00
28.55	.00	.00	20.5	.487E+02	1.65	1.00	1.65	.00
28.88	.00	.00	21.5	.464E+02	1.65	1.06	1.65	.00
29.21	.00	.00	22.0	.454E+02	1.65	1.12	1.65	.00

Cumulative travel time = 30. sec

END OF MOD133: LAYER BOUNDARY IMPINGEMENT/FULL VERTICAL MIXING

BEGIN MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

Phase 1: Vertically mixed, Phase 2: Re-stratified

Phase 1: The plume is VERTICALLY FULLY MIXED over the entire layer depth.
This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

Phase 2: The flow has RESTRATIFIED at the beginning of this zone.

This flow region is INSIGNIFICANT in spatial extent and will be by-passed.

END OF MOD153: VERTICALLY MIXED PLUME IN CO-FLOW

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 3.85 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and internal hydraulic JUMPS.
Flow appears highly UNSTEADY and prediction results are UNRELIABLE!

BEGIN MOD141: BUOYANT AMBIENT SPREADING

MAC5-5X.CX1

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
29.21	.00	.00	22.0	.454E+02	1.65	4.31	1.65	.00
33.51	.00	.00	23.4	.427E+02	1.40	5.40	1.40	.00
37.81	.00	.00	24.6	.406E+02	1.24	6.39	1.24	.00
42.12	.00	.00	25.7	.389E+02	1.14	7.31	1.14	.00
46.42	.00	.00	26.7	.374E+02	1.06	8.17	1.06	.00
50.72	.00	.00	27.7	.360E+02	1.00	8.99	1.00	.00
55.03	.00	.00	28.8	.348E+02	.95	9.77	.95	.00
59.33	.00	.00	29.8	.335E+02	.92	10.52	.92	.00
63.63	.00	.00	30.9	.323E+02	.89	11.25	.89	.00
67.94	.00	.00	32.1	.312E+02	.87	11.95	.87	.00
72.24	.00	.00	33.3	.300E+02	.85	12.63	.85	.00
76.54	.00	.00	34.6	.289E+02	.84	13.30	.84	.00
80.84	.00	.00	35.9	.278E+02	.83	13.95	.83	.00
85.15	.00	.00	37.3	.268E+02	.83	14.58	.83	.00
89.45	.00	.00	38.8	.257E+02	.83	15.20	.83	.00
93.75	.00	.00	40.4	.247E+02	.83	15.81	.83	.00
98.06	.00	.00	42.1	.238E+02	.83	16.40	.83	.00
102.36	.00	.00	43.9	.228E+02	.83	16.99	.83	.00
106.66	.00	.00	45.7	.219E+02	.84	17.56	.84	.00
110.97	.00	.00	47.7	.210E+02	.85	18.13	.85	.00
115.27	.00	.00	49.7	.201E+02	.86	18.68	.86	.00
119.57	.00	.00	51.9	.193E+02	.87	19.23	.87	.00
123.87	.00	.00	54.2	.185E+02	.89	19.77	.89	.00
128.18	.00	.00	56.5	.177E+02	.90	20.30	.90	.00
132.48	.00	.00	59.0	.169E+02	.92	20.83	.92	.00
136.78	.00	.00	61.6	.162E+02	.93	21.35	.93	.00
141.09	.00	.00	64.3	.155E+02	.95	21.86	.95	.00
145.39	.00	.00	67.1	.149E+02	.97	22.37	.97	.00
149.69	.00	.00	70.1	.143E+02	.99	22.87	.99	.00
154.00	.00	.00	73.1	.137E+02	1.01	23.37	1.01	.00
158.30	.00	.00	76.3	.131E+02	1.03	23.86	1.03	.00
162.60	.00	.00	79.6	.126E+02	1.06	24.34	1.06	.00
166.90	.00	.00	83.0	.121E+02	1.08	24.83	1.08	.00
171.21	.00	.00	86.5	.116E+02	1.11	25.30	1.11	.00
175.51	.00	.00	90.2	.111E+02	1.13	25.77	1.13	.00
179.81	.00	.00	94.0	.106E+02	1.16	26.24	1.16	.00
184.12	.00	.00	97.9	.102E+02	1.18	26.71	1.18	.00

188.42	.00	.00	101.9	.981E+01	1.21	27.17	1.21	.00
192.72	.00	.00	106.1	.942E+01	1.24	27.62	1.24	.00
197.03	.00	.00	110.4	.906E+01	1.27	28.07	1.27	.00
201.33	.00	.00	114.8	.871E+01	1.30	28.52	1.30	.00
205.63	.00	.00	119.4	.837E+01	1.33	28.97	1.33	.00
209.93	.00	.00	124.1	.806E+01	1.36	29.41	1.36	.00
214.24	.00	.00	129.0	.775E+01	1.40	29.85	1.40	.00
218.54	.00	.00	134.0	.746E+01	1.43	30.28	1.43	.00
222.84	.00	.00	139.1	.719E+01	1.46	30.72	1.46	.00
227.15	.00	.00	144.3	.693E+01	1.50	31.14	1.50	.00
231.45	.00	.00	149.7	.668E+01	1.53	31.57	1.53	.00
235.75	.00	.00	155.3	.644E+01	1.57	31.99	1.57	.00
240.06	.00	.00	161.0	.621E+01	1.61	32.42	1.61	.00
244.36	.00	.00	166.8	.599E+01	1.64	32.83	1.64	.00

Cumulative travel time = 811. sec

END OF MOD141: BUOYANT AMBIENT SPREADING

BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = .914E-02 m^2/s
Horizontal diffusivity (initial value) = .228E-01 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic centerline dilution
C = centerline concentration (includes reaction effects, if any)

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL
244.36	.00	.00	166.8	.599E+01	1.64	32.83	1.64	.00
259.47	.00	.00	168.0	.595E+01	1.65	32.89	1.65	.00
274.58	.00	.00	168.3	.594E+01	1.65	32.95	1.65	.00
289.70	.00	.00	168.7	.593E+01	1.65	33.01	1.65	.00
304.81	.00	.00	169.0	.592E+01	1.65	33.07	1.65	.00
319.92	.00	.00	169.3	.591E+01	1.65	33.13	1.65	.00
335.04	.00	.00	169.6	.590E+01	1.65	33.19	1.65	.00
350.15	.00	.00	169.9	.589E+01	1.65	33.25	1.65	.00
365.26	.00	.00	170.2	.588E+01	1.65	33.31	1.65	.00
380.37	.00	.00	170.5	.587E+01	1.65	33.37	1.65	.00
395.49	.00	.00	170.8	.586E+01	1.65	33.43	1.65	.00
410.60	.00	.00	171.1	.585E+01	1.65	33.49	1.65	.00

425.71	.00	.00	171.4	.584E+01	1.65	33.55	1.65	.00
440.83	.00	.00	171.7	.583E+01	1.65	33.60	1.65	.00
455.94	.00	.00	172.0	.581E+01	1.65	33.66	1.65	.00
471.05	.00	.00	172.3	.580E+01	1.65	33.72	1.65	.00
486.16	.00	.00	172.6	.579E+01	1.65	33.78	1.65	.00
501.28	.00	.00	172.9	.578E+01	1.65	33.84	1.65	.00
516.39	.00	.00	173.2	.577E+01	1.65	33.90	1.65	.00
531.50	.00	.00	173.5	.576E+01	1.65	33.95	1.65	.00
546.61	.00	.00	173.8	.576E+01	1.65	34.01	1.65	.00
561.73	.00	.00	174.1	.575E+01	1.65	34.07	1.65	.00
576.84	.00	.00	174.3	.574E+01	1.65	34.13	1.65	.00
591.95	.00	.00	174.6	.573E+01	1.65	34.19	1.65	.00
607.07	.00	.00	174.9	.572E+01	1.65	34.24	1.65	.00
622.18	.00	.00	175.2	.571E+01	1.65	34.30	1.65	.00
637.29	.00	.00	175.5	.570E+01	1.65	34.36	1.65	.00
652.40	.00	.00	175.8	.569E+01	1.65	34.42	1.65	.00
667.52	.00	.00	176.1	.568E+01	1.65	34.47	1.65	.00
682.63	.00	.00	176.4	.567E+01	1.65	34.53	1.65	.00
697.74	.00	.00	176.7	.566E+01	1.65	34.59	1.65	.00
712.86	.00	.00	177.0	.565E+01	1.65	34.64	1.65	.00
727.97	.00	.00	177.3	.564E+01	1.65	34.70	1.65	.00
743.08	.00	.00	177.6	.563E+01	1.65	34.76	1.65	.00
758.19	.00	.00	177.9	.562E+01	1.65	34.81	1.65	.00
773.31	.00	.00	178.1	.561E+01	1.65	34.87	1.65	.00
788.42	.00	.00	178.4	.560E+01	1.65	34.93	1.65	.00
803.53	.00	.00	178.7	.560E+01	1.65	34.98	1.65	.00
818.65	.00	.00	179.0	.559E+01	1.65	35.04	1.65	.00
833.76	.00	.00	179.3	.558E+01	1.65	35.10	1.65	.00
848.87	.00	.00	179.6	.557E+01	1.65	35.15	1.65	.00
863.98	.00	.00	179.9	.556E+01	1.65	35.21	1.65	.00
879.10	.00	.00	180.2	.555E+01	1.65	35.26	1.65	.00
894.21	.00	.00	180.4	.554E+01	1.65	35.32	1.65	.00
909.32	.00	.00	180.7	.553E+01	1.65	35.38	1.65	.00
924.44	.00	.00	181.0	.552E+01	1.65	35.43	1.65	.00
939.55	.00	.00	181.3	.552E+01	1.65	35.49	1.65	.00
954.66	.00	.00	181.6	.551E+01	1.65	35.54	1.65	.00
969.77	.00	.00	181.9	.550E+01	1.65	35.60	1.65	.00
984.89	.00	.00	182.1	.549E+01	1.65	35.65	1.65	.00
1000.00	.00	.00	182.4	.548E+01	1.65	35.71	1.65	.00

Cumulative travel time = 3556. sec

Simulation limit based on maximum specified distance = 1000.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

CORMIX1: Submerged Single Port Discharges End of Prediction File

MAC5-5X.CX1

1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111

Run		3.3 : 1	½ width B	34 : 1	½ width BH
Mac 1 - 1N	✓	1.97	.14	23.64	1.34
Mac 1 - 1X	✓	1.68	.17	37.34	2.32
Mac 2 - 1N	✓	1.41	.09	11.15	.89
Mac 2 - 1X	✓	2.11	.22	26.84	1.01
Mac 3 - 1N		1.33	.10	14.29	1.52
Mac 3 - 1X	✓	1.97	.21	26.63	1.01
Mac 3 - 3N	✓	3.41	.28	44.27	1.04
Mac 3 - 3X	✓	2.82	.29	35.43	1.34
Mac 4 - 1N		1.33	.10	14.6	1.54
Mac 4 - 1X		1.24	.13	12.24	1.01
Mac 4 - 3N	✓	3.30	.27	44.64	1.05
Mac 4 - 3X	✓	2.85	.28	34.48	1.35
Mac 4 - 4N	✓	4.22	.36	53.57	.69
Mac 4 - 4X	✓	3.48	.36	44.67	~~1.69~~ .89
Mac 5 - 1N		1.36	.10	14.4 ~~26.91~~	1.32 ~~1.07~~
Mac 5 - 1X	✓	2.98	.28	26.91	1.04
Mac 5 - 3N		1.61	.15	20.16	2.25
Mac 5 - 3X	✓	3.10	.31	35.33	1.37
Mac 5 - 4N		2.45	.23	37.13	4.57
Mac 5 - 4Y					
Mac 5 - 5N	✓	5.56	.46	70.65	.83
Mac 5 - 5X	✓	4.41	.49	76.54	13.3

Run		3.3:1 ½ width B	34:1 ½ width B H
Mac 1-1N	✓	1.97	.14	23.64	1.34
Mac 1-1X	✓	1.68	.17	37.34	2.32
Mac 2-1N	✓	1.41	.09	11.5	.89
Mac 2-1X	✓	2.11	.22	26.84	1.01
Mac 3-1N		1.33	.10	14.29	1.52
Mac 3-1X	✓	1.97	.21	26.63	1.01
Mac 3-3N	✓	3.41	.28	44.27	1.04
Mac 3-3X	✓	2.82	.29	35.43	1.34
Mac 4-1N		1.33	.10	14.6	1.54
Mac 4-1X		1.24	.13	12.24	1.01
Mac 4-3N	✓	3.30	.27	44.64	1.05
Mac 4-3X	✓	2.85	.28	34.48	1.25
Mac 4-4N	✓	4.22	.36	53.57	.69
Mac 4-4X	✓	3.48	.36	44.67	~~1.54~~ .89
Mac 5-1N		1.36	.10	14.4 ~~26.91~~	1.32 ~~1.07~~
Mac 5-1X	✓	2.98	.28	26.91	1.04
Mac 5-3N		1.61	.15	20.16	2.25
Mac 5-3X	✓	3.10	.31	35.33	1.37
Mac 5-4N		2.45	.23	37.13	4.57
Mac 5-4X					
Mac 5-5N	✓	5.56	.46	70.65	.83
Mac 5-5X	✓	4.41	.49	76.54	13.3

DOCUMENT

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ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
MINE RELATED WATER POLLUTION CONTROL PERMIT

PERMIT NO.: 2014-MW-4275

DATE ISSUED: October 2, 2014

FINAL PLANS, SPECIFICATIONS, APPLICATION AND SUPPORTING DOCUMENTS

EXPIRATION DATE: September 30, 2019

PREPARED BY: Stephen M. Sutphin, P.E./
Claudio E. Yon, P.E.
Alliance Consulting, Inc.

LOG NUMBERS: 4275-14-B

SUBJECT: Williamson Energy, L.L.C. – Pond Creek Mine
Geotextile Tube Refuse Disposal

Williamson Energy, L.L.C.
430 Harper Park Drive
Beckley, WV 25801

Permit is hereby granted to the above designated Permittee to develop and operate the mine refuse disposal area referenced in the above subject heading and described as follows:

A fine coal refuse (slurry) disposal area incorporating the use of geotextile tubes will be developed and operated as described and depicted in IEPA Log No. 4275-14-B. Development of this area will include the construction of a low permeability liner consisting of four (4) foot compacted clay with a hydraulic conductivity of $1x10^{-7}$ cm/sec, or less. With prior Agency approval, a synthetic liner capable of providing an equivalent level of groundwater protection may be utilized in lieu of the four (4) foot compacted clay. A subsurface underdrain system will be installed as depicted to assist in evacuating leachate from the geotextile tubes.

A dredge to be located within the existing embanked fine coal refuse disposal area will pump slurry into the geotextile tubes located as depicted. As the geotextile tubes de-water and the deposited fine coal refuse solidifies, additional geotextile tubes will be placed on top of the initially placed tubes in an offset manner. This process will continue until the current design of three (3) tiers of geotextile tubes have been placed.

(Continued on Page 2)

This permit is issued in accordance with the Illinois Environmental Protection Act of 1970, the Title 35, Subtitle C: Water Pollution and Subtitle D: Mine Related Pollution Regulations adopted pursuant thereto by the Illinois Environmental Protection Act. THE STANDARD CONDITIONS OF ISSUANCE INDICATED ON THE ATTACHMENT TO THIS PERMIT (PAGE 1a) MUST BE COMPLIED WITH IN FULL. READ ALL CONDITIONS CAREFULLY.

Larry D. Crislip

Larry D. Crislip, P.E.
Manager, Permit Section
Mine Pollution Control Program
Bureau of Water

cc: IDNR, Office of Mines and Minerals
IDNR, Division of Water Resources
BOW/MPCP/FOS/Marion ✓

LDC:cs/6823c/10-1-14

Surface runoff and de-watering of the geotextile tubes will be collected in a "no-discharge" perimeter containment basin. Operation and maintenance of the perimeter containment basin is subject to Special Condition No. 2.

Reclamation (abandonment) of the geotextile tube refuse disposal area will consist of construction of a low permeability cap consisting of four (4) foot compacted clay with a hydraulic conductivity of $1x10^{-7}$ cm/sec, or less. With prior Agency approval a synthetic liner capable of providing an equivalent level of protection may be utilized in lieu of the four (4) foot compacted clay. Rooting medium and topsoil required for establishment of vegetative cover shall be in addition to the four (4) foot compacted clay low permeability cap.

Four (4) monitoring wells identified as Well Nos. GW-29, GW-30, GW-31 and GW-32 shall be installed at each corner of the geotextile tube placement area as depicted in IEPA Log No. 4275-14-B. These wells will be completed in the first water bearing zone below the base of the disposal area. Groundwater monitoring shall be performed in accordance with Special Condition No. 3.

This Permit is issued subject to the following Special Conditions. If such Special Conditions require additional or revised facilities, satisfactory engineering plan documents must be submitted to this Agency for review and approval for issuance of a Supplemental Permit.

Special Condition No. 1: This permit is issued with the expressed understanding that there shall be no surface discharge from these facilities. If such discharge occurs, additional or alternate facilities shall be provided. The construction of such additional or alternate facilities may not be started until a Permit for the construction is issued by this Agency.

Special Condition No. 2: The perimeter containment basin surrounding the geotextile tube refuse disposal area shall be subject to the following requirements and limitations:

a. There shall be no discharge from the containment basin due to runoff from any storm event less than or equal to the highest single day rainfall of record (6.9 inches).

b. Pumpage capacity shall be available at all times sufficient to evacuate water collecting in the perimeter containment basins within a 24 hour period. All water pumped from the containment basin shall be directed to the existing embanked refuse disposal area or the coal preparation plant for use in the coal processing circuit.

c. A minimum of 2 feet of freeboard between the accumulated water surface within the containment basin and the basin embankment shall be maintained at all times.

Special Condition No. 3: Groundwater monitoring requirements for Well Nos. GW-29, GW-30, GW-31 and GW-32 are as follows:

a. Ambient background monitoring shall be performed for all referenced wells. Such ambient monitoring shall consist of a minimum of six (6) samples collected on a monthly basis immediately following well installation, but no later than during the first six (6) months of operation or disturbance of the geotextile tube disposal area. Background monitoring shall include the following list of constituents:

Aluminum	Fluoride	Sulfate
Antimony	Iron (dissolved)	Thallium
Arsenic	Iron (total)	Total Dissolved Solids
Barium	Lead	Vanadium
Beryllium	Manganese (dissolved)	Zinc
Boron	Manganese (total)	pH
Cadmium	Mercury	Acidity
Chloride	Molybdenum	Alkalinity
Chromium	Nickel	Hardness
Cobalt	Phenols	Static Water Elevation
Copper	Selenium	
Cyanide	Silver	

b. Following the ambient monitoring as required under Special Condition No. 3(a) above, routine monitoring shall continue on a quarterly basis for all wells identified above and shall include the entire list of constituents identified under Special Condition No. 3(a) above.

c. Following completion of active mining (refuse disposal) and reclamation, post-mining monitoring of all above referenced wells shall consist of six (6) samples collected during a 12-month period (approximately bi-monthly) to determine post-mining concentrations. Post-mining monitoring shall include the list of constituents identified in Special Condition No. 3(a) above.

d. Groundwater monitoring reports shall be submitted to the Agency in accordance with the following:

Mailing Address:

Illinois Environmental Protection Agency
Mine Pollution Control Program
2309 West Main Street, Suite 116
Marion, IL 62959

Should electronic filing be available and elected through IDNR/OMM, the Agency shall be notified via correspondence or e-mail at such time that the electronic filing has been completed.

Completed groundwater monitoring reports shall be filed electronically or mailed and received by the IEPA at the address indicated above in accordance with the following schedule:

Period	Received by IEPA
January, February, March	May 1st
April, May, June	August 1st
July, August, September	November 1st
October, November, December	February 1st

e. A statistically valid representation of background and/or post mining water quality required under Condition No. 3(a) above shall be submitted utilizing the following method. This method shall be used to determine the upper 95 percent confidence limit for each parameter listed above.

Should the Permittee determine that an alternate statistical method would be more appropriate based on the data being evaluated, the Permittee may request utilization of such alternate methodology. Upon approval from the Agency, the alternate methodology may be utilized to determine a statistically valid representation of background and/or post mining water quality.

This method should be used to predict the confidence limit when single groundwater samples are taken from each monitoring (test) well.

i. Determine the arithmetic mean $(\overline{X}_b)$ of each indicator parameter for the sampling period. If more than one well is used, an equal number of samples must be taken from each well.

$$\overline{X}_b = \frac{X_1 + X_2 + \ldots X_n}{n}$$

Where:

$\overline{X}_b$ = Average value for a given chemical parameter

X_n = Values for each sample

n = the number of samples taken

ii. Calculate the background and/or post mining variance (S_b^2) and standard deviation (S_b) for each parameter using the values (X_n) from each sample of the well(s) as follows:

$$S_b^2 = \frac{(X_1 - \overline{X}_b)^2 + (X_2 - \overline{X}_b)^2 + \ldots + (X_n - \overline{X}_b)^2}{n-1}$$

$$S_b = \sqrt{S_b^2}$$

iii. Calculate the upper confidence limit using the following formula:

$$CL = \overline{X}_b \pm t\sqrt{1+1/n}\ \ (S_b)$$

Where:

CL = upper confidence limit prediction
(upper and lower limits should be calculated for pH)
t = one-tailed t value at the required significance
level and at n-1 degrees of freedom from Table 1
(a two-tailed t value should be used for pH)

iv. If the values of any routine parameter for any monitoring well exceed the upper confidence limit for that parameter, the permittee shall conclude that a statistically significant change has occurred at that well.

v. When some of the background and/or post mining values are less than the Method Detection Limit (MDL), a value of one-half (1/2) the MDL shall be substituted for each value that is reported as less than the MDL. All other computations shall be calculated as given above.

If all the background and/or post mining values are less than the MDL for a given parameter, the Practical Quantitation Limit (PQL), as given in 35 Ill. Adm. Code Part 724 Appendix I shall be used to evaluate data from monitoring wells. If the analytical results from any monitoring well exceed two (2) times the PQL for any single parameter, or if they exceed the PQLs for two or more parameters, the permittee shall conclude that a statistically significant change has occurred.

Williamson Energy, L.L.C.
Pond Creek Mine
Permit No. 2014-MW-4275
October 2, 2014

Table 1
Standard t-Tables Level of Significance

Degrees of freedom	t-values (one-tail)		t-values (two-tail)*	
	99%	95%	99%	95%
4	3.747	2.132	4.604	2.776
5	3.365	2.015	4.032	2.571
6	3.143	1.943	3.707	2.447
7	2.998	1.895	3.499	2.365
8	2.896	1.860	3.355	2.306
9	2.821	1.833	3.250	2.262
10	2.764	1.812	3.169	2.228
11	2.718	1.796	3.106	2.201
12	2.681	1.782	3.055	2.179
13	2.650	1.771	3.012	2.160
14	2.624	1.761	2.977	2.145
15	2.602	1.753	2.947	2.131
16	2.583	1.746	2.921	2.120
17	2.567	1.740	2.898	2.110
18	2.552	1.734	2.878	2.101
19	2.539	1.729	2.861	2.093
20	2.528	1.725	2.845	2.086
21	2.518	1.721	2.831	2.080
22	2.508	1.717	2.819	2.074
23	2.500	1.714	2.807	2.069
24	2.492	1.711	2.797	2.064
25	2.485	1.708	2.787	2.060
30	2.457	1.697	2.750	2.042
40	2.423	1.684	2.704	2.021

Adopted from Table III of "Statistical Tables for Biological Agricultural and Medical Research" (1947, R.A. Fisher and F. Yates).

* For pH only when required.

DOCUMENT

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ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Illinois Department of Natural Resources

One Natural Resources Way Springfield, Illinois 62702-1271
www.dnr.illinois.gov

JB Pritzker, Governor
Colleen Callahan, Director

September 26, 2019

Christopher Skelton, Engineer
Williamson Energy, LLC.
P.O. Box 99
Johnston City, IL 62951

RE: Pond Creek Mine, Williamson Energy, Mine Dewatering at Depth
Consultation Program
EcoCAT Review #2001813
Williamson and Franklin Counties

Dear Mr. Skelton:

This letter is in reference to your Illinois Environmental Protection Agency (IEPA), National Pollutant Discharge Elimination System (NPDES) permit application No. IL0077666. The purpose of this letter is to satisfy consultation requirements pursuant to the *Illinois Endangered Species Protection Act* [520 ILCS 10/11], the *Illinois Natural Areas Preservation Act* [525 ILCS 30/17], and Title 17 *Illinois Administrative Code* Part 1075. Additionally, the Department may offer advice and recommendations for species covered under the *Fish & Aquatic Life Code* [515 ILCS 5, *et seq.*]; the *Illinois Wildlife Code* [520 ILCS 5, *et seq.*]; and the *Herptiles-Herps Act* [510 ILCS 69].

This review is specific to the NPDES permit application as the pipeline installation was previously reviewed in EcoCAT projects 1905659, 1905660, and 1905661 under the jurisdiction of the Department's Office of Mines and Minerals. This review does not include necessary permits for the outfall structure(s) from the Department's Office of Water Resources. A separate consultation will be required for those permits.

Per the NPDES permit narrative: *"The applicant proposes additional surface facilities area to an existing underground coal mine (SIC 1222). Mine operations result in the discharge of alkaline and acid mine drainage. Incorporates three (3) new outfalls designated as Outfall Nos. 009, 009ES and 011. Receiving waters are Big Muddy River, Pond Creek, and tributaries to Pond Creek."* The permit states that Pond Creek outfalls 009 and 009ES are permitted to discharge under stormwater conditions and are held to specified permit limits. For outfall 011 to the Big Muddy River, water will be conveyed from the mine to the river via a 12.5-mile pipeline with a maximum flow of 5,000 gpm at Outfall 011. Discharge will only be allowed when the Big Muddy River is flowing above 30 cfs. The permit states the applicant will perform real-time monitoring and flow control to achieve compliance with the water quality standards within the

maximum distance of 251 feet in length and 25 feet wide, otherwise known as the "mixing zone." The mixing zone for copper is more restrictive at 18.2 feet long by 4 feet wide.

EcoCAT has indicated no records in the vicinity of the proposed outfalls for state-listed species or protected natural areas. However, the Department offers the following general information on the aquatic community in the Big Muddy River:

> The Department's routine fish survey efforts indicate 96 species of fish occur in the Big Muddy River. These species include important sportfish and non-game species, as well as 11 species designated in the Illinois Wildlife Action Plan as "Species in Greatest Need of Conservation" *(SGNC)*. The SGNC that occur in the Big Muddy River include the Alligator Gar (*Atractosteus spatula*) Blacktail Shiner (*Cyprinella venusta*), Brown Bullhead (*Ameiurus nebulosus*), Flier (*Centrarchus macropterus*), Mooneye (*Hiodon tergisus*), Paddlefish (*Polyodon spathula*), Pugnose Minnow (*Opsopoeodus emiliae*), Ribbon Shiner (*Lythrurus fumeus*), River Darter (*Percina shumardi*) Spottail Darter (*Etheostoma squamiceps*), and Stripetail Darter (*Etheostoma kennicotti*). The Department also notes that the Lower Big Muddy River is one of several locations in the state where Alligator Gar have been released as part of our "Alligator Gar Reintroduction Program." The Lower Big Muddy River received a stocking of 500 Alligator Gar in the year 2017. Additionally, a survey by the Illinois Natural History survey detected 19 extant species of freshwater mussels in the Big Muddy River with one, the Pistolgrip (*Tritogonia verrucose*) classified as an SGNC (Shasteen *et al.* 2012).

While the fish and freshwater mussel species referenced above are not state-listed and therefore, not protected under the *Illinois Endangered Species Act,* their importance to the aquatic ecosystem and conservation need as a public trust resource are no less significant to the Department. Therefore, strict adherence to all effluent limits and all effluent monitoring requirements in accordance with NPDES Permit IL0077666 is requested.

Consultation on the part of the Department is closed unless Williamson Energy or the IEPA desires additional information or advice related to this proposal. Consultation for Part 1075 is valid for two years unless new information becomes available which was not previously considered; the proposed action is modified; or additional species, essential habitat, or Natural Areas are identified in the vicinity. **If the action has not been implemented within two years of the date of this letter, or any of the above listed conditions develop, a new consultation is necessary.**

This natural resource review reflects the information existing in the Illinois Natural Heritage Database at the time of the project submittal and should not be regarded as a final statement on the project being considered, nor should it be a substitute for detailed site surveys or field surveys required for environmental assessments. If additional protected resources are unexpectedly encountered during the project's implementation, the applicant must comply with the applicable statutes and regulations.

Please contact Mr. Brian Willard of this office at 217-557-0480 or brian.c.willard@illinois.gov for additional information on this review, or if providing a response to this correspondence. Please reference EcoCAT 2001813 in any communication.

Thank you,

Nathan Grider
Manager, Consultation Services
Office of Realty & Capital Planning
Illinois Dept. of Natural Resources
One Natural Resources Way
Springfield, IL 62702-1271
Email: Nathan.Grider@illinois.gov
Phone: 217-785-5500

References

Shasteen, D. K., A. L. Price, S. A. Bales. 2012. Freshwater Mussels of the Big Muddy River. INHS Technical Report 2012(11). Prairie Research Institute, University of Illinois at Urbana Champaign.

cc: IEPA, Division of Water Pollution Control
IDNR, ORC
IDNR, OWR
IDNR, OMM

DOCUMENT

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NPDES Permit No. IL0077666
Notice No. 7516c

Public Notice Beginning Date: **July 12, 2019**

Public Notice Ending Date: **August 12, 2019**

National Pollutant Discharge Elimination System (NPDES)
Permit Program

Draft Renewed NPDES Permit to Discharge into Waters of the State

Public Notice/Fact Sheet Issued By:

IEPA-DIVISION OF RECORDS MANAGEMENT
RELEASABLE

AUG 02 2019

REVIEWER: SAB

Illinois Environmental Protection Agency
Bureau of Water, Division of Water Pollution Control
Permit Section
1021 North Grand Avenue East
Post Office Box 19276
Springfield, Illinois 62794-9276
217/782-0610

Name and Address of Discharger:

Williamson Energy, LLC
P.O. Box 300
Johnston City, Illinois 62951

Name and Address of Facility:

Williamson Energy, LLC
Pond Creek Mine
4 miles east of Johnston City, Illinois
(Williamson and Franklin Counties)

The Illinois Environmental Protection Agency (IEPA or Agency) has made a tentative determination to issue an NPDES permit to discharge into waters of the state and has prepared a draft permit and associated fact sheet for the above named discharger. The Public Notice period will begin and end on the dates indicated in the heading of this Public Notice/Fact Sheet. Comments will be accepted until midnight of the Public Notice period ending date indicated above, unless a request for an extension of the original comment period is granted by the Agency. Interested persons are invited to submit written comments on the draft permit to the IEPA at the above address. Commenters shall provide his or her name, address and the nature of the issues raised and the evidence supporting those issues. Commenters may include a request for public hearing. The NPDES permit and notice number(s) must appear on each comment page.

The application, engineer's review notes, Public Notice/Fact Sheet, draft permit, comments received, and other documents are available for inspection and may be copied at the IEPA between 9:30 a.m. and 3:30 p.m. Monday through Friday when scheduled by the interested person.

As provided in 35 Ill. Adm. Code 309.115(a) any person may submit a request for a public hearing and if such written comments or requests indicate a significant degree of public interest in the draft permit, the permitting authority may, at its discretion, hold a public hearing. The Agency shall issue public notice of such hearing no less than thirty (30) days prior to the date of such hearing in the manner described by 35 Ill. Adm. Code 309.109 through 309.112 for public notice. The Agency's responses to written and/or oral comments will be provided in the Responsiveness Summary provided when the final permit is issued.

The applicant proposes additional surface facilities area to an existing underground coal mine (SIC 1222). Mine operations result in the discharge of alkaline and acid mine drainage.

Public comments are invited on the entire draft permit. The following proposed modifications were incorporated into this Permit renewal:

Incorporated three (3) new outfalls designated as Outfall Nos. 009, 009ES and 011.

Various mining operation and drainage control plan revisions.

229.78 acres incorporated for new Refuse Disposal Area No. 3.

70.7 acres incorporated for the pipeline to the Big Muddy River.

145.32 acres for various IBR's for additional permit area.

Addition of bi-annual metals monitoring of discharges from Outfall Nos. 006, 007, 008,009, 009ES and 011.

Incorporated previously issued State Construction and Operating Permits (Subtitle D Permits).

This facility has eight (8) existing discharges which are located in Williamson County, Illinois. The following information identifies the discharge points and receiving streams:

Outfall	Receiving Stream	Latitude (North)	Longitude (West)
001	Unnamed tributary of Pond Creek	37° 50' 59.2"	88° 49' 37.5"
002	Unnamed tributary of Pond Creek	37° 50' 26.0"	88° 49' 51.5"
003	Unnamed tributary of Pond Creek	37° 50' 26.0"	88° 49' 58.0"
004	Unnamed tributary of Pond Creek	37° 50' 25.0"	88° 49' 56.6"
005	Unnamed tributary of Pond Creek	37° 50' 9.1"	88° 50' 00.0"
006	Unnamed tributary of Pond Creek	37° 50' 28.4"	88° 50' 40.6"
007	Unnamed tributary of Pond Creek	37° 50' 29.5"	88° 49' 34.0"
008	Unnamed tributary of Pond Creek	37° 50' 31.4"	88° 49' 33.9"

The stream segment NG-02 of Pond Creek receiving the flow from the unnamed tributary into which Outfall 001, 002, 003, 004, 005, 006, 007 and 008 discharges is not on the 2016 303(d) list of impaired waters.

Application is made for three (3) new discharges which are located in Williamson and Franklin Counties, Illinois. The following information identifies the discharge points and receiving streams:

Outfall	Receiving Stream	Latitude (North)	Longitude (West)
009	Pond Creek	37° 51' 16.1"	88° 49' 25.5"
009ES	Unnamed tributary to Pond Creek	37° 50' 52.3"	88° 48' 43.7"
011	Big Muddy River	37° 52' 37"	89° 01' 49"

The stream segment NG-02 of Pond Creek receiving the discharge from Outfalls 009 and 009ES is on the 2016 303(d) list of impaired waters.
The following parameters have been identified as the pollutants causing impairment.

Outfall	Pollutant
009, 009ES	Alteration in stream-side or littoral vegetative cover Changes in stream depth and velocity patterns Chlorides Loss of instream cover, dissolved oxygen, Sedimentation/siltation

The stream segment N-11 of Big Muddy River receiving the discharge from Outfall 011 is on the draft 2016 303(d) list of impaired waters. The following parameters have been identified as the pollutants causing impairment.

Outfall	Pollutant
011	Iron, Oxygen, dissolved; Sedimentation/Siltation Total Suspended Solids (TSS) Mercury, Polychlorinated biphenyls Fecal Coliform

The alkaline mine discharge from this facility shall be monitored and limited at all times as follows:

Outfalls: 001, 002, 003, 004, 005

Discharge Condition	Parameters											
	Total Suspended Solids (3) (mg/l)		Iron (total) (3) (4) (mg/l)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/l)	Chloride (mg/l)	Cadmium (Cd) (mg/l) (6)	Hardness (5)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum								
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 5.21 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for alkaline mine discharges are contained in 35 Ill. Adm. Code 406.110.
(3) Effluent standards for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 001, 002, 003, 004 and 005 are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average.
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limit.
(6) The Cadmium water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).

The acid mine discharge from this facility shall be monitored and limited at all times as follows:

Outfalls: 006, 007

Discharge Condition	Parameters												
	Total Suspended Solids (3) (mg/L)		Iron (total) (3) (4) (mg/L)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/L)	Chloride (mg/L)	Cadmium (Cd) (mg/l) (6)	Mn (total) (mg/L)	Hardness (5)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum									
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	1.0	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	1.0	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(b), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 1-year, 24-hours precipitation event, but less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 1-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hours precipitation event for this area is considered to be 5.21 inches.

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for acid mine drainage discharges are contained in 35 Ill. Adm. Code 406.110(b), (c), and (d).
(3) Effluent limitations for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 006 and 007 are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average.
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.
(6) The Cadmium water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).

The acid mine discharge from this facility shall be monitored and limited at all times as follows:

Outfall: 008

Discharge Condition	Parameters											
	Total Suspended Solids (3) (mg/L)		Iron (total) (3) (4) (mg/L)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/L)	Chloride (mg/L)	Mn (total) (mg/L)	Hardness (5)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum								
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	1.0	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	1.0	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(b), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 1-year, 24-hours precipitation event, but less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 1-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hours precipitation event for this area is considered to be 5.21 inches.

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for acid mine drainage discharges are contained in 35 Ill. Adm. Code 406.110(b), (c), and (d).
(3) Effluent limitations for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 008 are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average.
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.

The alkaline mine discharge from this facility shall be monitored and limited at all times as follows:

Outfall: 009

Discharge Condition	Parameters													
	Total Suspended Solids (3) (mg/L)		Iron (total) (3) (4) (mg/L)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/L)	Chloride (mg/L)	Mn (total) (mg/L)		Hardness (5)	Copper (CU) (mg/L)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum				
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	See Special Condition No. 14	-	-	Monitor only	-	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	See Special Condition No. 14	-	-	Monitor only	-	Measure When Sampling	-
IV	35	70	3.0	6.0	6.0-9.0	Alk.>Acid	1250	See Special Condition No. 14	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall at times of "low flow" or "no flow" conditions in the receiving stream as defined in Special Condition No. 14.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. At such time that receiving stream flow subsides to the degree that the mixing ratio specified in Special Condition No. 14 is not available, monitoring requirements and permit limitations shall revert to Discharge Condition I.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for alkaline mine discharges are contained in 35 Ill. Adm. Code 406.110.
(3) Effluent standards for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 009 are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.

The alkaline mine discharge from this facility shall be monitored and limited at all times as follows:

Outfall: 009ES

Discharge Condition	Parameters													
	Total Suspended Solids (3) (mg/L)		Iron (total) (3) (4) (mg/L)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/L)	Chloride (mg/L)	Mn (total) (mg/L)		Hardness (5)	Copper (CU) (mg/L)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum				
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	-	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	-	Measure When Sampling	-
IV	35	70	3.0	6.0	6.0-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for alkaline mine discharges are contained in 35 Ill. Adm. Code 406.110.
(3) Effluent standards for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 009ES are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.

The alkaline mine discharge from this facility shall be monitored and limited at all times as follows:

Outfall: 011

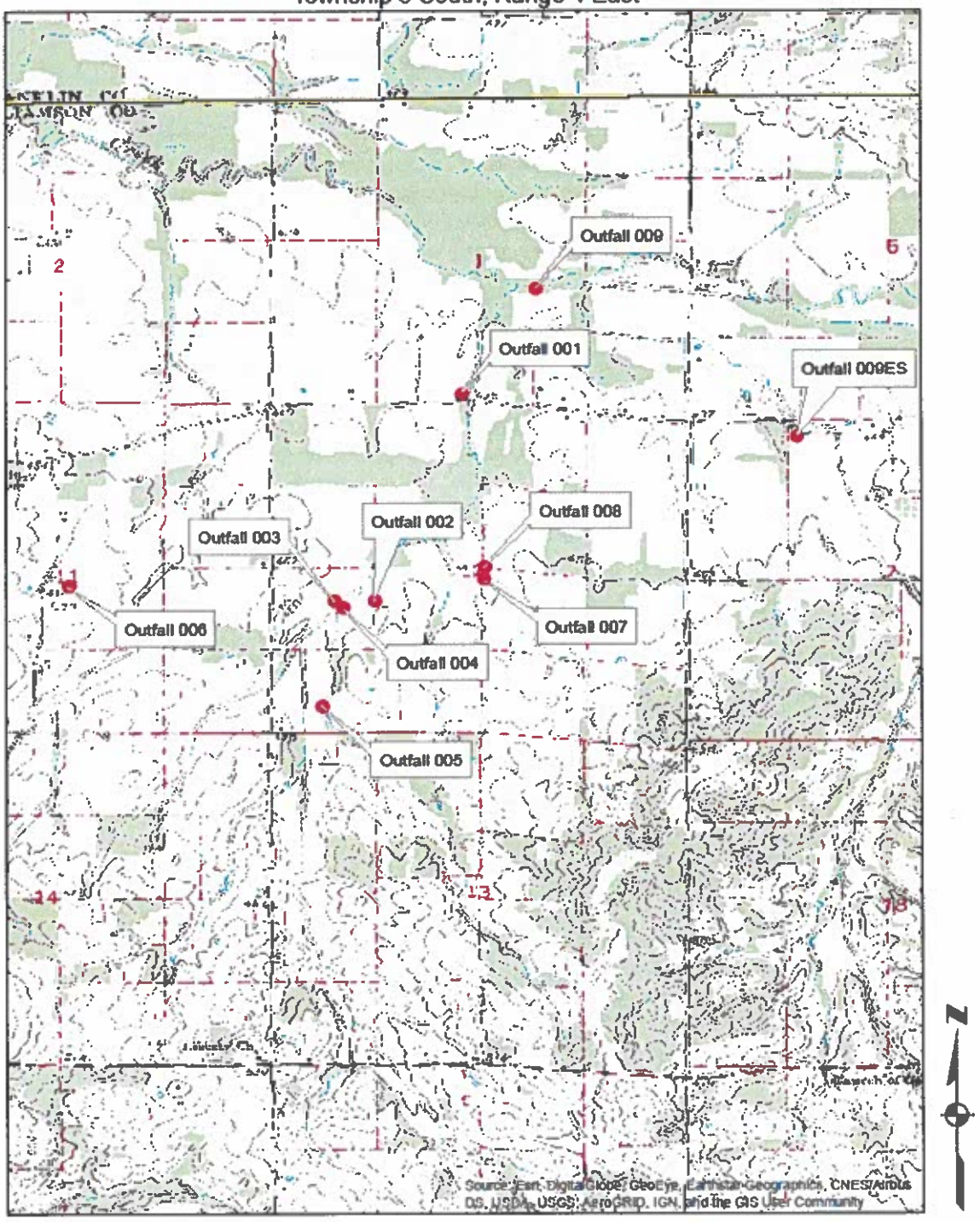
Parameters														
Total Suspended Solids (1) (mg/l)		Iron (total) (2) (mg/l)		pH (3) (S.U.)	Alkalinity/ Acidity (4)	Sulfate (5) (mg/l)	Chloride (mg/l)	Mn (total) (mg/l) (2)		Hardness (6)	Nickel (mg/L)	Copper (mg/L)	Flow (MGD)	Iron (Dissolved)
30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum					
35	70	3.0	6.0	6.0-9.0	Alk.>Acid	See Special Condition No. 16	See Special Condition No. 16	2.0	4.0	Monitor only	See Special Condition No. 16	See Special Condition No. 16	Measure When Sampling	See Special Condition No. 16

For any discharge not meeting the water quality standard for any of the above parameters, such discharge shall be subject to the limitations and monitoring requirements of Special Condition No. 16.

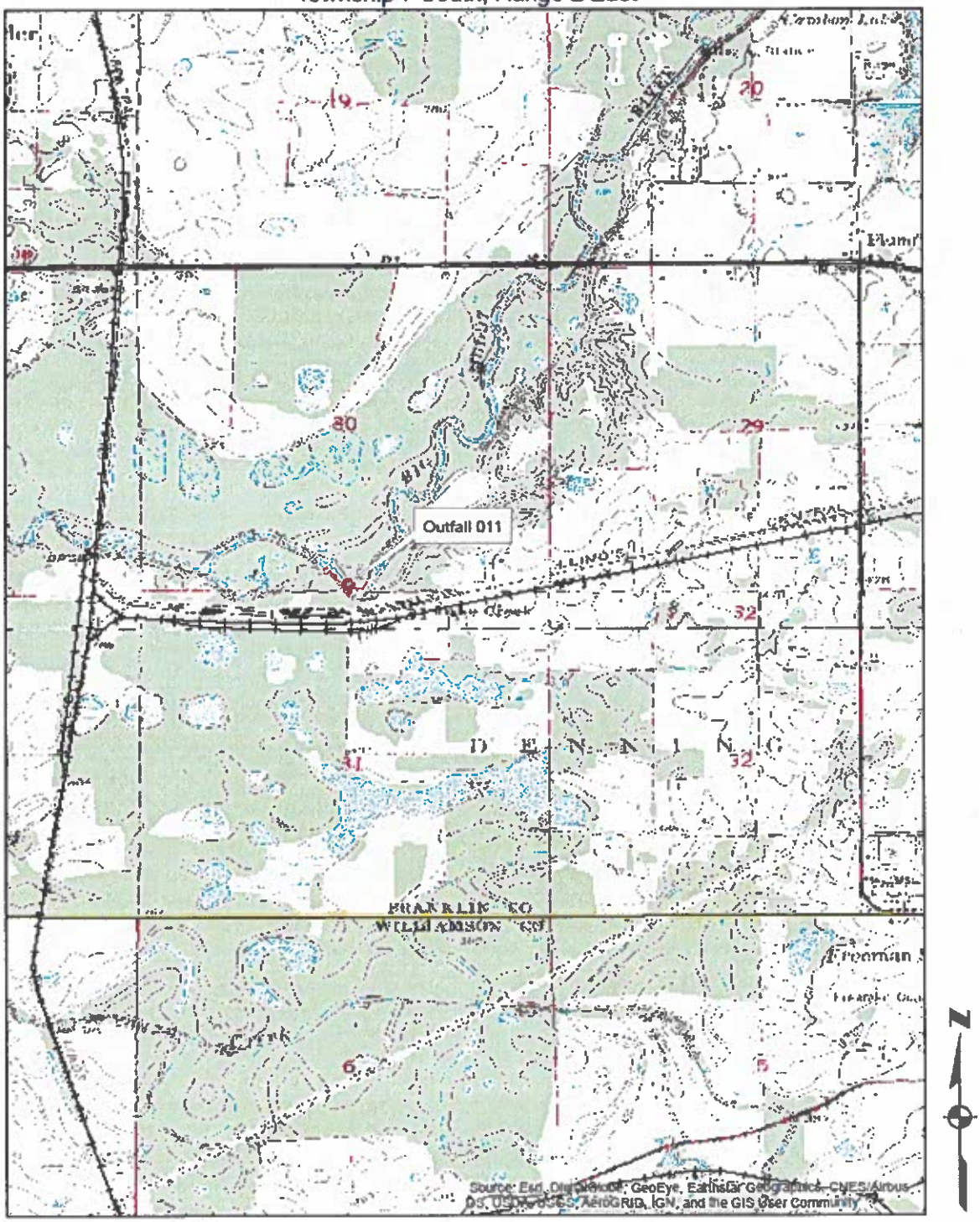
(1) Effluent standards for Total Suspended Solids in mine discharges are established pursuant to 35 Ill. Adm. Code 406.106.
(2) Effluent standards for Iron and Manganese are established pursuant to 35 Ill. Adm. Code 304.124.
(3) Pursuant to 35 Ill. Adm. Code 406.106, pH shall not be less than 6.0 or greater than 9.0 S.U.
(4) Pursuant to 35 Ill. Adm. Code 406.106, total acidity shall not exceed total alkalinity.
(5) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(6) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.

To assist you in identifying the location of the discharges, please refer to the attached map. The permit area for this facility is located in Sections 2, 3, 4, 7, 8, 9, 10, 12, 14, 15, 16, 17, 18 and 29, Township 8 South, Range 4 East, and Sections 11, 12, 13, 35, 36, Township 8 South, Range 3 East, Williamson County, 3rd P.M., Illinois, and Sections 1, 2 and 12, Township 8 South, Range 2 East, and Sections 7, 8, 9, 11, 14, 15, 16, and 17, Township 8 South, Range 3 East, and Sections 27, 28, 29, 30, 31, 32, 34 and 35, Township 7 South, Range 2 East, Franklin County , 3rd P.M., Illinois.

Williamson Energy, L.L.C. - Pond Creek Mine No. 1
NPDES No. IL0077666
Williamson County
Township 8 South, Range 3 East
Township 8 South, Range 4 East



Williamson Energy, L.L.C. - Pond Creek Mine No. 1
NPDES No. IL0077666
Franklin County
Township 7 South, Range 2 East



Antidegradation Assessment for RDA #3
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Williamson Energy, LLC –Pond Creek Mine No. 1 is creating a new Refuse Disposal Area No. 3. This proposed disposal area will tie into the existing Refuse Disposal Area No. 1 & 2. Associated with the new Refuse Disposal Area No. 3, a new sediment basin will be installed to control the rainfall that falls on the out-slopes of the sediment basin and will discharge through new Outfalls 009 and 009ES.

The facility is also requesting a modification to Outfall 005. The facility is proposing to stop using the geotextile tubes, which were operated in a no discharge configuration. The facility was using the geotextile tubes to remove fine refuse and collecting the water and pumping it to the existing refuse disposal area. Williamson Energy, LLC is requesting to modify the drainage control plan to allow stormwater runoff from the area to discharge through sediment ditches and spillway, into Ditch D-5C and through Pond 005. This drainage pattern is not a deviation from the originally approved drainage plan. Due to the nature of the geotextile tubes, surface water quality is not anticipated to be affected once the geotextile tubes are out of service and no longer being utilized.

To not increase chlorides and sulfates due to the construction of RDA No. 3, the mine is eliminating or reclaiming the outslopes of RDA No. 1 and RDA No. 2 that previously discharged through Outfalls 007 and 008. Therefore, there will not be an increase in loading due to the construction of RDA No. 3.

The information in this antidegradation assessment came from the December 2014 NPDES Renewal #2 for Permit #IL0077666 report by Alliance Consulting, Inc. titled "Pond Creek Mine No. 1 & Refuse Disposal Area No. 3" and the anti-degradation assessment provided on November 18, 2016.

Identification and Characterization of the Affected Water Body.

The subject facility proposed to discharge to Pond Creek through Outfall 009 at a point where 0 cfs of flow exists upstream of the outfalls during critical 7Q10 low-flow conditions. Pond Creek is classified as a General Use Water. Pond Creek is not listed as a biologically significant stream in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor is it given an integrity rating in that document. Pond Creek, Waterbody Segment, NG-02, is listed on the draft 2016 Illinois Integrated Water Quality Report and Section 303(d) List as impaired for aquatic life use with potential causes given as alteration in stream-side or littoral vegetative cover (non-pollutant), changes in stream depth and velocity patterns (non-pollutant), chlorides, loss of instream cover (non-pollutant), dissolved oxygen (non-pollutant), and sedimentation/siltation. Primary contact recreation and secondary contact uses are fully supported. Pond Creek is not subject to enhanced dissolved oxygen standards.

Identification of Proposed Pollutant Load Increases or Potential Impacts on Uses.

The mine outfalls will be classified as acid mine drainage. Suspended solids will be treated in the sedimentation ponds. Effluent discharged from these ponds will contain suspended solids loadings that are similar to those occurring from the land in its present use. Sulfates and chlorides will undergo an increase in loading to the receiving streams as a result of the mining activities. Based on estimated effluent concentrations for this mine, chloride and sulfate will meet water quality standards in the receiving stream based on the mixing provided by my December 13, 2016 water quality memo.

Fate and Effect of Parameters Proposed for Increased Loading.

Suspended solids discharged will eventually be incorporated into bed sediments and will continue to move downstream. Sulfate and chloride will remain dissolved in the water and will move through the downstream continuum. Small amounts of these substances will be removed by organisms as these substances are necessary for life. No adverse impacts to the receiving streams will occur as all water quality standards will be met.

Purpose and Social & Economic Benefits of the Proposed Activity.

The disposal of excess water, including the water infiltrating the mine, will allow the mine to continue to operate. The Pond Creek Mine is expected to generate 5 - 6 million tons of useable coal annually. According to information given in a document dated November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit IL0077666, continued operation of the existing mine will continue to provide jobs for 203 employees with an annual payroll of approximately $18 million. In addition to these 203 direct employees, it is estimated that another 100 persons are employed in daily work associated with the Mine's production. This includes truck drivers, supply and support personnel, train crews, and technical personnel. In addition, other local businesses would also benefit from the wealth created by the mine. The operation of the mine provides tax revenues through payroll, coal severance, and mineral resource taxes for the surrounding counties and the State of Illinois. The total local, state, and federal revenues generated by the continuation of this Mine are approximately $78 million annually. Current employment statistics indicate that the unemployment rate for Williamson County was 7.5%.

Antidegradation Assessment for RDA #3
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Assessments of Alternatives for Less Increase in Loading or Minimal Environmental Degradation.

Alternatives to discharge through Outfall 009 have been evaluated by the mine company in a document dated November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit and are summarized as follows:

Chloride and Sulfate

Membrane Processes. Standard reverse osmosis (RO) treatment results in a waste stream of water with a high concentration of contaminants that is typically 25% of the flow being sent to the RO treatment system. The reject stream must still be disposed of in a responsible manner. Due to the disposal issue, the Membrane Process is not viable.

Deep Well Injection of the Entire Groundwater Stream. The untreated groundwater infiltrate could be discharged directly to a deep well. Considering the cost and operational difficulties experienced to date for the two wells that have been installed at the nearby Sugar Camp Coal facility to accept 0.45 MGD each, deep well injection of the untreated groundwater infiltrate is not considered either applicable or feasible for the operation of the Mine.

Discharge to POTW or Other Sources. POTWs are not designed to treat wastewaters containing dissolved substances such as chloride or sulfate. This option is not feasible.

No discharge. Given the climate of Williamson County, the mine company concludes that evaporation is not a viable option for disposal of the stormwater runoff mine effluent.

Mechanical Evaporation. Mechanical evaporation uses high temperatures and pressure to remove the water. The equipment is expensive to construct/install, operate, and maintain. Also, there would be materials to dispose of either in a landfill or in the Injection Wells that have been found to be unreliable for nearby mines. Therefore, this option is not considered either applicable or feasible for the operation of the mine.

Crystallizaton. Crystallization equipment is expensive to construct/install, operate and maintain. The cost is estimated at $0.25/gallon, the mine company concludes that crystallization is not a viable option for disposal of the stormwater runoff mine effluent.

Cost Effective Sulfate Removal (CESR) process. This is a proprietary technology that uses hydrated lime and proprietary chemicals to precipitate gypsum, metals and ettringite. Sludge would be produced that would require landfill disposal. The proprietary technology is still being developed. Additionally, this method is not proven to remove chlorides. These drawbacks make the CESR process infeasible for use at the coal mine.

Chemical Precipitation. Alkaline chemicals may be added to acid mine effluent to precipitate metals. The sludge produced must be disposed of and in some cases will contain hazardous materials added to the wastewater to attain precipitation. The additives used require mining in their own right. The water discharged may contain these additives, such as aluminum, in elevated concentrations. Additionally, this method is not proven to remove chlorides. These drawbacks make chemical precipitation infeasible.

Sedimentation/Siltation

Sedimentation. The facility is proposing to pump the groundwater infiltration to a Water Staging Cell where the water will have an opportunity for solids to settle out. The water will then be discharged to the Big Muddy River though the diffuser.

Use alternate sediment control and treatment devices. Alternatives to the use of sediment control ponds exist for control of discharge of settleable solids. Such alternatives include chemical soil stabilizers, erosion control blankets, geotextile filter bags, fiber rolls, silt fencing, straw mulch, straw bale dikes, and temporary seeding. These measures are aimed at minimization of the generation of settable solids. Most of these measures have been used previously during the construction and operations and in accordance with the current permit, as supplemental treatment and prevention of generation of settable solids. The use of alternative sediment control measures is considered practical and cost effective for the treatment and control of surface runoff in conjunction with sediment control ponds. However, the use of these practices to eliminate the proposed sediment control ponds is not feasible. Instead, it is being proposed that these BMPs be incorporated into the proposed alternative as needed.

No discharge. Given the climate of Williamson County, the mine company concludes that evaporation is not a viable option for disposal of the stormwater runoff mine effluent.

Filtration. Filtration is a technology that is not feasible for the proposed facility because: filtration is much more expensive than sediment ponds, filtration processes require a steady stream of water for treatment which is not the case in treating stormwater runoff, a large area of land would be required for such a facility, and maintenance and supervision of the filtration and sludge disposal operation would be burdensome and would increase production costs.

Antidegradation Assessment for RDA #3
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Constructed Wetlands. Constructed wetlands have proven to be effective for treatment of suspended solids with several limitations. These limitations include; low and consistent rates of inflow, eventual sludge accumulation requiring dredging and wetland reconstruction, and release of hydrogen sulfide and other digestive gases into the atmosphere from sulfate digestion processes. Use of wetlands in mine stormwater runoff treatment would be limited by the enormous amount of land required to construct a wetland of sufficient size for the flow rates to be expected from such an operation.

Chemical Precipitation. Alkaline chemicals may be added to acid mine effluent to precipitate metals. The sludge produced must be disposed of and in some cases will contain hazardous materials added to the wastewater to attain precipitation. The additives used require mining in their own right. The water discharged may contain these additives, such as aluminum, in elevated concentrations. Concerns with the use of chemical precipitation at the proposed coal mine include; worker safety regarding the chemicals to be used, treatment costs, process operation and maintenance, disposal of precipitate sludge in a landfill, necessity of treatment considering that acid water is not considered a factor for the proposed operation, susceptibility to system malfunction due to high volume flows from storm events, and improbability of actual improvement in overall water quality when compared to the use of sediment ponds. These drawbacks make chemical precipitation infeasible.

Summary Comments of the Illinois Department of Natural Resources, Regional Planning Commissions, Zoning Boards or Other Entities

On November 2, 2016, the IDNR EcoCAT web-based tool was used and indicated that there were no aquatic endangered/threatened species present in the vicinity of the discharge. While the IDNR EcoCAT web-based tool did not terminate the consultation because of the nearby presence of Chuck-Will's-Willow (*Caprimulgus carolinensis*), future termination is likely.

Agency Conclusion.

This preliminary assessment was conducted pursuant to the Illinois Pollution Control Board regulation for Antidegradation found at 35 Ill. Adm. Code 302.105 (antidegradation standard) and was based on the information available to the Agency at the time the draft permit was written. We tentatively find that the proposed activity will result in the attainment of water quality standards; that all existing uses of the receiving stream will be maintained; that all technically and economically reasonable measures to avoid or minimize the extent of the proposed increase in pollutant loading have been incorporated into the proposed activity; and that this activity will benefit the community at large by allowing the continuation of coal mining with all of its economic benefits to the local economy. Comments received during the NPDES permit public notice period will be evaluated before a final decision is made by the Agency.

Antidegradation Assessment for Big Muddy River Mixing
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Williamson Energy, LLC operates the Pond Creek No. 1 Mine which is located in Williamson County. The mining complex contains an estimated 383.3 million tons of clean, recoverable coal reserves. Williamson Energy commenced construction of the Mine in 2005. The Mine has a life expectancy of more than 20 years. The mine has one operating longwall system. The Preparation Plant facilities are capable of processing 2,000 tons of coal per hour. The productive capacity of the mine is 5-6 million tons per year. Coal is shipped by rail, truck and barge (via railroad).

Williamson currently operates the mine under the existing Permit 375 and Permit 417 from the Illinois Department of Natural Resources, Office of Mines and Minerals (IDNR-OMM). The Mine currently discharges under NPDES Permits IL0077666.

The Pond Creek Mine has submitted an antidegradation report as part of the following NPDES permit activities:

- To respond to the over capacity of water on-site, a new outfall to the Big Muddy River is proposed. The outfall structure will be a multi-port diffuser and a mixing zone is being requested for the discharge; and
- The mine permit modification request includes the discharge of stormwater from stormwater ponds associated with the proposed Refuse Disposal Area No. 3 to Pond Creek. (Discussed under another antidegradation assessment.) A mixing zone is being requested for Pond Creek.

The mine uses water in two areas of operation; dust suppression during coal extraction and wash water in the preparation plant. The water used in the coal extraction process is fresh, untreated water purchased from the City of Johnston City and it not recoverable. The water used to wash the coal in the preparation plant comes from the fresh water lake. Over time, the fine solid particles present in the thickener underflow that is pumped to the Slurry Impoundment/RDA No. 3 settle to the bottom of the impoundment leaving clarified water on the surface. There is some loss of water during the washing process. Additionally, since the fines do not all settle immediately in the slurry impoundment, the quality of the clarified water results in a need for additional water for the preparation plant. Therefore, preparation plant water is supplemented with mine infiltration water and/or stormwater.

An aquifer above the coal seam causes an influx in water into the Mine. The infiltrating groundwater is from a saline aquifer, with a chloride content of approximately 1,099 to 2,799 mg/L. The sulfate ranges between 1,720 and 2,120 mg/L. Presently, the mine is removing 2.7 MGD of this high-chloride groundwater from the active mine. During normal coal processing operations, the preparation plant requires approximately 2.3 MGD. It is necessary to remove the water from the mine to protect the health and safety of the workforce, as well as, the overall mining operation.

Water will be stored in the Water Staging Cell and will be pumped to the Big Muddy River diffuser for mixing. An evaluation of the mixing zone will be reported in a separate memo.

The information in this antidegradation assessment came from the December 2014 NPDES Renewal #2 for Permit #IL0077666 report by Alliance Consulting, Inc. titled "Pond Creek Mine No. 1 & Refuse Disposal Area No. 3" and the anti-degradation assessment provided on November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit IL0077666

Identification and Characterization of the Affected Water Body.

The subject facility proposes to discharge to the Big Muddy River through Outfall 011 at a point where 37.0 cfs of flow exists upstream of the outfall during critical 7Q10 low-flow conditions. The Big Muddy River is classified as a General Use Water. The Big Muddy River is not listed as a biologically significant stream in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor is it given an integrity rating in that document. The Big Muddy River, Waterbody Segment, N-11, is listed on the draft 2016 Illinois Integrated Water Quality Report and Section 303(d) List as impaired for aquatic life use with potential causes given as iron (dissolved), dissolved oxygen (non-pollutant), sedimentation/siltation (non-pollutant), and total suspended solids; fish consumption use with potential causes given as mercury and polychlorinated biphenyls; and primary contact recreation use with potential cause given as fecal coliform. Aesthetic quality use is fully supported. This segment of the Big Muddy River is not subject to enhanced dissolved oxygen standards.

Identification of Proposed Pollutant Load Increases or Potential Impacts on Uses.

The constituents of concern are chloride, sulfates, manganese, iron, and total suspended solids. The chloride loading will range from 19,141 to 1,197,698 lbs/day at a concentration ranging from 1,699 to 12,000 mg/L. The sulfate loading will range from 9,720 to 476,031 lbs/day at a concentration ranging from 820 to 2,120 mg/L. The manganese loading will range from 33 to 336 lbs/day at a concentration ranging from 0.125 to 0.419 mg/L. The Iron (total) loading will range from 34 to 348 lbs/day at a concentration ranging from 0.216 to 1.835 mg/L. Iron (dissolved) is only a fraction of the Iron (total) and will meet the water quality standard at the end-of-pipe or at the edge of the mixing zone. The Nickel loading will range from 1 to 8 lbs/day at a concentration ranging from 0.004 to 0.014 mg/L. The Copper loading will range from 1 to 8 lbs/day at a concentration ranging from 0.011 to 0.32 mg/L. The TSS loading will range from 2,337 to 118,332 lbs/day at a concentration ranging from 7 to 70 mg/L.

Antidegradation Assessment for Big Muddy River Mixing
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Fate and Effect of Parameters Proposed for Increased Loading.

Chloride and sulfates would remain dissolved in the water and would move through the downstream continuum. Manganese, iron, Nickel, Copper, and total suspended solids will most likely settle and become part of the bed sediment load in the river. A mixing zone in the Big Muddy River will be utilized to dissipate chloride and sulfate to water quality standard levels. A zone of initial dilution will be utilized to dissipate Copper to water quality standard levels. Small amounts of chloride and sulfates would be removed by organisms as these substances are necessary for life. Because of the near real-time continuous monitoring of upstream and downstream conditions in the receiving stream, and the ability of the permittee's diffuser to adjust to flow and background concentration conditions, discharges will always be into a waterbody that is below water quality standards and in concentrations and flow combinations that will not cause or contribute to an exceedance downstream of the mixing zone. No adverse impacts to streams would occur as all water quality standards are expected to be met in the receiving water.

Purpose and Social & Economic Benefits of the Proposed Activity.

The disposal of excess water, including the water infiltrating the mine, will allow the mine to continue to operate. The Pond Creek Mine is expected to generate 5 - 6 million tons of useable coal. According to information given in a document dated November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit IL0077666, continued operation of the existing mine will continue to provide jobs for 203 employees with an annual payroll of approximately $18 million. In addition to these 203 direct employees, it is estimated that another 100 persons are employed in daily work associated with the Mine's production. This includes truck drivers, supply and support personnel, train crews, and technical personnel. In addition, other local businesses would also benefit from the wealth created by the mine. The operation of the mine provides tax revenues through payroll, coal severance, and mineral resource taxes for the surrounding counties and the State of Illinois. The total local, state, and federal revenues generated by the continuation of this Mine are approximately $78 million annually. Current employment statistics indicate that the unemployment rate for Williamson County was 7.5%.

Assessments of Alternatives for Less Increase in Loading or Minimal Environmental Degradation.

Excess water is proposed to be discharged to the Big Muddy River. Alternatives to this system have been evaluated by the mine company in a document dated November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit and are summarized as follows:

Chloride and Sulfate

Membrane Processes. Standard reverse osmosis (RO) treatment results in a waste stream of water with a high concentration of contaminants that is typically 25% of the flow being sent to the RO treatment system. The reject stream must still be disposed of in a responsible manner. Due to the disposal issue, the Membrane Process is not viable.

Deep Well Injection of the Entire Groundwater Stream. The untreated groundwater infiltrate could be discharged directly to a deep well. Considering the cost and operational difficulties experienced to date for the two wells that have been installed at the nearby Sugar Camp Coal facility to accept 0.45 MGD each, deep well injection of the untreated groundwater infiltrate is not considered either applicable or feasible for the operation of the Mine.

Discharge to POTW or Other Sources. POTWs are not designed to treat wastewaters containing dissolved substances such as chloride or sulfate. This option is not feasible.

No discharge. Given the climate of Williamson County, the mine company concludes that evaporation is not a viable option for disposal of the stormwater runoff mine effluent.

Mechanical Evaporation. Mechanical evaporation uses high temperatures and pressure to remove the water. The equipment is expensive to construct/install, operate, and maintain. Also, there would be materials to dispose of either in a landfill or in the Injection Wells that have been found to be unreliable for nearby mines. Therefore, this option is not considered either applicable or feasible for the operation of the mine.

Crystallizaton. Crystallization equipment is expensive to construct/install, operate and maintain. The cost is estimated at $0.25/gallon, the mine company concludes that crystallization is not a viable option for disposal of the stormwater runoff mine effluent.

Cost Effective Sulfate Removal (CESR) process. This is a proprietary technology that uses hydrated lime and proprietary chemicals to precipitate gypsum, metals and ettringite. Sludge would be produced that would require landfill disposal. The proprietary technology is still being developed. Additionally, this method is not proven to remove chlorides. These drawbacks make the CESR process infeasible for use at the coal mine.

Antidegradation Assessment for Big Muddy River Mixing
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Chemical Precipitation. Alkaline chemicals may be added to acid mine effluent to precipitate metals. The sludge produced must be disposed of and in some cases will contain hazardous materials added to the wastewater to attain precipitation. The additives used require mining in their own right. The water discharged may contain these additives, such as aluminum, in elevated concentrations. Additionally, this method is not proven to remove chlorides. These drawbacks make chemical precipitation infeasible.

Sedimentation/Siltation

Sedimentation. The facility is proposing to pump the groundwater infiltration to a Water Staging Cell where the water will have an opportunity for solids to settle out. The water will then be discharged to the Big Muddy River though the diffuser.

Use alternate sediment control and treatment devices. Alternatives to the use of sediment control ponds exist for control of discharge of settleable solids. Such alternatives include chemical soil stabilizers, erosion control blankets, geotextile filter bags, fiber rolls, silt fencing, straw mulch, straw bale dikes, and temporary seeding. These measures are aimed at minimization of the generation of settable solids. Most of these measures have been used previously during the construction and operations and in accordance with the current permit, as supplemental treatment and prevention of generation of settable solids. The use of alternative sediment control measures is considered practical and cost effective for the treatment and control of surface runoff in conjunction with sediment control ponds. However, the use of these practices to eliminate the proposed sediment control ponds is not feasible. Instead, it is being proposed that these BMPs be incorporated into the proposed alternative as needed.

No discharge. Given the climate of Williamson County, the mine company concludes that evaporation is not a viable option for disposal of the stormwater runoff mine effluent.

Filtration. Filtration is a technology that is not feasible for the proposed facility because: filtration is much more expensive than sediment ponds, filtration processes require a steady stream of water for treatment which is not the case in treating stormwater runoff, a large area of land would be required for such a facility, and maintenance and supervision of the filtration and sludge disposal operation would be burdensome and would increase production costs.

Constructed Wetlands. Constructed wetlands have proven to be effective for treatment of suspended solids with several limitations. These limitations include; low and consistent rates of inflow, eventual sludge accumulation requiring dredging and wetland reconstruction, and release of hydrogen sulfide and other digestive gases into the atmosphere from sulfate digestion processes. Use of wetlands in mine stormwater runoff treatment would be limited by the enormous amount of land required to construct a wetland of sufficient size for the flow rates to be expected from such an operation.

Chemical Precipitation. Alkaline chemicals may be added to acid mine effluent to precipitate metals. The sludge produced must be disposed of and in some cases will contain hazardous materials added to the wastewater to attain precipitation. The additives used require mining in their own right. The water discharged may contain these additives, such as aluminum, in elevated concentrations. Concerns with the use of chemical precipitation at the proposed coal mine include; worker safety regarding the chemicals to be used, treatment costs, process operation and maintenance, disposal of precipitate sludge in a landfill, necessity of treatment considering that acid water is not considered a factor for the proposed operation, susceptibility to system malfunction due to high volume flows from storm events, and improbability of actual improvement in overall water quality when compared to the use of sediment ponds. These drawbacks make chemical precipitation infeasible.

Summary Comments of the Illinois Department of Natural Resources, Regional Planning Commissions, Zoning Boards or Other Entities.

On November 2, 2016, the IDNR EcoCAT web-based tool was used and indicated that there were no aquatic endangered/threatened species present in the vicinity of the discharge. While the IDNR EcoCAT web-based tool did not terminate the consultation because of the nearby presence of Chuck-Will's-Willow (*Caprimulgus carolinensis*), future termination is likely.

Agency Conclusion.

This preliminary assessment was conducted pursuant to the Illinois Pollution Control Board regulation for Antidegradation found at 35 Ill. Adm. Code 302.105 (antidegradation standard) and was based on the information available to the Agency at the time the draft permit was written. We tentatively find that the proposed activity will result in the attainment of water quality standards; that all existing uses of the receiving stream will be maintained; that all technically and economically reasonable measures to avoid or minimize the extent of the proposed increase in pollutant loading have been incorporated into the proposed activity; and that this activity will benefit the community at large by allowing the continuation of coal mining with all of its economic benefits to the local economy. Comments received during the NPDES permit public notice period will be evaluated before a final decision is made by the Agency.

Antidegradation Assessment for RDA #3 (Supplemental Information)
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Pond 009 has an emergency discharge via Outfall 009ES. During normal operations, Pond 009 will discharge directly to Pond Creek via Outfall 009 and has provisions for allowed mixing. Outfall 009ES is not expected to have a discharge, except during an emergency.

Identification and Characterization of the Affected Water Body.

The subject facility discharges to an unnamed tributary of Pond Creek through Outfall 009ES at a point where 0 cfs of flow exists upstream of the outfalls during critical 7Q10 low-flow conditions. The unnamed tributary of Pond Creek is classified as a General Use Water. The unnamed tributary of Pond Creek is not listed as a biologically significant streams in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor is it given an integrity rating in that document. The unnamed tributary of Pond Creek, tributary to Waterbody Segment, NG-02, is not listed on the draft 2016 Illinois Integrated Water Quality Report and Section 303(d) List since it has not been assessed. The unnamed tributary of Pond Creek is not subject to enhanced dissolved oxygen standards.

Agency Conclusion.

Upon completing the assessment, it has been determined that the proposed activity will result in only short-term, temporary increases in pollutant loading and will not result in long term or permanent impacts to existing uses including aquatic life habitat; therefore, we find that it is subject to Subsection (d) "Activities Not Subject to a Further Antidegradation Assessment" of 35 Ill. Adm. Code 302.105.

DOCUMENT

21

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 · (217) 782-3397
JB PRITZKER, GOVERNOR
JOHN J. KIM, DIRECTOR

MEMORANDUM

DATE: July 12, 2019

TO: Manager, DWPC/FOS, Marion Region

FROM: Darin LeCrone, Manager, Industrial Unit, Permit Section DEL

SUBJECT: Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Bureau ID #W1998590001
Draft Renewed Permit, Public Notice/Fact Sheet

Please review the attached copy of the subject documents and notify the Mine Pollution Control Program if you take exception to the limitations, sampling frequency, sample type or other requirements therein.

If no response is received within fifteen (15) days from the date of this memorandum, we will assume that you concur in the issuance of the Public Notice.

If you have any questions, please contact Iwona Ward at 618/993-7200.

Thank you for your cooperation.

DEL:IKW:cs/7817c/6-28-19

Enclosures: Draft Permit, Public Notice/Fact Sheet

cc: Marion Region/Mine Pollution Control Program
BOW/DWPC/Records

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 · (217) 782-3397
JB PRITZKER, GOVERNOR
JOHN J. KIM, DIRECTOR

R06186

July 12, 2019

618/993-7200

U.S. Fish & Wildlife Service
Rock Island Field Office
1511 47th Avenue
Moline, Illinois 61265

Re: Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Bureau ID #W1998590001
Public Notice of Renewed Permit

IEPA-DIVISION OF RECORDS MANAGEMENT
RELEASABLE
AUG 02 2019
REVIEWER: SAB

Gentlemen:

In accordance with 40 CFR 124.10, we hereby submit a copy of the Public Notice/Fact Sheet for the above discharger. If no written reply is received at the address indicated below within 30 days of the date of this request, the Agency will assume that the U.S. Fish and Wildlife Service has no objection to the proposed discharge.

Illinois Environmental Protection Agency
Division of Water Pollution Control
1021 North Grand Avenue, East
P.O. Box 19276
Springfield, IL 62794-9276

Attn: NPDES PN Clerk

Sincerely,

Darin E. LeCrone, P.E.
Manager, Industrial Unit, Permit Section
Division of Water Pollution Control

DEL:IKW:cs/7817c/6-28-19

Enclosure: Public Notice/Fact Sheet

cc: Marion Region/Mine Pollution Control Program
BOW/DWPC/Records

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 · (217) 782-3397
JB PRITZKER, GOVERNOR JOHN J. KIM, DIRECTOR

July 12, 2019

618/993-7200

Franklin County Clerk
P.O. Box 607
Benton, Illinois 62812

Re: Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Bureau ID #W1998590001
Public Notice of Renewed Permit

County Clerk:

Please post the attached National Pollutant Discharge Elimination System Public Notice for a period of 30 days. In addition, complete and return the enclosed post card indicating the date of posting. Thank you for your cooperation.

Sincerely,

Darin E. LeCrone, P.E.
Manager, Industrial Unit, Permit Section
Division of Water Pollution Control

DEL:IKW:cs/7817c/6-28-19

Enclosures: Public Notice/Fact Sheet, Post Card

cc: Marion Region/Mine Pollution Control Program
BOW/DWPC/Records

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 · (217) 782-3397
JB PRITZKER, GOVERNOR JOHN J. KIM, DIRECTOR

July 12, 2019

618/993-7200

County Clerk
Williamson County Courthouse
200 W. Jefferson
Marion, Illinois 62959

Re: Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Bureau ID #W1998590001
Public Notice of Renewed Permit

County Clerk:

Please post the attached National Pollutant Discharge Elimination System Public Notice for a period of 30 days. In addition, complete and return the enclosed post card indicating the date of posting. Thank you for your cooperation.

Sincerely,

Darin E. LeCrone, P.E.
Manager, Industrial Unit, Permit Section
Division of Water Pollution Control

DEL:IKW:cs/7817c/6-28-19

Enclosures: Public Notice/Fact Sheet, Post Card

cc: Marion Region/Mine Pollution Control Program
BOW/DWPC/Records

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 · (217) 782-3397
JB PRITZKER, GOVERNOR JOHN J. KIM, DIRECTOR

July 12, 2019

618/993-7200

Department of the Army
St. Louis District
Corps of Engineers
1222 Spruce Street
St. Louis, Missouri 63103

Re: Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666 (Renewed)
Bureau ID #W1998590001
Request for Corps of Engineers Comment

Gentlemen:

Attached please find a copy of the Public Notice/Fact Sheet for the subject discharge. Please review for determination of the impact of this discharge on navigation and anchorage. If no written reply is received at the address indicated below within fifteen (15) days of the date of this request, the Agency will assume the Corps of Engineers has no objection to the proposed discharge.

Illinois Environmental Protection Agency
Division of Water Pollution Control
1021 North Grand Avenue, East
P.O. Box 19276
Springfield, Illinois 62794-9276

Attn: NPDES PN Clerk

Sincerely,

Darin E. LeCrone, P.E.
Manager, Industrial Unit, Permit Section
Division of Water Pollution Control

DEL:IKW:cs/7817c/6-28-19

Enclosure: Public Notice/Fact Sheet

cc: Marion Region/Mine Pollution Control Program
BOW/DWPC/Records

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 · (217) 782-3397
JB PRITZKER, GOVERNOR
JOHN J. KIM, DIRECTOR

R06190

July 12, 2019

618/993-7200

Williamson Energy, LLC
P.O. Box 300
Johnston City, Illinois 62951

Re: Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Bureau ID #W1998590001
Public Notice of Renewed Permit

Gentlemen:

Please post the attached Public Notice for the subject discharge for at least a period of thirty days from the date on the Notice in a conspicuous place on your premises.

We have enclosed a copy of the draft renewed NPDES permit on which this official Public Notice is based. If you wish to comment on the draft permit, please do so within 30 days of the Public Notice date. If there are any questions, please contact Iwona Ward at 618/993-7200.

Thank you for your cooperation.

Sincerely,

Darin E. LeCrone, P.E.
Manager, Industrial Unit, Permit Section
Division of Water Pollution Control

DEL:IKW:cs/7817c/6-28-19

Enclosures: Draft Permit, Public Notice/Fact Sheet

cc: GERPDC/with Enclosures
Marion Region/Mine Pollution Control Program
BOW/DWPC/Records

NPDES Permit No. IL0077666
Notice No. 7516c

Public Notice Beginning Date: **July 12, 2019**

Public Notice Ending Date: **August 12, 2019**

National Pollutant Discharge Elimination System (NPDES)
Permit Program

Draft Renewed NPDES Permit to Discharge into Waters of the State

Public Notice/Fact Sheet Issued By:

Illinois Environmental Protection Agency
Bureau of Water, Division of Water Pollution Control
Permit Section
1021 North Grand Avenue East
Post Office Box 19276
Springfield, Illinois 62794-9276
217/782-0610

Name and Address of Discharger:

Williamson Energy, LLC
P.O. Box 300
Johnston City, Illinois 62951

Name and Address of Facility:

Williamson Energy, LLC
Pond Creek Mine
4 miles east of Johnston City, Illinois
(Williamson and Franklin Counties)

The Illinois Environmental Protection Agency (IEPA or Agency) has made a tentative determination to issue an NPDES permit to discharge into waters of the state and has prepared a draft permit and associated fact sheet for the above named discharger. The Public Notice period will begin and end on the dates indicated in the heading of this Public Notice/Fact Sheet. Comments will be accepted until midnight of the Public Notice period ending date indicated above, unless a request for an extension of the original comment period is granted by the Agency. Interested persons are invited to submit written comments on the draft permit to the IEPA at the above address. Commenters shall provide his or her name, address and the nature of the issues raised and the evidence supporting those issues. Commenters may include a request for public hearing. The NPDES permit and notice number(s) must appear on each comment page.

The application, engineer's review notes, Public Notice/Fact Sheet, draft permit, comments received, and other documents are available for inspection and may be copied at the IEPA between 9:30 a.m. and 3:30 p.m. Monday through Friday when scheduled by the interested person.

As provided in 35 Ill. Adm. Code 309.115(a) any person may submit a request for a public hearing and if such written comments or requests indicate a significant degree of public interest in the draft permit, the permitting authority may, at its discretion, hold a public hearing. The Agency shall issue public notice of such hearing no less than thirty (30) days prior to the date of such hearing in the manner described by 35 Ill. Adm. Code 309.109 through 309.112 for public notice. The Agency's responses to written and/or oral comments will be provided in the Responsiveness Summary provided when the final permit is issued.

The applicant proposes additional surface facilities area to an existing underground coal mine (SIC 1222). Mine operations result in the discharge of alkaline and acid mine drainage.

Public comments are invited on the entire draft permit. The following proposed modifications were incorporated into this Permit renewal:

Incorporated three (3) new outfalls designated as Outfall Nos. 009, 009ES and 011.

Various mining operation and drainage control plan revisions.

229.78 acres incorporated for new Refuse Disposal Area No. 3.

70.7 acres incorporated for the pipeline to the Big Muddy River.

145.32 acres for various IBR's for additional permit area.

Addition of bi-annual metals monitoring of discharges from Outfall Nos. 006, 007, 008,009, 009ES and 011.

Incorporated previously issued State Construction and Operating Permits (Subtitle D Permits).

This facility has eight (8) existing discharges which are located in Williamson County, Illinois. The following information identifies the discharge points and receiving streams:

Outfall	Receiving Stream	Latitude (North)	Longitude (West)
001	Unnamed tributary of Pond Creek	37° 50' 59.2"	88° 49' 37.5"
002	Unnamed tributary of Pond Creek	37° 50' 26.0"	88° 49' 51.5"
003	Unnamed tributary of Pond Creek	37° 50' 26.0"	88° 49' 58.0"
004	Unnamed tributary of Pond Creek	37° 50' 25.0"	88° 49' 56.6"
005	Unnamed tributary of Pond Creek	37° 50' 9.1"	88° 50' 00.0"
006	Unnamed tributary of Pond Creek	37° 50' 28.4"	88° 50' 40.6"
007	Unnamed tributary of Pond Creek	37° 50' 29.5"	88° 49' 34.0"
008	Unnamed tributary of Pond Creek	37° 50' 31.4"	88° 49' 33.9"

The stream segment NG-02 of Pond Creek receiving the flow from the unnamed tributary into which Outfall 001, 002, 003, 004, 005, 006, 007 and 008 discharges is not on the 2016 303(d) list of impaired waters.

Application is made for three (3) new discharges which are located in Williamson and Franklin Counties, Illinois. The following information identifies the discharge points and receiving streams:

Outfall	Receiving Stream	Latitude (North)	Longitude (West)
009	Pond Creek	37° 51' 16.1"	88° 49' 25.5"
009ES	Unnamed tributary to Pond Creek	37° 50' 52.3"	88° 48' 43.7"
011	Big Muddy River	37° 52' 37"	89° 01' 49"

The stream segment NG-02 of Pond Creek receiving the discharge from Outfalls 009 and 009ES is on the 2016 303(d) list of impaired waters.
The following parameters have been identified as the pollutants causing impairment.

Outfall	Pollutant
009, 009ES	Alteration in stream-side or littoral vegetative cover Changes in stream depth and velocity patterns Chlorides Loss of instream cover, dissolved oxygen, Sedimentation/siltation

The stream segment N-11 of Big Muddy River receiving the discharge from Outfall 011 is on the draft 2016 303(d) list of impaired waters. The following parameters have been identified as the pollutants causing impairment.

Outfall	Pollutant
011	Iron, Oxygen, dissolved; Sedimentation/Siltation Total Suspended Solids (TSS) Mercury, Polychlorinated biphenyls Fecal Coliform

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The alkaline mine discharge from this facility shall be monitored and limited at all times as follows:

Outfalls: 001, 002, 003, 004, 005

Discharge Condition	Parameters											
	Total Suspended Solids (3) (mg/l)		Iron (total) (3) (4) (mg/l)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/l)	Chloride (mg/l)	Cadmium (Cd) (mg/l) (6)	Hardness (5)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum								
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 5.21 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for alkaline mine discharges are contained in 35 Ill. Adm. Code 406.110.
(3) Effluent standards for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 001, 002, 003, 004 and 005 are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average.
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limit.
(6) The Cadmium water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).

The acid mine discharge from this facility shall be monitored and limited at all times as follows:

Outfalls: 006, 007

Discharge Condition	Parameters												
	Total Suspended Solids (3) (mg/L)		Iron (total) (3) (4) (mg/L)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/L)	Chloride (mg/L)	Cadmium (Cd) (mg/l) (6)	Mn (total) (mg/L)	Hardness (5)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum									
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	1.0	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	1.0	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(b), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 1-year, 24-hours precipitation event, but less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 1-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hours precipitation event for this area is considered to be 5.21 inches.

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for acid mine drainage discharges are contained in 35 Ill. Adm. Code 406.110(b), (c), and (d).
(3) Effluent limitations for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 006 and 007 are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average.
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.
(6) The Cadmium water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).

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The acid mine discharge from this facility shall be monitored and limited at all times as follows:

Outfall: 008

Discharge Condition	Parameters											
	Total Suspended Solids (3) (mg/L)		Iron (total) (3) (4) (mg/L)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/L)	Chloride (mg/L)	Mn (total) (mg/L)	Hardness (5)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum								
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	1.0	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	1.0	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(b), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 1-year, 24-hours precipitation event, but less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 1-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hours precipitation event for this area is considered to be 5.21 inches.

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for acid mine drainage discharges are contained in 35 Ill. Adm. Code 406.110(b), (c), and (d).
(3) Effluent limitations for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 008 are subject to a 30-day average effluent limitation for iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average.
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.

The alkaline mine discharge from this facility shall be monitored and limited at all times as follows:

Outfall: 009

Discharge Condition	Parameters													
	Total Suspended Solids (3) (mg/L)		Iron (total) (3) (4) (mg/L)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/L)	Chloride (mg/L)	Mn (total) (mg/L)		Hardness (5)	Copper (CU) (mg/L)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum				
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	See Special Condition No. 14	-	-	Monitor only	-	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	See Special Condition No. 14	-	-	Monitor only	-	Measure When Sampling	-
IV	35	70	3.0	6.0	6.0-9.0	Alk.>Acid	1250	See Special Condition No. 14	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall at times of "low flow" or "no flow" conditions in the receiving stream as defined in Special Condition No. 14.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. At such time that receiving stream flow subsides to the degree that the mixing ratio specified in Special Condition No. 14 is not available, monitoring requirements and permit limitations shall revert to Discharge Condition I.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for alkaline mine discharges are contained in 35 Ill. Adm. Code 406.110.
(3) Effluent standards for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 009 are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.

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The alkaline mine discharge from this facility shall be monitored and limited at all times as follows:

Outfall: 009ES

Discharge Condition	Parameters													
	Total Suspended Solids (3) (mg/L)		Iron (total) (3) (4) (mg/L)		pH (3) (S.U.)	Alkalinity/ Acidity (3)	Sulfate (1) (mg/L)	Chloride (mg/L)	Mn (total) (mg/L)		Hardness (5)	Copper (CU) (mg/L)	Flow (MGD)	Settleable Solids (2) (ml/l)
	30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum				
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	-	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	-	Measure When Sampling	-
IV	35	70	3.0	6.0	6.0-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

(1) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(2) Settleable solids are monitored only as a result of a discharge due to precipitation events which exceed a predetermined 24-hour duration or snowmelt total. Settleable solids effluent limitations for alkaline mine discharges are contained in 35 Ill. Adm. Code 406.110.
(3) Effluent standards for mine discharges are contained in 35 Ill. Adm. Code 406.106.
(4) Discharges from Outfall 009ES are subject to a 30-day average effluent limitation for Iron of 3.0 mg/l. Daily maximum effluent concentrations are calculated as twice the 30-day average
(5) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.

The alkaline mine discharge from this facility shall be monitored and limited at all times as follows:

Outfall: 011

Parameters														
Total Suspended Solids (1) (mg/l)		Iron (total) (2) (mg/l)		pH (3) (S.U.)	Alkalinity/ Acidity (4)	Sulfate (5) (mg/l)	Chloride (mg/l)	Mn (total) (mg/l) (2)		Hardness (6)	Nickel (mg/L)	Copper (mg/L)	Flow (MGD)	Iron (Dissolved)
30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum					
35	70	3.0	6.0	6.0-9.0	Alk.>Acid	See Special Condition No. 16	See Special Condition No. 16	2.0	4.0	Monitor only	See Special Condition No. 16	See Special Condition No. 16	Measure When Sampling	See Special Condition No. 16

For any discharge not meeting the water quality standard for any of the above parameters, such discharge shall be subject to the limitations and monitoring requirements of Special Condition No. 16.

(1) Effluent standards for Total Suspended Solids in mine discharges are established pursuant to 35 Ill. Adm. Code 406.106.
(2) Effluent standards for Iron and Manganese are established pursuant to 35 Ill. Adm. Code 304.124.
(3) Pursuant to 35 Ill. Adm. Code 406.106, pH shall not be less than 6.0 or greater than 9.0 S.U.
(4) Pursuant to 35 Ill. Adm. Code 406.106, total acidity shall not exceed total alkalinity.
(5) Sulfate water quality standards and effluent limitations determined in accordance with 35 Ill. Adm. Code 302.208(h).
(6) Hardness monitoring is required to determine the appropriateness of the sulfate permit limitation.

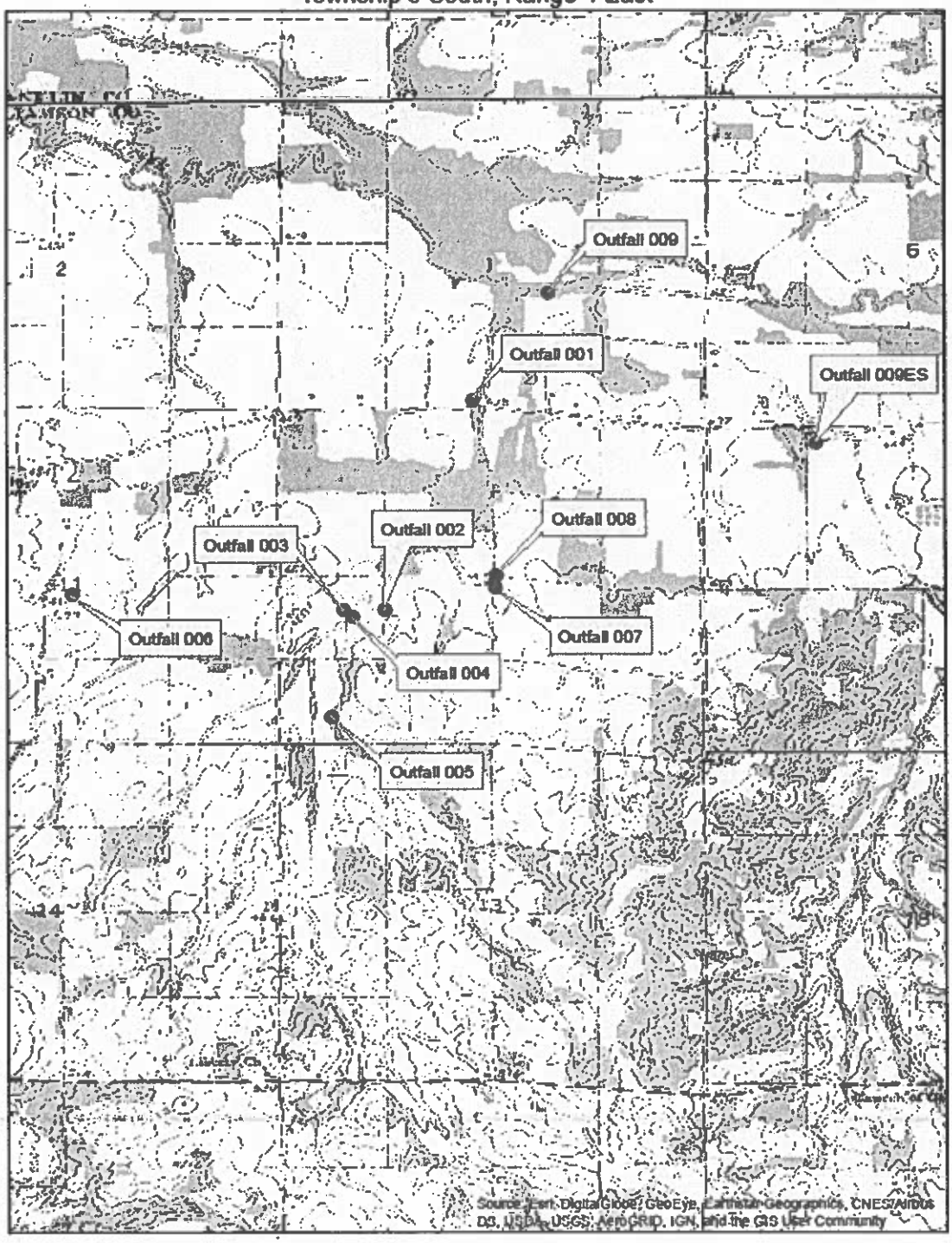
To assist you in identifying the location of the discharges, please refer to the attached map. The permit area for this facility is located in Sections 2, 3, 4, 7, 8, 9, 10, 12, 14, 15, 16, 17, 18 and 29, Township 8 South, Range 4 East, and Sections 11, 12, 13, 35, 36, Township 8 South, Range 3 East, Williamson County, 3rd P.M., Illinois, and Sections 1, 2 and 12, Township 8 South, Range 2 East, and Sections 7, 8, 9, 11, 14, 15, 16, and 17, Township 8 South, Range 3 East, and Sections 27, 28, 29, 30, 31, 32, 34 and 35, Township 7 South, Range 2 East, Franklin County , 3rd P.M., Illinois.

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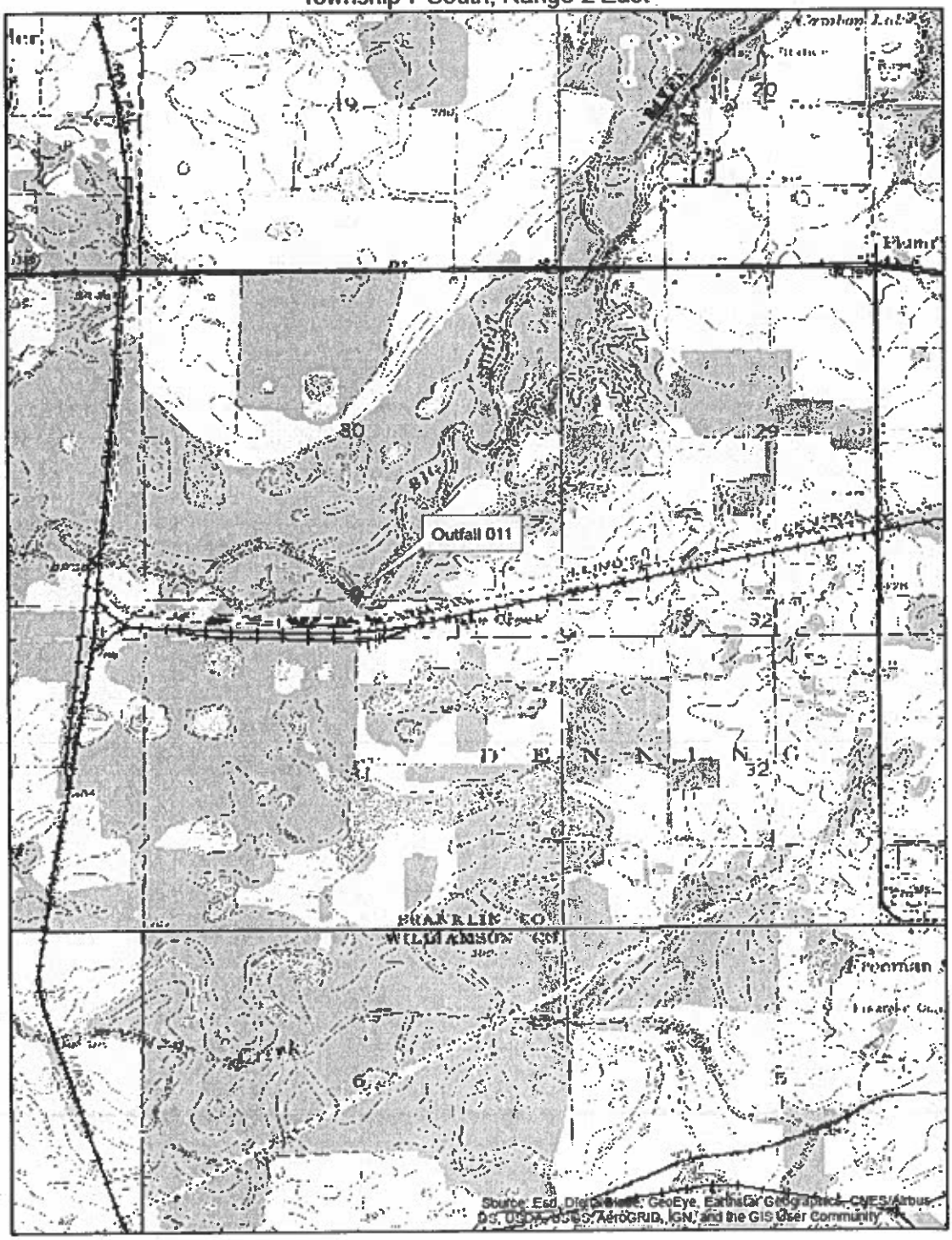
JUL 12 2019

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Williamson Energy, L.L.C. - Pond Creek Mine No. 1
NPDES No. IL0077666
Williamson County
Township 8 South, Range 3 East
Township 8 South, Range 4 East



Williamson Energy, L.L.C. - Pond Creek Mine No. 1
NPDES No. IL0077666
Franklin County
Township 7 South, Range 2 East



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PUBLIC NOTICE

Antidegradation Assessment for RDA #3
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Williamson Energy, LLC –Pond Creek Mine No. 1 is creating a new Refuse Disposal Area No. 3. This proposed disposal area will tie into the existing Refuse Disposal Area No. 1 & 2. Associated with the new Refuse Disposal Area No. 3, a new sediment basin will be installed to control the rainfall that falls on the out-slopes of the sediment basin and will discharge through new Outfalls 009 and 009ES.

The facility is also requesting a modification to Outfall 005. The facility is proposing to stop using the geotextile tubes, which were operated in a no discharge configuration. The facility was using the geotextile tubes to remove fine refuse and collecting the water and pumping it to the existing refuse disposal area. Williamson Energy, LLC is requesting to modify the drainage control plan to allow stormwater runoff from the area to discharge through sediment ditches and spillway, into Ditch D-5C and through Pond 005. This drainage pattern is not a deviation from the originally approved drainage plan. Due to the nature of the geotextile tubes, surface water quality is not anticipated to be affected once the geotextile tubes are out of service and no longer being utilized.

To not increase chlorides and sulfates due to the construction of RDA No. 3, the mine is eliminating or reclaiming the outslopes of RDA No. 1 and RDA No. 2 that previously discharged through Outfalls 007 and 008. Therefore, there will not be an increase in loading due to the construction of RDA No. 3.

The information in this antidegradation assessment came from the December 2014 NPDES Renewal #2 for Permit #IL0077666 report by Alliance Consulting, Inc. titled "Pond Creek Mine No. 1 & Refuse Disposal Area No. 3" and the anti-degradation assessment provided on November 18, 2016.

Identification and Characterization of the Affected Water Body.

The subject facility proposed to discharge to Pond Creek through Outfall 009 at a point where 0 cfs of flow exists upstream of the outfalls during critical 7Q10 low-flow conditions. Pond Creek is classified as a General Use Water. Pond Creek is not listed as a biologically significant stream in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor is it given an integrity rating in that document. Pond Creek, Waterbody Segment, NG-02, is listed on the draft 2016 Illinois Integrated Water Quality Report and Section 303(d) List as impaired for aquatic life use with potential causes given as alteration in stream-side or littoral vegetative cover (non-pollutant), changes in stream depth and velocity patterns (non-pollutant), chlorides, loss of instream cover (non-pollutant), dissolved oxygen (non-pollutant), and sedimentation/siltation. Primary contact recreation and secondary contact uses are fully supported. Pond Creek is not subject to enhanced dissolved oxygen standards.

Identification of Proposed Pollutant Load Increases or Potential Impacts on Uses.

The mine outfalls will be classified as acid mine drainage. Suspended solids will be treated in the sedimentation ponds. Effluent discharged from these ponds will contain suspended solids loadings that are similar to those occurring from the land in its present use. Sulfates and chlorides will undergo an increase in loading to the receiving streams as a result of the mining activities. Based on estimated effluent concentrations for this mine, chloride and sulfate will meet water quality standards in the receiving stream based on the mixing provided by my December 13, 2016 water quality memo.

Fate and Effect of Parameters Proposed for Increased Loading.

Suspended solids discharged will eventually be incorporated into bed sediments and will continue to move downstream. Sulfate and chloride will remain dissolved in the water and will move through the downstream continuum. Small amounts of these substances will be removed by organisms as these substances are necessary for life. No adverse impacts to the receiving streams will occur as all water quality standards will be met.

Purpose and Social & Economic Benefits of the Proposed Activity.

The disposal of excess water, including the water infiltrating the mine, will allow the mine to continue to operate. The Pond Creek Mine is expected to generate 5 - 6 million tons of useable coal annually. According to information given in a document dated November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit IL0077666, continued operation of the existing mine will continue to provide jobs for 203 employees with an annual payroll of approximately $18 million. In addition to these 203 direct employees, it is estimated that another 100 persons are employed in daily work associated with the Mine's production. This includes truck drivers, supply and support personnel, train crews, and technical personnel. In addition, other local businesses would also benefit from the wealth created by the mine. The operation of the mine provides tax revenues through payroll, coal severance, and mineral resource taxes for the surrounding counties and the State of Illinois. The total local, state, and federal revenues generated by the continuation of this Mine are approximately $78 million annually. Current employment statistics indicate that the unemployment rate for Williamson County was 7.5%.

Antidegradation Assessment for RDA #3
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Assessments of Alternatives for Less Increase in Loading or Minimal Environmental Degradation.

Alternatives to discharge through Outfall 009 have been evaluated by the mine company in a document dated November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit and are summarized as follows:

Chloride and Sulfate

Membrane Processes. Standard reverse osmosis (RO) treatment results in a waste stream of water with a high concentration of contaminants that is typically 25% of the flow being sent to the RO treatment system. The reject stream must still be disposed of in a responsible manner. Due to the disposal issue, the Membrane Process is not viable.

Deep Well Injection of the Entire Groundwater Stream. The untreated groundwater infiltrate could be discharged directly to a deep well. Considering the cost and operational difficulties experienced to date for the two wells that have been installed at the nearby Sugar Camp Coal facility to accept 0.45 MGD each, deep well injection of the untreated groundwater infiltrate is not considered either applicable or feasible for the operation of the Mine.

Discharge to POTW or Other Sources. POTWs are not designed to treat wastewaters containing dissolved substances such as chloride or sulfate. This option is not feasible.

No discharge. Given the climate of Williamson County, the mine company concludes that evaporation is not a viable option for disposal of the stormwater runoff mine effluent.

Mechanical Evaporation. Mechanical evaporation uses high temperatures and pressure to remove the water. The equipment is expensive to construct/install, operate, and maintain. Also, there would be materials to dispose of either in a landfill or in the Injection Wells that have been found to be unreliable for nearby mines. Therefore, this option is not considered either applicable or feasible for the operation of the mine.

Crystallizaton. Crystallization equipment is expensive to construct/install, operate and maintain. The cost is estimated at $0.25/gallon, the mine company concludes that crystallization is not a viable option for disposal of the stormwater runoff mine effluent.

Cost Effective Sulfate Removal (CESR) process. This is a proprietary technology that uses hydrated lime and proprietary chemicals to precipitate gypsum, metals and ettringite. Sludge would be produced that would require landfill disposal. The proprietary technology is still being developed. Additionally, this method is not proven to remove chlorides. These drawbacks make the CESR process infeasible for use at the coal mine.

Chemical Precipitation. Alkaline chemicals may be added to acid mine effluent to precipitate metals. The sludge produced must be disposed of and in some cases will contain hazardous materials added to the wastewater to attain precipitation. The additives used require mining in their own right. The water discharged may contain these additives, such as aluminum, in elevated concentrations. Additionally, this method is not proven to remove chlorides. These drawbacks make chemical precipitation infeasible.

Sedimentation/Siltation

Sedimentation. The facility is proposing to pump the groundwater infiltration to a Water Staging Cell where the water will have an opportunity for solids to settle out. The water will then be discharged to the Big Muddy River though the diffuser.

Use alternate sediment control and treatment devices. Alternatives to the use of sediment control ponds exist for control of discharge of settleable solids. Such alternatives include chemical soil stabilizers, erosion control blankets, geotextile filter bags, fiber rolls, silt fencing, straw mulch, straw bale dikes, and temporary seeding. These measures are aimed at minimization of the generation of settable solids. Most of these measures have been used previously during the construction and operations and in accordance with the current permit, as supplemental treatment and prevention of generation of settable solids. The use of alternative sediment control measures is considered practical and cost effective for the treatment and control of surface runoff in conjunction with sediment control ponds. However, the use of these practices to eliminate the proposed sediment control ponds is not feasible. Instead, it is being proposed that these BMPs be incorporated into the proposed alternative as needed.

No discharge. Given the climate of Williamson County, the mine company concludes that evaporation is not a viable option for disposal of the stormwater runoff mine effluent.

Filtration. Filtration is a technology that is not feasible for the proposed facility because: filtration is much more expensive than sediment ponds, filtration processes require a steady stream of water for treatment which is not the case in treating stormwater runoff, a large area of land would be required for such a facility, and maintenance and supervision of the filtration and sludge disposal operation would be burdensome and would increase production costs.

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Antidegradation Assessment for RDA #3
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Constructed Wetlands. Constructed wetlands have proven to be effective for treatment of suspended solids with several limitations. These limitations include; low and consistent rates of inflow, eventual sludge accumulation requiring dredging and wetland reconstruction, and release of hydrogen sulfide and other digestive gases into the atmosphere from sulfate digestion processes. Use of wetlands in mine stormwater runoff treatment would be limited by the enormous amount of land required to construct a wetland of sufficient size for the flow rates to be expected from such an operation.

Chemical Precipitation. Alkaline chemicals may be added to acid mine effluent to precipitate metals. The sludge produced must be disposed of and in some cases will contain hazardous materials added to the wastewater to attain precipitation. The additives used require mining in their own right. The water discharged may contain these additives, such as aluminum, in elevated concentrations. Concerns with the use of chemical precipitation at the proposed coal mine include; worker safety regarding the chemicals to be used, treatment costs, process operation and maintenance, disposal of precipitate sludge in a landfill, necessity of treatment considering that acid water is not considered a factor for the proposed operation, susceptibility to system malfunction due to high volume flows from storm events, and improbability of actual improvement in overall water quality when compared to the use of sediment ponds. These drawbacks make chemical precipitation infeasible.

Summary Comments of the Illinois Department of Natural Resources, Regional Planning Commissions, Zoning Boards or Other Entities

On November 2, 2016, the IDNR EcoCAT web-based tool was used and indicated that there were no aquatic endangered/threatened species present in the vicinity of the discharge. While the IDNR EcoCAT web-based tool did not terminate the consultation because of the nearby presence of Chuck-Will's-Willow (*Caprimulgus carolinensis*), future termination is likely.

Agency Conclusion.

This preliminary assessment was conducted pursuant to the Illinois Pollution Control Board regulation for Antidegradation found at 35 Ill. Adm. Code 302.105 (antidegradation standard) and was based on the information available to the Agency at the time the draft permit was written. We tentatively find that the proposed activity will result in the attainment of water quality standards; that all existing uses of the receiving stream will be maintained; that all technically and economically reasonable measures to avoid or minimize the extent of the proposed increase in pollutant loading have been incorporated into the proposed activity; and that this activity will benefit the community at large by allowing the continuation of coal mining with all of its economic benefits to the local economy. Comments received during the NPDES permit public notice period will be evaluated before a final decision is made by the Agency.

Antidegradation Assessment for Big Muddy River Mixing
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Williamson Energy, LLC operates the Pond Creek No. 1 Mine which is located in Williamson County. The mining complex contains an estimated 383.3 million tons of clean, recoverable coal reserves. Williamson Energy commenced construction of the Mine in 2005. The Mine has a life expectancy of more than 20 years. The mine has one operating longwall system. The Preparation Plant facilities are capable of processing 2,000 tons of coal per hour. The productive capacity of the mine is 5-6 million tons per year. Coal is shipped by rail, truck and barge (via railroad).

Williamson currently operates the mine under the existing Permit 375 and Permit 417 from the Illinois Department of Natural Resources, Office of Mines and Minerals (IDNR-OMM). The Mine currently discharges under NPDES Permits IL0077666.

The Pond Creek Mine has submitted an antidegradation report as part of the following NPDES permit activities:

- To respond to the over capacity of water on-site, a new outfall to the Big Muddy River is proposed. The outfall structure will be a multi-port diffuser and a mixing zone is being requested for the discharge; and
- The mine permit modification request includes the discharge of stormwater from stormwater ponds associated with the proposed Refuse Disposal Area No. 3 to Pond Creek. (Discussed under another antidegradation assessment.) A mixing zone is being requested for Pond Creek.

The mine uses water in two areas of operation; dust suppression during coal extraction and wash water in the preparation plant. The water used in the coal extraction process is fresh, untreated water purchased from the City of Johnston City and it not recoverable. The water used to wash the coal in the preparation plant comes from the fresh water lake. Over time, the fine solid particles present in the thickener underflow that is pumped to the Slurry Impoundment/RDA No. 3 settle to the bottom of the impoundment leaving clarified water on the surface. There is some loss of water during the washing process. Additionally, since the fines do not all settle immediately in the slurry impoundment, the quality of the clarified water results in a need for additional water for the preparation plant. Therefore, preparation plant water is supplemented with mine infiltration water and/or stormwater.

An aquifer above the coal seam causes an influx in water into the Mine. The infiltrating groundwater is from a saline aquifer, with a chloride content of approximately 1,099 to 2,799 mg/L. The sulfate ranges between 1,720 and 2,120 mg/L. Presently, the mine is removing 2.7 MGD of this high-chloride groundwater from the active mine. During normal coal processing operations, the preparation plant requires approximately 2.3 MGD. It is necessary to remove the water from the mine to protect the health and safety of the workforce, as well as, the overall mining operation.

Water will be stored in the Water Staging Cell and will be pumped to the Big Muddy River diffuser for mixing. An evaluation of the mixing zone will be reported in a separate memo.

The information in this antidegradation assessment came from the December 2014 NPDES Renewal #2 for Permit #IL0077666 report by Alliance Consulting, Inc. titled "Pond Creek Mine No. 1 & Refuse Disposal Area No. 3" and the anti-degradation assessment provided on November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit IL0077666

Identification and Characterization of the Affected Water Body.

The subject facility proposes to discharge to the Big Muddy River through Outfall 011 at a point where 37.0 cfs of flow exists upstream of the outfall during critical 7Q10 low-flow conditions. The Big Muddy River is classified as a General Use Water. The Big Muddy River is not listed as a biologically significant stream in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor is it given an integrity rating in that document. The Big Muddy River, Waterbody Segment, N-11, is listed on the draft 2016 Illinois Integrated Water Quality Report and Section 303(d) List as impaired for aquatic life use with potential causes given as iron (dissolved), dissolved oxygen (non-pollutant), sedimentation/siltation (non-pollutant), and total suspended solids; fish consumption use with potential causes given as mercury and polychlorinated biphenyls; and primary contact recreation use with potential cause given as fecal coliform. Aesthetic quality use is fully supported. This segment of the Big Muddy River is not subject to enhanced dissolved oxygen standards.

Identification of Proposed Pollutant Load Increases or Potential Impacts on Uses.

The constituents of concern are chloride, sulfates, manganese, iron, and total suspended solids. The chloride loading will range from 19,141 to 1,197,698 lbs/day at a concentration ranging from 1,699 to 12,000 mg/L. The sulfate loading will range from 9,720 to 476,031 lbs/day at a concentration ranging from 820 to 2,120 mg/L. The manganese loading will range from 33 to 336 lbs/day at a concentration ranging from 0.125 to 0.419 mg/L. The Iron (total) loading will range from 34 to 348 lbs/day at a concentration ranging from 0.216 to 1.835 mg/L. Iron (dissolved) is only a fraction of the Iron (total) and will meet the water quality standard at the end-of-pipe or at the edge of the mixing zone. The Nickel loading will range from 1 to 8 lbs/day at a concentration ranging from 0.004 to 0.014 mg/L. The Copper loading will range from 1 to 8 lbs/day at a concentration ranging from 0.011 to 0.32 mg/L. The TSS loading will range from 2,337 to 118,332 lbs/day at a concentration ranging from 7 to 70 mg/L.

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Antidegradation Assessment for Big Muddy River Mixing
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Fate and Effect of Parameters Proposed for Increased Loading.

Chloride and sulfates would remain dissolved in the water and would move through the downstream continuum. Manganese, iron, Nickel, Copper, and total suspended solids will most likely settle and become part of the bed sediment load in the river. A mixing zone in the Big Muddy River will be utilized to dissipate chloride and sulfate to water quality standard levels. A zone of initial dilution will be utilized to dissipate Copper to water quality standard levels. Small amounts of chloride and sulfates would be removed by organisms as these substances are necessary for life. Because of the near real-time continuous monitoring of upstream and downstream conditions in the receiving stream, and the ability of the permittee's diffuser to adjust to flow and background concentration conditions, discharges will always be into a waterbody that is below water quality standards and in concentrations and flow combinations that will not cause or contribute to an exceedance downstream of the mixing zone. No adverse impacts to streams would occur as all water quality standards are expected to be met in the receiving water.

Purpose and Social & Economic Benefits of the Proposed Activity.

The disposal of excess water, including the water infiltrating the mine, will allow the mine to continue to operate. The Pond Creek Mine is expected to generate 5 - 6 million tons of useable coal. According to information given in a document dated November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit IL0077666, continued operation of the existing mine will continue to provide jobs for 203 employees with an annual payroll of approximately $18 million. In addition to these 203 direct employees, it is estimated that another 100 persons are employed in daily work associated with the Mine's production. This includes truck drivers, supply and support personnel, train crews, and technical personnel. In addition, other local businesses would also benefit from the wealth created by the mine. The operation of the mine provides tax revenues through payroll, coal severance, and mineral resource taxes for the surrounding counties and the State of Illinois. The total local, state, and federal revenues generated by the continuation of this Mine are approximately $78 million annually. Current employment statistics indicate that the unemployment rate for Williamson County was 7.5%.

Assessments of Alternatives for Less Increase in Loading or Minimal Environmental Degradation.

Excess water is proposed to be discharged to the Big Muddy River. Alternatives to this system have been evaluated by the mine company in a document dated November 18, 2016 entitled Anti-degradation Assessment, Pond Creek No. 1 Mine, NPDES Permit and are summarized as follows:

Chloride and Sulfate

Membrane Processes. Standard reverse osmosis (RO) treatment results in a waste stream of water with a high concentration of contaminants that is typically 25% of the flow being sent to the RO treatment system. The reject stream must still be disposed of in a responsible manner. Due to the disposal issue, the Membrane Process is not viable.

Deep Well Injection of the Entire Groundwater Stream. The untreated groundwater infiltrate could be discharged directly to a deep well. Considering the cost and operational difficulties experienced to date for the two wells that have been installed at the nearby Sugar Camp Coal facility to accept 0.45 MGD each, deep well injection of the untreated groundwater infiltrate is not considered either applicable or feasible for the operation of the Mine.

Discharge to POTW or Other Sources. POTWs are not designed to treat wastewaters containing dissolved substances such as chloride or sulfate. This option is not feasible.

No discharge. Given the climate of Williamson County, the mine company concludes that evaporation is not a viable option for disposal of the stormwater runoff mine effluent.

Mechanical Evaporation. Mechanical evaporation uses high temperatures and pressure to remove the water. The equipment is expensive to construct/install, operate, and maintain. Also, there would be materials to dispose of either in a landfill or in the Injection Wells that have been found to be unreliable for nearby mines. Therefore, this option is not considered either applicable or feasible for the operation of the mine.

Crystallizaton. Crystallization equipment is expensive to construct/install, operate and maintain. The cost is estimated at $0.25/gallon, the mine company concludes that crystallization is not a viable option for disposal of the stormwater runoff mine effluent.

Cost Effective Sulfate Removal (CESR) process. This is a proprietary technology that uses hydrated lime and proprietary chemicals to precipitate gypsum, metals and ettringite. Sludge would be produced that would require landfill disposal. The proprietary technology is still being developed. Additionally, this method is not proven to remove chlorides. These drawbacks make the CESR process infeasible for use at the coal mine.

Antidegradation Assessment for Big Muddy River Mixing
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Chemical Precipitation. Alkaline chemicals may be added to acid mine effluent to precipitate metals. The sludge produced must be disposed of and in some cases will contain hazardous materials added to the wastewater to attain precipitation. The additives used require mining in their own right. The water discharged may contain these additives, such as aluminum, in elevated concentrations. Additionally, this method is not proven to remove chlorides. These drawbacks make chemical precipitation infeasible.

Sedimentation/Siltation

Sedimentation. The facility is proposing to pump the groundwater infiltration to a Water Staging Cell where the water will have an opportunity for solids to settle out. The water will then be discharged to the Big Muddy River though the diffuser.

Use alternate sediment control and treatment devices. Alternatives to the use of sediment control ponds exist for control of discharge of settleable solids. Such alternatives include chemical soil stabilizers, erosion control blankets, geotextile filter bags, fiber rolls, silt fencing, straw mulch, straw bale dikes, and temporary seeding. These measures are aimed at minimization of the generation of settable solids. Most of these measures have been used previously during the construction and operations and in accordance with the current permit, as supplemental treatment and prevention of generation of settable solids. The use of alternative sediment control measures is considered practical and cost effective for the treatment and control of surface runoff in conjunction with sediment control ponds. However, the use of these practices to eliminate the proposed sediment control ponds is not feasible. Instead, it is being proposed that these BMPs be incorporated into the proposed alternative as needed.

No discharge. Given the climate of Williamson County, the mine company concludes that evaporation is not a viable option for disposal of the stormwater runoff mine effluent.

Filtration. Filtration is a technology that is not feasible for the proposed facility because: filtration is much more expensive than sediment ponds, filtration processes require a steady stream of water for treatment which is not the case in treating stormwater runoff, a large area of land would be required for such a facility, and maintenance and supervision of the filtration and sludge disposal operation would be burdensome and would increase production costs.

Constructed Wetlands. Constructed wetlands have proven to be effective for treatment of suspended solids with several limitations. These limitations include; low and consistent rates of inflow, eventual sludge accumulation requiring dredging and wetland reconstruction, and release of hydrogen sulfide and other digestive gases into the atmosphere from sulfate digestion processes. Use of wetlands in mine stormwater runoff treatment would be limited by the enormous amount of land required to construct a wetland of sufficient size for the flow rates to be expected from such an operation.

Chemical Precipitation. Alkaline chemicals may be added to acid mine effluent to precipitate metals. The sludge produced must be disposed of and in some cases will contain hazardous materials added to the wastewater to attain precipitation. The additives used require mining in their own right. The water discharged may contain these additives, such as aluminum, in elevated concentrations. Concerns with the use of chemical precipitation at the proposed coal mine include; worker safety regarding the chemicals to be used, treatment costs, process operation and maintenance, disposal of precipitate sludge in a landfill, necessity of treatment considering that acid water is not considered a factor for the proposed operation, susceptibility to system malfunction due to high volume flows from storm events, and improbability of actual improvement in overall water quality when compared to the use of sediment ponds. These drawbacks make chemical precipitation infeasible.

Summary Comments of the Illinois Department of Natural Resources, Regional Planning Commissions, Zoning Boards or Other Entities.

On November 2, 2016, the IDNR EcoCAT web-based tool was used and indicated that there were no aquatic endangered/threatened species present in the vicinity of the discharge. While the IDNR EcoCAT web-based tool did not terminate the consultation because of the nearby presence of Chuck-Will's-Willow (*Caprimulgus carolinensis*), future termination is likely.

Agency Conclusion.

This preliminary assessment was conducted pursuant to the Illinois Pollution Control Board regulation for Antidegradation found at 35 Ill. Adm. Code 302.105 (antidegradation standard) and was based on the information available to the Agency at the time the draft permit was written. We tentatively find that the proposed activity will result in the attainment of water quality standards; that all existing uses of the receiving stream will be maintained; that all technically and economically reasonable measures to avoid or minimize the extent of the proposed increase in pollutant loading have been incorporated into the proposed activity; and that this activity will benefit the community at large by allowing the continuation of coal mining with all of its economic benefits to the local economy. Comments received during the NPDES permit public notice period will be evaluated before a final decision is made by the Agency.

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Antidegradation Assessment for RDA #3 (Supplemental Information)
Williamson Energy, LLC
Pond Creek Mine
NPDES Permit No. IL0077666
Williamson County

Pond 009 has an emergency discharge via Outfall 009ES. During normal operations, Pond 009 will discharge directly to Pond Creek via Outfall 009 and has provisions for allowed mixing. Outfall 009ES is not expected to have a discharge, except during an emergency.

Identification and Characterization of the Affected Water Body.

The subject facility discharges to an unnamed tributary of Pond Creek through Outfall 009ES at a point where 0 cfs of flow exists upstream of the outfalls during critical 7Q10 low-flow conditions. The unnamed tributary of Pond Creek is classified as a General Use Water. The unnamed tributary of Pond Creek is not listed as a biologically significant streams in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor is it given an integrity rating in that document. The unnamed tributary of Pond Creek, tributary to Waterbody Segment, NG-02, is not listed on the draft 2016 Illinois Integrated Water Quality Report and Section 303(d) List since it has not been assessed. The unnamed tributary of Pond Creek is not subject to enhanced dissolved oxygen standards.

Agency Conclusion.

Upon completing the assessment, it has been determined that the proposed activity will result in only short-term, temporary increases in pollutant loading and will not result in long term or permanent impacts to existing uses including aquatic life habitat; therefore, we find that it is subject to Subsection (d) "Activities Not Subject to a Further Antidegradation Assessment" of 35 Ill. Adm. Code 302.105.

NPDES Permit No. IL0077666

Illinois Environmental Protection Agency

Division of Water Pollution Control

1021 North Grand Avenue, East

P.O. Box 19276

Springfield, Illinois 62794-9276

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

Renewed NPDES Permit

Expiration Date:

Issue Date:
Effective Date:

Name and Address of Permittee:

Williamson Energy, LLC
P.O. Box 300
Johnston City, Illinois 62951

Facilty Name and Address:

Williamson Energy, LLC
Pond Creek Mine
4 miles east of Johnston City, Illinois
(Williamson and Franklin Counties)

Discharge Number and Classification:		Receiving waters
001, 002, 003, 004, 005	Alkaline Mine Drainage	Unnamed tributary to Pond Creek
006, 007, 008	Acid Mine Drainage	Unnamed tributary to Pond Creek
009	Alkaline Mine Drainage	Pond Creek
009ES	Alkaline Mine Drainage	Unnamed tributary to Pond Creek
011	Alkaline Mine Drainage	Big Muddy River

In compliance with the provisions of the Illinois Environmental Protection Act, Subtitle C and/or Subtitle D Rules and Regulations of the Illinois Pollution Control Board, and the Clean Water Act, the above-named permittee is hereby authorized to discharge at the above location to the above-named receiving stream in accordance with the standard conditions and attachments herein.

Permittee is not authorized to discharge after the above expiration date. In order to receive authorization to discharge beyond the expiration date, the permittee shall submit the proper application as required by the Illinois Environmental Protection Agency (IEPA) not later than 180 days prior to the expiration date.

Darin E. LeCrone, P.E.
Manager, Industrial Unit, Permit Section
Division of Water Pollution Control

DEL:IKW:cs/7516c/06-19-19

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NPDES Permit No. IL0077666

Effluent Limitations and Monitoring

From the effective date of this Permit until the expiration date, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfalls*: 001, 002, 003, 004, 005 (Alkaline Mine Drainage)

Discharge Condition	Parameters											
	Total Suspended Solids (mg/L) ***		Iron (total) (mg/L) ***		pH** (S.U.) ***	Alkalinity/ Acidity ***	Sulfate (mg/L) ***	Chloride (mg/L) ***	Cadmium (Cd) (mg/l)	Hardness ***	Flow (MGD)	Settleable Solids (ml/l)
	30 day average	daily maximum	30 day average	daily maximum								
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 5.21 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

Sampling during all Discharge Conditions shall be performed utilizing the grab sampling method.

*** There shall be a minimum of nine (9) samples collected during the quarter when the pond is discharging. Of these 9 samples, a minimum of one sample each month shall be taken during either Discharge Condition I or IV should such discharge condition occur. A "no flow" situation is not considered to be a sample of the discharge. In the event that Discharge Conditions II and/or III occur, grab sample of each discharge caused by the above precipitation events (Discharge Conditions II and/or III) shall be taken and analyzed for the parameters identified in the table above during at least 3 separate events each quarter. For quarters in which there are less than 3 such precipitation events resulting in discharges, a grab sample of the discharge shall be required whenever such precipitation event(s) occur(s). Should a sufficient number of discharge events occur during the quarter, the remaining three (3) quarterly samples may be taken during any of the Discharge Conditions described above.

The water quality standards for sulfate and chloride must be met in discharges from the above referenced outfall as well as in the receiving stream.

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* The Permittee is subject to the limitations, monitoring, and reporting requirements of Special Condition No. 13 for the discharges from Outfalls 001, 002, 003, 004 and 005 and unnamed tributary of Pond Creek receiving such discharges.

** No discharge is allowed from any above referenced permitted outfall during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

NPDES Permit No. IL0077666

Effluent Limitations and Monitoring

From the effective date of this Permit until the expiration date, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfalls*: 006, 007 (Acid Mine Drainage)

Discharge Condition	Parameters												
	Total Suspended Solids (mg/L) ***		Iron (total) (mg/L) ***		pH** (S.U.) ***	Alkalinity/ Acidity ***	Sulfate (mg/L) ***	Chloride (mg/L) ***	Cadmium (Cd) (mg/l) ***	Mn (total) (mg/L) ***	Hardness ***	Flow (MGD)	Settleable Solids (ml/l)
	30 day average	daily maximum	30 day average	daily maximum									
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	1.0	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	0.0144	1.0	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(b), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 1-year, 24-hour precipitation event, but less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 1-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 5.21 inches.

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

Sampling during all Discharge Conditions shall be performed utilizing the grab sampling method.

*** There shall be a minimum of nine (9) samples collected during the quarter when the pond is discharging. Of these 9 samples, a minimum of one sample each month shall be taken during either Discharge Condition I or IV should such discharge condition occur. A "no flow" situation is not considered to be a sample of the discharge. In the event that Discharge Conditions II and/or III occur, grab sample of each discharge caused by the above precipitation events (Discharge Conditions II and/or III) shall be taken and analyzed for the parameters identified in the table above during at least 3 separate events each quarter. For quarters in which there are less than 3 such precipitation events resulting in discharges, a grab sample of the discharge shall be required whenever such precipitation event(s) occur(s). Should a sufficient number of discharge events occur during the quarter, the remaining three (3) quarterly samples may be taken during any of the Discharge Conditions described above.

The water quality standards for sulfate and chloride must be met in discharges from the above referenced outfall as well as in the receiving stream.

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* The Permittee is subject to the limitations, monitoring, and reporting requirements of Special Condition No. 13 for the discharges from Outfalls 006 and 007 and unnamed tributary of Pond Creek receiving such discharges. Also, discharges from Outfalls 006 and 007 shall be subject to the limitations, monitoring, and reporting requirements of Special Condition No. 18.

** No discharge is allowed from any above referenced permitted outfall during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

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NPDES Permit No. IL0077666

Effluent Limitations and Monitoring

From the effective date of this Permit until the expiration date, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfall*: 008 (Acid Mine Drainage)

Discharge Condition	Parameters											
	Total Suspended Solids (mg/L) ***		Iron (total) (mg/L) ***		pH** (S.U.) ***	Alkalinity/ Acidity ***	Sulfate (mg/L) ***	Chloride (mg/L) ***	Mn (total) (mg/L) ***	Hardness ***	Flow (MGD)	Settleable Solids (ml/l)
	30 day average	daily maximum	30 day average	daily maximum								
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	1.0	Monitor only	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	Monitor only	Measure When Sampling	-
IV	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	1.0	Monitor only	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(b), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 1-year, 24-hour precipitation event, but less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 1-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 5.21 inches.

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

Sampling during all Discharge Conditions shall be performed utilizing the grab sampling method.

*** There shall be a minimum of nine (9) samples collected during the quarter when the pond is discharging. Of these 9 samples, a minimum of one sample each month shall be taken during either Discharge Condition I or IV should such discharge condition occur. A "no flow" situation is not considered to be a sample of the discharge. In the event that Discharge Conditions II and/or III occur, grab sample of each discharge caused by the above precipitation events (Discharge Conditions II and/or III) shall be taken and analyzed for the parameters identified in the table above during at least 3 separate events each quarter. For quarters in which there are less than 3 such precipitation events resulting in discharges, a grab sample of the discharge shall be required whenever such precipitation event(s) occur(s). Should a sufficient number of discharge events occur during the quarter, the remaining three (3) quarterly samples may be taken during any of the Discharge Conditions described above.

The water quality standards for sulfate and chloride must be met in discharges from the above referenced outfall as well as in the receiving stream.

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* The Permittee is subject to the limitations, monitoring, and reporting requirements of Special Condition No. 13 for the discharges from Outfalls 008 and unnamed tributary of Pond Creek receiving such discharges. Also, discharges from Outfalls 008 and 009ES shall be subject to the limitations, monitoring, and reporting requirements of Special Condition No. 18.

** No discharge is allowed from any above referenced permitted outfall during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

NPDES Permit No. IL000077666

Effluent Limitations and Monitoring

From the effective date of this Permit until the expiration date, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfall*: 009 (Alkaline Mine Drainage)

Discharge Condition	Parameters													
	Total Suspended Solids (mg/L) ***		Iron (total) (mg/L) ***		pH** (S.U.) ***	Alkalinity/ Acidity ***	Sulfate (mg/L) ***	Chloride (mg/L) ***	Mn (total) (mg/L) ***		Hardness ***	Copper (Cu) ***	Flow (MGD)	Settleable Solids (ml/l)
	30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum				
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	See Special Condition No. 14	-	-	Monitor only	-	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	See Special Condition No. 14	-	-	Monitor only	-	Measure When Sampling	-
IV	35	70	3.0	6.0	6.0-9.0	Alk.>Acid	1250	See Special Condition No. 14	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall at times of "low flow" or "no flow" conditions in the receiving stream are subject to Special Condition No. 14.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. At such time that receiving stream flow subsides to the degree that the mixing ratio specified in Special Condition No. 14 is not available, monitoring requirements and permit limitations shall revert to Discharge Condition I.

Sampling during all Discharge Conditions shall be performed utilizing the grab sampling method.

*** There shall be a minimum of nine (9) samples collected during the quarter when the pond is discharging. Of these 9 samples, a minimum of one sample each month shall be taken during either Discharge Condition I or IV should such discharge condition occur. A "no flow" situation is not considered to be a sample of the discharge. In the event that Discharge Conditions II and/or III occur, grab sample of each discharge caused by the above precipitation events (Discharge Conditions II and/or III) shall be taken and analyzed for the parameters identified in the table above during at least 3 separate events each quarter. For quarters in which there are less than 3 such precipitation events resulting in discharges, a grab sample of the discharge shall be required whenever such precipitation event(s) occur(s). Should a sufficient number of discharge events occur during the quarter, the remaining three (3) quarterly samples may be taken during any of the Discharge Conditions described above.

Discharges from the above referenced outfall that are subject to the requirements of Discharge Conditions II, III and/or IV must meet the water quality standards for sulfate and chloride in the receiving stream.

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* The Permittee is subject to the limitations, monitoring, and reporting requirements of Special Condition No. 14 for the discharges from Outfall 009 and Pond Creek receiving such discharges. Also, discharges from Outfall 009 shall be subject to the limitations, monitoring and reporting requirements of Special Condition No. 18.

** No discharge is allowed from any above referenced permitted outfall during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

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NPDES Permit No. IL000077666

Effluent Limitations and Monitoring

From the effective date of this Permit until the expiration date, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfall*: 009ES (Alkaline Mine Drainage)

Discharge Condition	Parameters													
	Total Suspended Solids (mg/L) ***		Iron (total) (mg/L) ***		pH** (S.U.) ***	Alkalinity/ Acidity ***	Sulfate (mg/L) ***	Chloride (mg/L) ***	Mn (total) (mg/L) ***		Hardness ***	Copper (Cu) ***	Flow (MGD)	Settleable Solids (ml/l)
	30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum				
I	35	70	3.0	6.0	6.5-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-
II	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	-	Measure When Sampling	0.5
III	-	-	-	-	6.0-9.0	-	1250	500	-	-	Monitor only	-	Measure When Sampling	-
IV	35	70	3.0	6.0	6.0-9.0	Alk.>Acid	1250	500	2.0	4.0	Monitor only	0.0245	Measure When Sampling	-

I Dry weather discharge (base flow or mine pumpage) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.110(a), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b). The 10-year, 24-hour precipitation event for this area is considered to be 2.97 inches.

III In accordance with 35 Ill. Adm. Code 406.110(d), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.106(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For outfalls which have no allowed mixing, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

Sampling during all Discharge Conditions shall be performed utilizing the grab sampling method.

*** There shall be a minimum of nine (9) samples collected during the quarter when the pond is discharging. Of these 9 samples, a minimum of one sample each month shall be taken during either Discharge Condition I or IV should such discharge condition occur. A "no flow" situation is not considered to be a sample of the discharge. In the event that Discharge Conditions II and/or III occur, grab sample of each discharge caused by the above precipitation events (Discharge Conditions II and/or III) shall be taken and analyzed for the parameters identified in the table above during at least 3 separate events each quarter. For quarters in which there are less than 3 such precipitation events resulting in discharges, a grab sample of the discharge shall be required whenever such precipitation event(s) occur(s). Should a sufficient number of discharge events occur during the quarter, the remaining three (3) quarterly samples may be taken during any of the Discharge Conditions described above.

The water quality standards for sulfate and chloride must be met in discharges from the above referenced outfall as well as in the receiving stream.

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* The Permittee is subject to the limitations, monitoring, and reporting requirements of Special Condition No. 14 for the discharges from Outfall 009ES and Pond Creek receiving such discharges. Also, discharges from Outfall 009ES shall be subject to the limitations, monitoring and reporting requirements of Special Condition No. 18.

** No discharge is allowed from any above referenced permitted outfall during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

NPDES Permit No. IL0077666

Effluent Limitations and Monitoring

From the effective date of this Permit until the expiration date, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfall*: 011* (Alkaline Mine Drainage)

Parameters														
Total Suspended Solids (mg/l)		Iron (total) (mg/l)		pH** (S.U.)	Alkalinity/ Acidity	Sulfate (mg/l)	Chloride (mg/l)	Mn (total) (mg/l)		Hardness	Nickel (mg/L)	Copper (mg/L)	Flow (MGD)	Iron (Dissolved)
30 day average	daily maximum	30 day average	daily maximum					30 day average	daily maximum					
35	70	3.0	6.0	6.5-9.0	Alk.>Acid	See Special Condition No. 16	See Special Condition No. 16	2.0	4.0	Monitor only	See Special Condition No. 16	See Special Condition No. 16	Measure When Sampling	See Special Condition No. 16

All sampling shall be performed utilizing the grab sampling method.

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* Operation and management of pumpage to Outfall 011 is subject to the requirements of Special Condition No. 16. Also, discharges from Outfall 011 shall be subject to the limitations, monitoring, and reporting requirements of Special Condition No. 18.

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NPDES Permit No. IL0077666

Effluent Limitations and Monitoring

Upon completion of Special Condition 10 and approval from the Agency, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfalls*: 001, 002, 003, 004, 005, 006, 007, 008, 009, 009ES (Reclamation Area Drainage)

Discharge Condition	Parameters					
	pH** (S.U.) ***	Sulfate (mg/L) ***	Chloride (mg/L) ***	Hardness ***	Flow (MGD)	Settleable Solids (ml/l) ***
I	6.5-9.0	1250	500	Monitor only	Measure When Sampling	0.5
II	6.0-9.0	1250	500	Monitor only	Measure When Sampling	0.5
III	6.0-9.0	1250	500	Monitor only	Measure When Sampling	-
IV	6.5-9.0	1250	500	Monitor only	Measure When Sampling	0.5

I Dry weather discharge (base flow, if present) from the outfall.

II In accordance with 35 Ill. Adm. Code 406.109(b), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations. The 10-year, 24-hour precipitation event for this area is considered to be 5.21 inches.

III In accordance with 35 Ill. Adm. Code 406.109(c), any discharge or increase in the volume of a discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) shall comply with the indicated limitations instead of those in 35 Ill. Adm. Code 406.109(b).

IV Discharges continuing 24 hours after cessation of precipitation event that resulted in discharge. For reclamation area discharges, monitoring requirements and permit limitations of Discharge Condition IV are identical to Discharge Condition I to which the outfall discharge has reverted.

Sampling during all Discharge Conditions shall be performed utilizing the grab sampling method. A "no flow" situation is not considered to be a sample of the discharge.

*** One sample per month (1/month) shall be collected if and/or when a discharge occurs under either Discharge Condition I, II or IV and analyzed for the parameters identified in the table above. In addition, at least three (3) grab samples shall be taken each quarter from separate precipitation events under Discharge Condition III and analyzed for parameters indicated in the above table. For quarters in which there are less than 3 such precipitation events, a grab sample of the discharge shall be required whenever such precipitation event(s) occur(s).

The water quality standards for sulfate and chloride must be met in discharges from the above referenced outfall as well as in the receiving stream.

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* The Permittee is subject to the limitations, monitoring, and reporting requirements of Special Condition Nos. 13 and 15 for the discharges from Outfalls 001, 002, 003, 004, 005, 006, 007, 008 and 009ES and unnamed tributary to Pond Creek and Outfall 009 tributary to Pond Creek receiving such discharges.

** No discharge is allowed from any above referenced permitted outfall during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

NPDES Permit No. IL0077666

Effluent Limitations and Monitoring

Upon completion of Special Condition No. 11 and approval from the Agency, the effluent of the following discharge shall be monitored and limited at all times as follows:

Outfalls: 001, 002, 003, 004, 05, 006, 007, 008, 009, 009ES (Stormwater Discharge)

Parameters	
pH* (S.U.) **	Settleable Solids (ml/l) **
6.0-9.0	0.5

Stormwater discharge monitoring is subject to the following reporting requirements:

Analysis of samples must be submitted with second quarter Discharge Monitoring Reports.

If discharges can be shown to be similar, a plan may be submitted by November 1 of each year preceding sampling to propose grouping of similar discharges and/or updated previously submitted groupings. If updating of a previously submitted plan is not necessary, a written notification to the Agency, indicating such is required. Upon approval from the Agency, one representative sample for each group may be submitted.

Annual stormwater monitoring is required for all discharges until Final SMCRA Bond is released and approval to cease such monitoring is obtained from the Agency.

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* No discharge is allowed from any above referenced permitted outfalls during "low flow" or "no flow" conditions in the receiving stream unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.204 for pH.

** One (1) sample per year shall be collected and analyzed for the indicated parameter; however, such sampling and analysis is required only if and/or when a discharge occurs from the individual Outfall(s) identified above.

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PUBLIC NOTICE

NPDES Permit No. IL0077666

Construction Authorization No. 3117-15

Authorization is hereby granted to the above designee to construct and operate the mine and mine refuse area described as follows:

Surface facilities in support of an underground mine containing a total of 986.10 acres, also identified as IDNR/OMM Permit Nos. 375 417 and 456, located in Sections 2, 3, 4, 7, 8, 9, 10, 12, 14, 15, 16, 17, 18 and 29, Township 8 South, Range 4 East, and Sections 11, 12, 13, 35, 36, Township 8 South, Range 3 East, Williamson County, 3rd P.M., Illinois, and Sections 1, 2 and 12, Township 8 South, Range 2 East, and Sections 7, 8, 9, 11, 14, 15, 16, and 17, Township 8 South, Range 3 East, and Sections 27, 28, 29, 30, 31, 32, 34 and 35, Township 7 South, Range 2 East, Franklin County , 3rd P.M., Illinois.

The surface facilities at this site contain drainage control structures (ditches) and nine (9) sediment basins, incline slope, coal preparation plant, coal stockpiles, refuse disposal areas, coal conveyors, railroad loop, ventilation shafts, parking areas, access roads, and office and maintenance buildings. The following additional areas are being added to the original facilities approved for this operation.

An additional area of 4.05 acres, identified as IBR No. 4 to OMM Permit No. 375, located in Section 12, Township 8 South, Range 3 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log Nos. 2416-06 and 2416-06-A, installation of three (3) boreholes and associated pipeline to ensure mine ventilation is approved. Runoff from the area approved herein should be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 9.71 acres, identified as IBR No. 5 to OMM Permit No. 375, located in Section 13, Township 8 South, Range 3 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log Nos. 2380-06 and 2380-06-A, installation of the support facilities to ensure mine ventilation is approved. Runoff from the area approved herein should be controlled by two temporary catch basins, silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 3.20 acres, identified as IBR No. 10 to OMM Permit No. 375, located in Section 8, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log Nos. 1396-07 and 1396-07-A, installation of two (2) boreholes and a vertical pump to ensure mine ventilation is approved. Runoff from the area approved herein should be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 12.50 acres, identified as IBR No. 11 to OMM Permit No. 375, located in Sections 4, 7 and 8, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log Nos. 1525-07 and 1525-07-A, this area is incorporated for the installation of the water line from the Locust Grove Shaft area to Pond 006. Runoff from the area approved herein should be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 0.36 acres, identified as IBR to OMM Permit No. 375, located in Sections 11 and 12, Township 8 South, Range 3 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log Nos. 0190-08 and 0190-08-A, re-alignment of access road is approved. Runoff from the area approved herein should be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc

An additional area of 3.57 acres, identified as IBR No. 14 to OMM Permit No. 375, located in Section 9, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 0369-08, two (2) boreholes will be drilled and a vertical pump will be installed to ensure mine ventilation. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 8.1 acres, identified as IBR No. 25 to OMM Permit No. 375, located in Sections 9 and 10, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 8091-10, two (2) concrete transport boreholes and access road will be constructed and a turbine pump, buried waterline and power line will be installed. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 2.13 acres, identified as IBR No. 55 to OMM Permit No. 375, located in Section 9 and 16, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 5530-13 a buried pump discharge pipeline and electrical power line will be installed. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 4.18 acres, identified as IBR No. 52 to OMM Permit No. 375, located in Section 15, Township 8 South, Range 4 East, Williamson County, Illinois. As proposed and depicted in IEPA Log No. 5168-13, this area is being incorporated for the construction of an underground mine support facility including a borehole and installation of an electric vertical turbine pump. The area will also include a buried pipeline and electric power line. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 3.3 acres, identified as IBR No. 57 to OMM Permit No. 375, located in Section 18, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 4088-14, two (2) boreholes will be constructed and a pump and waterline will be installed to pump underground mine pumpage to an existing waterline along Jordan Fort Road. Topsoil stockpiles will also be located with the IBR area. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 3.3 acres, identified as IBR No. 58 to OMM Permit No. 375, located in Sections 8 and 17, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 5477-13, two (2) boreholes will be constructed and a pump and waterline will be installed to pump underground mine water and to ensure underground ventilation. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 9.89 acres, identified as IBR No. 60 to OMM Permit No. 375, located in Section 13, Township 8 South, Range 3 East, Williamson County, Illinois. As proposed and depicted in IEPA Log No. 4237-14, this area is for the development of topsoil and subsoil storage areas and construction of associated drainage ditches. Two (2) drainage ditches, identified as Collection Ditch Nos. D-5E-1 and D-5D-1, directs runoff from this area to existing Ditch D-5c and Pond 005.

An additional area of 1.0 acres, identified as IBR No. 78 to OMM Permit No. 375, located in Section 13, Township 8 South, Range 3 East, and Sections 7 and 18, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 9082-19, this area is incorporated into this permit for a buried four-inch waterline to be installed. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 19.9 acres, identified as IBR No. 79 to OMM Permit No. 375, located in Sections 35 and 36, Township 7 South, Range 3 East, in Franklin County, Illinois. As proposed and depicted in IEPA Log No. 9083-19, this area is incorporated into this permit for installation of a supply shaft to transport supplies underground as required for the continued effective operation of approved mine plan, belt air shaft and fan to supply required ventilation along with six (6) steel cased boreholes with a diameter less ten 10 5/8 inches for power and other supplies, power substation, dry storage barn and equipment yard. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

An additional area of 17.01 acres, identified as IBR No. 83 to OMM Permit No. 375, located in Sections 2, 3, 9 and 10, Township 8 South, Range 4 East, in Williamson County, Illinois. As proposed and depicted in IEPA Log No. 9109-19, this area is incorporated into this permit for a access roadway, one 16.5 foot bleeder shaft, utility boreholes, concrete pad for transformer, a compressor station and a portable crib plant. Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

As described in IEPA Log No. 7395-11 and previously approved under Subtitle D Permit No. 2012-MA-7395-1, a permit area consisting of 9.82 acres located in Section 10, Township 8 South, Range 4 East, Williamson County, is incorporated into this permit for the construction of compressor bore hole, installation of a buried power line and an access road. All runoff from this area shall be monitored in accordance with stormwater monitoring requirements of Special Condition No. 11 of this NPDES Permit. This additional area is included in the total permit acreage cited above.

As described in IEPA Log No. 6141-12 and previously approved under Subtitle D Permit No. 2012-MA-6141-1, a permit area consisting of 0.64 acres located in Section 13, Township 8 South, Range 3 East, Williamson County, is incorporated into this permit for the construction of borehole for the batch material supply of crushed stone and concrete to the underground mine. All runoff from this area shall be monitored in accordance with stormwater monitoring requirements of Special Condition No. 11 of this NPDES Permit. This additional area is included in the total permit acreage cited above.

As described in IEPA Log No. 6562-12 and previously approved under Subtitle D Permit No. 2013-MA-6562, a permit area consisting of 3.81 acres located in Section 16, Township 8 South, Range 4 East, Williamson County, is incorporated into this permit for the construction of a steel-liner drill hole and temporary installation of a pumpable cement product mixing plant used for underground mine. All runoff from this area shall be monitored in accordance with stormwater monitoring requirements of Special Condition No. 11 of this NPDES Permit. This additional area is included in the total permit acreage cited above.

As described in IEPA Log No. 6039-12 and previously approved under Subtitle D Permit No. 2015-MA-6039, a permit area consisting of 4.65 acres located in Section 14, Township 8 South, Range 4 East, Williamson County, is incorporated into this permit for installation of ventilation shaft site. All runoff from this area shall be monitored in accordance with stormwater monitoring requirements of Special Condition No. 11 of this NPDES Permit. This additional area is included in the total permit acreage cited above.

As described in IEPA Log No. 2273-16 and previously approved under Subtitle D Permit No. 2016-MA-2273, a permit area consisting of 6.5 acres located in Section 29, Township 8 South, Range 4 East, Williamson County, is incorporated into this permit for the construction of a concrete lined South District Supply Shaft to provide supplies to underground workings, three (3) boreholes, a pole barn and an access road. All runoff from this area shall be monitored in accordance with stormwater monitoring requirements of Special Condition No. 11 of this NPDES Permit. This additional area is included in the total permit acreage cited above.

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PUBLIC NOTICE

As previously approved under Subtitle D Permit No. 2014-MW-4275, a fine coal refuse (slurry) disposal area incorporating the use of geotextile tubes was developed at Pond Creek Mine site. As described and depicted in IEPA Log Nos. 4275-14, 4275-14-A, 4275-14-B, 1475-14-C development of this area included construction of a low permeability liner consisting of four (4) foot compacted clay with a hydraulic conductivity of 1 x 10^{-7} cm/sec, or less. Surface runoff and dewatering of the geotextile tubes is collected in a "no-discharge" perimeter containment basin and pumped to existing refuse disposal area or coal preparation plant. Hereby incorporated into this permit is a modification of the drainage control plan to allow stormwater runoff from the area to discharge through sediment ditches and spillway into existing Ditch D-5C and through Pond No. 005, as described and depicted in IEPA Log No. 3117-15. Reclamation of the geotextile tube refuse disposal area shell consists of construction of a low permeability cap consisting of four (4) foot compacted clay with hydraulic conductivity of 1x10^{-7}cm/sec, or less. Rooting medium and topsoil required for establishment of vegetative cover shall be in addition to the four (4) foot compacted clay low permeability cap. Four (4) monitoring wells identified as Well Nos. GW-29, GW-30, GW-31 and GW-32 shall be installed at each corner of the geotextile tube placement area. Groundwater monitoring shall be performed in accordance with Special Condition No. 12.

As described in IEPA Log Nos.1186-17, 1186-17-Band 1385-17, and previously approved under Subtitle D Permit No. 2017-MA-1186-1, a permit area consisting of 17.7 acres located in Section 12, Township 8 South, Range 3 East, Williamson County, is incorporated into this permit for construction of a Water Management Facility consisting of three (3) water holding cells. Construction and development of the water Management facility includes topsoil removal, grading, foundation preparation and installation of a low permeability liner consisting of four (4) foot compacted clay liner with a hydraulic conductivity of 1 x 10^{-7} cm/sec within the water holding cells. Compacted clay liner shall also be subject to and in accordance with the specifications and testing requirements of Condition No. 12. All runoff from this area shall be monitored in accordance with stormwater monitoring requirements of Special Condition No. 11 of this NPDES Permit. This additional area is included in the total permit acreage cited above. Four (4) monitoring wells identified as Well Nos. GW-33, GW-34, GW-35 and GW-36 shall be installed as depicted in IEPA Log Nos. 1186-17, 1186-17-B and 1385-17 Groundwater monitoring shall be performed in accordance with Special Condition No.13. This additional area is included in the total permit acreage cited above.

The following mining operations plan changes are incorporated into this permit:

Log No. 2413-06	The Mining Operations Plan has been revised to include the construction of an access tunnel under the railroad loop and administration building.
Log No. 2414-06	The Mine Operations Map has been revised to depict the revised various structures within the support facility.
Log No. 0371-08	Installation of a concrete sump at the existing road tunnel and a pipeline which will discharge to Sediment Pond No. 003, identified as IPR No. 13 to OMM Permit No. 375.

Surface drainage control is provided by eleven (11) sedimentation ponds with discharges designated as 001, 002, 003, 004, 005, 009, 09ES and 011 classified as alkaline mine drainage, and Outfalls 006, 007, 008 classified as acid mine discharge. The sanitary wastewater water treatment system will be approved by the Illinois Department of Public Health.

The location and receiving stream of the Outfalls at this facility is as follows:

Outfall No.	Latitude			Longitude			Receiving Water
	DEG	MIN	SEC	DEG	MIN	SEC	
001	37°	50'	59.2"	88°	49'	37.5"	Unnamed tributary to Pond Creek
002	37°	50'	26.0"	88°	49'	51.5"	Unnamed tributary to Pond Creek
003	37°	50'	26.0"	88°	49'	58.0"	Unnamed tributary to Pond Creek
004	37°	50'	25.0"	88°	49'	56.6"	Unnamed tributary to Pond Creek
005	37°	50'	9.1"	88°	50'	00.0"	Unnamed tributary to Pond Creek
006	37°	50'	28.4"	88°	50'	40.6"	Unnamed tributary to Pond Creek
007	37°	50'	29.5"	88°	49'	34.0"	Unnamed tributary to Pond Creek
008	37°	50'	31.4"	88°	49'	33.9"	Unnamed tributary to Pond Creek
009	37°	51'	16.1"	88°	49'	25.5"	Pond Creek
009ES	37°	50'	52.3"	88°	48'	43.7"	Unnamed tributary to Pond Creek
011	37°	52'	37"	89°	01'	49"	Big Muddy River

Original Sedimentation Ponds with discharges designated as Outfall Nos. 007 and 008 have been re-designed as described and depicted in IEPA Log No. 8554-10.

Refuse disposal
Refuse Disposal Area as previously approved in IEPA Log No. 3054-05, was constructed in phases as depicted and described in IEPA Log No. 2377-06 (RDA No. 1), Refuse Disposal Area No. 2 was constructed at Pond Creek Mine facilities as proposed and described in IEPA Log Nos. 1465-07, 1465-07-B, 1465-07-D, 1465-07-E, 1465-07-G, 1520-07, 0346-08, 9005-09, 9198-09, 9198-09-A, 8114-10, 8114-10-A, 7185-11, 7225-11, 6431-12, 6431-12-A and 5378-13.

As previously approved under Subtitle D Permit No. 2015-MA-3432, construction and development of Refuse Disposal Area No. 3 includes topsoil removal, grading, foundation preparation for refuse area, also construction of the water holding cell and installation of four (4) foot compacted clay liner was performed in accordance with the procedures discussed and outlined in IEPA Log No. 3432-15. As described in IEPA Log No. 3432-15, all stormwater runoff from the deposited coarse refuse within the RDA No. 3 is collected and maintained within the RDA No. 3 and/or is pumped into the slurry impounding structure of the existing RDA, which is an integral part of the Pond Creek Mine No. 1 coal preparation plant closed circuit wastewater handling system.

As described and depicted in IEPA Log Nos. 3001-15 and 3001-15-C Refuse Disposal Area No. 3 (RDA 3) is approved for construction. RDA 3 is located immediately east of the RDA 1 and RDA 2 areas, contains 229.78 acres, and is included in the above cited total Permit acreage. The area for RDA 3 is located in Section 12, Township 8 South, Range 3 East and Section 7, Township 8 South, Range 4 East, Williamson County, Illinois. To not increase chloride and sulfates due to construction of RDA 3, the mine is reclaiming the outslopes of the RDA 1 and RDA 2 that previously discharged through Outfalls 007 and 008. There will be no increase in loading due to the construction of RDA 3. Runoff from this area will be tributary to previously constructed water holding cell with the designated NPDES Outfalls 009 and 009ES, as depicted in IEPA Log No. 3117-15-A. Construction of four (4) foot compacted clay liners for the Refuse Disposal Area No. 3, Sediment Pond 009 and associated drainage control structures shall be subject to and in accordance with the specifications and testing requirements of Condition No. 12. With prior approval as to thickness and installation procedures, an HDPE synthetic liner may be utilized in lieu of the compacted clay liners proposed.

Mixing Zone (Big Muddy River)
Excess water will be transported from the Pond Creek Mine to Outfall No. 011 on the Big Muddy River through a high-density polyethylene (HDPE) pipeline. Water will be pumped from the Water Holding Cell by pumps through approximately 12.5 miles of pipe to the diffuser located at the mixing zone location. The pipeline ROW will be approximately 50 feet in width with a total permitted area of approximately 70.7 acres. The amount of water that could be discharged through the Pipeline depends upon the chloride concentration in the discharge stream, the background chloride content and the flow in the Big Muddy River. The upper limit to the discharge will be based on the pumping capacity of the facility. Maximum pumping rate of 5,000 gallons per minute or 11.1 cfs. from the facility. The volume of water discharged to Big Muddy River will be dependent upon the flow in the Big Muddy River and the chloride concentration of the water in the Water Holding Cell and the chloride concentration coming downstream in the River.

During operations of the pipeline, continuous flow monitors will be installed to provide protection against leakage. Flow will be monitored near the pump discharge while the pipeline is within the sediment control structure of Pond Creek Mine. Flow will also be monitored at the mixing zone location. This instrumentation will be connected to an alarm monitoring system and flow data will be transmitted to a central location for tracking and assessing system operations. The flow monitoring system operation and maintenance is subject to the requirements of Special Condition No. 16.

Groundwater monitoring for the facility will consist of Monitoring Well Nos.GW-1, GW-2, GW-3, GW-4, GW-5GW-9, GW-30, GW-33, GW-34, GW-35 and GW-36. Monitoring Well Nos. MW-8R, MW-10, MW-11, MW-12, MW-13, MW-14 and MW-28, as depicted in IEPA Log No. 3001-15, will monitor effects of the initial refuse disposal area. Groundwater monitoring requirements are outlined in Condition No. 13.

This Construction Authorization replaces Construction Authorization No. 3054-05.

The abandonment plan shall be executed and completed in accordance with 35 Ill. Adm. Code 405.109.

All water remaining upon abandonment must meet the requirements of 35 Ill. Adm. Code 406.202. For the constituents not covered by 35 Ill. Adm. Code Parts 302 or 303, all water remaining upon abandonment must meet the requirements of 35 Ill. Adm. Code 406.106.

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NPDES Permit No. IL0077666

Construction Authorization No. 3117-15

This Authorization is issued subject to the following Condition(s). If such Condition(s) require(s) additional or revised facilities, satisfactory engineering plan documents must be submitted to this Agency for review and approval to secure issuance of a Supplemental Authorization to Construct.

1. If any statement or representation is found to be incorrect, this permit may be revoked and the permittee thereupon waives all rights thereunder.

2. The issuance of this permit (a) shall not be considered as in any manner affecting the title of the premises upon which the mine or mine refuse area is to be located; (b) does not release the permittee from any liability for damage to person or property caused by or resulting from the installation, maintenance or operation of the proposed facilities; (c) does not take into consideration the structural stability of any units or parts of the project; and (d) does not release the permittee from compliance with other applicable statutes of the State of Illinois, or with applicable local laws, regulations or ordinances.

3. Final plans, specifications, application and supporting documents as submitted by the permittee and approved by the Agency shall constitute part of this permit in the records of the Agency.

4. There shall be no deviations from the approved plans and specifications unless revised plans, specifications and application shall first have been submitted to the Agency and a supplemental permit issued.

5. The permit holder shall notify the Agency (217/782-3637) immediately of an emergency at the mine or mine refuse area which causes or threatens to cause a sudden discharge of contaminants into the waters of Illinois and shall immediately undertake necessary corrective measures as required by 35 Ill. Adm. Code 405.111. (217/782-3637 for calls between the hours of 5:00 p.m. to 8:30 a.m. and on weekends.)

6. The termination of an NPDES discharge monitoring point or cessation of monitoring of an NPDES discharge is not authorized by this Agency until the permittee submits adequate justification to show what alternate treatment is provided or that untreated drainage will meet applicable effluent and water quality standards.

7. Initial construction activities in areas to be disturbed shall be for collection and treatment facilities only. Prior to the start of other activities, surface drainage controls shall be constructed and operated to avoid violations of the Act or Subtitle D. At such time as runoff water is collected in the sedimentation pond, a sample shall be collected and analyzed, for the parameters designated as 1M through 15M under Part 5-C of Form 2C and the effluent parameters designated herein with the results sent to this Agency. Should additional treatment be necessary to meet the standards of 35 Ill. Adm. Code 406.106 or applicable water quality standards, a Supplemental Permit must be obtained. Discharge from ponds is not allowed unless applicable effluent and water quality standards are met in the basin discharge(s).

8. This Agency must be informed in writing and an application submitted if drainage, which was previously classified as alkaline (pH greater than 6.0), becomes acid (pH less than 6.0) or ferruginous (base flow with an iron concentration greater than 10 mg/L). The type of drainage discharging to the basin should be reclassified in a manner consistent with the applicable provisions of 35 Ill. Adm. Code Part 406. The application should discuss the treatment method and demonstrate how the discharge will meet the applicable standards.

9. A permittee has the obligation to add a settling aid if necessary to meet the suspended solids or settleable solids effluent standards. The selection of a settling aid and the application practice shall be in accordance with a. or b. below

   a. Alum ($Al_2(SO_4)_3$), hydrated lime ($Ca(OH)_2$), soda ash (Na_2CO_3), alkaline pit pumpage, acetylene production by-product (tested for impurities), and ground limestone are acceptable settling aids and are hereby permitted for alkaline mine drainage sedimentation ponds.

   b. Any other settling aids such as commercial flocculents and coagulants are permitted only on prior approval from the Agency. To obtain approval a permittee must demonstrate in writing to the Agency that such use will not cause a violation of the toxic substances standard of 35 Ill. Adm. Code 302.210 or of the appropriate effluent and water quality standards of 35 Ill. Adm. Code parts 302, 304, and 406.

10. A general plan for the nature and disposition of all liquids used to drill boreholes shall be filed with this Agency prior to any such operation. This plan should be filed at such time that the operator becomes aware of the need to drill unless the plan of operation was contained in a previously approved application.

11. Any of the following shall be a violation of the provisions required under 35 Ill. Adm. Code 406.202:

    a. It is demonstrated that an adverse effect on the environment in and around the receiving stream has occurred or is likely to occur.

b. It is demonstrated that the discharge has adversely affected or is likely to adversely affect any public water supply.

c. The Agency determines that the permittee is not utilizing Good Mining Practices in accordance with 35 Ill. Adm. Code 406.204 which are fully described in detail in Sections 406.205, 406.206, 406.207 and 406.208 in order to minimize the discharge of total dissolved solids, chloride, sulfate, iron and manganese. To the extent practical, such Good Mining Practices shall be implemented to:

i. Stop or minimize water from coming into contact with disturbed areas through the use of diversions and/or runoff controls (Section 406.205).

ii. Retention and control within the site of waters exposed to disturbed materials utilizing erosion controls, sedimentation controls, water reuse or recirculation, minimization of exposure to disturbed materials, etc. (Section 406.206).

iii. Control and treatment of waters discharged from the site by regulation of flow of discharges and/or routing of discharges to more suitable discharge locations (Section 406.207).

iv. Utilized unconventional practices to prevent the production or discharge of waters containing elevated contaminant concentrations such as diversion of groundwater prior to entry into a surface or underground mine, dewatering practices to remove clean water prior to contacting disturbed materials and/or any additional practices demonstrated to be effective in reducing contaminant levels in discharges (Section 406.208).

12. The four (4) foot compacted clay liner to be constructed course refuse disposal area, fine coal refuse area (RDA No. 3) and Sedimentation Basin 009 shall be subject to the specifications and procedures presented in IEPA Log No. 3001-15-C.

Construction Specifications

a. All soils to be used for the compacted clay liner shall be free of grass, vines, vegetation and rock or stones greater than four (4) inches in diameter.

b. Samples collected from the borrow area shall be evaluated in accordance with ASTM D422, D4318 and D2487 to ensure classification criteria are met.

c. Each successive soil lift shall be placed to a 6 to 8 inch loose thickness; however, in no instance shall the loose lift thickness exceed the length of the pads or feet on the compactor or roller.

d. Each soil lift shall be compacted to the minimum Standard Prototor (ASTM D698) density identified in item no. 12(q) below, at a moisture content of 0% to 5% above the optimum moisture content of the soil.

e. Inter-lift surfaces shall be adequately scarified to ensure inter-lifting bonding.

f. Liner construction shall be performed to consistent achievement of density, moisture content, and hydraulic conductivity for each successive lift.

g. The placement of frozen material or the placement material on frozen ground is prohibited.

h. Contemporaneous placement or protective covering shall be provided to prevent drying, desiccation and/or freezing where necessary.

i. Liner construction shall be completed in a manner which reduces void spaces within the soil and liner.

j. All construction stakes shall be removed during construction, and all test holes (Shelby tube samples) are to be backfilled with bentonite.

k. The compacted clay liner shall be constructed in a manner to achieve a uniform barrier with a hydraulic conductivity of 1×10^{-7} cm/sec.

l. In the event that acceptable compaction results are not achieved, the soil lift shall be reprocessed or removed and replaced. If moisture content is less than optimum, or greater than 5% above optimum, the falling material shall be wetted or dried to a moisture content within specification and re-compacted. If the dry density is below specification, the failing material shall be re-compacted until a passing test is achieved.

m. In the event of a failing conductivity test, the soil may be removed or re-compacted and retested until a passing result is obtained; or the soil immediately above and below the test specimen from the same Shelby tube may be tested. If both tests pass, the original test shall be nullified. If either test fails, that portion of the liner shall be rejected and shall be reconstructed and retested until passing results are obtained. The limits of necessary reconstruction shall be determined by additional sampling and testing within the failed region, thereby isolating the failing area of work.

Testing Specifications

n. Prior to initiating soil liner construction, borrow soils shall be identified, qualified, and verified. At minimum, a representative sample of each soil type identified within the borrow area is to be collected and analyzed for gradation, compaction, and hydraulic conductivity characteristics.

o. Samples collected from borrow area shall be evaluated in accordance with ASTM D422, D4318 and D2487 to ensure classification criteria are met.

p. Samples collected from the borrow area shall be tested in accordance with ASTM D 698 to determine maximum dry density and optimum moisture content of the soil.

q. Samples collect from the borrow area shall be compacted to 90% and 95% standard Proctor density at or near optimum moisture content. The hydraulic conductivity of the re-compacted samples shall be determined in accordance with ASTM D5084 procedures. The results of this testing shall be used to establish the minimum dry density for soil liner compaction necessary to achieve a hydraulic conductivity of 1×10^{-7} cm/sec or less.

r. Moisture and density testing by nuclear methods (ASTM D2922 and D3017) shall be conducted at a rate of at least one test per 1,000 cubic yards placed. Testing locations shall be random and shall not be known to the earthwork contractor prior to lift placement.

s. To ensure the accuracy and reproducibility of the nuclear testing, all nuclear density gauges shall be certified to calibration. Soil compaction tests shall be double-checked with independent test methods. A drive cylinder test and laboratory moisture content determination shall be conducted and compared to gauge readings. These independent checks shall be made at the outset of construction and on a bi-weekly basis (e.g., every ten working days) thereafter.

t. Samples for hydraulic conductivity verification shall be retrieved from the compacted soil liner and tested in accordance with ASTM D5084 procedures. Samples shall be retrieved using three-inch Shelby tubes. Samples shall be completed at frequency of one sample/test per 20,000 cubic yards placed. The vertical location of the recovered samples shall be varied so that representative portions or lifts of the contractor prior to soil liner construction.

u. Survey checks shall be conducted at a minimum spacing of 100 ft. centers, and at 100 ft. intervals along each line where a break in slope occurs, to verify liner thickness. To verify liner thickness, the survey checks shall be taken before and after liner construction.

13. Groundwater monitoring requirements for Well Nos. MW-12, MW-13, MW-14, MW-8R and MW-28 are as follows:

a. Ambient background monitoring shall be performed for all referenced wells. Such ambient monitoring shall consist of six (6) samples collected during the first year (approximately bi-monthly) following well installation but no later than during the first year of operation or disturbance to determine ambient background concentrations. Background monitoring shall include the following list of constituents:

Aluminum	Fluoride	Sulfate
Antimony	Iron (dissolved)	Thallium
Arsenic	Iron (total)	Total Dissolved Solids
Barium	Lead	Vanadium
Beryllium	Manganese (dissolved)	Zinc
Boron	Manganese (total)	pH (field)
Cadmium	Mercury	Acidity
Chloride	Molybdenum	Alkalinity
Chromium	Nickel	Hardness
Cobalt	Phenols	Static Water Elevation
Copper	Selenium	
Cyanide	Silver	

b. Following the ambient monitoring as required under Condition No. 13(a) above, routine monitoring shall continue on a quarterly basis as follows:

i. Monitoring Well Nos. MW-12, MW-13, MW-14, MW-8R and MW-28 shall continue to be monitored quarterly for the contaminants identified in Condition No. 12(a) above.

ii. Monitoring Well Nos. MW-12, MW-13, MW-14, MW-8R and MW-28 shall be monitored quarterly as required by IDNR/OMM for the following list of constituents:

Chloride	Total Dissolved Solids
Iron (dissolved)	Hardness
Iron (total)	Acidity
Manganese (dissolved)	Alkalinity
Manganese (total)	pH
Sulfate	Static Water Elevation

c. Following completion of active mining and reclamation, post-mining monitoring of all above referenced wells shall consist of six (6) samples collected during a 12-month period (approximately bi-monthly) to determine post-mining concentrations. Post-mining monitoring shall include the list of constituents identified in Condition No. 13(a) above.

d. Groundwater monitoring reports shall be submitted to the Agency in accordance with Special Condition Nos. 3 and 5 of this NPDES permit.

e. A statistically valid representation of background and/or post mining water quality required under Condition No. 13(b) above shall be submitted utilizing the following method. This method shall be used to determine the upper 95 percent confidence limit for each parameter listed above.

Should the Permittee determine that an alternate statistical method would be more appropriate based on the data being evaluated, the Permittee may request utilization of such alternate methodology. Upon approval from the Agency, the alternate methodology may be utilized to determine a statistically valid representation of background and/or post mining water quality.

The following method should be used to predict the confidence limit when single groundwater samples are taken from each monitoring (test) well.

i. Determine the arithmetic mean $\left(\overline{X}_b\right)$ of each indicator parameter for the sampling period. If more than one well is used, an equal number of samples must be taken from each well.

$$\overline{X}_b = \frac{X_1 + X_2 + \ldots X_n}{n}$$

Where:

$\overline{X}_b$ = Average value for a given chemical parameter

X_n = Values for each sample

n = the number of samples taken

ii. Calculate the background and/or post mining variance (S_b^2) and standard deviation (S_b) for each parameter using the values (X_n) from each sample of the well(s) as follows:

$$S_b^2 = \frac{(X_1 - \overline{X}_b)^2 + (X_2 - \overline{X}_b)^2 + \ldots + (X_n - \overline{X}_b)^2}{n-1}$$

$$S_b = \sqrt{S_b^2}$$

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iii. Calculate the upper confidence limit using the following formula:

$$CL = \overline{X}_b \pm t\sqrt{1 + 1/n}\ (S_b)$$

Where:

CL = upper confidence limit prediction
(upper and lower limits should be calculated for pH)
t = onetailed t value at the required significance
level and at n1 degrees of freedom from Table 1
(a twotailed t value should be used for pH)

iv. If the values of any routine parameter for any monitoring well exceed the upper confidence limit for that parameter, the permittee shall conclude that a statistically significant change has occurred at that well.

v. When some of the background and/or post mining values are less than the Method Detection Limit (MDL), a value of one-half (1/2) the MDL shall be substituted for each value that is reported as less than the MDL. All other computations shall be calculated as given above.

If all the background and/or post mining values are less than the MDL for a given parameter, the Practical Quantitation Limit (PQL), as given in 35 Ill. Adm. Code Part 724 Appendix I shall be used to evaluate data from monitoring wells. If the analytical results from any monitoring well exceed two (2) times the PQL for any single parameter, or if they exceed the PQLs for two or more parameters, the permittee shall conclude that a statistically significant change has occurred.

Table 1
Standard tTables Level of Significance

Degrees of freedom	tvalues (onetail)		tvalues (twotail)*	
	99%	95%	99%	95%
4	3.747	2.132	4.604	2.776
5	3.365	2.015	4.032	2.571
6	3.143	1.943	3.707	2.447
7	2.998	1.895	3.499	2.365
8	2.896	1.860	3.355	2.306
9	2.821	1.833	3.250	2.262
10	2.764	1.812	3.169	2.228
11	2.718	1.796	3.106	2.201
12	2.681	1.782	3.055	2.179
13	2.650	1.771	3.012	2.160
14	2.624	1.761	2.977	2.145
15	2.602	1.753	2.947	2.131
16	2.583	1.746	2.921	2.120
17	2.567	1.740	2.898	2.110
18	2.552	1.734	2.878	2.101
19	2.539	1.729	2.861	2.093
20	2.528	1.725	2.845	2.086
21	2.518	1.721	2.831	2.080
22	2.508	1.717	2.819	2.074
23	2.500	1.714	2.807	2.069
24	2.492	1.711	2.797	2.064
25	2.485	1.708	2.787	2.060
30	2.457	1.697	2.750	2.042
40	2.423	1.684	2.704	2.021

Adopted from Table III of "Statistical Tables for Biological Agricultural and Medical Research" (1947, R.A. Fisher and F. Yates).

* For pH only when required.

NPDES Permit No. IL0077666

Special Conditions

Special Condition No. 1: No effluent from any mine related facility area under this permit shall, alone or in combination with other sources, cause a violation of any applicable water quality standard as set out in the Illinois Pollution Control Board Rules and Regulations, Subtitle C: Water Pollution.

Special Condition No. 2: Samples taken in compliance with the effluent monitoring requirements shall be taken at a point representative of the discharge, but prior to entry into the receiving stream.

Special Condition No. 3: All periodic monitoring and reporting forms, including Discharge Monitoring Report (DMR) forms, shall be submitted to the Agency according to the schedule outlined in Special Condition No. 4 or 5 below with one (1) copy forwarded to each of the following addresses:

Illinois Environmental Protection Agency
Division of Water Pollution Control
1021 North Grand Ave., East
P.O. Box 19276
Springfield, IL 62794-9276

Attn: Compliance Assurance Section

Illinois Environmental Protection Agency
Mine Pollution Control Program
2309 West Main Street, Suite 116
Marion, Illinois 62959

The Permittee will be required to submit electronic DMRs (NetDMR) instead of mailing paper DMRs to the IEPA, unless a waiver is approved by the Agency. More information, including registration information for the NetDMR program, can be obtained on the IEPA website, https://www2.illinois.gov/epa/topics/water-quality/surface-water/netdmr/Pages/quick-answer-guide.aspx.

Special Condition No. 4: Completed Discharge Monitoring Report (DMR) forms and as well as upstream and downstream monitoring results, shall be retained by the Permittee for a period of three (3) months and shall be submitted electronically (or mailed if waiver is approved by the Agency) and received by the IEPA at the addresses indicated in Special Condition No. 3 above in accordance with the following schedule, unless otherwise specified by the permitting authority.

Period	Received by IEPA
January, February, March	April 15
April, May, June	July 15
July, August, September	October 15
October, November, December	January 15

The Permittee shall record discharge monitoring results on Discharge Monitoring Report (DMR) forms using one such form for each Outfall and Discharge Condition each month. In the event that an Outfall does not discharge during a monthly reporting period or under a given Discharge Condition, the DMR form shall be submitted with "No Discharge" indicated.

Any and all monitoring results, other than NPDES outfall discharge results reported through NetDMR, shall be submitted to the Agency at the addresses indicated in Special Condition No. 3 above.

Special Condition No. 5: Completed periodic monitoring and reporting, other than DMR's and stream monitoring (i.e., groundwater monitoring, coal combustion waste analysis reports, etc.), shall be retained by the Permittee for a period of three (3) months and shall be mailed and received by the IEPA at the addresses indicated in Special Condition No. 3 above in accordance with the following schedule, unless otherwise specified by the permitting authority.

Period	Received by IEPA
January, February, March	May 1
April, May, June	August 1
July, August, September	November 1
October, November, December	February 1

Special Condition No. 6: The Agency may revise or modify the permit consistent with applicable laws, regulations or judicial orders.

Special Condition No. 7: If an applicable effluent standard or limitation is promulgated under Sections 301(b)(2)(C) and (D), 304(b)(2), and 307(a)(2) of the Clean Water Act and that effluent standard or limitation is more stringent than any effluent limitation in the permit or controls a pollutant not limited in the NPDES Permit, the Agency shall revise or modify the permit in accordance with the more stringent standard or prohibition and shall so notify the permittee.

Special Condition No. 8: The permittee shall notify the Agency in writing by certified mail within thirty days of abandonment, cessation, or suspension of active mining for thirty days or more unless caused by a labor dispute. During cessation or suspension of active mining, whether caused by a labor dispute or not, the permittee shall provide whatever interim impoundment, drainage diversion, and wastewater treatment is necessary to avoid violations of the Act or Subtitle D Regulations.

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Special Conditions

Special Condition No. 9: Plans must be submitted to and approved by this Agency prior to construction of any future sedimentation ponds. At such time as runoff water is collected in the sedimentation pond, a sample shall be collected and analyzed for the parameters designated as 1M-15M under Part 5-C of Form 2C and the effluent parameters designated herein with the results sent to this Agency. Should additional treatment be necessary to meet these standards, a Supplemental Permit must also be obtained. Discharge from a pond is not allowed unless applicable effluent and water quality standards are met.

Special Condition No. 10: The special reclamation area effluent standards of 35 Ill. Adm. Code 406.109 apply only on approval from the Agency. To obtain approval, a request form and supporting documentation shall be submitted to request the discharge be classified as a reclamation area discharge. The Agency will notify the permittee upon approval of the change.

Special Condition No. 11: The special stormwater effluent standards apply only on approval from the Agency. To obtain approval, a request with supporting documentation shall be submitted to request the discharge to be classified as a stormwater discharge. The documentation supporting the request shall include analysis results indicating the discharge will consistently comply with reclamation area discharge effluent standards. The Agency will notify the permittee upon approval of the change.

Special Condition No. 12: Annual stormwater monitoring is required for all discharges not tributary to a sediment basin until Final SMCRA Bond is released and approval to cease such monitoring is obtained from the Agency.

a. Each discharge must be monitored for pH and settleable solids annually.

b. Analysis of samples must be submitted with second quarter Discharge Monitoring Reports. A map with discharge locations must be included in this submittal.

c. If discharges can be shown to be similar, a plan may be submitted by November 1 of each year preceding sampling to propose grouping of similar discharges and/or update previously submitted groupings. If updating of a previously submitted plan is not necessary, a written notification to the Agency indicating such is required. Upon approval from the Agency, one representative sample for each group may be submitted.

Special Condition No. 13: Sediment Pond Operation and Maintenance (Outfalls 001, 002, 003, 004, 005, 006, 007, 008, 009ES):

a. For discharges resulting from precipitation events, in addition to the alternate effluent (Discharge Condition Nos. II and III) monitoring requirements, as indicated on the applicable effluent pages of this Permit, discharges from Outfalls 001, 002, 003, 004, 005, 006, 007, 008, 009ES shall be monitored and reported for Discharge Rate, Sulfate, Chloride and Hardness.

b. The following sampling and monitoring requirements are applicable to flow in the unnamed tributary to Pond Creek which receive discharges from Outfalls 001, 002, 003, 004, 005, 006, 007, 008, 009ES.

   i. All sampling and monitoring required under 13(b)(ii) and (iii) below shall be performed during a discharge and monitoring event from the associated outfall.

   ii. Unnamed tributary to Pond Creek shall be monitored and reported quarterly for Discharge Rate, Chloride, Sulfate and Hardness downstream of the associated outfall. This downstream monitoring shall be performed a sufficient distance downstream of the associated outfall to ensure that complete mixing has occurred. At such time that sufficient information has been collected regarding receiving stream flow characteristics and in-stream contaminant concentrations the permittee may request a re-evaluation of the monitoring frequency required herein for possible reduction or elimination. For the purpose of re-evaluating the downstream monitoring frequency of the receiving stream, "sufficient information" is defined as a minimum of ten (10) quarterly sampling events.

   In the event that downstream monitoring of the receiving waters is eliminated during the term of this permit based on an evaluation of the quarterly data, a minimum of three (3) additional samples analyzed for the parameters identified above must be submitted with the permit renewal application a minimum of 180 days prior to expiration of this permit.

   iii. Unnamed tributary to Pond Creek shall be monitored and reported annually for Discharge Rate, Chloride, Sulfate and Hardness upstream of the associated outfall.

Special Condition No. 14: Sediment Pond Operation and Maintenance (Outfall 009):

a. No discharge is allowed from Outfall No. 009 during "low flow" or "no flow" conditions in the receiving stream, unless such discharge meets the water quality standards of 35 Ill. Adm. Code 302.

Pursuant to 35 Ill. Adm. Code Part 302.102, discharges from the referenced outfalls that otherwise would not meet the water quality standards of 35 Ill. Adm. Code Part 302 may be permitted if sufficient flow exists in the receiving stream to ensure that applicable water quality standards are met. That is, discharges not meeting the water quality standards of 35 Ill. Adm. Code Part 302 may only be discharged in combination with stormwater discharges from the basin, and only at such times that sufficient flow exists in the receiving stream to ensure that water quality standards in the receiving stream beyond the area of allowed mixing will not be exceeded.

The permittee shall determine the effluent limitation for chloride and/or the maximum effluent flow rate allowable to maintain water quality in the receiving stream. The following equations shall be used to make such determinations:

$$C_{DS} = [C_E Q_E + 0.25 C_{US} Q_{US}]/ (0.25 Q_{US} + Q_E)$$

Where:

C_E = Effluent concentration (mg/L)

Q_E = Effluent flow rate (cfs) for Outfall 009

Q_{US} = Upstream flow rate (cfs)

C_{US} = Upstream concentration (mg/L)

C_{DS} = Downstream concentration

The "calculated" downstream concentration shall be less than 500 mg/L for chloride and reported on the discharge monitoring reports (DMRs).

The permittee shall install a gauging station and conductivity monitor upstream of the discharge to determine an upstream flow (Q_{US}) and a chloride concentration (C_{US}) correlated to the conductivity value. In addition, the permittee shall install a continuous conductivity monitor downstream to ensure that the chloride concentration (correlated to the conductivity value) stays within the chloride water quality standard. The daily maximum downstream chloride concentration controlled to conductivity shall be reported on the DMR"s.

If there is no upstream mixing available for Outfall 009, the NPDES permit shall be regulated at 500 mg/L for Chloride and 1250 mg/L for Sulfate.

The upstream and downstream conductivity monitoring locations need to be approved by the Agency.

b. The following sampling and monitoring requirements are applicable to flow in Pond Creek which receives the discharges from Outfall 009.

   i. All sampling and monitoring required under 14(b)(ii) and (iii) below shall be performed during a discharge and monitoring event from the associated outfall.

   ii. Pond Creek shall be monitored and reported quarterly for Discharge Rate, Sulfate, Chloride and Hardness downstream of the associated outfall. This downstream monitoring shall be performed a sufficient distance downstream of the associated outfall to ensure that complete mixing has occurred. At such time that sufficient information has been collected regarding stream flow characteristics and in-stream contaminant concentrations, the permittee may request a re-evaluation of the monitoring frequency required herein for possible reduction or elimination. For the purpose of re-evaluating the downstream monitoring frequency of the receiving stream, "sufficient information" is defined as a minimum of ten (10) quarterly sampling events.

   In the event that downstream monitoring of the receiving waters is eliminated during the term of this permit based on an evaluation of the quarterly data, a minimum of three (3) additional samples analyzed for the parameters identified above must be submitted with the permit renewal application a minimum of 180 days prior to expiration of this permit.

   iii. Pond Creek shall be monitored and reported annually for Discharge Rate, Sulfate, Chloride and Hardness upstream of the associated outfall.

Special Condition No. 15: Sediment Pond Operation and Maintenance (Outfall 009 – Reclamation Area Discharge Classification):

a. For discharges resulting from precipitation events, in addition to the alternate effluent (Discharge Condition Nos. II and III) monitoring requirements, as indicated on the applicable effluent pages of this Permit, discharges from Outfall 009 shall be monitored and reported for Discharge Rate, Sulfate, Chloride and Hardness.

b. The following sampling and monitoring requirements are applicable to flow in the Middle Fork Big Muddy River which receive discharges from Outfall 009.

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Special Conditions

i. All sampling and monitoring required under 15(b)(ii) and (iii) below shall be performed during a discharge and monitoring event from the associated outfall.

ii. Middle Fork Big Muddy River shall be monitored and reported quarterly for Discharge Rate, Chloride, Sulfate and Hardness downstream of the associated outfall. This downstream monitoring shall be performed a sufficient distance downstream of the associated outfall to ensure that complete mixing has occurred. At such time that sufficient information has been collected regarding receiving stream flow characteristics and in-stream contaminant concentrations the permittee may request a re-evaluation of the monitoring frequency required herein for possible reduction or elimination. For the purpose of re-evaluating the downstream monitoring frequency of the receiving stream, "sufficient information" is defined as a minimum of ten (10) quarterly sampling events.

In the event that downstream monitoring of the receiving waters is eliminated during the term of this permit based on an evaluation of the quarterly data, a minimum of three (3) additional samples analyzed for the parameters identified above must be submitted with the permit renewal application a minimum of 180 days prior to expiration of this permit.

iii. Middle Fork Big Muddy River shall be monitored and reported annually for Discharge Rate, Chloride, Sulfate and Hardness upstream of the associated outfall.

Special Condition No. 16: Sediment Pond Operation and Maintenance (Outfall 011):

a. Pursuant to 35 Ill. Adm. Code Part 302.102, discharges from the referenced outfalls that otherwise would not meet the water quality standards of 35 Ill. Adm. Code Part 302 may be permitted if sufficient flow exists in the receiving stream to ensure that applicable water quality standards are met. That is, discharges not meeting the water quality standards of 35 Ill. Adm. Code Part 302 may only be discharged in combination with stormwater discharges from the basin, and only at such times that sufficient flow exists in the receiving stream to ensure that water quality standards in the receiving stream beyond the area of allowed mixing will not be exceeded.

The permittee shall determine the effluent limitation for chloride and/or the maximum effluent flow rate allowable to maintain water quality in the receiving stream. The following equations shall be used to make such determinations:

$$C_{DS} = [C_E Q_E + 0.25 C_{US} Q_{US}]/ (0.25 Q_{US} + Q_E)$$

Where:

C_E = Effluent concentration (mg/L)

Q_E = Effluent flow rate (cfs) for Outfall 011

Q_{US} = Upstream flow rate (cfs)

C_{US} = Upstream concentration (mg/L)

C_{DS} = Downstream concentration

The "calculated" downstream concentration (CDS) shall be less than 500 mg/L for chloride and reported on the discharge monitoring reports (DMRs).

Chloride is limited in the NPDES permit at the limits described below. The maximum flow from Outfall 011 is 5,000 gpm and the maximum chloride concentration is 12,000 mg/L.

Sulfate and Iron (dissolved) shall be monitored from the effluent monthly when discharging.

The permit only allows a discharge when the Big Muddy River is flowing above 30 cfs. The maximum dispersion required for all water quality parameters is 34:1. Model predictions have been made for a maximum effluent total flow rate of 11.1 cfs. At the maximum chloride concentration of 12,000 mg/L, this maximum discharge requires a river flow of 1,734 cfs to meet a dispersion of 34:1 in less than 25 % of the river volume. The maximum distance to meet the water quality standard for all scenarios is 251 feet downstream with a plume width of 25 feet. The maximum zone of initial dilution to meet the acute Copper water quality standard for all scenarios is 18.2 feet downstream with a plume width of 4 feet.

The upstream flow (Q_{US}) should be based on the full flow measurement upstream of the proposed Outfall 011 that shall be approved by the Agency.

The upstream and downstream conductivity monitoring locations need to be approved by the Agency.

Special Conditions

The permittee shall install a conductivity monitor upstream of the discharge to determine a chloride concentration (C_{US}) correlated to the conductivity value. In addition, the permittee shall install a continuous conductivity monitor downstream to ensure that the chloride concentration (correlated to the conductivity value) stays within the chloride water quality standard. The daily maximum downstream chloride concentration controlled to conductivity shall be reported on the DMR's.

b. The following sampling and monitoring requirements are applicable to flow in Big Muddy River which receives the discharges from Outfall 011.

i. All sampling and monitoring required under 16(b)(ii) and (iii) below shall be performed during a discharge and monitoring event from the associated outfall.

ii. The Big Muddy River shall be monitored and reported quarterly for Discharge Rate, Sulfate, Chloride and Hardness downstream of the associated outfall. This downstream monitoring shall be performed a sufficient distance downstream of the associated outfall to ensure that complete mixing has occurred. At such time that sufficient information has been collected regarding stream flow characteristics and in-stream contaminant concentrations, the permittee may request a re-evaluation of the monitoring frequency required herein for possible reduction or elimination. For the purpose of re-evaluating the downstream monitoring frequency of the receiving stream, "sufficient information" is defined as a minimum of ten (10) quarterly sampling events.

In the event that downstream monitoring of the receiving waters is eliminated during the term of this permit based on an evaluation of the quarterly data, a minimum of three (3) additional samples analyzed for the parameters identified above must be submitted with the permit renewal application a minimum of 180 days prior to expiration of this permit.

iii. The Big Muddy River shall be monitored and reported annually for Discharge Rate, Sulfate, Chloride and Hardness upstream of the associated outfall.

Special Condition No. 17: Data collected in accordance with Special Condition Nos. 13, 14, 15 and 16 above will be utilized to evaluate the appropriateness of the effluent limits established in this Permit. Should the Agency's evaluation of this data indicate revised effluent limits are warranted; this permit may be reopened and modified to incorporate more appropriate effluent limitations. This data will also be used for determination of effluent limitations at the time of permit renewal.

Special Condition No. 18: Discharges from Outfalls 006, 007, 008, 009, 009ES and 011 shall be monitored twice annually with such monitoring spaced at approximately 6-month intervals during the entire 5-year term of this NPDES Permit. Sampling of the discharges shall be performed utilizing the grab sampling method and analyzed for total (unfiltered) concentrations. The results of the sampling required under this Special Condition shall be submitted twice annually to the Agency in January and July of each calendar year to the addresses indicated in the Special Condition No. 3 above. The parameters to be sampled and the detection limits (minimum reported limits) are as follows:

Parameter	Detection Limit
Arsenic	0.05 mg/L
Barium	0.50 mg/L
Cadmium	0.001 mg/L
Chromium (hexavalent)	0.01 mg/L
Chromium	0.05 mg/L
Copper	0.005 mg/L
Lead	0.05 mg/L
Manganese	0.50 mg/L
Mercury*	1.00 ng/l**
Nickel	0.005 mg/L
Phenols	0.005 mg/L
Selenium	2.000 µg/l***
Silver	0.003 mg/L
Zinc	0.025 mg/L

* Utilize USEPA Method 1631E and the digestion procedure described in Section 11.1.1.2 of 1631E.
** 1.00 ng/l (nanogram/liter) = 1 part per trillion.
*** µg/l = micrograms/liter

Attachment H

Standard Conditions

Definitions

Act means the Illinois Environmental Protection Act, 415 ILCS 5 as Amended.

Agency means the Illinois Environmental Protection Agency.

Board means the Illinois Pollution Control Board.

Clean Water Act (formerly referred to as the Federal Water Pollution Control Act) means Pub. L 92-500, as amended. 33 U.S.C. 1251 et seq.

NPDES (National Pollutant Discharge Elimination System) means the national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under Sections 307, 402, 318 and 405 of the Clean Water Act.

USEPA means the United States Environmental Protection Agency.

Daily Discharge means the discharge of a pollutant measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. For pollutants with limitations expressed in units of mass, the "daily discharge" is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurements, the "daily discharge" is calculated as the average measurement of the pollutant over the day.

Maximum Daily Discharge Limitation (daily maximum) means the highest allowable daily discharge.

Average Monthly Discharge Limitation (30 day average) means the highest allowable average of daily discharges over a calendar month, calculated as the sum of all daily discharges measured during a calendar month divided by the number of daily discharges measured during that month.

Average Weekly Discharge Limitation (7 day average) means the highest allowable average of daily discharges over a calendar week, calculated as the sum of all daily discharges measured during a calendar week divided by the number of daily discharges measured during that week.

Best Management Practices (BMPs) means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the State. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Aliquot means a sample of specified volume used to make up a total composite sample.

Grab Sample means an individual sample of at least 100 milliliters collected at a randomly-selected time over a period not exceeding 15 minutes.

24-Hour Composite Sample means a combination of at least 8 sample aliquots of at least 100 milliliters, collected at periodic intervals during the operating hours of a facility over a 24-hour period.

8-Hour Composite Sample means a combination of at least 3 sample aliquots of at least 100 milliliters, collected at periodic intervals during the operating hours of a facility over an 8-hour period.

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Flow Proportional Composite Sample means a combination of sample aliquots of at least 100 milliliters collected at periodic intervals such that either the time interval between each aliquot or the volume of each aliquot is proportional to either the stream flow at the time of sampling or the total stream flow since the collection of the previous aliquot.

(1) **Duty to comply.** The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Act and is grounds for enforcement action, permit termination, revocation and reissuance, modification, or for denial of a permit renewal application. The permittee shall comply with effluent standards or prohibitions established under Section 307(a) of the Clean Water Act for toxic pollutants within the time provided in the regulations that establish these standards or prohibitions, even if the permit has not yet been modified to incorporate the requirements.

(2) **Duty to reapply.** If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee must apply for and obtain a new permit. If the permittee submits a proper application as required by the Agency no later than 180 days prior to the expiration date, this permit shall continue in full force and effect until the final Agency decision on the application has been made.

(3) **Need to halt or reduce activity not a defense.** It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

(4) **Duty to mitigate.** The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

(5) **Proper operation and maintenance.** The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with conditions of this permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of back-up, or auxiliary facilities, or similar systems only when necessary to achieve compliance with the conditions of the permit.

(6) **Permit actions.** This permit may be modified, revoked and reissued, or terminated for cause by the Agency pursuant to 40 CFR 122.62 and 40 CFR 122.63. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition.

(7) **Property rights.** This permit does not convey any property rights of any sort, or any exclusive privilege.

(8) **Duty to provide information.** The permittee shall furnish to the Agency within a reasonable time, any information which the Agency may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with the permit. The permittee shall also furnish to the Agency upon request, copies of records required to be kept by this permit.

(9) **Inspection and entry.** The permittee shall allow an authorized representative of the Agency or USEPA (including an authorized contractor acting as a representative of the Agency or USEPA), upon the presentation of credentials and other documents as may be required by law, to:

(a) Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;

(b) Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

(c) Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and

(d) Sample or monitor at reasonable times, for the purpose of assuring permit compliance, or as otherwise authorized by the Act, any substances or parameters at any location.

(10) **Monitoring and records.**

(a) Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.

(b) The permittee shall retain records of all monitoring information, including all calibration and maintenance records, and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least 3 years from the date of this permit, measurement, report or application. Records related to the permittee's sewage sludge use and disposal activities shall be retained for a period of at least five years (or longer as required by 40 CFR Part 503). This period may be extended by request of the Agency or USEPA at any time.

(c) Records of monitoring information shall include:

(1) The date, exact place, and time of sampling or measurements;

(2) The individual(s) who performed the sampling or measurements;

(3) The date(s) analyses were performed;

(4) The individual(s) who performed the analyses;

(5) The analytical techniques or methods used; and

(6) The results of such analyses.

(d) Monitoring must be conducted according to test procedures approved under 40 CFR Part 136, unless other test procedures have been specified in this permit. Where no test procedure under 40 CFR Part 136 has been approved, the permittee must submit to the Agency a test method for approval. The permittee shall calibrate and perform maintenance procedures on all monitoring and analytical instrumentation at intervals to ensure accuracy of measurements.

(11) **Signatory requirement.** All applications, reports or information submitted to the Agency shall be signed and certified.

(a) **Application.** All permit applications shall be signed as follows:

(1) For a corporation: by a principal executive officer of at least the level of vice president or a person or position having overall responsibility for environmental matters for the corporation:

(2) For a partnership or sole proprietorship: by a general partner or the proprietor, respectively; or

(3) For a municipality, State, Federal, or other public agency: by either a principal executive officer or ranking elected official.

(b) **Reports.** All reports required by permits, or other information requested by the Agency shall be signed by a person described in paragraph (a) or by a duly authorized representative of that person. A person is a duly authorized representative only if:

(1) The authorization is made in writing by a person described in paragraph (a); and R06232

(2) The authorization specifies either an individual or a position responsible for the overall operation of the facility, from which the discharge originates, such as a plant manager, superintendent or person of equivalent responsibility; and

(3) The written authorization is submitted to the Agency.

(c) **Changes of Authorization.** If an authorization under (b) is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of (b) must be submitted to the Agency prior to or together with any reports, information, or applications to be signed by an authorized representative.

(d) **Certification.** Any person signing a document under paragraph (a) or (b) of this section shall make the following certification:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

(12) **Reporting requirements.**

(a) **Planned changes.** The permittee shall give notice to the Agency as soon as possible of any planned physical alterations or additions to the permitted facility. Notice is required when:

(1) The alteration or addition to a permitted facility may meet one of the criteria for determining whether a facility is a new source pursuant to 40 CFR 122.29 (b); or

(2) The alteration or addition could significantly change the nature or increase the quantity of pollutants discharged. This notification applies to pollutants which are subject neither to effluent limitations in the permit, nor to notification requirements pursuant to 40 CFR 122.42 (a)(1).

(3) The alteration or addition results in a significant change in the permittee's sludge use or disposal practices, and such alteration, addition, or change may justify the application of permit conditions that are different from or absent in the existing permit, including notification of additional use or disposal sites not reported during the permit application process or not reported pursuant to an approved land application plan.

(b) **Anticipated noncompliance.** The permittee shall give advance notice to the Agency of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

(c) **Transfers.** This permit is not transferable to any person except after notice to the Agency.

(d) **Compliance schedules.** Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of this permit shall be submitted no later than 14 days following each schedule date.

(e) **Monitoring reports.** Monitoring results shall be reported at the intervals specified elsewhere in this permit.

(1) Monitoring results must be reported on a Discharge Monitoring Report (DMR).

(2) If the permittee monitors any pollutant more frequently than required by the permit, using test procedures approved under 40 CFR 136 or as specified in the permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the DMR.

(3) Calculations for all limitations which require averaging of measurements shall utilize an arithmetic mean unless otherwise specified by the Agency in the permit.

(f) **Twenty-four hour reporting.** The permittee shall report any noncompliance which may endanger health or the environment. Any information shall be provided orally within 24-hours from the time the permittee becomes aware of the circumstances. A written submission shall also be provided within 5 days of the time the permittee becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause; the period of noncompliance, including exact dates and time; and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance. The following shall be included as information which must be reported within 24-hours:

(1) Any unanticipated bypass which exceeds any effluent limitation in the permit.

(2) Any upset which exceeds any effluent limitation in the permit.

(3) Violation of a maximum daily discharge limitation for any of the pollutants listed by the Agency in the permit or any pollutant which may endanger health or the environment.

The Agency may waive the written report on a case-by-case basis if the oral report has been received within 24-hours.

(g) **Other noncompliance.** The permittee shall report all instances of noncompliance not reported under paragraphs (12) (d), (e), or (f), at the time monitoring reports are submitted. The reports shall contain the information listed in paragraph (12) (f).

(h) **Other information.** Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application, or in any report to the Agency, it shall promptly submit such facts or information.

(13) **Bypass.**

(a) Definitions.

(1) Bypass means the intentional diversion of waste streams from any portion of a treatment facility.

(2) Severe property damage means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

(b) Bypass not exceeding limitations. The permittee may allow any bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to assure efficient operation. These bypasses are not subject to the provisions of paragraphs (13)(c) and (13)(d).

(c) Notice.

(1) Anticipated bypass. If the permittee knows in advance of the need for a bypass, it shall submit prior notice, if possible at least ten days before the date of the bypass.

(2) Unanticipated bypass. The permittee shall submit notice of an unanticipated bypass as required in paragraph (12)(f) (24-hour notice).

(d) Prohibition of bypass.

(1) Bypass is prohibited, and the Agency may take enforcement action against a permittee for bypass, unless:

(i) Bypass was unavoidable to prevent loss of life personal injury, or severe property damage;

(ii) There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and

(iii) The permittee submitted notices as required under paragraph (13)(c).

(2) The Agency may approve an anticipated bypass, after considering its adverse effects, if the Agency determines that it will meet the three conditions listed above in paragraph (13)(d)(1).

(14) **Upset.**

(a) Definition. Upset means an exceptional incident in which there is unintentional and temporary noncompliance with technology based permit effluent limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

(b) Effect of an upset. An upset constitutes an affirmative defense to an action brought for noncompliance with such technology based permit effluent limitations if the requirements of paragraph (14)(c) are met. No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review.

(c) Conditions necessary for a demonstration of upset. A permittee who wishes to establish the affirmative defense of upset shall demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

(1) An upset occurred and that the permittee can identify the cause(s) of the upset;

(2) The permitted facility was at the time being properly operated; and

(3) The permittee submitted notice of the upset as required in paragraph (12)(f)(2) (24-hour notice).

(4) The permittee complied with any remedial measures required under paragraph (4).

(d) Burden of proof. In any enforcement proceeding the permittee seeking to establish the occurrence of an upset has the burden of proof.

(15) **Transfer of permits.** Permits may be transferred by modification or automatic transfer as described below:

(a) Transfers by modification. Except as provided in paragraph (b), a permit may be transferred by the permittee to a new owner or operator only if the permit has been modified or revoked and reissued pursuant to 40 CFR 122.62 (b) (2), or a minor modification made pursuant to 40 CFR 122.63 (d), to identify the new permittee and incorporate such other requirements as may be necessary under the Clean Water Act.

(b) Automatic transfers. As an alternative to transfers under paragraph (a), any NPDES permit may be automatically transferred to a new permittee if:

(1) The current permittee notifies the Agency at least 30 days in advance of the proposed transfer date;
(2) The notice includes a written agreement between the existing and new permittees containing a specified date for transfer of permit responsibility, coverage and liability between the existing and new permittees; and
(3) The Agency does not notify the existing permittee and the proposed new permittee of its intent to modify or revoke and reissue the permit. If this notice is not received, the transfer is effective on the date specified in the agreement.

(16) All manufacturing, commercial, mining, and silvicultural dischargers must notify the Agency as soon as they know or have reason to believe:
(a) That any activity has occurred or will occur which would result in the discharge of any toxic pollutant identified under Section 307 of the Clean Water Act which is not limited in the permit, if that discharge will exceed the highest of the following notification levels:
(1) One hundred micrograms per liter (100 ug/l);
(2) Two hundred micrograms per liter (200 ug/l) for acrolein and acrylonitrile; five hundred micrograms per liter (500 ug/l) for 2,4-dinitrophenol and for 2-methyl-4,6 dinitrophenol; and one milligram per liter (1 mg/l) for antimony.
(3) Five (5) times the maximum concentration value reported for that pollutant in the NPDES permit application; or
(4) The level established by the Agency in this permit.
(b) That they have begun or expect to begin to use or manufacture as an intermediate or final product or byproduct any toxic pollutant which was not reported in the NPDES permit application.

(17) All Publicly Owned Treatment Works (POTWs) must provide adequate notice to the Agency of the following:
(a) Any new introduction of pollutants into that POTW from an indirect discharge which would be subject to Sections 301 or 306 of the Clean Water Act if it were directly discharging those pollutants; and
(b) Any substantial change in the volume or character of pollutants being introduced into that POTW by a source introducing pollutants into the POTW at the time of issuance of the permit.
(c) For purposes of this paragraph, adequate notice shall include information on (i) the quality and quantity of effluent introduced into the POTW, and (ii) any anticipated impact of the change on the quantity or quality of effluent to be discharged from the POTW.

(18) If the permit is issued to a publicly owned or publicly regulated treatment works, the permittee shall require any industrial user of such treatment works to comply with federal requirements concerning:
(a) User charges pursuant to Section 204 (b) of the Clean Water Act, and applicable regulations appearing in 40 CFR 35;
(b) Toxic pollutant effluent standards and pretreatment standards pursuant to Section 307 of the Clean Water Act; and
(c) Inspection, monitoring and entry pursuant to Section 308 of the Clean Water Act.

(19) If an applicable standard or limitation is promulgated under Section 301(b)(2)(C) and (D), 304(b)(2), or 307(a)(2) and that effluent standard or limitation is more stringent than any effluent limitation in the permit, or controls a pollutant not limited in the permit, the permit shall be promptly modified or revoked, and reissued to conform to that effluent standard or limitation.

(20) Any authorization to construct issued to the permittee pursuant to 35 Ill. Adm. Code 309.154 is hereby incorporated by reference as a condition of this permit. R06234

(21) The permittee shall not make any false statement, representation or certification in any application, record, report, plan or other document submitted to the Agency or the USEPA, or required to be maintained under this permit.

(22) The Clean Water Act provides that any person who violates a permit condition implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Clean Water Act is subject to a civil penalty not to exceed $25,000 per day of such violation. Any person who willfully or negligently violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318 or 405 of the Clean Water Act is subject to a fine of not less than $2,500 nor more than $25,000 per day of violation, or by imprisonment for not more than one year, or both.
Additional penalties for violating these sections of the Clean Water Act are identified in 40 CFR 122.41 (a)(2) and (3).

(23) The Clean Water Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000, or by imprisonment for not more than 2 years, or both. If a conviction of a person is for a violation committed after a first conviction of such person under this paragraph, punishment is a fine of not more than $20,000 per day of violation, or by imprisonment of not more than 4 years, or both.

(24) The Clean Water Act provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or non-compliance shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than 6 months per violation, or by both.

(25) Collected screening, slurries, sludges, and other solids shall be disposed of in such a manner as to prevent entry of those wastes (or runoff from the wastes) into waters of the State. The proper authorization for such disposal shall be obtained from the Agency and is incorporated as part hereof by reference.

(26) In case of conflict between these standard conditions and any other condition(s) included in this permit, the other condition(s) shall govern.

(27) The permittee shall comply with, in addition to the requirements of the permit, all applicable provisions of 35 Ill. Adm. Code, Subtitle C, Subtitle D, Subtitle E, and all applicable orders of the Board or any court with jurisdiction.

(28) The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit is held invalid, the remaining provisions of this permit shall continue in full force and effect.

(Rev. 7-9-2010 bah)

DOCUMENT

22

9198-/19
Due date: 8-4-19
R008236

From: James Plumley <james.plumley@foresight.com>
Sent: Thursday, June 27, 2019 4:54 PM
To: Ward, Iwona <Iwona.Ward@Illinois.gov>
Cc: Clayton Cross <ccross@foresight.com>
Subject: [External] NPDES Permit IL0077666

Iwona,

Williamson Energy is requesting to waive the 15 day notice for the above mention NPDES Permit Renewal.

If you have any question please let me know.

James Plumley

DOCUMENT

23

3117-115-A
R06238
Due date: 8-1-19

Williamson Energy, LLC
P.O. Box 99
Johnston City, IL 62951

Mr. Iwona Ward
Environmental Protection Engineer
Mine Pollution Control Program
2309 W. Main Street
Marion, Illinois 62959

June 18, 2019

IEPA-DIVISION OF RECORDS MANAGEMENT
RELEASABLE
AUG 02 2019
REVIEWER: SAB

RE: Pond Creek Mine
NPDES Permit No. IL0077666
I.D.N.R. Permits 375 and 417
Supplemental Information Concerning Outlets 009 and 009ES

Dear Mr. Stitely,

Please find attached two (2) copies of the supplemental information concerning outfalls 009 and 009ES for the pending NPDES Renewal for NPDES Permit No. IL0077666 and IDMM Permit No.s 375 and 417 for Williamson Energy, LLC's Pond Creek Mine. If you have any questions concerning this submittal, or require additional information, please contact me at (618) 969-8259.

Respectfully Submitted,

James Plumley

James Plumley, P.E.

RECEIVED
JUN 19 2019
IL Environmental Protection Agency
MARION REGIONAL OFFICE

P06239

NPDES 001

POND 001

21 ACRES OF REFUSE OUTSLOPE RECLAIMED

Pump Station to NPDES 009 Pond Creek Stormwater Mixing Zone

NPDES 009ES

POND 009

14 ACRES OF REFUSE OUTSLOPE TO BE RECLAIMED

PROPOSED LIMITS OF REFUSE DISPOSAL

78 ACRES OF REFUSE OUTSLOPE BEING ADDED FOR NEW REFUSE AREA

Settling Pond

Water Holding Cell

Pump Station to NPDES 011 Big Muddy River Mixing Zone

NPDES 002

NPDES 008

NPDES 007

EAST OF DWINA REFUSE DISPOSAL FACILITY RDA NO. 3

REFUSE DISPOSAL FACILITY RDA NO. 1 AND RDA NO. 2

POND 003

NPDES 004

NPDES 003

POND 004

POND 006

FILL

PREPARATION PLANT

37 ACRES OF REFUSE OUTSLOPE RUNOFF PREVIOUSLY REPORTING TO POND CREEK WILL BE INTERNAL TO THE IMPOUNDMENT AND CAN ONLY DISCHARGE TO THE BIG MUDDY RIVER

PROPOSED LIMITS OF REFUSE DISPOSAL

10 ACRES OF REFUSE OUTSLOPE TO BE RECLAIMED

NPDES 005

POND 005

POND CREEK LOADING

REFUSE SURFACE AREA REPORTING DECREASE

78 ACRES	TOTAL REFUSE OUTSLOPE BEING ADDED
37 ACRES	REFUSE OUTSLOPE BEING ELIMINATED
21 ACRES	REFUSE OUTSLOPE CURRENTLY RECLAIMED
24 ACRES	REFUSE OUTSLOPE LEFT TO BE RECLAIMED
4 ACRES	TOTAL PROPOSED EXPOSED REFUSE OUTSLOPE AREA DECREASE

MINE WATER LOAD DECREASE

ELIMINATION OF MINE WATER DISCHARGE TO POND CREEK.
MINE WATER WILL ONLY DISCHARGE TO THE BIG MUDDDY RIVER.

LEGEND

PERMIT BOUNDARY

NPDES OUTLET

0 600 1200 2400

SCALE: 1" = 600'

WILLIAMSON ENERGY LLC
POND CREEK #1 MINE
PO BOX 99, JOHNSTON CITY, ILLINOIS 62951

REFUSE RECLAMATION AND LOADING DECREASE

Drawn By: SS

Date: 11/11/2016 8:41 AM

R06240

Mine Intake - 720,000 gpd

Mine

Anticipated Maximum Combined for All Turbine Pumps - 3,500,000 gpd

Stormwater pond dewatering pumps run as necessary to supply additional processing water for the preparation plant.

Pond Creek Stormwater Mixing Zone

Proposed NPDES Outlet 009-0
Lat: /Long: 37°51'17" 88°49'25.5"

009

001
37°50'59.2"
88°49'37.5"

POND 001

POND 009

Proposed 009ES
37°50'52.3"
88°48'43.7"

003
37°50'26"
88°49'58"

POND 003

POND 004

POND 002

POND 006

002
37°50'30"
88°49'51.5"

004
37°50'25"
88°49'56.6"

006
37°50'28.4"
88°50'40.6"

008
37°50'31.4"
88°49'33.9"

007
37°50'29.5"
88°49'34"

POND 007/008

RDA No. 1 and RDA No. 2

RDA No. 3 (East of Dwina Refuse Area)

005
37°50'09.1"
88°50'00"

POND 005

Prep Plant Supply - 2,300,000 gpd

SHUT-OFF VALVE

PREPARATION PLANT

FLOAT SYSTEM TO CONTROL POOL LEVEL

FRESH WATER LAKE

Johnston City Lake Pumps - 720,000 gpd

Proposed NPDES Outlet 011-0
Lat: /Long: 37°52'37" 89°01'49"

011

Big Muddy River Mixing Zone

WATER HOLDING CELL

Figure 2-2

LEGEND

- Mine/Plant Fresh Water Supply
- Pond Dewatering / Stormwater Mixing Zone
- Fresh Water Intake Supply
- Mine Pumpage
- RDA Decant Water
- Plant Slurry Pumpage
- Big Muddy River Mixing Zone
- Existing NPDES Outlet
- Proposed NPDES Outlet

WILLIAMSON ENERGY LLC
POND CREEK #1 MINE
PO BOX 99, JOHNSTON CITY, ILLINOIS 62951

WATER FLOW DIAGRAM PROPOSED SYSTEM

Drawn By: SS
Date: 11/11/2016 12:38 PM

SCALE: NTS

DOCUMENT

24

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 • (217) 782-3397
BRUCE RAUNER, GOVERNOR ALEC MESSINA, ACTING DIRECTOR

Memorandum

DATE: 18 June 2019

TO: Iwona Ward

FROM: Scott Twait ST

SUBJECT: WQBELs
Williamson Energy, LLC – Pond Creek Mine
NPDES Permit No. IL007766 (Williamson County)

The subject facility discharges to an unnamed tributary of Pond Creek through Outfall 009ES at a point where 0 cfs of flow exists upstream of the outfalls during critical 7Q10 low-flow conditions. The unnamed tributary of Pond Creek is classified as a General Use Water. The unnamed tributary of Pond Creek is not listed as a biologically significant streams in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor is it given an integrity rating in that document. The unnamed tributary of Pond Creek, tributary to Waterbody Segment, NG-02, is not listed on the draft 2016 Illinois Integrated Water Quality Report and Section 303(d) List since it has not been assessed. The unnamed tributary of Pond Creek is not subject to enhanced dissolved oxygen standards.

Outfall 009ES is acid mine drainage. The NPDES application did not indicate any watershed sizes or flow expected for mixing.

Chloride should be regulated as a daily maximum at the water quality standard of 500 mg/L for Outfall 009ES.

Where appropriate, Manganese should be regulated as a daily maximum at the water quality standard of 1.0 mg/L.

The Sulfate limit is determined according to the water quality standards at 302.208(h)(2). The chloride and hardness data is from AWQMN station NG-02, Pond Creek, South edge of West Frankfort, downstream of the Williamson Energy, LLC – Pond Creek Mine No. 1 property, so this limit should be used for all outfalls. No mixing was used in the derivation of the effluent limit. The following table shows the results of downstream chloride and hardness.

Outfalls	Average Receiving Stream Chloride (mg/L)	Receiving Stream Critical Hardness (mg/L)	Sulfate Water Quality Standard (mg/L)
009ES	21.5	141	1250

The sulfate values in the far-right column are applied as daily maximum permit limits.

Monitoring for chloride, sulfate and hardness should be periodically required at a downstream location from each outfall, or downstream of the mine property, during the course of the permit. This data will be used to recalculate sulfate limits for the next renewed or modified permit.

These recommendations reflect a water quality standards perspective only and should not be construed as being inclusive of all factors that must be taken into consideration by the permit writer.

cc: Carol Selinger
Chron

DOCUMENT

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ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 • (217) 782-3397
JB PRITZKER, GOVERNOR JOHN J. KIM, ACTING DIRECTOR

Memorandum

Date: 18 June 2019

To: Iwona Ward

From: Scott Twait ST

Subject: Williamson Energy, LLC – Pond Creek Mine
Antidegradation Assessment
NPDES Permit No. IL0077666 (Williamson County)

Pond 009 has an emergency discharge via Outfall 009ES. During normal operations, Pond 009 will discharge directly to Pond Creek via Outfall 009 and has provisions for allowed mixing. Outfall 009ES is not expected to have a discharge, except during an emergency.

Identification and Characterization of the Affected Water Body.

The subject facility discharges to an unnamed tributary of Pond Creek through Outfall 009ES at a point where 0 cfs of flow exists upstream of the outfalls during critical 7Q10 low-flow conditions. The unnamed tributary of Pond Creek is classified as a General Use Water. The unnamed tributary of Pond Creek is not listed as a biologically significant streams in the 2008 Illinois Department of Natural Resources Publication *Integrating Multiple Taxa in a Biological Stream Rating System*, nor is it given an integrity rating in that document. The unnamed tributary of Pond Creek, tributary to Waterbody Segment, NG-02, is not listed on the draft 2016 Illinois Integrated Water Quality Report and Section 303(d) List since it has not been assessed. The unnamed tributary of Pond Creek is not subject to enhanced dissolved oxygen standards.

Agency Conclusion.

Upon completing the assessment, it has been determined that the proposed activity will result in only short-term, temporary increases in pollutant loading and will not result in long term or permanent impacts to existing uses including aquatic life habitat; therefore, we find that it is subject to Subsection (d) "Activities Not Subject to a Further Antidegradation Assessment" of 35 Ill. Adm. Code 302.105.

CC: Carol Selinger
Chron

DOCUMENT

26

9152 9
Rec date: 6-7-19 R062469

AquAeTer

optimizing
resources | water, air, earth

MEMORANDUM

TO: James Plumley
FROM: John Michael Corn, P.E. and Pam Hoover, P.E., **AquAeTer, Inc.**
DATE: April 26, 2019
JOB NO.: 192569
RE: **Supplemental Information**
2019 Mach Mine Pond 009 Effluent Results

AquAeTer, Inc. (**AquAeTer**) reviewed the February 28, March 4, and March 6, 2019 laboratory results for the sampling at Mach Mine Pond 009. The results were added to a summary table with the 2016 laboratory results for comparison. The average, maximum, and minimum values were provided on the attached table for both the 2016 laboratory results and for the combined 2016 and 2019 laboratory results. A copy of the summary table is attached.

The Illinois Environmental Protection Agency (IEPA) reviewed the 2016 and 2019 data and stated that the 2019 nickel data does not exceed the acute water quality standard (WQS). Further, the IEPA stated that the average of the 2016 and 2019 nickel data does exceed the chronic WQS; however, a mixing zone has already been demonstrated. Based on the findings, the IEPA indicated in electronic mail correspondence, that, as a result, the laboratory data can be submitted to the Agency as supplemental information to the 2016 Antidegradation Report. The attached summary table is being provided to satisfy the supplemental requirement.

If you have any questions or comments, please do not hesitate to contact us by telephone at (615) 373-8532, by facsimile at (615) 373-8512, or by electronic mail at jmcorn@aquaeter.com or phoover@aquaeter.com.

ATTACHMENT

TABLE

R06248

TABLE 1. DRAFT COMPARISON OF THE 2016 DATASET AND THE 2016+2019 DATASET
Mach Mine Discharge to the Big Muddy River

CONSTITUENT	SAMPLE COLLECTION DATE/LAB REPORT												2016			2016 & 2019		
	HOLDING CELL									POND 9								
	30-Sep-16 18089-1 (mg/L)	6-Oct-16 18095-1 (mg/L)	10-Oct-16 18097-1 (mg/L)	13-Oct-16 18114-1 (mg/L)	17-Oct-16 18118-1 (mg/L)	19-Oct-16 18124-1 (mg/L)	27-Oct-16 18149-1 (mg/L)	31-Oct-16 18165-1 (mg/L)	2-Nov-16 18176-1 (mg/L)	28-Feb-19 20641 (mg/L)	4-Mar-19 20647 (mg/L)	6-Mar-19 20654 (mg/L)	AVERAGE (mg/L)	MAXIMUM (mg/L)	MINIMUM (mg/L)	AVERAGE (mg/L)	MAXIMUM (mg/L)	MINIMUM (mg/L)
pH	7.2	7.4	7.5	7.1	7.1	7.8	8.0	7.0	7.0	8.1	8.3	8.4	7.2	8.0	7.0	7.3	8.4	7.0
Acidity	5	18	5	20	24	5	22	10	20	5	5	10	14.3	24.0	< 10	12.4	24.0	< 10
Alkalinity	492	64	468	440	612	588	608	444	464	472	460	456	464.4	612.0	64.0	464.0	612.0	64.0
Hardness	760	610	712	870	970	950	970	640	770	380	380	388	805.8	970.0	610.0	700.0	970.0	380.0
Chlorides	2,049	1,699	2,199	2,799	2,229	2,449	2,449	2,349	2,040	795	844	1,200	2251.3	2799.0	1699.0	1925.1	2799.0	795.0
Sulfates	1,880	1,720	2,000	1,880	2,040	2,120	820	1,400	1,809	800	1,060	1160	1741.0	2120.0	820.0	1557.4	2120.0	800.0
Settleable solids	--	--	--	--	--	--	--	--	--	< 0.25	-	-	--	--	--	< 0.25	< 0.25	< 0.25
TSS	10	53	43	72	47	44	7	21	38	13	28	47	37.2	72.0	7.0	35.3	72.0	7.0
Cyanide	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	-	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Phenols, TR	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	0.002	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.002	0.001	0.001	0.003	0.001	0.002	< 0.001	0.001	0.003	< 0.001
Arsenic	0.001	0.0005	0.002	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.002	0.003	0.001	0.002	< 0.002	0.002	0.003	< 0.002
Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001	< 0.001	< 0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, total	0.0007	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0004	0.0005	0.0001	0.0001	0.0001	0.0002	0.0007	<0.002	0.0002	0.0007	<0.002
Cadmium, dissolved	0.0006	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003	0.0004	0.0001	0.0001	0.0001	0.0002	0.0006	<0.002	0.0002	0.0006	<0.002
Chromium	0.008	0.002	0.005	0.008	0.005	0.003	0.004	0.003	0.003	0.004	0.005	0.007	0.005	0.008	0.002	0.005	0.008	0.002
Copper	0.024	0.011	0.026	0.031	0.032	0.018	0.022	0.022	0.022	0.019	0.021	0.028	0.023	0.032	0.011	0.023	0.032	0.011
Iron, total	0.216	0.28	0.946	1.835	1.332	0.569	0.253	0.402	0.332	0.157	0.402	1.242	0.685	1.835	0.216	0.664	1.835	0.157
Iron, dissolved	0.159	0.28	0.441	0.709	0.347	0.137	0.061	0.078	0.153	0.025	0.025	0.025	0.263	0.709	0.061	0.203	0.709	< 0.05
Lead	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.001	<0.001	<0.001	<0.001	0.001	< 0.002	< 0.001
Manganese, total	0.419	0.163	0.183	0.313	0.212	0.149	0.125	0.133	0.142	0.346	0.32	0.218	0.204	0.419	0.125	0.227	0.419	0.125
Manganese, dissolved	0.405	0.163	0.2	0.264	0.212	0.134	0.121	0.131	0.135	0.223	0.1	0.061	0.192	0.405	0.121	0.176	0.405	0.061
Mercury	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Nickel, total	0.014	0.004	0.007	0.006	0.007	0.006	0.006	0.010	0.01	0.057	0.045	0.033	0.008	0.014	0.004	0.017	0.057	0.004
Nickel, dissolved	0.013	0.004	0.007	0.004	0.007	0.006	0.006	0.010	0.009	0.052	0.04	0.028	0.007	0.013	0.004	0.016	0.052	0.004
Selenium	0.008	0.006	0.007	0.007	0.004	0.004	0.004	0.008	0.009	0.008	0.009	0.012	0.006	0.009	0.004	0.007	0.012	0.004
Silver	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Zinc	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.025	0.025	0.025	< 0.02	< 0.02	< 0.02	0.014	< 0.05	< 0.02
PCBs	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

DOCUMENT

27

Twait, Scott

From: Twait, Scott
Sent: Thursday, March 28, 2019 2:58 PM
To: Ward, Iwona
Cc: Sofat, Sanjay; LeCrone, Darin
Subject: RE: Williamson Energy - Pond Creek

Iwona,

Is this data for the discharge to the Big Muddy River via Outfall 011?
If so, the new Nickel data does not exceed the acute WQS. The average of the Nickel data does exceed the chronic WQS, however, they have already demonstrated a mixing zone. This new data can just be submitted as supplemental information.

As to the flood zone information, if the impact would increase as it goes downstream, they should evaluate the Big Muddy River further downstream. I the point of discharge would be the largest impact, then what they have submitted will be sufficient.

Scott

From: Ward, Iwona
Sent: Wednesday, March 27, 2019 4:44 PM
To: Twait, Scott <Scott.Twait@Illinois.gov>
Cc: Sofat, Sanjay <Sanjay.Sofat@Illinois.gov>; LeCrone, Darin <Darin.LeCrone@Illinois.gov>
Subject: Williamson Energy - Pond Creek

Scott,
James Plumley delivered today couple documents I would like to share them with you and ask you for your comments. First is updated dataset for the discharge that we requested from the Applicant. The question is do they need to submit all new antidegradation assessment or if they could submit supplemental information to the existing AA?
Second question was about flood zone. They wanted to check with us how they supposed to submit the info to us? How far down the stream they should provide data. From the table that is in the attachment they show profile from 2 yr24 hr to 100 yr 24 hr they additionally discharge 13.2 cfs and change in the W.S. elevation is not significant.

Let me know if you have a questions

Thank you
Iwona

Iwona K. Ward
Environmental Protection Engineer
Mine Pollution Control Program
2309 W. Main St., Suite 116
Marion, IL 62959

Phone: 618/993-7200
Fax: 618/997-1281
e-mail: Iwona.Ward@illinois.gov

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AquAeTer

optimizing
resources | water, air, earth

DRAFT
MEMORANDUM

TO: James Plumley
FROM: John Michael Corn, P.E. and Pam Hoover, P.E., **AquAeTer, Inc.**
DATE: April 3, 2019
JOB NO.: 192569
RE: **Supplemental Information**
2019 Mach Mine Pond 009 Effluent Results

AquAeTer, Inc. (AquAeTer) reviewed the February 28, March 4, and March 6, 2019 laboratory results for the sampling at Mach Mine Pond 009. The results were added to a summary table with the 2016 laboratory results for comparison. The average, maximum, and minimum values were provided on the attached table for both the 2016 laboratory results and for the combined 2016 and 2019 laboratory results. A copy of the summary table is attached.

The Illinois Environmental Protection Agency (IEPA) reviewed the 2016 and 2019 data and stated that the 2019 nickel data does not exceed the acute water quality standard (WQS). Further, the IEPA stated that the average of the 2016 and 2019 nickel data does exceed the chronic WQS; however, a mixing zone has already been demonstrated. Based on the findings, the IEPA indicated in electronic mail correspondence, that, as a result, the laboratory data can be submitted to the Agency as supplemental information to the 2016 Antidegradation Report. The attached summary table is being provided to satisfy the supplemental requirement.

If you have any questions or comments, please do not hesitate to contact us by telephone at (615) 373-8532, by facsimile at (615) 373-8512, or by electronic mail at jmcorn@aquaeter.com or phoover@aquaeter.com.

TABLE 2. DRAFT COMPARISON OF THE 2016 DATASET AND THE 2016+2019 DATASET
Mach Mine Discharge to the Big Muddy River

CONSTITUENT	SAMPLE COLLECTION DATE/LAB REPORT												2016			2016 & 2019		
	HOLDING CELL									POND 9								
	30-Sep-16 18089-1 (mg/L)	6-Oct-16 18095-1 (mg/L)	10-Oct-16 18097-1 (mg/L)	13-Oct-16 18114-1 (mg/L)	17-Oct-16 18118-1 (mg/L)	19-Oct-16 18124-1 (mg/L)	27-Oct-16 18149-1 (mg/L)	31-Oct-16 18165-1 (mg/L)	2-Nov-16 18176-1 (mg/L)	28-Feb-19 20641 (mg/L)	4-Mar-19 20647 (mg/L)	6-Mar-19 20654 (mg/L)	AVERAGE (mg/L)	MAXIMUM (mg/L)	MINIMUM (mg/L)	AVERAGE (mg/L)	MAXIMUM (mg/L)	MINIMUM (mg/L)
pH	7.2	7.4	7.5	7.1	7.1	7.8	8.0	7.0	7.0	8.1	8.3	8.4	7.2	8.0	7.0	7.3	8.4	7.0
Acidity	5	18	5	20	24	5	22	10	20	5	5	10	14.3	24.0	< 10	12.4	24.0	< 10
Alkalinity	492	64	468	440	612	588	608	444	464	472	460	456	464.4	612.0	64.0	464.0	612.0	64.0
Hardness	760	610	712	870	970	950	970	640	770	380	380	388	805.8	970.0	610.0	700.0	970.0	380.0
Chlorides	2,049	1,699	2,199	2,799	2,229	2,449	2,449	2,349	2,040	795	844	1,200	2251.3	2799.0	1699.0	1925.1	2799.0	795.0
Sulfates	1,880	1,720	2,000	1,880	2,040	2,120	820	1,400	1,809	800	1,060	1160	1741.0	2120.0	820.0	1557.4	2120.0	800.0
Settleable solids	--	--	--	--	--	--	--	--	--	< 0.25	-	-	--	--	--	< 0.25	< 0.25	< 0.25
TSS	10	53	43	72	47	44	7	21	38	13	28	47	37.2	72.0	7.0	35.3	72.0	7.0
Cyanide	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	-	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Phenols, TR	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	0.002	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.002	0.001	0.001	0.003	0.001	0.002	< 0.001	0.001	0.003	< 0.001
Arsenic	0.001	0.0005	0.002	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.002	0.003	0.001	0.002	< 0.002	0.002	0.003	< 0.002
Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001	< 0.001	< 0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, total	0.0007	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0004	0.0005	0.0001	0.0001	0.0001	0.0002	0.0007	<0.002	0.0002	0.0007	<0.002
Cadmium, dissolved	0.0006	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003	0.0004	0.0001	0.0001	0.0001	0.0002	0.0006	<0.002	0.0002	0.0006	<0.002
Chromium	0.008	0.002	0.005	0.008	0.005	0.003	0.004	0.003	0.003	0.004	0.005	0.007	0.005	0.008	0.002	0.005	0.008	0.002
Copper	0.024	0.011	0.026	0.031	0.032	0.018	0.022	0.022	0.022	0.019	0.021	0.028	0.023	0.032	0.011	0.023	0.032	0.011
Iron, total	0.216	0.28	0.946	1.835	1.332	0.569	0.253	0.402	0.332	0.157	0.402	1.242	0.685	1.835	0.216	0.664	1.835	0.157
Iron, dissolved	0.159	0.28	0.441	0.709	0.347	0.137	0.061	0.078	0.153	0.025	0.025	0.025	0.263	0.709	0.061	0.203	0.709	< 0.05
Lead	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.001	<0.001	<0.001	<0.001	0.001	< 0.002	< 0.001
Manganese, total	0.419	0.163	0.183	0.313	0.212	0.149	0.125	0.133	0.142	0.346	0.32	0.218	0.204	0.419	0.125	0.227	0.419	0.125
Manganese, dissolved	0.405	0.163	0.2	0.264	0.212	0.134	0.121	0.131	0.135	0.223	0.1	0.061	0.192	0.405	0.121	0.176	0.405	0.061
Mercury	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Nickel, total	0.014	0.004	0.007	0.006	0.007	0.006	0.006	0.010	0.01	0.057	0.045	0.033	0.008	0.014	0.004	0.017	0.057	0.004
Nickel, dissolved	0.013	0.004	0.007	0.004	0.007	0.006	0.006	0.010	0.009	0.052	0.04	0.028	0.007	0.013	0.004	0.016	0.052	0.004
Selenium	0.008	0.006	0.007	0.007	0.004	0.004	0.004	0.008	0.009	0.008	0.009	0.012	0.006	0.009	0.004	0.007	0.012	0.004
Silver	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Zinc	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.025	0.025	0.025	< 0.02	< 0.02	< 0.02	0.014	< 0.05	< 0.02
PCBs	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

R06253

Twait, Scott

From: Ward, Iwona
Sent: Wednesday, March 27, 2019 4:44 PM
To: Twait, Scott
Cc: Sofat, Sanjay; LeCrone, Darin
Subject: Williamson Energy - Pond Creek
Attachments: Xerox Scan_03272019161336.pdf

Scott,
James Plumley delivered today couple documents I would like to share them with you and ask you for your comments. First is updated dataset for the discharge that we requested from the Applicant. The question is do they need to submit all new antidegradation assessment or if they could submit supplemental information to the existing AA?
Second question was about flood zone. They wanted to check with us how they supposed to submit the info to us? How far down the stream they should provide data. From the table that is in the attachment they show profile from 2 yr24 hr to 100 yr 24 hr they additionally discharge 13.2 cfs and change in the W.S. elevation is not significant.

Let me know if you have a questions

Thank you
Iwona

Iwona K. Ward
Environmental Protection Engineer
Mine Pollution Control Program
2309 W. Main St., Suite 116
Marion, IL 62959

Phone: 618/993-7200
Fax: 618/997-1281
e-mail: Iwona.Ward@illinois.gov

State of Illinois - CONFIDENTIALITY NOTICE: The information contained in this communication is confidential, may be attorney-client privileged or attorney work product, may constitute inside information or internal deliberative staff communication, and is intended only for the use of the addressee. Unauthorized use, disclosure or copying of this communication or any part thereof is strictly prohibited and may be unlawful. If you have received this communication in error, please notify the sender immediately by return e-mail and destroy this communication and all copies thereof, including all attachments. Receipt by an unintended recipient does not waive attorney-client privilege, attorney work product privilege, or any other exemption from disclosure.

James, We are providing the following project update.

1. Compare the 2016 dataset for the discharge to the 2016+2019 dataset

The following table provides the compounds of concern 2016 dataset and the combined 2016 and 2019 dataset.

CONSTITUENT	2016			2016 & 2019 DRAFT			DIFFERENCE (%)
	AVERAGE (mg/L)	MAXIMUM (mg/L)	MINIMUM (mg/L)	AVERAGE (mg/L)	MAXIMUM (mg/L)	MINIMUM (mg/L)	
pH	7.2	8	7	7.3	8.4	7	-2%
Acidity	14.3	24	< 10	12.4	24	< 10	13%
Alkalinity	464.4	612	64	464	612	64	0%
Hardness	805.8	970	610	700	970	380	13%
Chlorides	2251.3	2799	1699	1925.1	2799	795	14%
Sulfates	1741	2120	820	1557.4	2120	800	11%
Settleable solids	--	--	--	< 0.25	< 0.25	< 0.25	NC
TSS	37.2	72	7	35.3	72	7	5%
Cyanide	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	NC
Phenols, TR	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
Antimony	0.001	0.002	< 0.001	0.001	0.003	< 0.001	-17%
Arsenic	0.001	0.002	< 0.002	0.002	0.003	< 0.002	-11%
Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NC
Cadmium, total	0.0002	0.0007	<0.002	0.0002	0.0007	<0.002	15%
Cadmium, dissolved	0.0002	0.0006	<0.002	0.0002	0.0006	<0.002	13%
Chromium	0.005	0.008	0.002	0.005	0.008	0.002	-4%
Copper	0.023	0.032	0.011	0.023	0.032	0.011	0%
Iron, total	0.685	1.835	0.216	0.664	1.835	0.157	3%
Iron, dissolved	0.263	0.709	0.061	0.203	0.709	< 0.05	23%
Lead	<0.001	<0.001	<0.001	0.001	< 0.002	< 0.001	NC
Manganese, total	0.204	0.419	0.125	0.227	0.419	0.125	-11%
Manganese, dissolved	0.192	0.405	0.121	0.176	0.405	0.061	8%
Mercury	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	NC
Nickel, total	0.008	0.014	0.004	0.017	0.057	0.004	-120%
Nickel, dissolved	0.007	0.013	0.004	0.016	0.052	0.004	-111%
Selenium	0.006	0.009	0.004	0.007	0.012	0.004	-13%
Silver	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NC
Thallium	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	NC
Zinc	< 0.02	< 0.02	< 0.02	0.014	< 0.05	< 0.02	NC
PCBs	--	--	--	--	--	--	

As shown on the table, for the compounds of concern, the datasets are the same or the values decreased; except for nickel. We would expect that IEPA will require that the Antidegradation Report be updated for nickel. It might be useful to discuss this with the Permit Writer in order to find out if an addendum with the new nickel information would be acceptable or if they will require a complete update of the Report.

2. Evaluate the new background dataset from IEPA.

At this time, we are working on the evaluating the background data provided by IEPA for Station N-11 and potentially N-08. Previously, the IEPA database was limited and did not include a number of compounds. The new IEPA background database does now include all compounds on this list. We will compare the background values to the 2016 values used in the original report to determine if the background dataset has changed significantly.

3. Calculate new loadings for the compounds of concern using the new discharge data and the new IEPA background data.

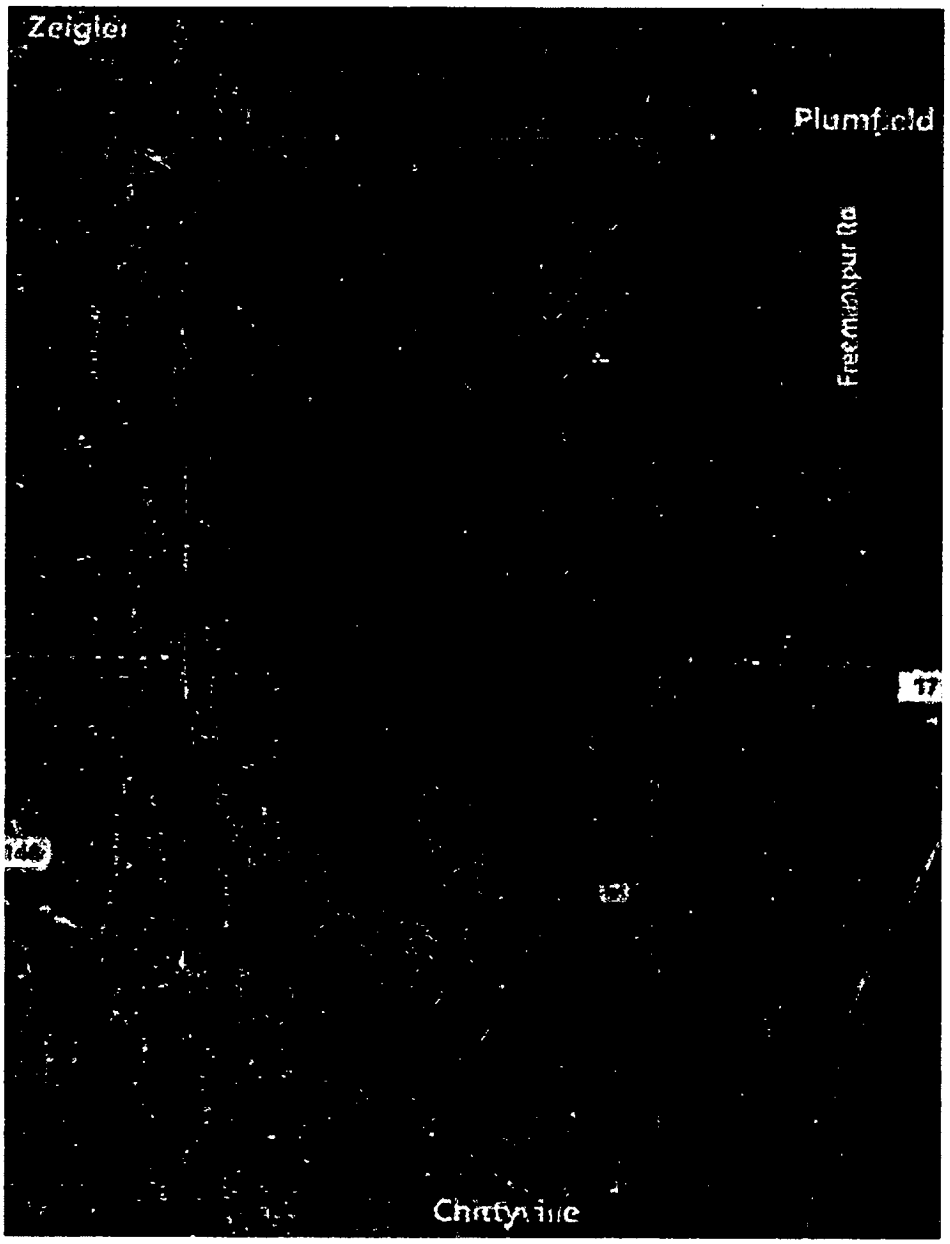
To be completed when the background dataset is compiled.

If you have any questions, please let me know. We will send an update with the background analysis soon.

Regards,
John Michael

John Michael Corn, P.E.
AquAeTer, Inc.
Phone: (615) 373-8532
Fax: (615) 373-8512
www.aquaeter.com

Reach	River Sta	Profile	Proposed Discharge (cfs)	Existing Storm Event Flow (cfs)	Final Proposed Flow (cfs)	Change in W.S. Elev. (ft)
Big Muddy	11463	2 Yr 24 Hr	13.2	8,550	8,563.2	0.007
Big Muddy	11463	5 Yr 24 Hr	13.2	13,200	13,213.2	0.004
Big Muddy	11463	10 Yr 24 Hr	13.2	16,400	16,413.2	0.004
Big Muddy	11463	25 Yr 24 Hr	13.2	20,600	20,613.2	0.004
Big Muddy	11463	50 Yr 24 Hr	13.2	23,900	23,913.2	0.004
Big Muddy	11463	100 Yr 24 Hr	13.2	27,000	27,013.2	0.003



DOCUMENT

28

STATE OF ILLINOIS

ENVIRONMENTAL PROTECTION AGENCY

Subject: Williamson Energy, LLC – Pond Creek Mine No. 1

Data: Log No. 9109-19

Reviewed by: I. Ward **Date:** 06/10/19

Log No. 9109-19 ⇒IBR No. 83 to OMM Permit No. 375.

Log No. 9109-19

- IBR to OMM Permit No. 375 requests the addition of 17.01 acres.
- IBR area is located in Sections 2, 3, 9 and 10, Township 8 South, Range 4 East, Williamson County.
- IBR is for an access roadway, one 16.5-foot bleeder shaft, utility boreholes, concrete pad for transformer, a compressor station and a portable crib plant.
- Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

* Action: Reference Log Nos. 9109-19 in CA as additional permit acreage.

9109 · / 19
Due date: 5.9.19
R06259

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Illinois Department of
Natural Resources

One Natural Resources Way Springfield, Illinois 62702-1271
www.dnr.illinois.gov

JB Pritzker, Governor
Colleen Callahan, Director

March 26, 2019

Mr. Carson Pollastro
Williamson Energy, LLC
P.O. Box 99
Johnston City, IL 62951

RECEIVED
MAR 28 2019
IL Environmental Protection Agency
MARION REGIONAL OFFICE

Re: Permit No. 375
Incidental Boundary Revision No. 83

Dear Mr. Pollastro:

The appropriate Department technical staff have reviewed the proposed incidental boundary revision dated January 28, 2019, and the supplemental information dated, March 5, 2019, submitted by the permittee for the Pond Creek No. 1 Mine. The request would add 17.01 acres to conduct surface coal mining activities. The additional acres would be used for the installation of a support site consisting of gravel entrance road and work area, a 16.5-foot diameter bleeder fan shaft, one 16-inch diameter borehole for a vertical turbine pump, one 8.625-inch diameter borehole for compressed air, three 12.75-inch diameter utility boreholes, one 24-inch diameter utility borehole, associated concrete pads for the boreholes, and a 10,900 linear foot water line (12-inch diameter) for the conveyance of mine infiltration water.

Section 1774.13: The Department finds the permittee has demonstrated in its request, and field inspections by the Department's field representative have confirmed, that these areas meet the requirements for an incidental boundary revision, as outlined in 62 Ill. Adm. Code 1774.13(d). Section 1774.13(d)(6) publication requirements have been met. Section 1774.13(c) findings are below.

DEPARTMENT FINDINGS

Section 1761.11(d): The proposed area is within one hundred (100) feet measured horizontally of the outside right-of-way line of public roads in Williamson County, described as follows:

> The proposed area is adjacent to the right-of-way of Kraatz, Crawford, and Locust Grove Roads. The proposed activities in the application area include the development of a support area with a gravel setup yard and the installation of an

underground waterline. Also, an access road will be constructed from Crawford Road to the support area.

No approvals from the authority with jurisdiction over the roads were required.

The applicant provided proper public notice and opportunity for a public hearing. No hearing was requested, and no written comments were submitted to the Department concerning these roads.

The Department finds the interests of the public and affected landowners will be protected from the proposed mining operations as a result of the measures to be taken by the applicant as described in the mining operations plan concerning these roads.

Section 1761.11(e): The proposed area is within three hundred (300) feet measured horizontally of two occupied dwellings.

The applicant shall establish a three hundred (300) foot buffer around the dwelling located to the northeast, not disturb within the buffer zone and shall install and maintain buffer zone markers to prevent disturbance within the buffer zone.

The owner of the dwelling located to the southwest has provided a written waiver pursuant to Section 1761.15 consenting to surface coal mining operations closer than 300 feet.

Section 1773.15(c)(12): The effect of the proposed permitting action on properties listed on or eligible for listing on the National Register of Historic Places has been taken into account by the Department.

Sections 1784.14(e)(4) and 1784.14(f)(2), respectively: The Department has determined that neither a new or updated probable hydrologic consequences determination nor a new or updated assessment of the probable cumulative hydrologic impacts is required.

Section 1817.46(e): A sediment pond exemption is requested for an area delineated in the application. The regulations at Section 1817.46(e) allow the Department to grant exemptions from the requirement to pass all disturbed drainage through a siltation structure when:

a. The disturbed drainage area within the total disturbed area is small; and

b. Alternate sediment control measures as described in Section 1817.45(b) are used in lieu of a siltation structure, and the applicant demonstrates that siltation structures are not necessary for drainage from the disturbed area to meet the effluent limitations and water quality standards for the receiving waters set forth in Section 1817.42.

The Department has determined that the area for which a sediment pond exemption is requested meets the criteria established in Section 1817.46(e) and hereby grants an exemption from the use of a sedimentation pond for this area.

Section 1817.57(a)(1): The applicant has requested a stream buffer zone variance for an area as delineated in the application. In accordance with Section 1817.57(a)(1), the Department finds that:

a. The original stream channel and its associated riparian vegetation will be restored; and

b. Surface mining activities will not cause or contribute to a violation of Section 1817.42 and will not adversely affect the water quantity and quality or other environmental resources of the stream.

Therefore, the Department authorizes surface mining activities closer than one hundred (100) feet of the top of the bank of the normal channel of the perennial or intermittent stream or through the stream.

Section 1773.15 (c)(10) and 1816.97(b): Based on 17 Ill. Adm Code Section 1075 consultation and consultation with the U. S. Fish and Wildlife Service (USFWS), the Department has determined that the operations as approved will not affect the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitats, as determined under the Endangered Species Act of 1973 (16 USC 1531 et seq.).

Incidental Take Authorization: A federal Incidental Take Authorization for the Indiana bat (*Myotis sodalis*) has been requested as part of this submittal. A Protection and Enhancement Plan (PEP) has been provided that meets the specifications for the 2013 revised edition of the guidance document provided by the USFWS, including planting of a minimum of 0.70 acres of approved tree species at reclamation. The Incidental Take Authorization for the Indiana bat is hereby granted under the authority granted to the Department by the 1996 Biological Opinion, OSM, and the USFWS.

The applicant utilized the federal actions key to the 4(d) rule regarding Incidental Take of the northern-long eared bat (*Myotis septentrionalis*). The Department has determined that this project may affect northern long-eared bat habitat, but that any resulting incidental take is not prohibited by the federal final 4(d) rule. Therefor this project is consistent with the USFWS Jan 2016 Programmatic Biological Opinion on the final 4(d) rule. The Department and the applicant are in compliance with Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq).

Section 1817.150: The applicant has proposed the creation of a road in the permit area. Pursuant to Section 1817.150(a)(2)&(3) the Department has determined that the road is an ancillary road.

FEE AND BOND

Section 1777.17(c): The fee for the area will be $425.00. The fee is comprised of $425.00 for non-surface mining area ($5/acres x 17.0 acres x the 5 years the bond is in force).

Section 1800.15(d): The bond for the area will be $253,500.00.

PERMIT CONDITIONS

Section 1778.15: Pursuant to Section 1778.15, the permittee shall possess all necessary legal rights to enter and conduct surface coal mining and reclamation operations within the permit area until final bond release is obtained.

Section 1817.13: Upon completion of drilling activities, a borehole/well completion diagram shall be submitted to the Department for all boreholes (dewater, injection, observation, methane vent, rockdust, power supply, etc.) within thirty (30) days of completion of drilling activities. Pursuant to 62 Ill. Adm. Code 1817.13, each borehole shall be properly cased/lined. The construction diagram shall include the location and surveyed elevation of each borehole, a unique name for the borehole and details on the casing/construction materials used. A copy of the borehole/well completion diagram can be found on the Department's Forms webpage at: https://www.dnr.illinois.gov/mines/LRD/Pages/FormsApplicationsMemoranda.aspx under Miscellaneous Permittee/Operator Forms. Construction all boreholes/monitoring wells shall be in accordance with Operator Memorandum 2017-01.

Section 1817.15: Pursuant to 62 Ill. Adm. Code 1817.15, each borehole shall be properly abandoned and sealed when no longer needed for its intended purpose. A copy of the plugging affidavit form can be found on the Department's Forms webpage at: https://www.dnr.illinois.gov/mines/LRD/Pages/FormsApplicationsMemoranda.aspx, under Miscellaneous Permittee/Operator Forms. Proof of plugging of all boreholes shall be in accordance with Operator Memorandum 2015-02.

All conditions and provisions contained in the approved permit also apply to this revision. Approval from this agency does not relieve the permittee from obtaining approval from other agencies requiring such.

The Department is in receipt of the fee and bond. Please forward two copies of your request letter and maps to Illinois Environmental Protection Agency, Mine Pollution Control Program, 2309 West Main Street, Suite 116, Marion, Illinois 62959. Mining activities on these 17.01 acres may commence.

Should you have any questions, please contact Will Gillespie at our Benton Office.

Sincerely,

Nick San Diego, Supervisor
Land Reclamation Division

NSD:WG:sp

cc: W. Gillespie
Mine Pollution Control Program, IEPA
J. Kuhlman

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020

INCIDENTIAL BOUNDARY REVISION FOR PERMIT NO. 375

North Bleeder Shaft

WILLIAMSON COUNTY, IL
Pond Creek #1 Mine

January 28, 2019

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020 Fax: 618-983-3017

March 5, 2019

Mr. Nick San Diego
Illinois Department of Natural Resources
Land Reclamation Division
One Natural Resources Way.
Springfield, Il. 62702

RE: IBR to Permit No. 375, Williamson Energy, LLC: **17.01-acre IBR for North Bleeder Shaft with a Submittal Date of 1-28-19.**

Dear Mr. San Diego:

A submittal of supplemental information (2 Copies) for the above-referenced IBR is enclosed for Williamson Energy, LLC

One copy was hand delivered to Williams Gillespie at the IDNR office in Benton, IL.

Please let me know if you have any questions or need further information.

Sincerely,

James Plumley
Permit Coordinator—Foresight Energy, LLC

enclosure
Cc:
Williams Gillespie

RECEIVED
MAR 27 2019
IL Environmental Protection Agency
MARION REGIONAL OFFICE

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020 Fax: 618-983-3017

January 28, 2019

Mr. Nick San Diego
Illinois Department of Natural Resources
Land Reclamation Division
One Natural Resources Way.
Springfield, Il. 62702

RE: IBR to Permit No. 375, Williamson Energy, LLC: **17.01-acre IBR for North Bleeder Shaft.**

Dear Mr. San Diego:

An application (2 Copies) for the above-referenced IBR is enclosed for Williamson Energy, LLC

One copy was hand delivered to Williams Gillespie at the IDNR office in Benton, IL.

Please let me know if you have any questions or need further information.

Sincerely,

James Plumley
Permit Coordinator—Foresight Energy, LLC

enclosure
Cc:
Williams Gillespie

Cover Sheet: Application for Coal Mining and Reclamation Operations

Applicant: Williamson Energy, LLC
Name of Company, Corporation, Partnership or Individual. [1777.11]

AVS ID: *(Optional)* 156747

Applicant is a: [X] Corporation [ ] Partnership [ ] Sole Proprietor

[ ] Association or other Business Entity **[1778.13(a)]**

Mine Name: Pond Creek No. 1 Mine
Address/PO: PO Box 99
City: Johnston City
State: IL
Zip Code: 62951
Email Address: James.plumley@foresight.com
Phone Number: 618-983-3020
Fax Number: 618-983-3017
Tax ID/FEIN: 41-2178049

Application Type:
[X] New [ ] MUF
[ ] Existing Permit No(s). 375
[ ] Sig. Rev No. _____ [ ] Renewal [ ] Transfer No. ___
[X] IBR [ ] SIBR
[ ] IPR

Type of Operation: [ ] Surface [X] Underground [ ] Carbon Recovery

Mine Safety Health Administration Information:

MSHA ID Number 11-03141 **[1778.13(d)(1)]**
Date of Issuance _____

List the Mine Safety and Health Administration (MSHA) number(s) for all mine associated structures that require MSHA approval. **[1778.13(g)]**

Structure Type	Structure Name	MSHA No.

Illinois Environmental Protection Agency Information:

Is application to be used as an application for an NPDES and/or Subtitle D?

☐ YES ☒ NO

NOTE: If this is an application for an NPDES permit, the Consolidated Permits Program, Application Form 2C (renewal), Form 2D (new), or Form 2E (sanitary) must be completed.

If YES, check the appropriate box below:

☐ IEPA Subtitle D State Permit
☐ NPDES *(New)*
☐ NPDES *(Renewal)*
☐ NPDES *(Modification)*

☐ I waive my right of the 90-day permit issuance deadline as required by Section 39(a)(4) of the Illinois Environmental Protection Act and 35 Ill. Adm. Code 309.225(c) of the Illinois Pollution Control Board Rules and Regulations.

Affidavits, Certifications, Insurance Certificates, Newspaper Notice, Financial Assurance. The applicant shall attach the appropriate affidavits required for the type of operations proposed, a draft public notice, and a valid certificate of insurance.

Check and attach the completed documents for the proposed operations, if applicable:

	Underground Mining Affidavit
	Planned Subsidence Mitigation Right of Entry Affidavit
	Underground Slurry Disposal Affidavit
	Public Land Survey Monuments Certification
X	Engineering Certification
	Technical Data Information Sheet
	Occupied Dwelling Buffer Zone Waiver

Complete below and attach the draft public notice for review. **[1778.21].**

X	*Marion Daily Republican*

Proof of general liability insurance from an authorized provider (licensed to write from the Illinois Department of Insurance), Performance bond

	Certificate of Insurance **[1778.18, 1817.121(c)(3)]**
	Evidence of required bond **(Renewals only) 1774.15**

☐ I waive the time limits for the Department to make its final permit decision pursuant to 62 Ill. Adm. Code 1773.19(a)(2)

I, James P Lumley Authorized Person , under penalties
(Signature, Title)

of perjury, declare that I have examined this application, including the accompanying statements and documents, and that, to the best of my knowledge, it is true and correct. I also certify that all printed copies of this application provided to the Department and County Clerk(s) are identical. **(Signer must be at least a Vice-President or duly authorized representative)**

Dated: 1/28/19

Description of Proposed Permitting Action:

Describe in sufficient detail the proposed activities. The information should summarize the requested permitting action to assist the Department in determining the scope and magnitude of the proposal.

This IBR is requesting to install the following: a access road, one 16.5 foot bleeder shaft, one 16 inch turbine borehole, one 8.625 inch utility borehole, three 12.75 inch steel utility boreholes, one 24 inch utility borehole, (each borehole has a 10'x10'x1' concrete pad), transformer with a 10'x8'x1' concrete pad, compressor station, crib plant (Jenchem Plant) with associated facilities. The shaft will a large concrete pad poured irregularly shaft with a surface area of ~2430 square feet and a thickness of 4 feet. Two temporary drill pits (one ~20'x40'x10' and one ~ 10'x20'x10) will be used during the development of the turbine and utility boreholes. The IBR drill site will be gravel with 8 inches of crusher run gravel ~(1.56 acres). HDPE water (12") and power lines will be installed back connection into the existing shaft site along Locust Grove Road.

Application Part Inventory:

Application Part	Application Part Title	Indicate with an "X" all Parts modified with this submittal
1.0	**Administrative Information**	
1.1	General Information	X
1.2	Acreage and Timetable	X
1.3	Ownership and Control Information	
1.4	Violation History	
1.5	Property Ownership	X
2.0	**Pre-Mining information**	
2.1	Pre-Mining Land Use Information	X
2.2	Pre-Mining Soils Information	X
2.3	Areas Where Mining is Limited or Prohibited	X
2.4	Public Parks, Historic Properties	X
2.5	Valid Existing Rights (VER) - Good Faith/All Permits Standard	
2.6	Valid Existing Rights (VER) - Needed for and Adjacent Standard	
2.7	Valid Existing Rights (VER) - Standards for Mine Roads	
3.0	**Mining Operations Plan**	
3.1	General Description of Operations	X
3.2	Description of Mine Facilities	X
3.3	Signs and Markers	X
3.4	Soil and Overburden Handling and Protection	X
3.5	Lateral Support	
3.6	Surface Mining Near Underground Mining	
3.7	Existing Structures	X
3.8	Transportation Facilities	X
3.9	Non-Coal Mine Waste Material	
3.10	Coal Preparation	
3.11	Coal Processing Waste and Underground Development Waste	X
3.12	Coal Refuse Disposal Area	
3.13	Air Pollution Control Plan	
3.14	Fire Control Plan	
4.0	**Hydrologic and Geologic Information**	

4.1	Regional Characteristics	
4.2	Hydrogeologic Information	
4.3	Area Specific Characteristics	
4.4	Ground Water Information	
4.5	Ground Water Monitoring Program	
4.6	Surface Water Information	
4.7	NPDES Monitoring Program	
4.8	Protection of Hydrologic Balance	
4.9	Preventative and Remedial Measures Plan	
4.10	Liners	
4.11	Coal Combustion Materials	
5.0	**Drainage Control**	
5.1	Pre-Mining Drainage Patterns Mapping	X
5.2	General Drainage Control Description	X
5.3	Conveyance Ditch Design	
5.4	Impoundments	
6.0	**Streams**	
6.1	Disturbance Information	X
6.2	Stream Information	X
6.3	Stream Buffer Variance	X
6.4	Streams Outside Permit Boundary	X
6.5	Existing Stream Locations	
6.6	Temporary Stream Diversions	
6.7	Permanent Stream Diversions	
6.8	Culverts and Crossing of Non-Diverted, Temporary, and/or Permanent Stream Channels	
6.9	Stream Buffer Zone	X
7.0	**Fish and Wildlife**	
7.1	Pre-Mining Fish and Wildlife Resources	X
7.2	Threatened and Endangered Species	X
7.3	General Fish and Wildlife Protection and Enhancement Measures	
8.0	**Cropland Capability Soils**	
8.1	High Capability Post-Mining Land Use	
8.2	Pre-Mining Prime Farmland Soils	X
8.3	Prime Farmland Soil Handling	X
8.4	Prime Farmland Reclamation Plan and Map	X
9.0	**Reclamation Plan**	
9.1	Post-mining Land Uses	X
9.2	Backfilling and Grading	X
9.3	Shaft, Slope, and Borehole Sealing	X
9.4	Abandonment and Closure of Refuse Disposal Areas	
9.5	Bond Estimation	X
10.0	**Revegetation and Reclamation**	
10.1	Revegetation of Drainage Control Ditches	
10.2	Revegetation of Faces of Embankments	
10.3	Revegetation of Soil Stockpiles	X
10.4	Revegetation of Refuse Disposal Facilities	
10.5	Pasture Reclamation Plan	
10.6	Fish and Wildlife Herbaceous Reclamation Plan	
10.7	Fish and Wildlife Woody Reclamation Plan	
10.8	Fish and Wildlife Wetland Reclamation Plan	
10.9	Fish and Wildlife Water and/or Developed Water Resources Reclamation Plan	

10.10	Forest Reclamation Plan	
10.11	Industrial/Commercial Reclamation Plan	
10.12	Recreation Reclamation Plan	
10.13	Habitat Diversification in Cropland	
11.0	**Blasting**	
11.1	Proposed Blasting	
11.2	Surface Mine Blasting	
11.3	Underground Mine Blasting	
12.0	**Shaft, Slope, and Miscellaneous Borehole Construction**	
12.1	Shafts and/or Slopes	
12.2	Miscellaneous Boreholes	X
13.0	**Underground Extraction**	
13.1	General Shadow Area Information	
13.2	Unplanned Subsidence Control Plan	
13.3	Planned Subsidence Control Plan	
13.4	Subsidence Damage Mitigation	
13.5	Water Supplies	
13.6	Auger Mining	
14.0	**Disposal of Coal Waste in Underground Workings**	
14.1	MSHA Approval	
14.2	Waste Material Description	
14.3	Pneumatic Injection	
14.4	Surface Disturbance Operations	
14.5	Underground Workings Disposal Area	
14.6	Circuitry of the Disposal Operation	
14.7	Subsidence Control	
14.8	Hydrologic Balance Protection	
15.0	**Coal Combustion Materials**	
15.1	Coal Combustion By-Products (CCB)	
15.2	Coal Combustions Waste (CCW)	

PART 1: Administrative Information

1.1 General Information.

1.1.1 Applicant: Williamson Energy, LLC

Applicant is a: [X] Corporation [ ] Partnership [ ] Sole Proprietor
[ ] Association or other Business Entity **[1778.13(a)]**

Individual Contact: **[1778.13(b)]**
(Name and Title)

Address/PO Box:	Po Box 99
City:	Johnston City
State:	IL
Zip Code:	62951
Email Address:	james.plumley@Foresight.com
Phone Number:	618-983-3020
Fax Number:	618-983-3017
Tax ID/FEIN No.	20-0888529

1.1.2 Resident Agent who will accept service of process for the applicant: **[1778.13(b)]**

Company:	Williamson Energy, LLC
Individual Contact:	James Plumley *(Authorized Person)*
Address/PO Box:	PO Box 99
City:	Johnston City
State:	IL
Zip Code:	62951
Email Address:	James.plumley@foresight.com
Phone Number:	618-435-2491
Fax Number:	618-435-3648
Tax ID/FEIN No.	41-21788049

1.1.3 Who will be the operator at the permit site? **[1778.13(b)]**

[X] Applicant [ ] Other/Contract operator

If the operator is not the applicant, then complete Table 1.3.1 for the company/entity.

1.1.4 Who will pay Abandoned Mine Land Reclamation fees? **[1778.13(b)]**

[X] Applicant [ ] Other/Contract operator

1.2 Acreage and Timetable.

Pit or Portal No./Name	County	Sec(s)	Twp	Range	Total Acres
Pond Creek No. 1 Mine	Williamson	2	8S	4E	8.82
Pond Creek No. 1 Mine	Williamson	3	8S	4E	8.03
Pond Creek No. 1 Mine	Williamson	9	8S	4E	0.04
Pond Creek No. 1 Mine	Williamson	10	8S	4E	0.12
				TOTAL:	17.01

Shadow Area	County	Sec(s)	Twp	Range	Total Acres
				TOTAL:	

1.2.1 Indicate type of disturbance from mining and acreage associated with each type. **[1780.11/1784.11]**

Type of Disturbance:	**Acres**
Surface Mined Area	
Processing Areas & Support Facilities	15.91
Undisturbed Areas (optional)	1.10
TOTAL ***(must equal total acres being permitted)***	17.01
Shadow Area	

1.2.2 Indicate on the Pre-Mining Land Use Map where future permits for coal refuse piles, coal waste impoundments, or other surface facilities would be located. Provide a general statement that future facilities will be located X number of miles from the current permit. **[1778.17(a); 1779.24(c)]**

N/A

1.3 Ownership and Control Information. NOT APPLICABLE

1.3.1 Complete Table 1.3.1 to identify all owners/controllers of the applicant. Separate sheet/table shall be provided for each entity or individual deemed to be an owner/controller of the applicant.

Ownership or control is evidenced by:

- Being a permittee of a surface coal mining operation; or
- Based on instruments of ownership or voting securities, owning of record in excess of fifty (50) percent of an entity; or
- Having any other relationship which gives one person authority directly or indirectly to determine the manner in which an applicant, an operator, or other entity conducts surface coal mining operations

The following relationships are presumed to constitute ownership or control unless a person can demonstrate that the person subject to the presumption does not in fact have the authority directly or indirectly to determine the manner in which the relevant surface coal mining operation is conducted.

- Being an officer or director of an entity; or
- Being the operator of a surface coal mining operation; or
- Having the ability to commit the financial or real property assets or working resources of an entity;
- Being a general partner in a partnership; or
- Based on the instruments of ownership or the voting securities of a corporate entity, owning of record ten (10) through fifty (50) percent of the entity; or
- Owning or controlling coal to be mined by another person under a lease, sublease or other contract and having the right to receive such coal after mining or having authority to determine the manner in which that person or another person conducts a surface coal mining operation. **[1773.5, 1778.13(c)(1) to (c)(3)]**

1.3.2 Complete Table 1.3.2 for surface coal mining and reclamation operations, within the five (5) years preceding the date of the application for associated with: **[1778.13(c)(4)/1778.13(c)(5)]**

- Each Owner/Controller identified in Table 1.3.1
- The applicant.

1.4 Violation History. NOT APPLICABLE

1.4.1 Has the applicant, any subsidiary, affiliate, or persons controlled by or under common control with the applicant, had Federal, State, or Tribal coal mining permit suspended or revoked in the last five (5) years preceding the date of submission of the application? **[1778.14(a)(1)]**

☐ Yes ☐ No

1.4.2 Has the applicant, any subsidiary, affiliate, or persons controlled by or under common control with the applicant, had forfeited a performance bond or similar security deposited in lieu of bond? **[1778.14(a)(2)]**

☐ Yes ☐ No

If YES to either Questions 1.4.1 or 1.4.2, the applicant shall complete Table 1.4 for any permit/company associated with permit suspension, revocation or bond forfeiture. **[1778.14(a) and (b)]**

1.4.3 The applicant shall complete Table 1.4.3 for all violations received by the applicant or any one owning/controlling the applicant as provided in Table 1.3.1 during the three (3) year period preceding the application date. **[1778.14(c)]**

For any outstanding violation or violation under appeal listed in Table 1.4.3, the applicant shall provide supporting documentation showing good faith efforts for the violation from the issuing agency, or in the case of appeals provide documentation of current proceedings. **[1773.15(b), 1778.14(c)]**

NOTE: Provide as an Attachment to Part 1.4.3.

1.5 Property Ownership.

1.5.1 Complete Table 1.5.1 for (1) each legal or equitable owner of record, (2) each holder of leasehold interest, and (3) any purchaser of record under a real estate contract for the surface and mineral property within the proposed permit boundary. **[1778.13(e), 1778.15(a)]**

If the proposed permit is for a surface mine where the private mineral estate has been severed from the private surface estate, applicant must also provide the Department with:

- A copy of the written consent of the surface owner to the extraction of coal by surface mining methods; or
- A copy of the conveyance that expressly grants or reserves the right to extract the coal by surface mining methods; or
- If the conveyance does not expressly grant the right to extract the coal by surface mining methods, provide the Department with documentation that, under the applicable State law, the applicant has the legal authority to extract the coal by surface mining methods. **[1778.15(b)]**
- See Part 1.5.3, below, for additional requirements to uncontrolled properties.

NOTE: Provide as an Attachment to Part 1.5.1.

1.5.2 Complete Table 1.5.2 for any owner of record for property (surface and subsurface) contiguous to any part of the proposed permit boundary. **[1778.13(f)]**

Does the applicant have an interest in any lands, options or pending bids on interest for lands which are contiguous to the proposed permit area?

☐ Yes ☒ No

If YES, the applicant shall indicate in Table 1.5.2 all lands, interest in lands, options, or pending bids on interests held or made by the applicant for lands contiguous to the area described in the permit application. **[1778.13(h)]**

Upon request by the applicant, this information may be held in confidence by the Department, if not on public file. Does the applicant wish any of the above information to be held confidential?

☐ Yes ☒ No

If YES, the applicant shall identify which information is to be held confidential in its statement. **[1778.13(h)]**

1.5.3 Complete Table 1.5.3 for any owner of record for property (surface and subsurface) identified in Table 1.5.1 and shown on the Pre-Mining Land Use Map identified in 1.5.4, not owned by the applicant, identifying the documents and legal rights claimed to enter and mine.

All properties identified in Table 1.5.1 that the applicant does not have a legal right to enter and begin mining operations shall require submission of a Property Ownership Waiver form for each property identified for the application to be considered administratively complete [see Operator Memorandum No. 2011-01]

NOTE: Provide as an Attachment to Part 1.5.3.

1.5.4 Delineate all boundaries of lands and names of present owners of record of those lands, both surface and subsurface, included in or contiguous to the permit area on the Pre-Mining Land Use Map. The map shall also show lands within the permit area that are controlled properties (i.e. applicant is claiming legal right to enter and begin surface coal mining and reclamation operations) versus uncontrolled properties (i.e. applicant does not yet have the legal right of entry). **[1779.24(a) and (b)]**

ENGINEERING CERTIFICATION

I hereby certify the engineering design used in preparation of this application, attachments, and supplements were done by me or under my direct supervision.

I certify that I am familiar with all of the plans, specifications, reports, and maps submitted as part of this application and that said information is accurate.

I certify to the best of my knowledge all such design is in accordance with all applicable local, state and federal laws, rules and regulations.

I further certify that all applicable maps and/or drawings have been individually sealed in accordance with the Professional Engineering Act, 225 ILCS 325/15.

INDIVIDUAL P.E. CERTIFICATION

James Plumley
Name

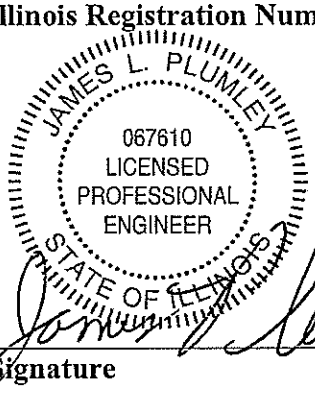
IL 067610
Illinois Registration Number (Seal)

Williamson Energy, LLC
Firm

PO Box 99

Johnston City, IL 62959

Address



Signature

618-969-8254
Phone Number

3-5-19
Date

PROFESSIONAL DESIGN FIRM CERTIFICATION

Complete if applicable. If not, respond N/A.

_____ As an employee of a Professional Design Firm as defined by the Illinois Department of Financial and Professional Regulation, I certify that the professional design firm is registered and in good standing with the Illinois Department of Financial and Professional Regulation.

Professional Design Firm Name

Professional Design Firm Number

PUBLIC NOTICE

Pursuant to the Surface Coal Mining Land Conservation and Reclamation Act (PA-81-1015, as amended) and the Rules and Regulations of the Act, Williamston Energy, LLC, PO Box 99, Johnston City, IL 62959 hereby gives notice that under the prevision of Section 1743.13 (d) (2) of 62 Ill. Admin. Code, a request for 17.01 acres Contiguous IBR Surface Permit application to Permit No. 375 was submitted to the Illinois Department of Natural Resources, Office of Mines and Minerals, Land Reclamation Division, a access roadway , one 16.5 foot bleeder shaft, one 16 inch utility borehole, one 8.625 inch utility borehole, three 12.75 inch utility boreholes, and one 24 inch utility borehole , (each borehole having a 10'x10'x1' concrete pad), a 10'x8'x1' concrete pad for transformer, a compressor station, and a portable crib plant. The shaft will a large concrete pad poured irregularly shaft with a surface area of ~2430 square feet and a thickness of 4 feet. Two temporary drill pits (one ~20'x40'x10' and one ~ 10'x20'x10) will be used during the development of the boreholes. The site will be gravel with 8 inches of gravel ~(1.56 acres). HDPE water (12") and power lines will be installed back connection into the existing shaft site along Locust Grove Road.

Approval is also requested to operate within 100 feet of the outside right-of-way of a public road (Kraatz Road, Crawford Road, and Locust Grove Road) which is located as follows: Kraatz Road and Crawford Road - Along the North and West side of the northwest quarter of the northeast quarter of Section 2 and northeast side of the northwest quarter of Section 2, Township 8 South, Range 4 East and Locust Grove Road – Along the southeast quarter of the southeast quarter of Section 3 and northwest quarter of the northwest quarter of Section 10, Township 8 South, Range 4 East. In accordance to the prevision of Section 1761.14 of 62 Ill. Administrative Code a public hearing may be requested to determine whether the interests of the public and affected landowners will be protected.

The Proposed IBR is described as: Part of the NW/4 of NE/4 of Section 2, W/2 of Section 2, S/2 of Section 3, NE4 of NE/4 of Section 9 and NW/4 of NW/4 of Section 10, Township 8S, R4E of the 3rd Principal Meridian, Williamson County, IL, containing approximately 17.01 acres. Copies of the application are on file for inspection at the following office, and written comment may be addressed to Illinois Department of Natural Resources, Office of Mines and Minerals, Land Reclamation Division, One Natural Resources Way, Springfield, IL 62702-1271.

The closing date of the comment period and the request of a public hearing for this IBR is fourteen (14) days from the date of this Public Notice.

Public Notice to be advertised in the Marion Daily Republican.

1.5.1 Property Ownership
Within Permit Area

Name	Address	Type of Holder: Legal/Equitable/Leaseholder/Purchaser	Surface or Mineral Property	Parcel ID	Map ID Reference
David M & Karen Y Mandrell	17889 Crawford Road, Thompsonville, IL 62890	Legal	Surface	A080402-201	A080402-201
Williamson Energy, LLC	P.O. Box 99, Johnston City, IL 62951	Legal	Surface	A080402-102	A080402-102
Ameren Illinois Company	P.O. Box 66149 (MC 210), St. Louis, MO 63166-6149	Legal	Surface	A080402-105	A080402-105
Joyce L King	23825 Lites Road, Thompsonville, IL 62890	Legal	Surface	A080402-107	A080402-107
Robert Wayne Wilkas	22698 Locust Grove Road, Thompsonville, IL 62890	Legal	Surface	A080402-315	A080402-315
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Legal	Surface	A080403-408	A080403-408
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Legal	Surface	A080403-307	A080403-307
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Legal	Surface	A080403-303	A080403-303
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Legal	Surface	A080403-304	A080403-304
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Legal	Surface	A080410-101	A080410-101
Williamson Energy, LLC	P.O. Box 99, Johnston City, IL 62951	Legal	Surface	A080409-202	A080409-202

1.5.2 Property Ownership
Contiguous to the Permit Area

Name	Address	Options/Interests on Property	Surface or Mineral Property	Parcel ID	Map ID Reference
Williamson Energy, LLC	P.O. Box 99, Johnston City, IL 62951	Owner	Surface	A080402-101	A080402-101
Williamson Energy, LLC	P.O. Box 99, Johnston City, IL 62951	Owner	Surface	A080402-103	A080402-103
Joyce L King	23825 Liles Road, Thompsonville, IL 62890	Owner	Surface	A080402-106	A080402-106
Ameren Illinois Company	P.O. Box 66149 (MC 210), St. Louis, MO 63166-6149	Owner	Surface	A080402-104	A080402-104
Ameren Illinois Company	P.O. Box 66149 (MC 210), St. Louis, MO 63166-6149	Owner	Surface	A080402-203	A080402-203
Ameren Illinois Company	P.O. Box 66149 (MC 210), St. Louis, MO 63166-6149	Owner	Surface	A080402-204	A080402-204
Willard & Marina F. Gore	2144 Clearview Dr., Cookeville, TN 38506	Owner	Surface	A080403-207	A080403-207
Robert Wayne Wilkas	22698 Locust Grove Road, Thompsonville, IL 62890	Owner	Surface	A080403-402	A080403-402
Thomas D. Canup	22255 Fancy Farm Road, Thompsonville, IL 62896	Owner	Surface	A080403-208	A080403-208
David & Alyssa Adams	18024 Thompsonville Road, Thompsonville, IL 62896	Owner	Surface	A080403-106	A080403-106
David & Alyssa Adams	18024 Thompsonville Road, Thompsonville, IL 62896	Owner	Surface	A080403-306	A080403-306
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Owner	Surface	A080403-308	A080403-308
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Owner	Surface	A080403-409	A080403-409
Ivey Wece	622 W. Old Andrew Johnson HWY, New Market, TN 37820	Owner	Surface	A080403-107	A080403-107
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Owner	Surface	A080404-208	A080404-208
Robert & Beverly Galloway	17557 Thompsonville Road, Thompsonville, IL 62896	Owner	Surface	A080404-414	A080404-414
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Owner	Surface	A080404-413	A080404-413
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Owner	Surface	A080404-415	A080404-415
Robert & Beverly Galloway	17557 Thompsonville Road, Thompsonville, IL 62896	Owner	Surface	A080404-412	A080404-412
Robert & Beverly Galloway	17557 Thompsonville Road, Thompsonville, IL 62896	Owner	Surface	A080404-411	A080404-411
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Owner	Surface	A080404-408	A080404-408
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Owner	Surface	A080409-201	A080409-201
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Owner	Surface	A080409-215	A080409-215
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Owner	Surface	A080410-107	A080410-107
David & Sheila Papez	3306 Springfield Way, St. Charles, IL 60175	Owner	Surface	A080410-102	A080410-102
David & Sheila Papez	3306 Springfield Way, St. Charles, IL 60175	Owner	Surface	A080410-105	A080410-105
Barron & Jo Ann Chronister	22021 Locust Grove Road, Thompsonville, IL 62896	Owner	Surface	A080410-103	A080410-103
Ken Petty Ministries, Inc.	10328 Iowa Street, Benton, IL 62812	Owner	Surface	A080410-214	A080410-214
Ronald L. Madinger	22192 Locust Grove Road, Thompsonville, IL 62896	Owner	Surface	A080403-404	A080403-404
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Owner	Surface	A080402-316	A080402-316
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Owner	Surface	A080402-314	A080402-314
New River Royalty, LLC	P.O. Box 609, Benton, IL 62812	Owner	Surface	A080402-407	A080402-407
Robert Wayne Wilkas	22698 Locust Grove Road, Thompsonville, IL 62890	Owner	Surface	A080402-304	A080402-304
Michael E. & Wheeler Craig	Rt 1, Thompsonville, 62890	Owner	Surface	A080402-305	A080402-305
David M & Karen Y Mandrell	17889 Crawford Road, Thompsonville, IL 62890	Owner	Surface	A080402-313	A080402-313
David M & Karen Y Mandrell & W&W Hawkins	17889 Crawford Road, Thompsonville, IL 62890	Owner	Surface	A080402-311	A080402-311
David M & Karen Y Mandrell	17889 Crawford Road, Thompsonville, IL 62890	Owner	Surface	A080402-406	A080402-406
R M & T Land Trust	17867 State HWY 34, Thompsonville, IL 62890	Owner	Surface	A080402-402	A080402-402
Robert Leon McClerron	19734 McClerren Road, Thompsonville, IL 62890	Owner	Surface	A080402-207	A080402-207
Michael A. Ferando	23479 Kaskaskia Road, Thompsonville, IL 62890	Owner	Surface	A080402-206	A080402-206
Danny Sweet	218528 Kimmel Road, Thompsonville, IL 62890	Owner	Surface	13-35-300-007	13-35-300-007
Robert Leon McClerren Living Trust	19736 McClerren Road, Thompsonville, IL 62890	Owner	Surface	13-35-400-006	13-35-400-006
Compass West, Inc	2425 Veterans A-2, Vandalia, IL 62471	Owner	Surface	13-35-300-007	13-35-300-007
Compass West, Inc	2425 Veterans A-2, Vandalia, IL 62471	Owner	Surface	13-35-400-010	13-35-400-010
Stacy J Sweet	23071 Kraatz Road, Thompsonville, IL 62890	Owner	Surface	A080402-402	A080402-402
Illinois Central Railroad	17641 South Ashland Avenue, Homewood, IL 60430	Owner	Surface	04-02-501-001	04-02-501-001

R06279

OCCUPIED DWELLING BUFFER ZONE WAIVER

(Williamson Energy, LLC) will conduct surface coal mining operations (Bleeder shaft IBR with Fan and Utility boreholes) within the permitted area for (Pond Creek #1 Mine), Permit No. 375, Insignificant Boundary Revision (North Bleeder Shaft) in Williamson County, Illinois.

These mining activities will be conducted within 300 feet measured horizontally of the occupied dwelling located at:

WILLIAMSON ENERGY LLC, 18399 CRAWFORD RD; THOMPSONVILLE IL; 62890 (04-02-100-003) or Map ID (100.003)

I (we), as signator(s) below, verify that I am (we are) the legal owner(s) of the occupied dwelling.

I (we) acknowledge that I (we) have the legal right to deny mining activities within a 300-ft. buffer zone from my (our) occupied dwelling.

I (we), as the legal owner(s) of the dwelling and associated property on which the dwelling is located, do knowingly waive this right and hereby consent to the mining activities to be conducted within 300 feet of the occupied dwelling.

Owner(s) of Occupied Dwelling

Williamson Energy, LLC
(Printed Name)

James P Lumley 3-22-19
(Signature) (Date)

Staci R Lowry
(Printed Name)

STACI R LOWRY
Official Seal
Notary Public - State of Illinois
My Commission Expires Jan 14, 2023

Staci R Lowry 3-22-19
(Signature) (Date)

NOTARY

EASEMENT

Prepared by and return to:
Williamson Energy, LLC
P.O. Box 99
Johnston City, IL 62951

EASEMENT

KNOW ALL MEN BY THESE PRESENTS:

That AMEREN ILLINOIS COMPANY d/b/a AMEREN ILLINOIS, an Illinois corporation, 1901 Chouteau Avenue, Mail Code 700, St. Louis, Missouri 63103, its successors, assigns, agents, lessees, tenants, contractors, sub-contractors and licensees, (herein the "Grantor"), for and in consideration of Ten Dollars ($10.00), and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, has granted unto Grantee an easement and surface waiver and consent on, over, across, through or under a strip of land (hereafter defined) of Grantor, unto WILLIAMSON ENERGY, LLC, a Delaware limited liability company, of P.O. Box 99, Johnston City, Illinois 62951 (herein "Williamson"), and all of Williamson's successors, licensees, agents, lessees, contractors, sub-contractors, tenants and assigns (herein collectively the "Grantee").

Grantor does hereby give and grant to Grantee the right and easement, for a term as hereinafter defined, to construct, reconstruct, install and lay underground and thereafter use, operate, inspect, repair, maintain, replace and remove a water line lines and any and all associated appurtenances and facilities (with such right and easement being collectively either the "Easement" or the "Easement Rights," and with such line or lines and any and all associated appurtenances and facilities being collectively the "Lines and Appurtenances") on, over, across, through or under a strip of land fifty feet (50') in width on the land of Grantor in Williamson County, Illinois (herein the "Easement Area," and with such land being the "Land"), said Land being described as follows:

From a stone at the Northwest corner (NW Cor) of the Northeast Quarter (NE ¼) of the Northwest Quarter (NW ¼) of section two (Sec.2) Township Eight South (T8S) Range Four East (R4E) of the Third Principal Meridian (3PM) measure southwardly along the west line of said quarter quarter section seven hundred fifty six and thirty nine hundredths (756.39') feet to a point for the Point of Beginning. Thence continuing the last described course measure sixty one and twenty two hundredths (61.22') feet. Thence deflecting seventy eight degrees and twenty five minutes (78° 25') to the left measure southeastwardly one thousand three hundred forty one and twelve hundredths (1341.12') feet to the east line of said quarter quarter section. Thence deflecting one hundred one degrees and fourteen minutes (101° 14') to the left measure northwardly along the east line of said quarter quarter section sixty one and sixteen hundredths (61.16') feet. Thence deflecting seventy eight degrees and forty six minutes (78° 46') to the left measure northwestwardly on thousand three hundred forty one and forty eight hundredths (1341.48') feet to the Point of Beginning. Containing an area of two (2.0) acres more of less situated in the County of Williamson, in the State of Illinois.

Parcel Index Number: 04-02-100-005

And being the same lands described in that certain Deed dated August 9, 1922, recorded August 26, 1922 at Book 170 Page 481.

The general location of the Easement Area is shown or depicted on the Plat entitled Exhibit "A" attached hereto and made a part hereof.

Grantor, also grants to Grantee the following, but only to the extend they do not interfere with Grantor's use of the land: (i) all rights reasonably implied by and/or incidental to the complete and full exercise and enjoyment of the Easement Rights, including without limitation the right of ingress and egress to, from, over and across the Easement Area for all necessary or convenient purposes; (ii) the right to trim, cut, and/or remove at any time, and from time to time, any and all brush, bushes, trees, roots, undergrowth, rock or other substances or obstructions upon, over or under the surface of the Easement Area deemed by Grantee to interfere with the Easement Rights or endanger the safety of or interfere with the Lines and Appurtenances; and (iii) the right to license, permit or otherwise agree to the use, operation or occupancy of the Lines and Appurtenances by any other person, association, authority, entity or corporation for the purposes stated herein.

The Easement is subject to the following:

- The Easement shall be expressly limited to an area totaling 50 feet in width and running along and with and being 25 feet each side of the center line of the Lines and Appurtenances as installed; provided, however, that the Easement Area shall not apply at any time when Grantee is constructing, installing, replacing or removing the Lines or Appurtenances or conducting significant maintenance or repairs thereto. At such time when Grantee is constructing, installing, replacing or removing the Lines or Appurtenances or conducting significant maintenance or repairs thereto, the Easement shall be expressly expanded within reason to allow for and area as necessary to conduct said installation or significant maintenance or repairs thereto.

- The Lines and Appurtenances to be installed shall be trenched and laid, except as otherwise allowed herein, at a minimum of 30 inches below the surface.

- Prior to commencement of work contemplated hereunder, Grantee will stake the center line of the Easement on Grantor's Land.

- Subsequent to the installation, operation, maintenance and/or removal of the Lines and Appurtenances under or from the Land, Grantee will perform the necessary reclamation work on and respecting the Land.

- Grantor reserves the right to use the Easement Area for purposes of an electrical transmission line and Grantee may use the Easement area for purposes that do not unreasonably interfere with Grantor's use.

- Grantee agrees that it will conduct its operations hereunder and on the Land in a workmanlike manner and in accordance with industry practice; that it will comply with all applicable laws and regulations; and that it will obtain all necessary permits.

- Grantor understands and acknowledges that the Land will be used in connection with the present and future business operations of Grantee. At such time as Grantee or any person or entity doing business with Grantee no longer does business in the State of Illinois in any mineral or energy related industry, this Easement will terminate, and thereupon Grantee shall deliver a release of easement to Grantor to place of record in the Office of the County Recorder of Franklin County, Illinois.

- Nothing contained herein shall prevent Grantor from claiming damages to other lands as a result of Grantee's installation, use and/or maintenance of the Lines and Appurtenances.

This Easement shall be in force and have effect for as long thereafter as mining operations are being conducted.

For and in consideration of the sum of Ten Dollars ($10.00), the receipt and sufficiency of which is hereby acknowledged, and other good and valuable consideration to be paid to Grantor by Grantee as total consideration in full payment for all benefits secured by Grantee under or in connection with this Easement.

Grantee shall provide, and shall require all persons acting under or with the consent of Grantee to provide, no less than twenty-five (25') feet radial clearance from

all of Grantor's overhead lines. Grantee shall provide, and shall require all persons acting under or with the consent of Grantee to provide, no less than fifteen (15') feet radial clearance from all of Grantor's facilities on or adjacent to the Easement Area and Land, including towers, poles, anchors and structures. Grantee shall warn and instruct each and every person acting under or with the consent of Grantee as to the existence, location and nature of Grantor's electric lines and electrical facilities on or adjacent to the Easement Area and Land. As and to the extent applicable, Grantee shall comply with, and shall require any person(s) acting under Grantee including without limitation agents, contractors and employees, to comply with 765 ILCS 140 ("Adjacent Landowner Excavation Protection Act") and the National Electrical Safety Code (collectively "Laws"), as such Laws may be amended from time to time. Nothing contained in this instrument shall be construed to relieve Grantee, or any person(s) acting under Grantee, from the duty to comply with the Laws; but if and to the extent that this instrument provides for precautions or specific clearances which are greater than those imposed by the Laws, such greater precautions or clearances provided for in this instrument shall be binding on Grantee and any such person(s) acting under Grantee. Grantee agrees not to make any excavations within thirty (30) feet radial clearance for any of Grantee.

Grantee shall be responsible for actual damages occurring on Easement Area, Land and property adjacent thereto, including damages, if any, done as a result of ingress or egress over Grantors adjoining property, or as a result of the construction,

operation, maintenance or repair, including anything whatsoever described herein as allowed to Grantee.

Grantee will indemnify and hold Grantor harmless from any and all liability, expense, judgment, suit, cause of action, or demand for personal injury, death, or direct damage to tangible property which may accrue against Grantor, its subcontractors, or their employees or agents, as a result of Grantee performing its activities under this Easement Agreement,

The provisions of the Easement shall constitute covenants "running with the land" for the benefit of Grantee (as herein defined).

The Easement granted herein and the provisions relating thereto shall be binding upon and inure to the benefit of both Grantor and its successors and assigns and Grantee (as herein defined). This Easement and the Easement Rights are fully assignable, in whole or in part, by Grantee, without the consent or approval of Grantor, to any person, entity, public utility, and/or governmental or quasi-governmental authority, board or association whatsoever who or which will use or utilize the Easement to serve (or use or utilize the Easement in conjunction with) any business and/or operations of Grantee or any person or entity affiliated with Grantee. Any such assignment shall be encumbered by the terms of this Easement, and any successor, licensee, agent, lessee, contractor, sub- contractor, tenant or assignee of or to this Easement shall be bound thereby.

DATED this 30 day of January, 2019.

GRANTOR

By _____

Name GEOFFREY D. DOUGLASS

Title DIRECTOR

STATE OF Missouri)
City) SS
~~COUNTY~~ OF St. Louis)

I, the undersigned, a Notary Public in and for said County and State aforesaid, do hereby certify that Geoffrey D. Douglass, Director of Real Estate of AMEREN ILLINOIS COMPANY d/b/a AMEREN ILLINOIS who is personally known to me to be the same person whose name is subscribed to the foregoing instrument, appeared before me this day in person and acknowledged that they signed and delivered the said instrument of writing as their free and voluntary act, and as the free and voluntary act of the said corporation, for the uses and purposes therein set forth, pursuant to authority given by the Board of Directors of said corporation.

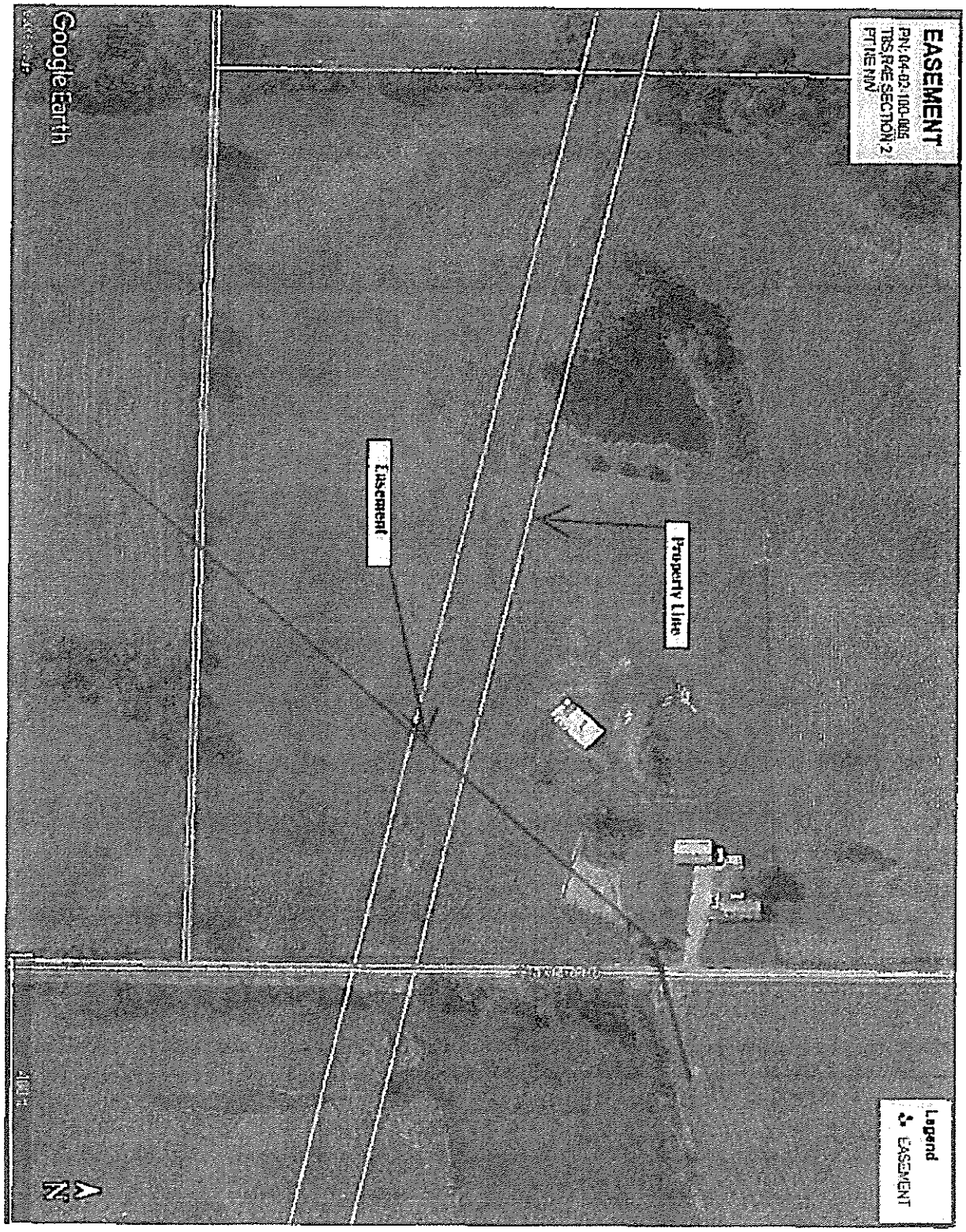
Given under my hand and notarial seal this 31st day of January, 2019.

_____
Notary Public

NOTARY PUBLIC NOTARY SEAL STATE OF MISSOURI

DENISE M. THOMPSON
My Commission Expires
November 15, 2020
Jefferson County
Commission #10434211

EXHIBIT A


EASEMENT
PIN: 04-02-100-005
T6S,R4E,SECTION 2
PT NE NW
Google Earth
Easement
Property Line
Legend
EASEMENT

REAL ESTATE LEASE

This Real Estate Lease, hereinafter called "Lease" made and entered into this 18th day of July, 2018, by and between David M. Mandrell and Karen Y. Mandrell, husband and wife, with a mailing address at 17889 Crawford Road, Thompsonville, Illinois 62890, hereinafter called "Lessor", and Williamson Energy, LLC, a Delaware Limited Liability Company, with a mailing address at P.O. Box 99, Johnston City, Illinois 62951 hereinafter called "Lessee".

For and in consideration of the mutual covenants herein contained, the parties agree as follows:

1. Lessor hereby leases unto Lessee the surface only of the following described premises, hereinafter called "Leased Premises," located in Williamson County, Illinois:

> THE SURFACE ONLY of the West One-Half (W ½) of the Northeast Quarter (NE ¼) And the Northwest Quarter (NW ¼) of the Southeast Quarter (SE ¼) of Section Two (2), all in Township Eight (8) South, Range Four East of the Third Principal Meridian.
> Subject to all public and private roadways or easements as now located.
> PIN: 04-02-200-001

Upon the terms and conditions hereinafter stated.

2. With respect to the Leased Premises, Lessee is privileged to use same in connection with the drilling, construction, operation, repair, replacement and dismantling of a certain air bleeder shaft, air intake shaft and bore hole facilities. Lessee may construct the foregoing shafts and may install related facilities, structures and equipment, including, but not limited to, a high-powered electrical fan, communication lines, rock dust conveyor, compressed air, electrical power lines and substation or gas turbine generator, top soil stockpile sites and cutting pit sites and other related maintenance and operation equipment, structures and facilities.

In addition, Lessee will install necessary culverts and construct a road for access to the site. In addition, Lessee will be privileged to install a three phase power line to serve the various facilities. Also, in addition, Lessee shall be privileged to install facilities for the transporting of water to the site.

In connection with the initial construction activities, Lessee may use the premises for a cuttings pit and for drilling equipment and related activities as reasonably needed. Lessee will strip all top soil which may be affected by the activities contemplated hereunder and will store the same on site in suitable berms.

After construction is completed, the facility site, the substation site and the cutting pit site may be enclosed by fencing, at the discretion of Lessee.

3. The term of this Lease shall be for a period of Ten (10) years, beginning on the date this lease was entered into, and for as long as Lessee, at its discretion, requires the use of the above described facilities in connection with its mining activities or permitting, or until reclamation activity on and respecting the Affected Lands, as may be required by all regulatory agencies having jurisdiction over the operations hereunder, have been completed.

4. After expiration or termination of this Lease, Williamson Energy shall re-enter the Affected Lands and remove all of its equipment and related property and begin reclamation and environmental work on and respecting the Affected Lands within one hundred eighty (180) days thereafter. Further, prior to performing such reclamation and environmental work on the Affected Lands, and subject to the expressed prior approval of any regulatory agency having jurisdiction over Williamson Energy's operations on the Property and Affected Lands under this Lease; Lessor may desire to retain certain Facilities and Appurtenances existing on the Affected Lands, and upon written notice to Williamson Energy, and, thereafter, if mutual acceptable and

agreeable to and by Williamson Energy, matters as may be requested by Lessor shall transfer, in whole or in part, and become the sole possession and ownership of the Lessor and Lessor shall accept said such Facilities and Appurtenances on an "as is", "with all faults", and/or "environmental liabilities". Notwithstanding, if expressed prior approval is not granted for such transfer by any such regulatory agency having jurisdiction over Williamson Energy's said operations; Williamson Energy shall have the continuing right during which Williamson Energy may re-enter the Affected Lands and remove all Facilities and Appurtenances from the Affected Lands in accordance with then applicable laws and regulations.

5. In consideration thereof, Lessee agrees to pay to Lessor the sum [redacted] with the first payment being due within 30 days from the execution of this Lease, and subsequent annual payments being due on or before the anniversary date thereof. Lessor agrees to accept Lessee's corporate check as good and sufficient payment.

6. Lessee will protect and indemnify Lessor from any and all claims for property damage, personal injury or death resulting from the occupation of the Leased Premises by Lessee and resulting from Lessee's operations thereon.

7. At the termination of this Lease, Lessee agrees to restore the Leased Premises, as nearly as is reasonable and practical to the condition in which they existed prior to the time of this Lease. Restoration work shall commence during appropriate periods of favorable weather and suitable soil conditions as mutually agreed to by both parties. Once started, the work shall proceed in an orderly and timely manner until completed. Lessee's compliance with such requirements as are imposed by regulatory agencies having jurisdiction shall be determinative as to Lessee's obligation to repair and restore as provided in this Real Estate Lease. If mining

operations and reclamation activities of Lessee cause disturbance of the roadways or utilities located on the premises described above, and if additional easements or rights of way are required by the state, county, or by the township, to repair said roadways, or by a public utility providing utility service of any nature whatsoever, including but not limited to, electricity, water, telephone service, cable service and the like, Lessor agrees, upon request, to convey, to the relevant entity, without additional consideration, such additional rights of way or easements as are required to restore, repair, or replace previously existing roadways or utilities. At Lessee's cost, Lessee will fill and restore the shaft site, remove roadways, remove the equipment associated therewith and remove and restore the substation site and the cutting pit site. Lessee shall also arrange for the removal of the electrical power line. Lessee will redistribute the top soil previously stored onto the area previously stripped.

8. Lessee agrees to pay the real estate taxes of Leased Premises for 2019, payable in 2020, and subsequent years for as long as Lessee, at its discretion, requires the use of the above described facilities in connection with its mining activities or permitting, or until reclamation activity on and respecting the Affected Lands, as may be required by all regulatory agencies having jurisdiction over the operations hereunder, have been completed.

9. Lessor agrees to execute a Memorandum of this Lease suitable for recording in the form attached hereto as Exhibit A, if requested by Lessee.

10. If it becomes necessary for either party to enforce any of the terms of this Lease against the other, the party in default shall pay all costs and expenses incident thereto, including reasonable attorneys' fees.

11. Any notices to be given under this Lease shall be deemed to have been properly given if in writing and delivered in person, by certified mail or telegram, with all necessary postage or charges fully prepaid, at the address for the respective parties as shown below.

To Lessor: David M. Mandrell and Karen Y. Mandrell
17889 Crawford Road
Thompsonville, Illinois 62890

To Lessee: Williamson Energy, LLC
Attn: Land Department
P.O. Box 99
Johnston City, Illinois 62951

12. This instrument constitutes the entire Lease between the parties hereto and such Lease shall not be changed except in writing signed by all parties.

13. Time is of the essence of the Lease and the terms hereof shall be binding upon, and inure of the benefit of the parties hereto, their heirs, devisees, legal representatives, successors and assigns.

14. This Lease shall be construed under the laws of the State of Illinois.

IN WITNESS WHEREOF, the parties hereto have executed this Lease as of the day and year hereinabove set forth.

David M. Mandrell

Karen Y. Mandrell

WILLIAMSON ENERGY, LLC

BY: _____
Ron Koontz, General Manager

STATE OF ILLINOIS)
) SS
COUNTY OF Williamson)

I, the undersigned, a Notary Public, in and for said County, in the State aforesaid, do hereby certify that David M. Mandrell, personally known to me to be the same person whose name is subscribed to the foregoing instrument, appeared before me this day in person, and acknowledged that he signed, sealed, and delivered the said instrument as his free and voluntary act and deed, for the uses and purposes herein set forth, including the release and waiver of the right of homestead.

Given under my hand and seal this 18 day of July, 2018.

_____
Notary Public

OFFICIAL SEAL
IAN D. FEE
Notary Public, State of Illinois
My Commission Expires 12-11-2021

STATE OF ILLINOIS)

) SS

COUNTY OF Williamson)

I, the undersigned, a Notary Public, in and for said County, in the State aforesaid, do hereby certify that Karen Y. Mandrell, personally known to me to be the same person whose name is subscribed to the foregoing instrument, appeared before me this day in person, and acknowledged that she signed, sealed, and delivered the said instrument as her free and voluntary act and deed, for the uses and purposes herein set forth, including the release and waiver of the right of homestead.

Given under my hand and seal this 18 day of July, 2018.

Notary Public

OFFICIAL SEAL
IAN D. FEE
Notary Public, State of Illinois
My Commission Expires 12-11-2021

STATE OF ILLINOIS)

) SS

COUNTY OF WILLIAMSON)

I, the undersigned Notary Public, in and for said County in the State aforesaid, do hereby certify that Ron Koontz, General Manager personally known to me to be a duly authorized person of WILLIAMSON ENERGY, LLC, a Delaware Limited Liability Company, and personally known to me to be the same person whose name is subscribed to the foregoing instrument, appeared before me this day in person, and acknowledged that he signed, sealed and delivered the said instrument as such authorized person pursuant to authority given by the Members of said limited liability company, as his free and voluntary act, and as the free and voluntary act and deed of said Company, for the uses and purposes therein set forth.

Given under my hand and seal this 26th day of July, 2018.

Casey Jo Mowery

Notary Public

CASEY JO MOWERY
Official Seal
Notary Public - State of Illinois
My Commission Expires Oct 19, 2020

PIN
04-09-200-001 WC0283
04-10-100-001 WC0022
04-03-300-003 WC0300
04-03-300-005 WC0039
04-03-400-001 WC0039
04-03-400-006 WC0039

Image# 006107140007 Type: MEMORAN
Recorded: 08/29/2018 at 01:03:29 PM
Page 1 of 7
Fees: $60.00
IL Rental Housing Fund: $9.00
Williamson County, IL
Amanda Barnes Clerk & Recorder
Book 368 Page 486
File 2018-00006561

MEMORANDUM OF SURFACE EASEMENT AND AGREEMENT

This Memorandum of Surface Easement and Agreement, with an Effective Date of the August 21, 2018, by and between **New River Royalty, LLC**, a Delaware limited liability company duly authorized to transact business in the State of Illinois whose mailing address is 3801 PGA Blvd. Suite 903, Palm Beach Gardens, FL 33410, hereinafter called "Grantor", and **Williamson Energy, LLC**, P.O. Box 99, Johnson City, Illinois 62951, hereinafter called "Grantee",

WITNESSETH:

WHEREAS, Grantor owns or controls certain real property situated in Williamson County, Illinois as depicted on **Exhibit A** attached hereto and incorporated herein by reference (the "**Property**"); and

WHEREAS, Grantor and Grantee entered into a Surface Easement and Agreement ("**Agreement**") which Grantor thereby did Grant and Convey unto Grantee a non-exclusive Twenty-foot (20') easement (the "**Easement**") over a portion of the Property depicted in or on Exhibits B1 attached hereto and incorporated herein by reference (the "**Easement Premises**")

Said Agreement describes the conveyance of certain rights to install water, power, and communication lines, across the property listed on Exhibit A attached hereto, related to and necessary for the operation of the Williamson Energy (Mach) Mine by Grantee or its affiliates, successors and permitted assigns in Williamson County, Illinois (the "**Mine**").

The term of the Easement shall continue in force and effect until the waterline is no longer utilized by the Mine, or the date which is Two (2) years after the date on which Grantee or its affiliates, succors or permitted assigns cease to actively mine coal in Williamson or Franklin County, under IDNR Permit #375, whichever date comes first (the "**Term**") at which time the Easement and the Agreement shall cease and terminate without any further action or documentation.

All persons having reason to be concerned with the title as to the foregoing Premises are hereby given notice of the existence of said Easement and of the duty to inquire about its terms and conditions with regard to the title to the foregoing Premises. Inquiries may be made to Grantee at the address set forth above.

GRANTOR:

By: Robert R. Boyd

Robert R. Boyd
Name

Its: Authorized Person

GRANTEE:

By: _____

Its: _____

STATE OF Florida)
) SS.
COUNTY OF Palm Beach)

I, the undersigned, a notary public in and for said County, in the State aforesaid, do hereby certify that Robert R. Boyd, personally known to me to be an Authorized Person of New River Royalty, LLC, a Delaware limited liability company, whose name is subscribed to the foregoing instrument, appeared before me this day in person and acknowledged that he signed and delivered the said instrument of writing as an Authorized Person of said limited liability company, pursuant to proper authority given, as his free and voluntary act and as the free and voluntary act and deed of said company, for the uses and purposes therein set forth.

Given under my hand and notarial seal this 21st day of August, 2018.

SAMANTHA LEA WRIGHT
MY COMMISSION # FF983995
EXPIRES August 06, 2020
(407) 398-0153 FloridaNotaryService.com

Samantha Lea Wright
Notary Public

STATE OF Illinois)
) SS.
COUNTY OF Franklin)

I, the undersigned, a notary public in and for said County, in the State aforesaid, do hereby certify that Ron Koontz, personally known to me to be the Authorized Person of **Williamson Energy, LLC**, a Delaware limited liability company, whose name is subscribed to the foregoing instrument, appeared before me this day in person and acknowledged that he signed and delivered the said instrument of writing as the Authorized Person of said limited liability company, pursuant to proper authority given, as his free and voluntary act and as the free and voluntary act and deed of said company, for the uses and purposes therein set forth.

Given under my hand and notarial seal, this 29 day of August, 2018

Notary Public

OFFICIAL SEAL
LYNNE ELLEN JONES
Notary Public - State of Illinois
My Commission Expires Apr 27, 2019

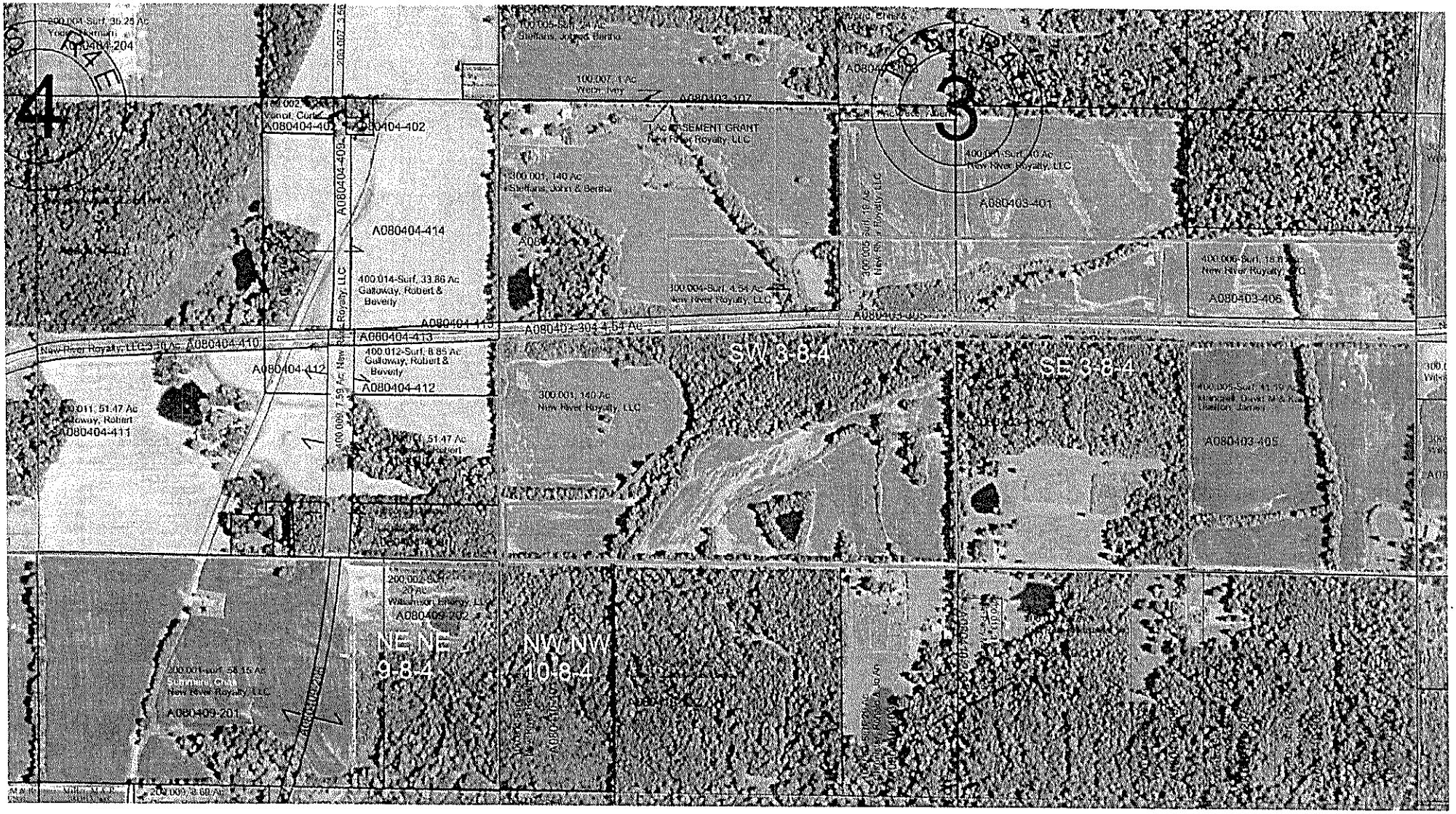
EXHIBIT A

PIN Numbers

PIN(s):
04-09-200-001
04-10-100-001
04-03-300-003
04-03-300-005
04-03-400-001
04-03-400-006

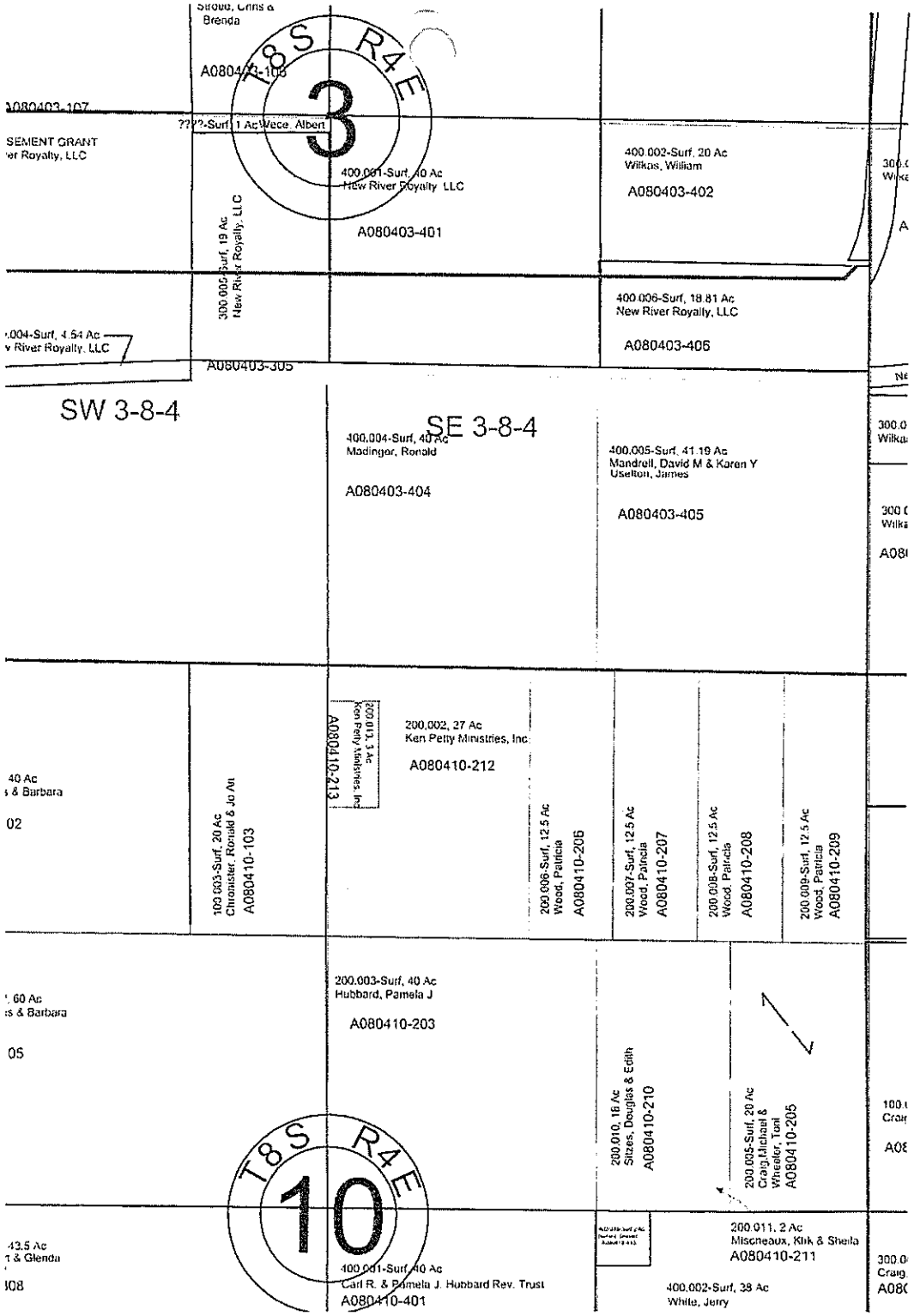
EXHIBITS B1

EXHIBIT B1



R06302

EXHIBIT B1



R06303

PIPELINE EASEMENT

KNOW ALL MEN BY THESE PRESENTS that for and in consideration of the payment of Ten Dollars ($10), the receipt of which is hereby acknowledged, the undersigned, ***Mary E. Wilkas, surviving spouse of Robert Wayne Wilkas, (deceased) and Executor of his Estate, and Eric J. Wilkas, Erica D. Coram, and Courtney J. Wilkas, surviving descendants of Robert Wayne Wilkas,*** *with an address of,* ***22698 Locust Grove RD. Thompsonville, Illinois 62890***, hereinafter called Grantor, do hereby grant and convey unto Williamson Energy, LLC, with an address of P.O. Box 99, Johnston City, Illinois 62951, hereinafter called Grantee, its successors, licensees, agents, lessees, contractors, sub-contractors and assigns, an easement across the described Premises attached as Exhibit A hereto, and in the general area of the Premises as shown on the plat attached as Exhibit B hereto.

This easement shall be for the purpose of constructing, reconstructing, installing and laying, using, operating, inspecting, repairing, maintaining, replacing and removing a pipeline or other utility lines (underground) and all associated appurtenances and facilities for the transportation of fluids over and across ***a strip of land twenty feet wide and with an additional 30 feet of workspace during times of construction or making***

repairs across the aforementioned Premises . Grantee will also pay Grantor the fair market value for any crop loss incurred from time to time by Grantor and/or its tenant farmer by reason of the exercise by Grantee of the rights granted herein. In the event of a pipeline leak or other significant adverse event, Grantee will compensate Grantor for crops damaged or destroyed and will remediate lingering effects to the affected area.

Subsequent to each incident of constructing, reconstructing, installing and laying, using, operating, inspecting, repairing, maintaining, replacing and removing a pipeline or pipelines or other utility lines (underground) and all associated appurtenances and facilities, Grantee will perform all necessary reclamation and restoration work at its sole expense on and respecting the Premises described herein. Grantee shall also repair any fencing, driveways, field access roads, field tile, or other structures and appurtenances damaged by Grantee's actions.

Grantee agrees that it will conduct all operations hereunder in a workmanlike manner and in accordance with industry practice; that it will comply with all applicable laws and regulations and that it will obtain all necessary permits. Grantee shall have the right to cut and remove trees, brush, vegetation and other materials on the easement Premises as necessary.

All pipelines shall be buried to a minimum depth of thirty-six (42) inches.

Any assignee, transferee or successor in interest shall be encumbered by the terms of this Easement.

Route to be installed as generally shown in attached EXHIBIT "B".

Grantor reserves the right to use the easement for any purpose that will not interfere with Grantee's full enjoyment of the rights granted herein, including agricultural use, provided, however, that Grantor agrees that no building or permanent structure will be constructed on the easement Premises. It is permissible for the Grantor to construct roads or driveways across the Easement.

Grantee shall indemnify and defend Grantor against all claims, losses and expenses by reason of liability imposed or claimed to be imposed by law for damage due to bodily injuries (including death) and property damage sustained by any persons, including Grantor, arising out the consequences of Grantee's exercise of its rights hereunder.

The parties acknowledge that the use of this easement will be regulated in part, by the Illinois Department of Natural Resources and may be subject to requirements of said Department. Grantor agrees to cooperate with Grantee with regard to any such matters.

The parties acknowledge that the use of this easement will be regulated in part, by the Illinois Department of Natural Resources and may be subject to requirements of said Department. Grantor agrees to cooperate with Grantee with regard to any such matters.

This easement and the provisions thereof shall be binding upon and inure to the benefit of Grantor, their successors and assigns, and Grantee and its successors or assigns.

DATED this 24 day of August, 2018.

Eric J. Wilkas

STATE OF INDIANA)
) SS.
COUNTY OF Gibson)

I, the undersigned a Notary Public in and for said County, in the State aforesaid, do hereby certify that that ***Eric J. Wilkas*** personally known to me to be the same person whose name is subscribed to the foregoing instrument, as having executed the same, appeared before me this day in person, and acknowledged that he signed, sealed and delivered the said instrument as his free and voluntary act, for the uses and purposes therein set forth, including the release and waiver of the right of homestead.

Given under my hand and notarial seal this 24 day of August, 2018.

Notary Public

THIS DOCUMENT PREPARED BY:
WILLIAMSON ENERGY, LLC.

Jeffrey J. Smith
My Commission Expires
Feb
3
2021
Seal
State of Indiana
Notary Public

DATED this 26th day of August 2018.

Courtney J. Wilkas

STATE OF INDIANA)
) SS.
COUNTY OF WILLIAMSON)

I, the undersigned a Notary Public in and for said County, in the State aforesaid, do hereby certify that that ***Courtney J. Wilkas*** personally known to me to be the same person whose name is subscribed to the foregoing instrument, as having executed the same, appeared before me this day in person, and acknowledged that he signed, sealed and delivered the said instrument as his free and voluntary act, for the uses and purposes therein set forth, including the release and waiver of the right of homestead.

Given under my hand and notarial seal this 26 day of August, 2018.

Notary Public

THIS DOCUMENT PREPARED BY:
WILLIAMSON ENERGY, LLC.

OFFICIAL SEAL
IAN D. FEE
Notary Public, State of Illinois
My Commission Expires 12-11-2021

DATED this 24 day of August, 2018.

Erica D. Coram

Erica D Coram

STATE OF ILLINOIS)
) SS.
COUNTY OF WILLIAMSON)

I, the undersigned a Notary Public in and for said County, in the State aforesaid, do hereby certify that that ***Erica D. Coram*** personally known to me to be the same person whose name is subscribed to the foregoing instrument, as having executed the same, appeared before me this day in person, and acknowledged that he signed, sealed and delivered the said instrument as his free and voluntary act, for the uses and purposes therein set forth, including the release and waiver of the right of homestead.

Given under my hand and notarial seal this 24 day of August, 2018.

Notary Public

THIS DOCUMENT PREPARED BY:
WILLIAMSON ENERGY, LLC.

OFFICIAL SEAL
IAN D. FEE
Notary Public, State of Illinois
My Commission Expires 12-11-2021

DATED this 27 day of August, 2018.

Mary E Wilkas

Mary E. Wilkas, Individually

Mary E Wilkas

Mary E. Wilkas, as Executor of the Estate of Robert Wayne Wilkas

STATE OF ILLINOIS)
) SS.
COUNTY OF WILLIAMSON)

I, the undersigned a Notary Public in and for said County, in the State aforesaid, do hereby certify that that ***Mary E. Wilkas, Individually, and as Executor of the Estate of Robert Wayne Wilkas*** personally known to me to be the same person whose name is subscribed to the foregoing instrument, as having executed the same, appeared before me this day in person, and acknowledged that he signed, sealed and delivered the said instrument as his free and voluntary act, for the uses and purposes therein set forth, including the release and waiver of the right of homestead.

Given under my hand and notarial seal this 27 day of August, 2018.

Notary Public

THIS DOCUMENT PREPARED BY:
WILLIAMSON ENERGY, LLC.

OFFICIAL SEAL
IAN D. FEE
Notary Public, State of Illinois
My Commission Expires 12-11-2021

EXHIBIT A

THE NORTHWEST QUARTER (NW1/4) OF THE SOUTHWEST QUARTER (SW1/4) AND A TEN (10) ACRE STRIP ACROSS THE NORTH SIDE OF THE SOUTHWEST ONE-FOURTH (SW1/4) OF THE SOUTHWEST QUARTER (SW1/4) OF SECTION TWO (2), TOWNSHIP EIGHT (8) SOUTH, RANGE FOUR (4) EAST OF THE THIRD PRINCIPAL MERIDIAN, EXCEPT THAT PART DESCRIBED AS FOLLOWS; COMMENCING AT AN IRON PIN FOUND AT THE SOUTHWEST CORNER OF THE NORTHWEST QUARTER (NW1/4) OF THE SOUTHWEST QUARTER (SW1/4) OF SECTION TWO (2), TOWNSHIP EIGHT (8) SOUTH, RANGE FOUR (4) EAST OF THE THIRD PRINCIPAL MERIDIAN; THENCE NORTH 00° 07' 04" E ALONG THE WEST LINE OF SAID QUARTER-QUARTER A DISTANCE OF 92.77' TO THE START OF A CENTERLINE AND POINT OF BEGINNING OF A TRACT OF LAND BEING 100.00 ' WIDE AND ALL CONTAINED IN SAID QUARTER-QUARTER; THENCE WITH A CURVE TURNING TO THE LEFT WITH AN ARC LENGTH OF 416.62' WITH A RADIUS OF 2864.93' WITH A CHORD BEARING OF N82° 55' 57" E WITH A CHORD LENGTH OF 416.25', THENCE N 78° 33' 36" E A DISTANCE 31.00'; THENCE N 78° 27' 24" E A DISTANCE OF 906.51' TO THE EAST LINE OF SAID QUARTER-QUARTER AND THE END OF SAID CENTERLINE.

SITUATED IN WILLIAMSON COUNTY, ILLINOIS.

Parcel Index Number: 04-02-300-015

OPTION

This Option made and entered into this 16th day of August, 2018, by and between, ***Joyce L. King, a married person acting in her individual right,*** *with an address of,* ***23825 Liles Road Thompsonville, Illinois 62890,*** hereinafter called "Optionor", and Williamson Energy, LLC, with an address of P.O. Box 99, Johnston City, Illinois 62951, hereinafter called "Optionee."

For and in consideration of the mutual covenants herein contained, the parties hereby agree as follows:

1. In consideration of the payment of the sum of [redacted] hereinafter "Option Payment", Optionor hereby grants to Optionee the right and option to purchase a pipeline easement on the following described property attached as "Exhibit A" hereto, hereinafter "Premises", upon the terms and conditions hereinafter stated.

2. The terms and conditions of the easement will be as set forth on Exhibit B attached hereto. Upon execution of the Easement, Grantee agrees to pay to Grantor a one-time payment of [redacted] in full consideration of the privileges granted herein. This consideration shall constitute payment in full for any damages to the easement Premises incurred by reason of the installation, operation and maintenance of the facilities of Grantee, or otherwise

arising from Grantee's use and enjoyment of the easement except as stated below.

3. This Option shall remain in effect for a term of 12 months from the date hereof or until the Option is exercised or terminated as provided for herein, whichever occurs first.

4. In the event of the exercise of this Option, the consideration for the Option shall be credited toward said purchase price if this Option is exercised and shall be retained by Optionor if the Option is not exercised.

5. If Optionee elects to exercise this Option, it shall give to Optionor, at any time during the option period, notice in writing of its election to exercise, and the exercise shall be effective as of the date the notice is given. If exercised, this Option shall become a contract between the parties upon the terms and conditions set forth herein.

6. At any time while this Option is in effect, Optionee or its agents may enter upon the Premises with necessary personnel and equipment for the purpose of conducting surveys and other activities related to the ascertainment of boundaries. If such activities result in crop damages, Optionee agrees to compensate Optionor or the agricultural tenant for such crop damages as their interests may appear.

7. Optionee shall have the right to terminate the Option for any reason at any time by giving written notice to Optionor.

8. Any notices to be given hereunder shall be in writing and shall be deemed given when personally delivered or mailed, postage charges prepaid, to the parties as follows:

To Optionor: ***Joyce L. King***
23825 Liles Road
Thompsonville, Illinois 62890

To Optionee: Williamson Energy, LLC
P.O. Box 99
Attn: Land Department
Johnston City, IL 62951

or to such other address as each party may choose by giving notice thereof to the other.

9. Optionor agrees to execute a memorandum of this Option suitable for recording if requested by Optionee.

10. This instrument constitutes the entire agreement between the parties.

11. This Option shall be construed in accordance with the laws of the State of Illinois. All terms and conditions of this Option shall be binding on and shall extend to the heirs, administrators, executors, successors or assigns of the respective parties. This Option shall be fully assignable.

12. Time is of the essence of this Option and the terms hereof shall be binding.

IN WITNESS WHEREOF, the parties hereto have executed this Option the day and year first above written.

OPTIONOR:

Joyce L. King

Joyce L. King

STATE OF ILLINOIS)
) SS.
COUNTY OF FRANKLIN)

I, the undersigned a Notary Public in and for said County, in the State aforesaid, do hereby certify that ***Joyce L. King*** personally known to me to be the same person whose name is subscribed to the foregoing instrument, as having executed the same, appeared before me this day in person, and acknowledged that he signed, sealed and delivered the said instrument as his free and voluntary act, for the uses and purposes therein set forth, including the release and waiver of the right of homestead.

Given under my hand and notarial seal this 16 day of August, 2018.

OFFICIAL SEAL
IAN D. FEE
Notary Public, State of Illinois
My Commission Expires 12-11-2021

Notary Public

This Instrument Was Prepared By:
WILLIAMSON ENERGY, LLC

OPTIONEE:

OPTIONEE:
WILLIAMSON ENERGY, LLC

By _____

Its _____

STATE OF _____)
) SS.
COUNTY OF _____)

I, the undersigned, a notary public in and for said County, in the State aforesaid, do hereby certify that _____, personally known to me to be the Authorized Person of Williamson Energy, LLC, whose name is subscribed to the foregoing instrument, appeared before me this day in person and acknowledged that he signed and delivered the said instrument of writing as the Authorized Person of said limited liability company, pursuant to authority given, as his free and voluntary act and as the free and voluntary act and deed of said company, for the uses and purposes therein set forth, including the release and waiver of the right of homestead.

Given under my hand and notarial seal this _____ day of _____, 2016.

_____
Notary Public

This Instrument Was Prepared By:
WILLIAMSON ENERGY, LLC

EXHIBIT A

THE SOUTHEAST QUARTER (SE1/4) OF THE NORTHWEST QUARTER (NW1/4); AND THE NORTHWEST QUARTER (NW1/4) OF THE SOUTHWEST QUARTER (SW1/4); THE NORTH ONE HALF (N1/2) OF THE SOUTHWEST QUARTER (SW1/4) OF THE NORTHWEST QUARTER (NW1/4); THE SOUTH ONE HALF (S1/2) OF THE SOUTHWEST QUARTER (SW1/4) OF THE NORTHWEST QUARTER (NW1/4) ; AND A TEN (10) ACRE STRIP ACROSS THE NORTH SIDE OF THE SOUTHWEST ONE-FOURTH (SW1/4) OF THE SOUTHWEST QUARTER (SW1/4) ALL IN SECTION TWO (2) TOWNSHIP EIGHT (8) SOUTH, RANGE FOUR (4) EAST OF THE THIRD PRINCIPAL MERIDIAN.

SITUATED IN WILLIAMSON COUNTY, ILLINOIS.

Parcel Index Number: 04-02-100-007

EXHIBIT B

PIPELINE EASEMENT

KNOW ALL MEN BY THESE PRESENTS that for and in consideration of the payment of Ten Dollars ($10), the receipt of which is hereby acknowledged, the undersigned ***Joyce L. King, a married person acting in her individual right,*** *with an address of,* ***23825 Liles Road Thompsonville, Illinois 62890***hereinafter called Grantor, do hereby grant and convey unto Williamson Energy, LLC, with an address of P.O. Box 99, Johnston City, Illinois 62951, hereinafter called Grantee, its successors, licensees, agents, lessees, contractors, sub-contractors and assigns, an easement across the described Premises attached as Exhibit A hereto, and in the general area of the Premises as shown on the plat attached as Exhibit B hereto.

This easement shall be for the purpose of constructing, reconstructing, installing and laying, using, operating, inspecting, repairing, maintaining, replacing and removing a pipeline or other utility lines (underground) and all associated appurtenances and facilities for the transportation of fluids over and across ***a strip of land twenty feet wide and with an additional 30 feet of workspace during times of construction or making repairs across the aforementioned Premises***. Grantee will also pay Grantor the fair market value for any crop loss incurred from time to time by Grantor and/or its tenant

farmer by reason of the exercise by Grantee of the rights granted herein. In the event of a pipeline leak or other significant adverse event, Grantee will compensate Grantor for crops damaged or destroyed and will remediate lingering effects to the affected area.

Subsequent to each incident of constructing, reconstructing, installing and laying, using, operating, inspecting, repairing, maintaining, replacing and removing a pipeline or pipelines or other utility lines (underground) and all associated appurtenances and facilities, Grantee will perform all necessary reclamation and restoration work at its sole expense on and respecting the Premises described herein. Grantee shall also repair any fencing, driveways, field access roads, field tile, or other structures and appurtenances damaged by Grantee's actions.

Grantee agrees that it will conduct all operations hereunder in a workmanlike manner and in accordance with industry practice; that it will comply with all applicable laws and regulations and that it will obtain all necessary permits. Grantee shall have the right to cut and remove trees, brush, vegetation and other materials on the easement Premises as necessary.

All pipelines shall be buried to a minimum depth of fourty-two (42) inches.

Any assignee, transferee or successor in interest shall be encumbered by the terms of this Easement. Route to be installed as generally shown in attached EXHIBIT "B".

Grantor reserves the right to use the easement for any purpose that will not interfere with Grantee's full enjoyment of the rights granted herein, including agricultural use, provided, however, that Grantor agrees that no building or permanent structure will

be constructed on the easement Premises. It is permissible for the Grantor to construct roads or driveways across the Easement.

Grantee shall indemnify and defend Grantor against all claims, losses and expenses by reason of liability imposed or claimed to be imposed by law for damage due to bodily injuries (including death) and property damage sustained by any persons, including Grantor, arising out the consequences of Grantee's exercise of its rights hereunder.

The parties acknowledge that the use of this easement will be regulated in part, by the Illinois Department of Natural Resources and may be subject to requirements of said Department. Grantor agrees to cooperate with Grantee with regard to any such matters.

This easement and the provisions thereof shall be binding upon and inure to the benefit of Grantor, their successors and assigns, and Grantee and its successors or assigns.

This easement shall be governed by the laws of the State of Illinois. This agreement constitutes the full agreement between the parties relating to the matters set forth herein.

DATED this 16 day of August, 2018.

Joyce L. King

Joyce L. King

STATE OF ILLINOIS)
) SS.
COUNTY OF FRANKLIN)

I, the undersigned a Notary Public in and for said County, in the State aforesaid, do hereby certify that ***Joyce L. King*** personally known to me to be the same person whose name is subscribed to the foregoing instrument, as having executed the same, appeared before me this day in person, and acknowledged that he signed, sealed and delivered the said instrument as his free and voluntary act, for the uses and purposes therein set forth, including the release and waiver of the right of homestead.

Given under my hand and notarial seal this 16 day of August, 2018.

This Instrument Was Prepared By:
WILLIAMSON ENERGY, LLC

Notary Public

OFFICIAL SEAL
IAN D. FEE
Notary Public, State of Illinois
My Commission Expires 12-11-2021

EXHIBIT A

THE SOUTHEAST QUARTER (SE1/4) OF THE NORTHWEST QUARTER (NW1/4); AND THE NORTHWEST QUARTER (NW1/4) OF THE SOUTHWEST QUARTER (SW1/4); THE NORTH ONE HALF (N1/2) OF THE SOUTHWEST QUARTER (SW1/4) OF THE NORTHWEST QUARTER (NW1/4); THE SOUTH ONE HALF (S1/2) OF THE SOUTHWEST QUARTER (SW1/4) OF THE NORTHWEST QUARTER (NW1/4) ; AND A TEN (10) ACRE STRIP ACROSS THE NORTH SIDE OF THE SOUTHWEST ONE-FOURTH (SW1/4) OF THE SOUTHWEST QUARTER (SW1/4) ALL IN SECTION TWO (2) TOWNSHIP EIGHT (8) SOUTH, RANGE FOUR (4) EAST OF THE THIRD PRINCIPAL MERIDIAN.

SITUATED IN WILLIAMSON COUNTY, ILLINOIS.

Parcel Index Number: 04-02-100-007

EXHIBIT C

MEMORANDUM OF OPTION

This Memorandum dated this 16th day of August, 2018, by and between ***Joyce L. King, a married person acting in her individual right,*** *with an address of,* ***23825 Liles Road Thompsonville, Illinois 62890,*** hereinafter called "Optionor", and Williamson Energy, LLC, with an address of P.O. Box 99, Johnston City, Illinois 62951, hereinafter called "Optionee",

KNOW ALL MEN BY THESE PRESENTS that Optionor and Optionee have entered into an Option of even date herewith concerning the Premises located in Franklin County, Illinois, described in Exhibit A attached hereto.

Optionor is the owner of the rights and estates to be granted pursuant to said Option.

Said Option contemplates conveyance within a reasonable, specified time period, but extensions are provided for therein based on various contingencies.

All persons having reason to be concerned with the title as to the foregoing Premises are hereby given notice of the existence of said Option and of the duty to inquire about its terms and conditions with regard to the title to the foregoing Premises. Inquiries may be made to Optionee at the address set forth above.

Dated the date set forth above.

Joyce L. King

Joyce L. King

STATE OF ILLINOIS)
) SS.
COUNTY OF FRANKLIN)

I, the undersigned a Notary Public in and for said County, in the State aforesaid, do hereby certify that ***Joyce L. King*** personally known to me to be the same persons whose name is subscribed to the foregoing instrument, as having executed the same, appeared before me this day in person, and acknowledged that he signed, sealed and delivered the said instrument as his free and voluntary act, for the uses and purposes therein set forth, including the release and waiver of the right of homestead.

Given under my hand and notarial seal this 16 day of August, 2018.

Notary Public

This Instrument Was Prepared By:
WILLIAMSON ENERGY, LLC

OFFICIAL SEAL
IAN D. FEE
Notary Public, State of Illinois
My Commission Expires 12-11-2021

EXHIBIT A

THE SOUTHEAST QUARTER (SE1/4) OF THE NORTHWEST QUARTER (NW1/4); AND THE NORTHWEST QUARTER (NW1/4) OF THE SOUTHWEST QUARTER (SW1/4); THE NORTH ONE HALF (N1/2) OF THE SOUTHWEST QUARTER (SW1/4) OF THE NORTHWEST QUARTER (NW1/4); THE SOUTH ONE HALF (S1/2) OF THE SOUTHWEST QUARTER (SW1/4) OF THE NORTHWEST QUARTER (NW1/4) ; AND A TEN (10) ACRE STRIP ACROSS THE NORTH SIDE OF THE SOUTHWEST ONE-FOURTH (SW1/4) OF THE SOUTHWEST QUARTER (SW1/4) ALL IN SECTION TWO (2) TOWNSHIP EIGHT (8) SOUTH, RANGE FOUR (4) EAST OF THE THIRD PRINCIPAL MERIDIAN.

SITUATED IN WILLIAMSON COUNTY, ILLINOIS.

Parcel Index Number: 04-02-100-007

PART 2: Pre-Mining Information

2.1 Pre-Mining Land Use Information.

2.1.1 Pre-Mining Land Use and Capability Acreages. Complete Table 2.1.1: Pre-Mining Land Use Capability giving the acreage and capability of each land use within the proposed permit area, employing only land use categories of 62 Ill. Adm. Code 1701.5, the "fish and wildlife" land use category must be subdivided as required by Operator Memorandum 2015-01. Use only these land uses for completing the land use maps.

The information shall be broken down with a separate table for each landowner. In addition, the applicant shall complete Table 2.1.1 - Grand Total: Pre-Mining Land Use Capability Summary. This table is a compilation of all Pre-Mining Land Use Capability tables filled out for each individual land owner.

For IBR applications, complete Table 2.1.1: Pre-Mining Land Use Capability for each landowner and update Table 2.1.1 - Grand Total: Pre-Mining Land Use Capability Summary. **[1780.23/1784.15]**

Note: other agencies, such as USACE, may define land uses differently.

See Table 2.1.1

2.1.2 Provide slope measurements to represent existing land surface configuration of proposed permit area. A soils map of medium intensity prepared to NRCS specifications or a contoured aerial photo may be submitted to meet this requirement. **[1779.24/1783.24(l)]**

☒ Check here if using one of the above maps or photos.

Does the Soils Map submitted with the application meet the requirements to provide slope measurements?

☒ YES ☐ NO

If NO, provide a contoured aerial photo for the proposed boundary.

2.1.3 For any proposed surface coal mining and reclamation operation, has previous mining activity including active, inactive or abandoned underground mine workings along with any mine opening to the surface occurred within the permit and/or adjacent area? **[1816.133/1817.133]**

☒ YES ☐ NO

If YES, complete Table 2.1.3: Previous Mining Activity - Surface Permit Areas and delineate the areas disturbed by previous mining activities, including active, inactive or abandoned underground mine work along with any mine opening to the surface on the Pre-Mining Land Use Map. In addition, the map shall identify areas where surface coal mining operations were conducted prior to August 3, 1977; after August 3, 1977 and prior to May 3, 1978; after May 3, 1978 and prior to February 1, 1983; and any permanent regulatory program permit issued after February 1, 1983. **[1777.14(b); 1779.25(a)(8)/1783.25(a)(8)]**

2.1.3.1 Identify the land uses preceding any type of mining, if known. **[1780.23(a)(1)/1784.15(a)(1)]**

Cropland, Industrial, Fish and Wildlife – Herbaceous, Fish and Wildlife-Woody, Residential. Note: Area identified as residential is owned by the applicant.

2.1.4 Is any of the permit area subject to local or county zoning?

☐ YES ☒ NO

If YES, provide a description of the existing land uses and land classifications under local law, if any, for the proposed permit and adjacent areas.

2.1.5 Provide the location of surface and subsurface man-made features within, passing through, or passing over the proposed permit area on the Pre-Mining Land Use Map. Such features should include, but are not limited to, major electric transmission lines, pipelines, agricultural drainage tile fields, gas and oil wells, and water wells. For gas, oil, and water wells provide the depth, if available, of the well in Table 2.1.5: Oil and Gas Well Information. **[1779.24(e)/1783.24(e)]**

2.1.6 If any of the land uses changed within the last five (5) years, indicate the acreage and changes of land uses. **[1780.23(a)(1)/1784.15(a)(1)]**

N/A

2.2 Pre-Mining Soils Information. The applicant is strongly recommended to use the USDA Web Soil Survey. The web soil survey has the ability to create a Custom Soil Survey report for the application area which will generate many of the information requirements for pre-mining soils and prime farmland restoration plans which may reference this report. Please note there are extra soil data tables, including Land Classification, Non-irrigated Capability Class, and Vegetation Productivity, and the data from the Soil Property and Qualities tab which must specifically be extracted when creating a custom report.

NOTE: The acreage of the Area of Interest must agree with the permit acreage. This report may be referenced in responding to portions of the required soil information.

2.2.1 The narrative of land capability and productivity shall employ the USDA National Resources Conservation Service's Land-Capability Classification (Agriculture Handbook No. 210) in conjunction with the soil information provided under the published soil survey when completing Part 2.2.9. Optimum levels management productivity information may be found in Bulletin 811. **[1779.21/1783.21].**

NOTE: This Bulletin has periodic updates in a supplemental table.

See Attachment 2.2

2.2.2 A Soils Map shall be provided as required by Part 2.2. The scale of the Soil Map scale must be the same scale as the Pre-Mining Land Use Map and Post-Mining Land Use/Capability Reclamation Map, unless otherwise approved by the Department. Does the submitted Soils Map represent a map developed by the National Resources Conservation Service (NRCS)? **[1779.21/1783.21]**

☒ YES ☐ NO

If YES, complete the following:

2.2.2.1 Has the NRCS soil map been modified in any way except by a change in scale?

☐ YES ☒ NO

If YES, explain the nature of the changes.

2.2.3 For surface mines, delineate on the Soils Map, the area which will incur actual mining (removal of overburden and/or deposition of overburden for the extraction of coal). Identify any areas proposed to remain undisturbed. **[1780.14]**

For underground mines, identify any areas proposed to remain undisturbed. **[1784.23]**

N/A. All area is underground mine support

2.2.4 Are any of the identified map units correlated as prime farmland by NRCS criteria?

☒ YES ☐ NO

If YES, explain and provide documentation to meet the requirements of 62 Ill. Adm. Code 1785.17 or 1823.11, if a request for grandfathering, negative determination or underground mine exemption is sought. If prime farmlands exist which will not meet the exemption criteria described above, a prime farmlands restoration plan must be provided in Parts 8.2 through 8.4. **[1785.17(b)/1823.11]**

See attached Soil map and soil report.

2.2.5 Indicate the average topsoil thickness of each of the Soil Map units to be affected. Locate on Soils Map the test holes for soil horizon thickness sampling. Provide the average and methodology for determining the average pre-mining topsoil thickness in inches for: **[1779.21/1783.21]**

- Non-cropland capability 6-9 inches
- High capability 6-9 inches
- Prime Farmland 6-9 inches

2.2.6 List the soil types and acreages of areas that will require the B and/or portions of the C horizon to be removed and replaced in order to establish the root medium necessary to achieve soil productivity consistent with the proposed post-mining land use. Alternatively, a narrative description explaining why specific soil type acres information for reclamation plan achievement is not necessary may be provided. **[1780.18(b)(4)/1784.13(b)(4)]**

N/A

2.2.7 Are selected overburden materials proposed to be used in lieu of or as a supplement to the A-horizon?

☐ YES ☒ NO

If YES, provide the appropriate information required by 62 Ill. Adm. Code 1779.21(b) or 1783.21(b).

Also, identify the source of the substitute materials and the topsoil to be substituted away from (not removed) on a separate soils map, labeled Topsoil Substitution Map and/or describe the area in narrative form. **[1780.14/1784.23]**

2.2.8 Explain why the proposed plan will provide the best available material of equal or better quality than present topsoil or surface existing material. **[1816.22(b)/1817.22(b)].** This section must be addressed when affecting previously disturbed areas if the surface soil is not to be salvaged. If topsoil substitutes or supplements are proposed, a demonstration of their suitability shall be required based on analysis of thickness of soil horizons, total depth, texture, percent coarse fragments, pH, and aerial extent of the different kinds of soils. The Department shall require other chemical and physical analyses, field-site trials, or greenhouse tests if determined to be necessary or desirable to demonstrate the stability of the topsoil substitutes or supplements. **[1780.18(b)(4)/1784.13(b)(4); 1779.21/1783.21]**

N/A. Topsoil will be replaced.

2.2.9 Complete Table 2.2.9: Soils Information Chart acreage for each of the map units (soil type and slope classification) of prime farmland, high capability (include grandfathered and negatively determined prime farmland) and non-cropland capability land with respect to areas within the permit area. All soils previously disturbed by home sites, farmsteads, roads, etc., shall be tabulated as non-cropland capability and need not undergo a negative determination. The Soil Information Chart must be broken out by land owner, if there is more than one. **[1779.21(a)/1783.21(a); 1785.17]**

Table 2.2.9 included

Optional-addition: If applicable, quantify map units acreage values on Table 2.2.9: Soils Information Chart for areas which will not be disturbed. **[1779.21(a)/1783.21(a)]**

2.3 Areas Where Mining is Limited or Prohibited.

Complete Table 2.3: Areas Prohibiting or Limiting Mining Operations for each structure (occupied dwelling, public building, school, church, community/institutional building, public park, cemeteries, public road) identified in question 2.3.2 through 2.3.9 with respect to areas where mining is prohibited. Indicate if the buffer zone will be in effect or if a waiver is obtained. **[1761.11(c)(d)(e)(f)(g)]**

2.3.1 Does the proposed permit area include areas designated unsuitable for surface coal mining and reclamation operations, or under study for designation in an administrative proceedings as unsuitable for surface coal mining and reclamation operations? **[1773.15(c)(3)]**

☐ YES ☒ NO

If YES, identify these areas on the Pre-Mining Land Use and Operations Map.

2.3.2 Does the proposed permit area include lands within boundaries of the National Park System, National Wildlife Refuge System, the National System of Trails, the National Wilderness Preservation System, the Wild and Scenic Rivers System, and National Recreation Areas, etc.? **[1761.11(a)]**

☐ YES ☒ NO

If YES, identify these areas on the Pre-Mining Land Use and Operations Map.

2.3.3 Does the proposed permit area include lands within the boundaries of any national forest? **[1761.11(b)]**

☐ YES ☒ NO

If YES, identify these areas on the Pre-Mining Land Use and Operations Map.

2.3.4 Are there any publicly owned parks or any places included in the National Register of Historic Places on or within 1,000 feet of the proposed permit area? **[1761.11(c)]**

☐ YES ☒ NO

If YES, identify these areas on the Pre-Mining Land Use and Operations Map.

2.3.5 Does the operations plan propose any surface coal mining operations within 100 feet measured horizontally of the outside right-of-way line of any public road? **[1761.11(d)]**

☒ YES ☐ NO

If YES, complete the following:

2.3.5.1 Describe the measures to be used to insure that the interest of the affected public and landowners will be protected. **[1761.11(d)(2)(B)]**

The Bleeder site is located adjacent to Kraatz and Crawford roads and will be accessed off Crawford Road via North Bleeder access road and the associated waterline and powerline corridor will be accessed from Crawford Road and Locust Grove Road. Crawford Road and Locust Grove Road will have water line install up to the road right of way and the waterline will be bored underneath the roads from outside of the road right of way. The entrances will comply with the Williamson County Road Authority to ensure the safety of the affected public and the land owner. Installation and construction activities will be completed over a short period of time and once completed there will be no further construction activities. During construction, no equipment will be allowed to endanger the public or landowner.

2.3.5.2 In the public notice of the application required in the Cover Sheet, identify the public road(s), describe the activities to be conducted within 100 feet of the road(s), and indicate the opportunity for a public hearing on this matter. **[1761.11(d)(2)(A)]**

See public notice

2.3.6 Does the proposed permit area include any public roads which are to be removed, relocated or closed? **[1761.14]**

☐ YES ☒ NO

If YES, complete the following:

2.3.6.1 Submit the necessary approvals of the authority with jurisdiction over the public road. **[1761.14(b)(2)]**

N/A

2.3.6.2 If a public road is to be replaced or re-located within the permit area, provide evidence that a bond has or will be posted with the authority with jurisdiction over the public road. If such bond has not been nor will be posted, address road replacement costs in Table 9.5.1.14: Public Road Replacement.

N/A

2.3.6.3 Describe the measures to be used to insure that the interest of the affected public and landowners will be protected. **[1761.14(b)(5)]**

2.3.6.4 As required in the Cover Sheet, the public notice shall identify the public road(s) to be removed, relocated or closed, and indicate the opportunity for a public hearing on this matter. **[1761.14(b)(3) and (4)]**

See public notice

2.3.7 Does the operations plan propose any surface coal mining operations within 300 feet measured horizontally from any occupied dwelling other than a haul road or access road which connects with an existing public road on the side of the public road opposite the dwelling? **[1761.11(e)]**

☐ YES ☒ NO

If YES, include a waiver from the owner of the dwelling meeting the following requirements: **[1761.15]**

- The waiver shall be by lease, deed, or other conveyance from the owner of the dwelling. The waiver must clarify that the owner and signator had the legal right to deny mining and knowingly waived that right.
- Provide proof that the waiver has been properly filed in public property records pursuant to State laws.

If NO, and occupied dwellings are located either within the permit boundary or within 300 feet of the permit boundary but no disturbance is proposed within 300 feet, then indicate 300 foot buffer markers around all applicable occupied dwellings on the Operations Map

NOTE: If a valid waiver was obtained before August 3, 1977 from the owner of an occupied dwelling to conduct operations within 300 feet of the dwelling, a new waiver need not be obtained. [1761.15(c)]

300 foot buffer shown on the Operations Map. Williamson Energy owns two the of structures within 300 feet of the site therefore no waiver is require, the third structure a 300 feet buffer zone will be observed.

2.3.8 Does the operations plan propose any surface coal mining operations within 300 feet measured horizontally of any public building, school, church, community or institutional building or public park? **[1761.11(f)]**

☐ YES ☒ NO

2.3.9 Are there any public or private cemeteries or Indian burial grounds or other areas where human bodies are interred located in or within one hundred (100) feet of the proposed permit area? **[1761.11(g)]**

☐ YES ☒ NO

If YES, locate on the Pre-Mining Land Use, Operations and Post-Mining Land Use/Capability Reclamation Plan Maps the boundaries of the above-referenced areas and indicate a 100 foot buffer zone around the cemetery or burial ground. **[1779.24(j)/1783.24(j)]**

2.3.10 Are valid existing rights claimed for any part of the permit area? **[1761.5; 1761.16] N/A**

☐ YES ☒ NO

If YES, complete Part 2.6 or 2.7 to substantiate the claim.

2.4 Public Parks, Historic Properties.

2.4.1 Provide a description of the historic properties (archeological sites and/or historic standing structures) listed or potentially eligible for listing on the National Register of Historic Places and any known archeological features within the proposed permit and adjacent areas. The description of the historic properties occurring within the permit area and adjacent areas shall be based upon available data. If studies have been completed and submitted for review prior to this application, attach a copy of the results of that review. For significant revisions other than shadow area revisions, attach a copy of the IHPA review. Also, with regard to historic properties, provide the anticipated start date when the area is to be affected. **[1779.12/1783.12]**

See Attachment 2.4.1

2.4.2 If investigations are underway or under review, reference the current status. **[1779.12(b)/1783.12(b)]**

NOTE: Studies which are submitted to the Department shall be submitted as a separate document (3 hard copies, plus one on disk in pdf format or other format as directed by the Department)

N/A

2.4.3 If historic properties are to be avoided, provide a map showing their location in lieu of either a Phase I evaluation or a Phase II evaluation. A qualified archaeologist shall create the map and identifying field markings to be employed to ensure the site(s) will not be disturbed by surface coal mining and reclamation operations. The map is to be submitted in duplicate in separate cover from the rest of the application and labeled Historic Properties Protection Map. The Department will hold the map as a confidential document. If a revision proposes a disturbance not previously identified, identify its location to any avoidance area. **[1773.13(d)(3)].**

N/A

2.4.4 Provide a plan for publicly owned park(s), or place(s) listed on the National Register of Historic Places, that may be adversely affected by the proposed operation describing the measures to be employed: **[1780.31/1784.17]**

- To prevent adverse impacts caused by surface mining related activities including, but not limited to, loss or destruction of historic properties; or
- If valid existing rights exist or joint agency approval is to be obtained under 62 Ill. Adm. Code 1761.17(d), to minimize adverse impacts. If valid existing rights are to be claimed, complete Sections 2.5 or 2.6 of this application, whichever is applicable.

N/A

2.5 Valid Existing Rights (VER) Good Faith/All Permits Standard. [1761.16(b)(2)] N/A

The applicant must provide a property rights demonstration under 62 Ill. Adm. Code 1761.5(a) if the applicant's request for VER is based upon the good faith/all permits standard in Section 1761.5(b)(1). This demonstration must include the following items: **[1761.16(b)]**

2.5.1 A legal description of the land to which the request pertains.

2.5.2 Complete documentation of the character and extent of the current interests in the surface and mineral estates of the land to which the request pertains.

2.5.3 A complete chain of title for the surface and mineral estates of the land to which the request pertains.

2.5.4 A description of the nature and effect of each title instrument that forms the basis for the request, including any provision pertaining to the type of method of mining or mining-related surface disturbances and facilities.

2.5.5 A description of the type and extent of surface coal mining operations that the applicant or permittee claims the right to conduct, including the method of mining and mining-related surface activities and facilities, and an explanation of how those operations would be consistent with State property law.

2.5.6 Complete documentation of the nature and ownership, as of the date that the land came under the protection of 62 Ill. Adm. Code 1761.11, of all property rights for the surface and mineral estates of the land to which the request pertains.

2.5.7 Names and addresses of the current owners of the surface and mineral estates of the land to which the request pertains.

2.5.8 If the coal interests have been severed from other property interests, documentation that the owners of other property interests in the land to which the request pertains have been notified and provided a minimum of 14 days to comment on the validity of the applicant or permittee's property rights claims.

2.5.9 Provide any comments received in response to the notification provided under Part 2.5.8. above.

2.5.10 Approval and issuance dates and identification numbers for any permits, licenses, and authorizations that the applicant, permittee or a predecessor in interest obtained before the land came under the protection of 62 Ill. Adm. Code 1761.11.

2.5.11 Application dates and identification numbers for any permits, licenses, and authorizations for which the applicant, permittee or a predecessor in interest submitted an application before the land came under the protection of 62 Ill. Adm. Code 1761.11.

2.5.12 An explanation of any other good faith effort that the applicant, permittee or a predecessor in interest made to obtain the necessary permits, licenses, and authorizations as of the date that the land came under the protection of 62 Ill. Adm. Code 1761.11.

2.6 Valid Existing Rights (VER) Needed for and Adjacent Standard. [1761.16(b)(3)] N/A

The applicant must provide a property rights demonstration under 62 Ill. Adm. Code 1761.5(a) if the applicant's request for VER is based upon the needs for and adjacent standard in Section 1761.5(b)(1). This demonstration must include the following items: **[1761.16(b)]**

2.6.1 A legal description of the land to which the request pertains.

2.6.2 Complete documentation of the character and extent of the current interests in the surface and mineral estates of the land to which the request pertains.

2.6.3 A complete chain of title for the surface and mineral estates of the land to which the request pertains.

2.6.4 A description of the nature and effect of each title instrument that forms the basis for the request, including any provision pertaining to the type of method of mining or mining-related surface disturbances and facilities.

2.6.5 A description of the type and extent of surface coal mining operations that the applicant or permittee claims the right to conduct, including the method of mining and mining-related surface activities and facilities, and an explanation of how those operations would be consistent with State property law.

2.6.6 Complete documentation of the nature and ownership, as of the date that the land came under the protection of 62 Ill. Adm. Code 1761.11, of all property rights for the surface and mineral estates of the land to which the request pertains.

2.6.7 Names and addresses of the current owners of the surface and mineral estates of the land to which the request pertains.

2.6.8 If the coal interests have been severed from other property interests, documentation that the owners of other property interests in the land to which the request pertains have been notified and provided a minimum of 14 days to comment on the validity of the applicant or permittee's property rights claims.

2.6.9 Provide any comments received in response to the notification provided under Part 2.6.8 above.

2.6.10 Explain how and why the land is needed for and immediately adjacent to the operation upon which the request is based. This explanation shall include a demonstration that prohibiting expansion of the operation onto that land would unfairly impact the viability of the operation as originally planned before the land came under the protection of 62 Ill. Adm. Code 1761.11.

2.7 Valid Existing Rights (VER) Standards for Mine Roads. [1761.16(b)(4)] N/A

If the request relies upon one of the standards for roads in 62 Ill. Adm. Code 1761.5(c)(1) through (c)(4), satisfactory documentation of one or more of the following must be submitted showing that: **[1761.5(c)]**

2.7.1 The road existed when the land upon which it is located came under the protection of 62 Ill. Adm. Code 1761.11, and the applicant has a legal right to use the road for surface coal mining operations.

2.7.2 A properly recorded right of way or easement for a road in that location existed when the land came under the protection of 62 Ill. Adm. Code 1761.11, and, under the document creating the right-of-way or easement, and under any subsequent conveyances, the applicant has a legal right to use or construct a road across that right of way or easement to conduct surface coal mining operations.

2.7.3 A valid permit for use or construction of a road in that location for surface coal mining operations existed when the land came under the protection of 62 Ill. Adm. Code 1761.11.

2.7.4 Valid existing rights exist under 62 Ill. Adm. Code 1761.5(a) and (b).

Table 2.1.1
Pre-Mining Land Use Capability

Land Owner: *David M. & Karen Y. Mandrel*

DISTURB CATEGORY	LAND CAPABILITY	PRE-MINE LAND USE ACREAGE														Subtotal
		Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	
Mining Area	Prime	3.30														3.30
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	3.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.30
Unaffected (Optional)	Prime	1.10														1.10
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10
Total Area	Prime	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.40
	Neg. Det.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	High Cap.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Limited Capability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Subtotal	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.40

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06337

Table 2.1.1
Pre-Mining Land Use Capability

Land Owner: *Williamson Energy, LLC*

DISTURB CATEGORY	LAND CAPABILITY	PRE-MINE LAND USE ACREAGE														Subtotal
		Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	
Mining Area	Prime															0.00
	Neg. Det.								0.06							0.06
	High Cap.															0.00
	Limited Capability				0.67				0.28							0.95
	Subtotal	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	1.01
Unaffected (Optional)	Prime															0.00
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Area	Prime	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Neg. Det.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.06
	High Cap.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Limited Capability	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.95
	Subtotal	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	1.01

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06338

Table 2.1.1
Pre-Mining Land Use Capability

Land Owner: *Ameren Illinois Company*

DISTURB CATEGORY	LAND CAPABILITY	PRE-MINE LAND USE ACREAGE														Subtotal
		Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	
Mining Area	Prime															0.00
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability				0.12											0.12
	Subtotal	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Unaffected (Optional)	Prime															0.00
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Area	Prime	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Neg. Det.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	High Cap.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Limited Capability	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
	Subtotal	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06339

Table 2.1.1
Pre-Mining Land Use Capability

Revised 1/9/2019

Land Owner: *Joyce L King*

DISTURB CATEGORY	LAND CAPABILITY	PRE-MINE LAND USE ACREAGE														Subtotal
		Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	
Mining Area	Prime															0.00
	Neg. Det.				1.00											1.00
	High Cap.															0.00
	Limited Capability				1.08											1.08
	Subtotal	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08
Unaffected (Optional)	Prime															0.00
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Area	Prime	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Neg. Det.	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
	High Cap.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Limited Capability	0.00	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.08
	Subtotal	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06340

Table 2.1.1
Pre-Mining Land Use Capability

Revised 1/9/2019

Land Owner: *Robert Wayne Wilkas*

DISTURB CATEGORY	LAND CAPABILITY	PRE-MINE LAND USE ACREAGE														Subtotal
		Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	
Mining Area	Prime															0.00
	Neg. Det.				1.27											1.27
	High Cap.				0.04											0.04
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.31
Unaffected (Optional)	Prime															0.00
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Area	Prime	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Neg. Det.	0.00	0.00	0.00	1.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.27
	High Cap.	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
	Limited Capability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Subtotal	0.00	0.00	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.31

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06341

Table 2.1.1
Pre-Mining Land Use Capability

Revised 1/9/2019

Land Owner: *New River Royalty, LLC*

DISTURB CATEGORY	LAND CAPABILITY	PRE-MINE LAND USE ACREAGE														Subtotal
		Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	
Mining Area	Prime	3.96														3.96
	Neg. Det.				0.21	0.70										0.91
	High Cap.	0.06														0.06
	Limited Capability	2.50			0.28	0.33				0.05						3.16
	Subtotal	6.52	0.00	0.00	0.49	1.03	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	8.09
Unaffected (Optional)	Prime															0.00
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Area	Prime	3.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.96
	Neg. Det.	0.00	0.00	0.00	0.21	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91
	High Cap.	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
	Limited Capability	2.50	0.00	0.00	0.28	0.33	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	3.16
	Subtotal	6.52	0.00	0.00	0.49	1.03	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	8.09

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06342

Table 2.1.1 - Grand Total
Pre-Mining Land Use Capability Summary

NOTE: This table must reflect the summary of all individual Pre-mining Land Use Capability tables

Revised 1/9/2019

DISTURB CATEGORY	LAND CAPABILITY	PRE-MINE LAND USE ACREAGE															Subtotal
		Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery		
Mining Area	Prime	7.26															7.26
	Neg. Det.				2.48	0.70			0.06								3.24
	High Cap.	0.06			0.04												0.10
	Limited Capability	2.50			2.15	0.33			0.28	0.05							5.31
	Subtotal	9.82	0.00	0.00	4.67	1.03	0.00	0.00	0.34	0.05	0.00	0.00	0.00	0.00	0.00		15.91
Unaffected (Optional)	Prime	1.10															1.10
	Neg. Det.																0.00
	High Cap.																0.00
	Limited Capability																0.00
	Subtotal	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		1.10
Total Area	Prime	8.36															8.36
	Neg. Det.				2.48	0.70			0.06								3.24
	High Cap.	0.06			0.04												0.10
	Limited Capability	2.50			2.15	0.33			0.28	0.05							5.31
	Subtotal	10.92	0.00	0.00	4.67	1.03	0.00	0.00	0.34	0.05	0.00	0.00	0.00	0.00	0.00		17.01

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06343

TABLE 2.1.3
Previous Mining Activity - Surface Permit Areas

NAME OF MINE	TYPE OF MINING (Surface/Underground)	MATERIAL MINED (Coal/Other)	METHOD OF UNDERGROUND MINING (Room and Pillar/Longwall)	NAME OF COAL SEAM MINED	STATUS OF MINING (Active/Inactive/Abandoned)
M-Class #1 Mine	Underground	Coal	Longwall	#6	Active

R06344

Table 2.2.9
Soils Information Chart

Revised 1/9/2019

SURFACE OWNER	SOIL IDENTIFICATION					MINING OR DISTURBANCE AREA				UNAFFECTED (OPTIONAL)				
						Prime Soils		NonPrime Soils		Prime Soils		NonPrime Soils		
	Soil Map Symbol	Soil Name	Slope [%]	Capability Class	Productivity Index (optimum)*	Prime Farmland [acres]	Neg Det PFL [acres]	High Capability [acres]	Limited Capability [acres]	Prime Farmland [acres]	Neg Det PFL [acres]	High Capability [acres]	Limited Capability [acres]	TOTALS [acres]
David M. & Karen Y Mandrel	3382A	Belknap	0 to 2	3w	117	3.30				1.10				4.40
														0.00
Williamson Energy, LLC	10D	Plumfield	10 to 18	6e	56				0.95					0.95
	3382A	Belknap	0 to 2	3w	117		0.06							0.06
														0.00
Ameren Illinois Company	10D	Plumfield	10 to 18	6e	56				0.12					0.12
														0.00
Joyce L King	10D	Plumfield	10 to 18	6e	56				1.08					1.08
	14B	Ava	2 to 5	2e	93		1.00							1.00
														0.00
Robert Wayne Wilkas	13B2	Bluford	2 to 5	2e	96		0.52							0.52
	14B	Ava	2 to 5	2e	93		0.75							0.75
	14C2	Ava	5 to 10	3e	74			0.04						0.04
														0.00
New River Royalty, LLC	10C	Plumfield	5 to 10	4e	70				3.16					3.16
	13B2	Bluford	2 to 5	2e	96		0.02							0.02
	14B	Ava	2 to 5	2e	93	0.66	0.05							0.71
	14C3	Ava	5 to 10	3e	74			0.06						0.06
	337A	Creal	0 to 2	2w	110	0.34								0.34
	3382A	Belknap	0 to 2	3w	117	2.96	0.84							3.80
														0.00
														0.00
														0.00
														0.00
														0.00
														0.00
					TOTALS:	7.26	3.24	0.10	5.31	1.10	0.00	0.00	0.00	17.01

*** Bulletin 811 (adjusted for slope and erosion)**

Information required under 1785.17, 1823,1779.21 and/or 1783.21

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06345

TABLE 2.3

Areas Prohibiting or Limiting Mining Operations

Refer to the index below for a list of areas/features to be identified

Owner/Structure ID/ Area/Feature	Address/Location	Type of Structures	Map ID	Reason for Mining (dwelling owner waiver/ cemetery relocation)	Buffer Distance
Kraatz Road	NW/4, NE/4, Section 2, T8S, R4E	Road	Road	North Bleeder Shaft Site - Site development located to minimize to minimize disturbance to farm fields and wooded areas	10
Crawford Road	NW/4, NE/4, Section 2, T8S, R4E	Road	Road	North Bleeder Shaft Site - Site development located to minimize to minimize disturbance to farm fields and wooded areas	10
Crawford Road	NE/4, NW/4, Section 2, T8S, R4E	Road	Road	Waterline crosses roadway at 45	30
Locust Grove Road	SW/4, SW/4, Section 3 and NW/4, NW/4, Section 10, and NE/4, NE/4, Section 9, all of T8S, R4E	Road	Road	Waterline crosses roadway at 90 and parallels roadway	10
Willaimson Energy, LLC owned	NW/4, SW/4, Sect 8, T6S, R5E	Dwelling	Dwelling	Waiver	35
Willaimson Energy, LLC owned	NE/4, NW/4, Section 2, T8S, R4E	Dwelling	Dwelling	Waiver	95
Compass West, Inc.	SE/4, SW/4, Section 35, T7S, R4E	Dwelling	Dwelling	No Disturbance proposed within 300'	300

Areas/Features Prohibiting or Limiting Mining Operations [62 Ill Adm. Code 1761.11]
Lands within boundaries of the National Park System, National Wildlife Refuge System, the National System of Trails, the National Wilderness Preservation System, the Wild and Scenic Rivers System, and National Recreation Areas, etc
Lands within the boundaries of any national forest.
Areas on or within 1,000 feet of Publicly Owned Parks or any places included in the National Register of Historic Places.
Areas within 100' horizontally of right of way line of Public Road.
Areas within 300 feet measured horizontally from an Occupied Dwelling
Areas within 300 feet measured horizontally from Public Building (e.g School, church, community/institutional building etc.)
Areas within 100 feet horizontally of a Cemetery.

Attachment 2.2

United States Department of Agriculture

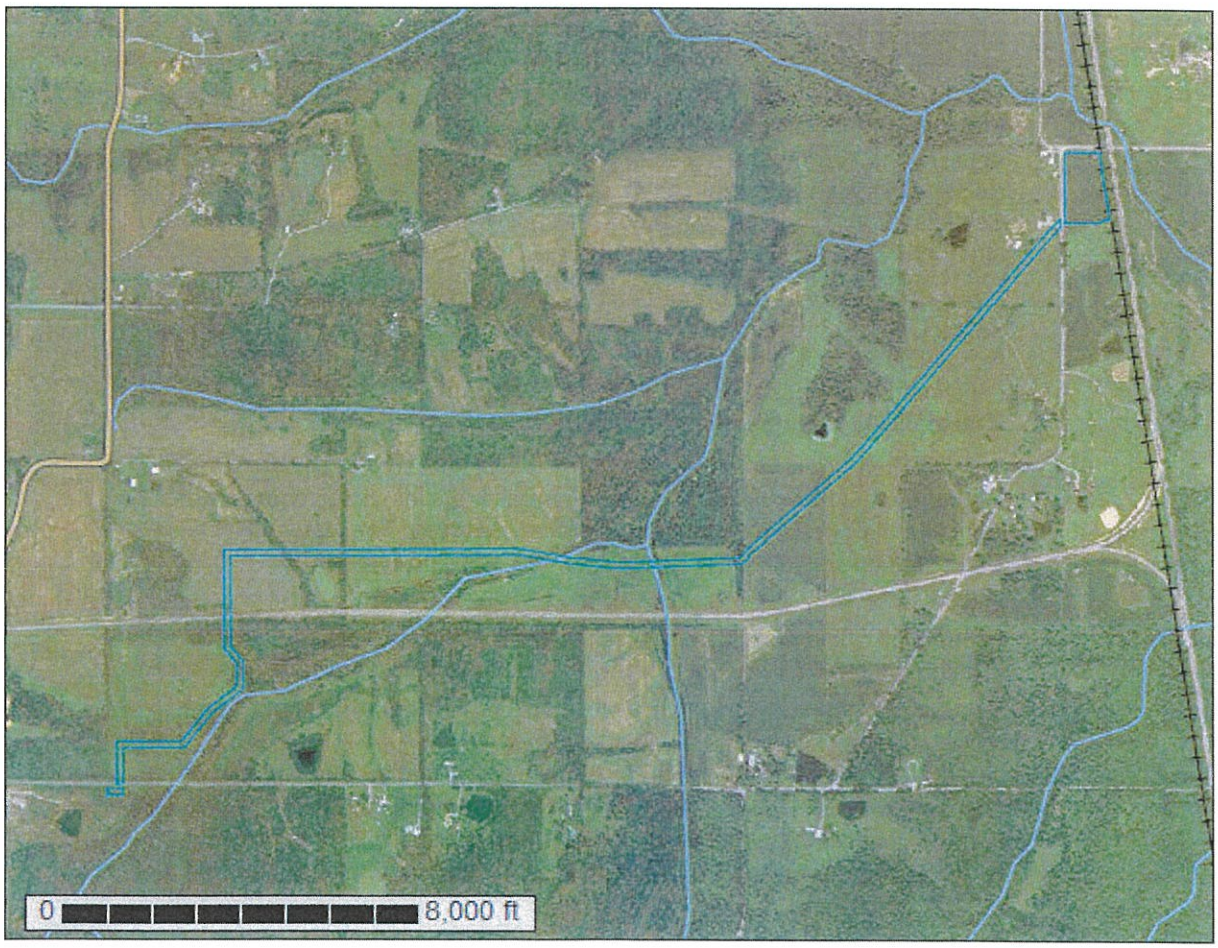
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Franklin County, Illinois, and Williamson County, Illinois

North Bleeder Shaft



January 28, 2019

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

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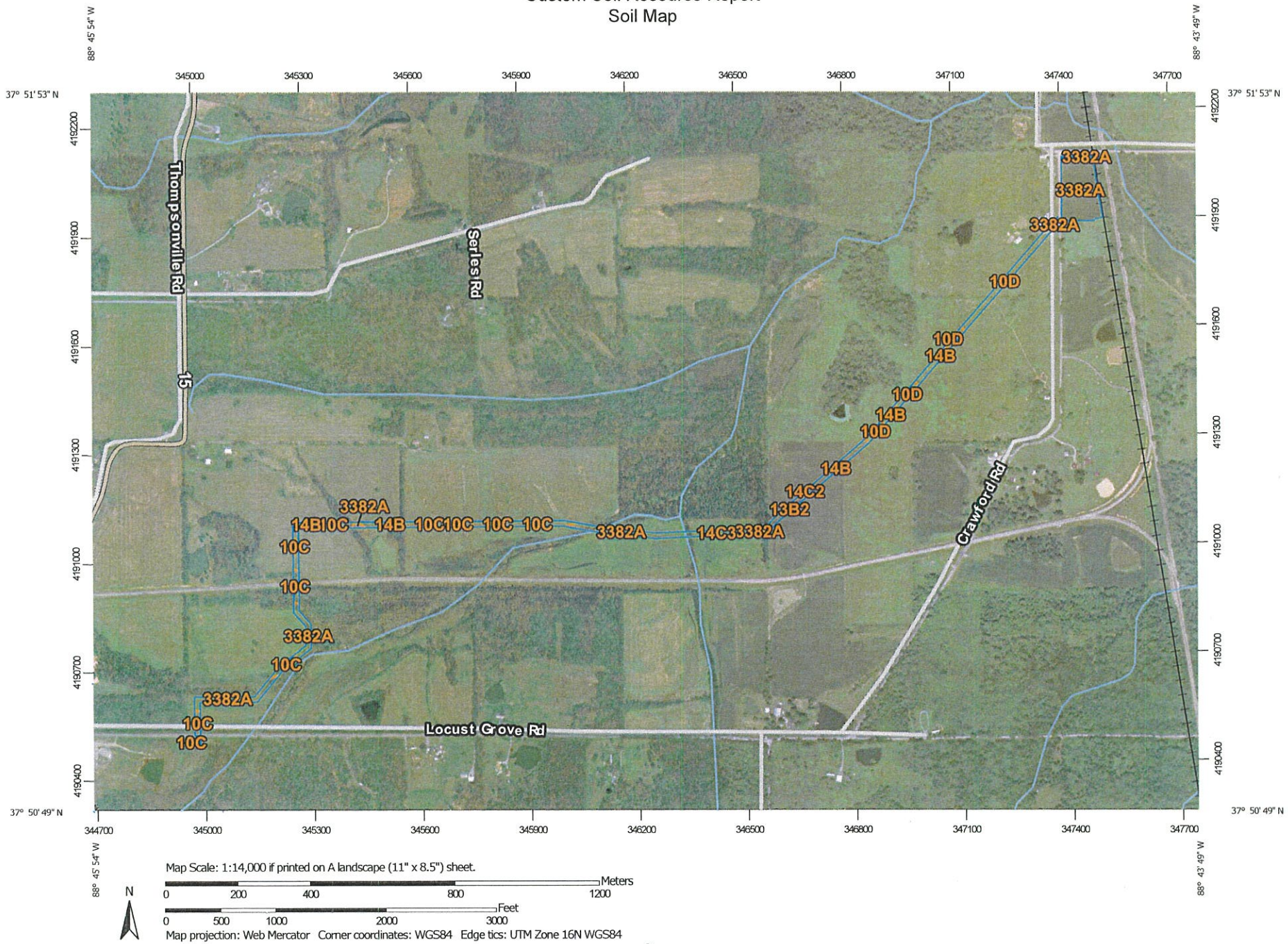
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Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:14,000 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 200 400 800 1200

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

R06352

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Franklin County, Illinois
Survey Area Data: Version 12, Sep 12, 2018

Soil Survey Area: Williamson County, Illinois
Survey Area Data: Version 13, Sep 12, 2018

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Feb 11, 2012—Mar 14, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

R06353

MAP LEGEND

MAP INFORMATION

imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

R06354

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
3382A	Belknap silt loam, 0 to 2 percent slopes, frequently flooded	0.0	0.0%
Subtotals for Soil Survey Area		**0.0**	**0.0%**
Totals for Area of Interest		**17.0**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
10C	Plumfield silty clay loam, 5 to 10 percent slopes	3.2	18.6%
10D	Plumfield silty clay loam, 10 to 18 percent slopes	2.1	12.2%
13B2	Bluford silt loam, 2 to 5 percent slopes, eroded	0.5	3.2%
14B	Ava silt loam, 2 to 5 percent slopes	2.5	14.6%
14C2	Ava silt loam, 5 to 10 percent slopes, eroded	0.0	0.0%
14C3	Ava silty clay loam, 5 to 10 percent slopes, severely eroded	0.1	0.5%
337A	Creal silt loam, 0 to 2 percent slopes	0.3	2.0%
3382A	Belknap silt loam, 0 to 2 percent slopes, frequently flooded	8.3	48.8%
Subtotals for Soil Survey Area		**17.0**	**100.0%**
Totals for Area of Interest		**17.0**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made

up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series.* Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases.* Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Franklin County, Illinois

3382A—Belknap silt loam, 0 to 2 percent slopes, frequently flooded

Map Unit Setting

National map unit symbol: 2tbrv
Elevation: 330 to 490 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 175 to 200 days
Farmland classification: Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season

Map Unit Composition

Belknap, frequently flooded, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Belknap, Frequently Flooded

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Silty alluvium

Typical profile

Ap - 0 to 7 inches: silt loam
Bw - 7 to 59 inches: silt loam
Bg - 59 to 79 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: About 6 to 24 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very high (about 12.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: B/D
Hydric soil rating: No

Minor Components

Bonnie, frequently flooded

Percent of map unit: 5 percent

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Piopolis, frequently flooded

Percent of map unit: 5 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Williamson County, Illinois

10C—Plumfield silty clay loam, 5 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2wk1l
Elevation: 330 to 820 feet
Mean annual precipitation: 38 to 46 inches
Mean annual air temperature: 54 to 58 degrees F
Frost-free period: 180 to 195 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Plumfield and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Plumfield

Setting

Landform: Ground moraines
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope, head slope
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Loess over mixed loess and drift over till

Typical profile

Ap - 0 to 5 inches: silty clay loam
2Btx1 - 5 to 12 inches: silty clay loam
2Btx2 - 12 to 36 inches: silt loam
3Btgb - 36 to 70 inches: silty clay loam

Properties and qualities

Slope: 5 to 10 percent
Depth to restrictive feature: 5 to 20 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.02 to 0.06 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 5.0
Available water storage in profile: Very low (about 1.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Passport, eroded

Percent of map unit: 4 percent
Landform: Hillslopes
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Belknap, occasionally flooded

Percent of map unit: 4 percent
Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Bluford

Percent of map unit: 2 percent
Landform: Ground moraines
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

10D—Plumfield silty clay loam, 10 to 18 percent slopes

Map Unit Setting

National map unit symbol: 2wk1m
Elevation: 330 to 820 feet
Mean annual precipitation: 38 to 46 inches
Mean annual air temperature: 54 to 58 degrees F
Frost-free period: 180 to 195 days
Farmland classification: Not prime farmland

Map Unit Composition

Plumfield and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Plumfield

Setting

Landform: Ground moraines
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Head slope, side slope
Down-slope shape: Convex

Across-slope shape: Linear
Parent material: Loess over mixed loess and drift over till

Typical profile

Ap - 0 to 5 inches: silty clay loam
2Btx1 - 5 to 12 inches: silty clay loam
2Btx2 - 12 to 36 inches: silt loam
3Btgb - 36 to 70 inches: silty clay loam

Properties and qualities

Slope: 10 to 18 percent
Depth to restrictive feature: 5 to 20 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.02 to 0.06 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 5.0
Available water storage in profile: Very low (about 1.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Belknap, occasionally flooded

Percent of map unit: 5 percent
Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Bluford

Percent of map unit: 5 percent
Landform: Ground moraines
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

13B2—Bluford silt loam, 2 to 5 percent slopes, eroded

Map Unit Setting

National map unit symbol: 2t95f
Elevation: 360 to 840 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 53 to 58 degrees F
Frost-free period: 175 to 195 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Bluford and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bluford

Setting

Landform: Ground moraines
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loess over mixed loess and drift

Typical profile

Ap - 0 to 6 inches: silt loam
E - 6 to 9 inches: silt loam
Btg - 9 to 32 inches: silty clay
2Btgx - 32 to 47 inches: silty clay loam
2Btg - 47 to 60 inches: silty clay loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: 5 to 20 inches to abrupt textural change; 19 to 45 inches to fragipan
Natural drainage class: Somewhat poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 6 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 13.0
Available water storage in profile: Very low (about 2.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C/D
Hydric soil rating: No

Minor Components

Ava

Percent of map unit: 5 percent
Landform: Ridges
Landform position (two-dimensional): Shoulder, summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Wynoose

Percent of map unit: 5 percent
Landform: Ground moraines
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

14B—Ava silt loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: 2t95h
Elevation: 360 to 840 feet
Mean annual precipitation: 38 to 46 inches
Mean annual air temperature: 54 to 58 degrees F
Frost-free period: 180 to 195 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Ava and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ava

Setting

Landform: Ridges
Landform position (two-dimensional): Shoulder, summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loess over mixed loess and drift over till

Typical profile

Ap - 0 to 6 inches: silt loam

E - 6 to 14 inches: silt loam
Bt - 14 to 34 inches: silty clay loam
2Btx - 34 to 50 inches: silty clay loam
3Btb - 50 to 79 inches: loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: 25 to 40 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.02 to 0.06 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 5.0
Available water storage in profile: Moderate (about 6.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Bluford

Percent of map unit: 10 percent
Landform: Ground moraines
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

14C2—Ava silt loam, 5 to 10 percent slopes, eroded

Map Unit Setting

National map unit symbol: 2t95l
Elevation: 360 to 840 feet
Mean annual precipitation: 38 to 46 inches
Mean annual air temperature: 54 to 58 degrees F
Frost-free period: 180 to 195 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Ava, eroded, and similar soils: 90 percent
Minor components: 10 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ava, Eroded

Setting

Landform: Hillslopes, ridges
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Convex
Across-slope shape: Linear, convex
Parent material: Loess over mixed loess and drift over till

Typical profile

Ap - 0 to 9 inches: silt loam
Bt and E - 9 to 28 inches: silty clay loam
Btx - 28 to 36 inches: silty clay loam
2Btx - 36 to 64 inches: silt loam
3Btb - 64 to 78 inches: silt loam

Properties and qualities

Slope: 5 to 10 percent
Depth to restrictive feature: 25 to 40 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.01 to 0.06 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 5.0
Available water storage in profile: Low (about 5.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Bluford, eroded

Percent of map unit: 10 percent
Landform: Ground moraines
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

14C3—Ava silty clay loam, 5 to 10 percent slopes, severely eroded

Map Unit Setting

National map unit symbol: 1lm1b
Elevation: 360 to 660 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 175 to 195 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Ava, severely eroded, and similar soils: 90 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ava, Severely Eroded

Setting

Landform: Till plains
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Peoria and roxana loess over glacial drift

Typical profile

H1 - 0 to 9 inches: silty clay loam
H2 - 9 to 28 inches: silty clay loam
H3 - 28 to 64 inches: silt loam
H4 - 64 to 78 inches: silt loam

Properties and qualities

Slope: 5 to 10 percent
Depth to restrictive feature: 25 to 40 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.01 to 0.06 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Sodium adsorption ratio, maximum in profile: 5.0
Available water storage in profile: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Hydric soil rating: No

337A—Creal silt loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 1lm36
Elevation: 360 to 660 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 175 to 195 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Creal and similar soils: 90 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Creal

Setting

Landform: Fans
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixture of loess and local silty alluvium

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 27 inches: silt loam
H3 - 27 to 55 inches: silty clay loam
H4 - 55 to 80 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 12 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 11.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Racoon

Percent of map unit: 5 percent
Landform: Depressions
Landform position (two-dimensional): Toeslope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

3382A—Belknap silt loam, 0 to 2 percent slopes, frequently flooded

Map Unit Setting

National map unit symbol: 2tbrv
Elevation: 330 to 490 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 175 to 200 days
Farmland classification: Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season

Map Unit Composition

Belknap, frequently flooded, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Belknap, Frequently Flooded

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Silty alluvium

Typical profile

Ap - 0 to 7 inches: silt loam
Bw - 7 to 59 inches: silt loam
Bg - 59 to 79 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: About 6 to 24 inches
Frequency of flooding: Frequent
Frequency of ponding: None

Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very high (about 12.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: B/D
Hydric soil rating: No

Minor Components

Bonnie, frequently flooded

Percent of map unit: 5 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Piopolis, frequently flooded

Percent of map unit: 5 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

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Part 2 of 3

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

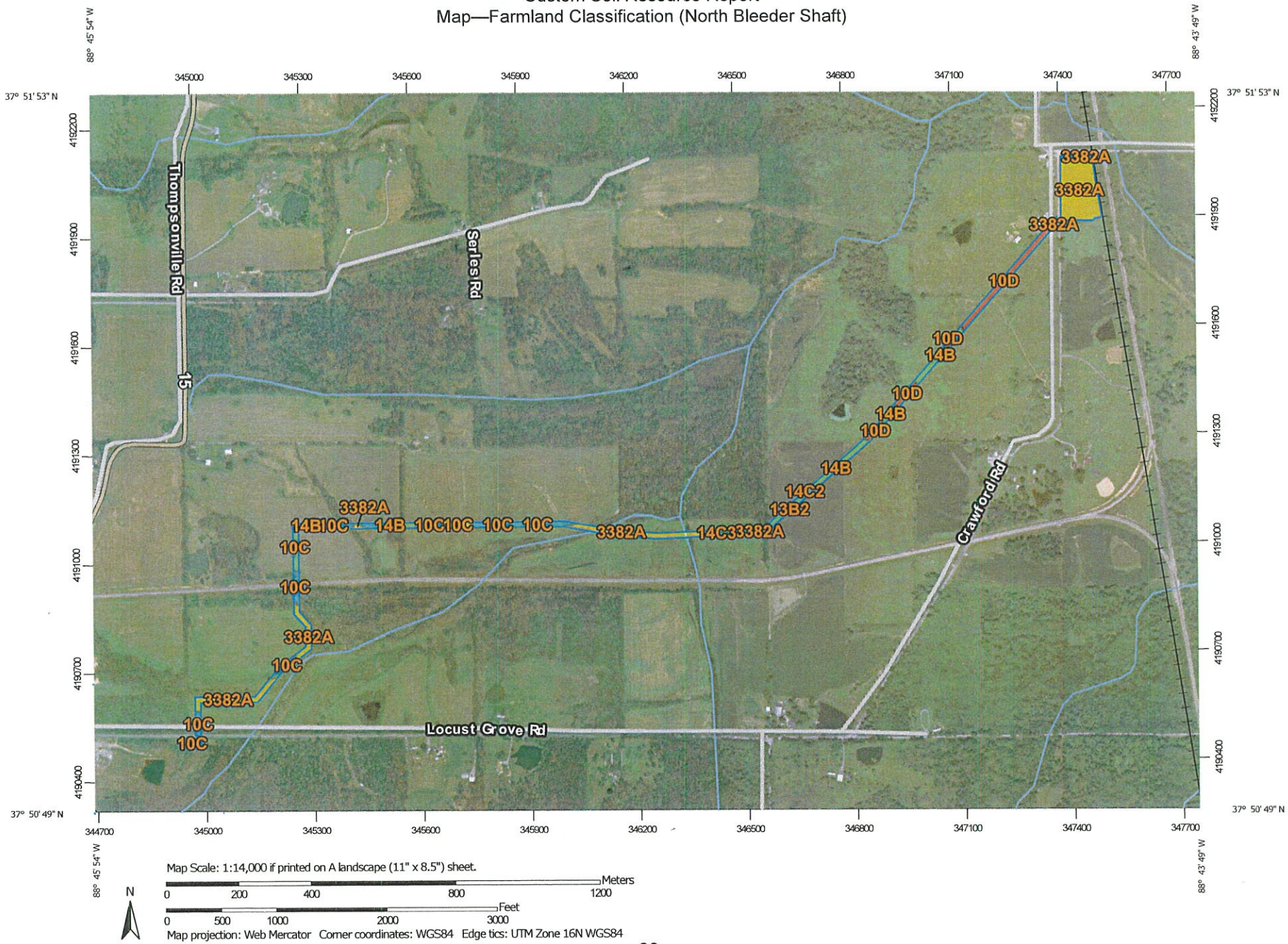
Land Classifications

Land Classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Farmland Classification (North Bleeder Shaft)

Farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. It identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the "Federal Register," Vol. 43, No. 21, January 31, 1978.

Custom Soil Resource Report
Map—Farmland Classification (North Bleeder Shaft)



R06372

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of local importance
- Farmland of unique importance
- Not rated or not available

Soil Rating Lines

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of local importance
- Farmland of unique importance
- Not rated or not available

Soil Rating Points

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of local importance
- Farmland of unique importance
- Not rated or not available

Water Features

R06373

MAP INFORMATION

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Franklin County, Illinois
Survey Area Data: Version 12, Sep 12, 2018

Soil Survey Area: Williamson County, Illinois
Survey Area Data: Version 13, Sep 12, 2018

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Feb 11, 2012—Mar 14, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

R06374

MAP INFORMATION

imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

R06375

Table—Farmland Classification (North Bleeder Shaft)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
3382A	Belknap silt loam, 0 to 2 percent slopes, frequently flooded	Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season	0.0	0.0%
Subtotals for Soil Survey Area			**0.0**	**0.0%**
Totals for Area of Interest			**17.0**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
10C	Plumfield silty clay loam, 5 to 10 percent slopes	Farmland of statewide importance	3.2	18.6%
10D	Plumfield silty clay loam, 10 to 18 percent slopes	Not prime farmland	2.1	12.2%
13B2	Bluford silt loam, 2 to 5 percent slopes, eroded	All areas are prime farmland	0.5	3.2%
14B	Ava silt loam, 2 to 5 percent slopes	All areas are prime farmland	2.5	14.6%
14C2	Ava silt loam, 5 to 10 percent slopes, eroded	Farmland of statewide importance	0.0	0.0%
14C3	Ava silty clay loam, 5 to 10 percent slopes, severely eroded	Farmland of statewide importance	0.1	0.5%
337A	Creal silt loam, 0 to 2 percent slopes	Prime farmland if drained	0.3	2.0%
3382A	Belknap silt loam, 0 to 2 percent slopes, frequently flooded	Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season	8.3	48.8%
Subtotals for Soil Survey Area			**17.0**	**100.0%**
Totals for Area of Interest			**17.0**	**100.0%**

Rating Options—Farmland Classification (North Bleeder Shaft)

Aggregation Method: No Aggregation Necessary

Tie-break Rule: Lower

PART 3: Mining Operations Plan

3.1 General Description of Operations.

3.1.1 Describe the type of operation (surface, underground or carbon recovery) and method of mining procedures (surface, room and pillar or longwall). **[1780.11(a)/1784.11(a)]**

This IBR is requesting to install the following: a Bleeder site access (30 feet wide), one (1) 16.5 foot concrete finished bleeder shaft (Hole A) (~500' deep), one (1) 16 inch steel lined turbine utility borehole (Hole B), one (1) 8.625 inch compressed air steel lined utility borehole (Hole C), three (3) 12.75 inch steel lined power drop/Jenchem utility boreholes (Holes D, E & F), one (1) 24 inch pump drop steel lined utility borehole (Hole F), (each borehole having a 10'x10'x1' concrete pad and each ~500' deep), a transformer with a 10' x 8' x 1' concrete pad, a compressor station, crib plant (Jenchem Plant) with associated facilities.

The shaft will a large concrete pad poured irregularly shaft with a surface area of ~2430 square feet and a thickness of 4 feet. Two temporary drill pits (one ~20'x40'x10' and one ~ 10'x20'x10) will be used during the development of the turbine and utility boreholes. The IBR drill site will be gravel with 8 inches of crusher run gravel (~2.07 acres). HDPE water (12") and power lines will be installed back connection into the existing shaft site along Locust Grove Road. A mobile crib plant will be used this site. All tanks with crib plant chemical will have temporary berm construct around each for spill prevention.

Within the bleeder shaft IBR site Jenchem plant will be used to provide underground roof support, compress to provide underground air and various service boreholes for power and material drops in to the mine and water recovery from the mine.
Installation of a 12" HPDE water line to return excess mine water back to IBR #11 where it will connect into and existing water line to return the water from underground back to the mine site. The pipeline will constructed with SDR 17 HDPE pipe or equivalent which has a pressure rating of 125 psi Pipe are constructed by fusing joints whenever possible. Operation of vertical turbine pumps is managed through a PLC system that turns pumps on and off and monitors their operation. The pipelines are inspected once per month to check for leaks and other conditions that require maintenance. If leaks are detected, they are immediately addressed.
Historically, no impacts have been seen when undermining these heavy walled HPDE pipeline but the most critical points of this pipeline, based on severity of subsidence, will be inspected on an as needed basis during periods of subsidence while the pipelines are being undermined. During the longwall process prior to and during subsidence the pipeline will be inspected on a more frequent basis as needed to ensure integrity and for a period after until subsidence in the pipeline area has ceased, then the inspection schedule will resume to monthly.
Please see the Operations Map in the Map Section.

3.1.2 Describe the major equipment to be employed and how such equipment will be used in the different aspects of the mining operation. **[1780.11(a)/1784.11(a)]**

Bulldozers, Scrapers, Loaders, Excavators, rotary drill

3.1.3 Provide an estimation of the anticipated annual coal production and anticipated total coal production by tonnage once the mine is at full operational capacity. Define the annual progression of mining on the Operations Map. For underground mines, show annual progression of surface disturbance for support facilities. **[1780.11(a)/1784.11(a)]**

N/A

3.2 Description of Mine Facilities. Provide a narrative that explains the construction, modification, use maintenance and removal of the following structures and facilities as applicable to the proposed operations. If not applicable to this permitting action, indicate such. **[1780.11(b)/1784.11(b)]**.

3.2.1 Dams, Embankments, and other impoundments. List all such structures, their use, maintenance practices and whether they will be retained permanently or removed as applicable. Please note that an impoundment includes incised structures. **[1780.11(b)/1784.11(b)]**

N/A

3.2.2 Coal storage, coal preparation and cleaning facilities, loading and transportation areas. **[1780.11(b)/1784.11(b)]**

N/A

3.2.3 Water treatment facilities including but not limited to, sediment ponds, chemical treatment of discharge, and any special water treatment facilities beyond sediment ponds. **[1780.11(b)/1784.11(b)]**

N/A. Sediment pond exemption requested.

3.2.4 Air pollution control facilities **[1780.11(b)/1784.11(b)]**

N/A

3.2.5 Buried Pipelines. Are pipelines proposed to be buried within the permit boundary? **[1816.133/1817.133]**

☒ YES ☐ NO

If YES, locate pipeline corridors on the operations map. Provide a description of the pipeline operation including but not limited to: the material to be transported, the type, diameter and wall thickness of the pipe and the depth of burial to the top of pipe. Indicate whether the pipe is to be removed when no longer needed. It is recommended that pipeline burials follow the Illinois Department of Agriculture guidelines if they are intended to be left in place permanently. IDOA guidelines for different types of pipelines may be found at: https://www2.illinois.gov/sites/agr/Resfv ources/LandWater/Documents/pipelinestandardspolicies.pdf#search=pipeline https://www2.illinois.gov/sites/agr/Resources/LandWater/Documents/waterandsewerlines.pdf

See Operations Map, 12" HDPE (minimum SDR of 19) waterline buried a minimum of 5 feet deep and buried electrical and communication wires in the same ditch. All lines will be capped and left in place during reclamation.

3.3 Signs and Markers. All signs and markers required to be posted shall be easily seen and read, uniform in design and made of durable material. Signs and markers shall also be maintained and retained in place throughout the life of specific mining activity. Boundary or buffer markers shall be spaced to be visible from one to another. Describe the signs and markers in terms of material type, color, and wording to be used for the following boundary(s) and/or protected feature(s). If not applicable to this permitting action, indicate as such. **[1816.11(a)/1817.11(a)]**.

3.3.1 Permit Perimeter markers (Include incremental bond areas, unaffected areas, uncontrolled properties, pending archeological areas, and areas of lateral support) **[1816.11(d)/1817.11(d)]**

Permit perimeter will be marked in accordance with the provisions specified in Permit 375.

3.3.2 Stockpile Markers **[1816.11(f)/1817.11(f)]**

Topsoil stockpiles will be marked with an identifying sign.

3.3.3 Stream buffer zones **[1816.57(b)/1817.57(b)]**

There are five (5) intermittent streams that pass through the proposed IBR site. The applicant is requesting a waiver to the 100 foot stream buffer restriction. This is justified because no runoff from the operations will flow into this stream segment. The intermittent stream segments will be bored underneath. There will be no adverse impact to the quantity or quality of water going into this ditch. There will be no adverse impact to stream biota. See Part 6 for more details.

3.3.4 Prohibited or limited areas identified on Table 2.3: Areas Prohibiting or Limiting Mining Operations **[1816/1817.11(d)]**

Structures with 300 feet waiver will have metal fence post place at the edge of the buffer zone and the tops of the metal post will be painted red.

3.4 Soil and Overburden Handling and Protection.

3.4.1 Describe how each type of overburden (soil horizons, glacial drift and consolidated material) will be handled with regards to different types of mining equipment. **[1780.18(b)(7)/1784.13(b)(7)]**

Topsoil and Subsoil will be stockpile on site by dozer, truck and excavators.

3.4.2 If toxic materials have been identified as occurring in the overburden, describe how these materials will be segregated and handled to insure proper disposal. This includes, shaft and slope cuttings, excavation of incised portions of ponds, ditches, stream diversions or refuse disposal areas. **[1780.11(b)/1784.11(b); 1780.18(b)(7)/1784.13(b)(7)]**

N/A

3.4.3 Locate all soil horizon storage areas and/or root medium stock piles on the Operations Map and describe measures to be employed to prevent or minimize exposure of soil stockpiles to excessive water and wind erosion, unnecessary compaction and contamination by undesirable materials. **[1780.11(b)(2)/1784.11(b)(2); 1780.14(b)(5)/1784.23(b)(5)]**

See operation map for storage area location, stockpiles will be seed and strawed during the first appropriate seeding period after completion of used.

3.4.4 Describe methods and treatment measures to be used on exposed areas where topsoil has been removed to prevent excess air and water pollution. **[1816.95/1817.95]**

Stockpiles will be seed and strawed during the first appropriate seeding period after completion of used.

3.5 Lateral Support. For excavations locate all areas on the Operations Map where lateral support removal will approach the minimum distance allowed. State the minimum width of lateral support to be left in appropriate areas, including adjacent landowners, road right-of-way's, pipelines and power line easements. Account for highwall sloping when such slopes are to be incorporated into the proposed reclamation plan. **[1816.99]**

N/A

3.6 Surface Mining Near Underground Mining. If surface mining activities are to be conducted within 500 feet of an underground mine describe the measures to be employed to comply with the requirements of 62 Ill. Adm. Code 1780.27 and 1816.79

N/A

3.7 Existing Structures. The definition of an "existing structure" is a structure used in connection with surface coal mining and reclamation operations for which construction began prior to June 1, 1982. Are existing structures proposed to be used in connection with or to facilitate the surface coal mining and reclamation operations? **[1701.APP.A]**

☐ YES ☒ NO

If YES, complete the following:

3.7.1 Use of Existing Structures. Provide a list of all of the existing structures to be used **[1780.12/1784.12]**

3.7.2 Provide the location of all existing structures on the Operations Map and provide the following information for each existing structure to be used: **[1780.12(a)/1784.12(a)]**

- Plans of the structure detailing its current, pre-mining condition.
- Approximate dates, beginning and completion for construction of the structure.
- A showing that the structure meets the performance standards of 62 Ill. Adm. Code 1810 through 1828. The showing shall include monitoring data or other substantiating evidence.

3.7.3 Modification or Reconstruction of Existing Structures. Provide a plan for each existing structure to be modified or reconstructed for use in connection, or to facilitate coal mining and reclamation operations. The plan shall include the following information: **[1780.12(b)/1784.12(b)]**

- Design specifications for reconstruction or modification of the structure to meet the design and performance standards of 62 Ill. Adm. Code 1810 through 1828,
- A schedule for reconstruction or modification of the structure showing dates for beginning and completing interim steps as well as final reconstruction,
- Provisions for monitoring the structure during and after modification to ensure that the performance standards of 62 Ill. Adm. Code 1810 through 1828 are met, and
- A showing that the risk of harm to the environment or to public health or safety is not significant during the period of modification or reconstruction.

3.8 Transportation Facilities.

3.8.1 Which, if any of the following facilities, are to be constructed, used, modified or maintained within the proposed permit area?

- ☒ Roads
- ☐ Conveyors
- ☐ Rail Systems

3.8.2 For all roads proposed, indicate the classification of each as either Primary or Ancillary in accordance with 62 Ill. Adm. Code 1816.150/1817.150 below: **[1816.150(a)/1817.150(a)]**

Road Identification	Road Classification (Primary or Ancillary)
North Bleeder Site Access Road	Ancillary

3.8.3 For each transportation facility, provide a detailed description of their design, construction and maintenance that includes the following information: **[1780.37/1784.24]**

3.8.3.1 A general description of each road, conveyor, or rail system to be constructed, used, or maintained within the proposed permit area. **[1780.37(a)(6)/1784.24(a)(6)]**

The North Bleeder Site Access Entrance will be an infrequently used entrance to allow construction of the IBR site and long term monitoring of the bleeder shaft, turbine pump and associated facilities. Please see the Operations Map in the Map Section.

3.8.3.2 Specifications for each road width, existing grade line, proposed road gradient, road surface, road cut, fill embankment, culvert, bridge, drainage ditch, and drainage structure. Provide information as Attachment 3.8.3.2. **[1780.37(a)(1)/1784.24(a)(1)]**

See Drawing of Entrance Plan.

3.8.3.3 Provide a report of appropriate geotechnical analysis, where the Department's approval is required for alternative specifications, or for steep cut slopes. This report shall be included as Attachment 3.8.3.3. **[1780.37(a)(2)/1784.24(a)(2); 1816.150/1817.150]**

N/A

3.8.3.4 A description of measures to be taken to obtain the Department's approval for alteration or relocation of a natural drainageway. **[1780.37(a)(3)/1784.24(a)(3); 1816.150/1817.150]**

N/A

3.8.3.5 A description of measures, other than use of a rock headwall, to be taken to protect the inlet end of a ditch relief culvert. **[1780.37(a)(4)/1784.24(a)(4); 1816/1817.150]**

N/A

3.8.3.6 The drawings and specifications for each proposed ford of a perennial or intermittent stream that is used as a temporary route. **[1780.37(a)(5)/1784.24(a)(5); 1816.151(c)(2)/1817.151(c)(2)]**

N/A

3.8.3.7 A description of the plans to remove and reclaim each road that will not be retained under an approved post-mining land use, and the schedule for this removal and reclamation. **[1780.37(a)(7)/1784.24(a)(7)]**

Ancillary road will be removed at time of reclamation of the IBR. Road gravel will be hauled to future IBR site for re-use.

3.8.3.8 A discussion of the removal/construction/or relocation of powerlines related to transportation facilities and structures associated with roads. **[1780.11(b)(3)/1784.11(b)(3)]**

N/A

3.8.4 Primary Roads. If any roads identified in Part 3.8.2 are classified as primary, provide the design criteria and construction procedures used for each primary road proposed. Design calculations and/or drawings shall be included as attachments to this part. **[1816.151/1817.151]**

3.8.5 Are any roads constructed to facilitate surface coal mining operations proposed to be permanent? **[1816.150(b)/1817.150(b)]**

☐ YES ☒ NO

If YES, locate on the Post-Mining Land Use/Capability Reclamation Map and include appropriate discussion on how modifications will be accomplished, including the removal and disposition of any excess road material.

3.9 Non-Coal Mine Waste Material.

3.9.1 Identify all non-coal waste material to be disposed within the permit area, including but not limited to, grease, lubricants, paints, flammable liquids, garbage, tires, abandoned mining machinery, lumber and other hazardous and/or combustible materials generated during coal mining operations. **[1780/1784.11(b)(4)]**

N/A

3.9.2 Describe how each non-coal waste will be stored on site, disposed on site or removed from the site. Also, describe the measures to be employed to ensure that all debris, acid-forming and toxic-forming materials, and materials constituting a fire hazard are disposed in a safe manner. Indicate on the Operations Map the location of each non-coal waste storage area. **[1780.14(b)(5)/1784/23(b)(5); 1816.89/1817.89].**

N/A

3.10 Coal Preparation.

3.10.1 Will processing of coal take place within the proposed permit area? **[1780.11(b)(3)/1784.11(b)(3)]**

☐ YES ☒ NO

If YES, locate processing facilities on the Operations Map and give a general description of the coal processing operation at this facility. **[1780.14(b)(4)/1784.23(b)(4)].**

If NO, and coal preparation plants are not located within the permit area, the applicant shall explain where coal processing would occur. The applicant is required to possess or obtain a separate permit for coal preparation plants that are not located within the proposed permit area. **[1785.21; 1827]**

N/A

3.10.2 Will in-situ processing activities be conducted? **[1785.22]**

☐ YES ☒ NO

If YES, provide information to assure compliance with 62 Ill. Adm. Code 1785.22 and 1828. **[1785.22; 1828]**

3.10.3 Provide an annual estimation of the volume of both coarse and fine coal waste streams generated. **[1780/1784.11(b)(4)]**

3.10.4 Describe the processing water (fresh water/make-up water) and slurry line circuitry. Incorporate flow diagrams as necessary. Provide locations of all processing water transport lines and slurry transport lines on the Operations Map. **[1780.11(b)/1784.11(b)]**

3.10.5 What safeguards are provided to prevent the discharge of slurry fines and untreated slurry water during emergency situations (e.g. power outages, mechanical equipment breakdown, plant shutdowns, etc.)? Indicate where the slurry would go by gravity flow in the event of an emergency discharge, and the environmental impact this would have **[1780.21(h)/1784.14(g)]**

3.11 Coal Processing Waste and Underground Development Waste.

3.11.1 Will coal processing waste and/or underground development waste be disposed of within the proposed permit area?

☐ YES ☒ NO

If NO, explain how coal processing waste and underground development waste will be handled and disposed?

Drill cuttings will be stored in a temporary drill pit. See Operations Map.

If YES, complete Table 3.11.1: List of Coal Waste Materials to be Disposed within the Permit Area providing analytical data to describe the nature of all coal processing waste and underground development waste material that will be disposed within the proposed permit area.

Note: If this is a new facility and no processed refuse has been generated, provide an estimated analysis in the table and a discussion of the basis for the assumptions in the space below. Also, please note the Department will require submittal of actual analytical results of the refuse material within 60 days after the preparation facility is operational.

Table 3.11.1: List of Coal Waste Materials to be Disposed within the Permit Area

Type of material includes but is not limited to *Coarse Coal Refuse Filter Cake, Fine Coal Refuse (Slurry), immediate floor and roof rock potentially removed and not sent to the preparation plant with coal.*

Type of Material	Source Mine Permit and Preparation Plant	Potential Acidities	Net Neutralization Potential

3.11.2 Is Disposal of Coal Waste in Underground Workings proposed in this application?

☐ YES ☒ NO

If YES, complete and include Part 14: Disposal of Coal Waste in Underground Workings

3.12 Coal Refuse Disposal Area. Is the construction or modification of a Coal Refuse Disposal Area proposed in this application?

☐ YES ☒ NO

If YES, complete the following

3.12.1 Complete Table 3.12.1: List of Coal Refuse Disposal Areas to be Constructed or Modified for each Coal Refuse Disposal Area to be constructed or modified with this application.

Table 3.12.1 List of Coal Refuse Disposal Areas to be Constructed or Modified.

Name of Facility			
***Type of Facility**			

(Coal Refuse Pile, Coal Slurry Waste Impoundment)			
Latitude (DD)			
Longitude (DD)			
Approx. Start of Construction (month/yr)			
Estimated Lifespan			
Coarse refuse			
Slurry			
Surface Acreage footprint			
Total Coarse Coal Refuse Storage Volume (cubic yards)			
Total Fine Coal Refuse Storage Volume (cubic yards)			
*Dam Class (According to TR-60, if applicable)			
*Hazard Classification (According to MSHA determination, if applicable)			
Associated NPDES Permit			

3.12.2 Design and Construction Details of Coal Refuse Disposal Areas. Coal mine waste shall be disposed of in compliance with requirements of 62 Ill. Adm. Code 1816.81/1817.81 through 1816.84/1817.84.

3.12.2.1 Provide location and describe refuse disposal capacity requirements, facility configuration/staging and scheduling in a detailed construction plan. The plan shall include: acreage of disposal and borrow areas associated with the coal waste disposal area, engineering calculations, cross sections, maps, drawings and design certification for each proposed structure. **[1780.14(b)(8)/1784.23(b)(7); 1816/1817.81(c)]**

3.12.2.2 Provide measures to be taken to: control surface drainage, provide surface area stabilization and minimize erosion of the coarse refuse disposal facility and of areas that receive runoff from the coarse refuse disposal facility. Include detail engineering design of all proposed surface drainage control structures. **[1816/1816.81(a)(1); 1816/1817.83(a); 1816.84/1817.84(d)]**

3.12.2.3 Provide measures that will be taken to ensure mass stability and prevent mass movement of the structure during and after construction. **[1816/1817.49(a)(4); 1816.81(a)(2)/1817.81(a)(2)]**

3.12.2.4 Provide all necessary on-site investigations results, test borings, and laboratory results of foundation material and coal waste that was used to determine the design requirements for the foundation stability of the coarse refuse disposal area and/or structure as Attachment 3.12.2.4. **[1816/1817.49(a)(6); 1816/1817.81(d)]**

3.12.2.5 For coal processing waste dams and embankments meeting the Mine Safety and Health Administration (MSHA) size criteria, each design and operations plan shall comply with the requirements of MSHA 30 CFR 77.216-1 and 77.216-2.

3.12.2.5.1 Is the applicant proposing to construct or modify a coal waste disposal structure that impounds water and/or slurry to an elevation of five (5) feet or more above the upstream toe of the structure and can have a storage volume of 20 acre-feet or more?

☐ YES ☐ NO

3.12.2.5.2 Is the applicant proposing to construct or modify a coal waste disposal structure that impounds water and/or slurry to an elevation of twenty (20) feet or more above the upstream toe of the structure?

☐ YES ☐ NO

If the answer to either above is YES, the applicant shall provide in this application the plan submitted to the District Manager of the Mine Safety and Health Administration (MSHA) under 77.216 insofar as the MSHA informational design standard requirements are duplicative of the Department's requirements. **[1816/1817.49(a)(2)]**.

3.12.3 Operation and Maintenance of Coal Refuse Disposal Areas.

3.12.3.1 Describe measures to be taken to safely operate the coal refuse disposal area including but not limited to: Scope and frequency of inspections, maintenance of embankments and liners, controls to ensure compaction standards and maintenance of runoff conveyance and discharge structures **[1816/1817.81(a)(4)]**

3.12.3.2 For all coal waste disposal areas explain measures to be taken to ensure that final disposal facility is suitable for reclamation. **[1816/1817.81(a)(3)]**

3.12.3.3 Provide the emergency guidelines that will be followed in the case that a potential hazard develops associated with the coarse refuse disposal area(s) being discussed. **[1816/1817.81(e)]**

3.13 Air Pollution Control Plan.

3.13.1 Provide a plan detailing fugitive dust control practices to be employed during proposed surface coal mining and reclamation operations. **[1780.15/1784.26; 1816.150(b)(1)/1817.150(b)(1)]**

N/A

3.13.2 Provide a description of the steps to be taken to comply with the requirements of the Clean Air Act (42 U.S.C. 7401 et seq.), and other applicable air and water quality laws and regulations and health and safety standards. **[1780.18(b)(9)/1784.13(b)(9)]**

N/A

3.14 Fire Control Plan.

3.14.1 Concerning non-coal mine waste, all debris, acid-forming and toxic-forming materials, and materials constituting a fire hazard, provide a description of contingency plans which have been developed to preclude sustained combustion of such materials. **[1780.18(b)(7)/1784.13(b)(7)].**

N/A

3.14.2 Provide a plan detailing how coal mine waste fires shall be extinguished. **[1816.87/1817.87]**

N/A

3.14.3 Provide a plan detailing how coal stockpile fires shall be extinguished. [225 ILCS 720/4.08]

N/A

PART 5: Drainage Control

5.1 Pre-mining Drainage Patterns Mapping. On the Existing Streams Location and Watershed Map, show the pre-mining drainage patterns of all areas to be affected by the mining and reclamation activities within the permit boundary and properties adjacent to the permit boundary. The map shall include, at minimum, adequate contour mapping, a delineation of the watershed boundaries both within and adjacent to the permit boundary, and shall depict the size of each watershed. **[1780.14/1784.23]**

5.2 General Drainage Control Description.

5.2.1 Will all surface drainage from the affected mining area be collected and treated prior to leaving the permit area? **[1816.46(b)(2)/1817.46(b)(2)]**

☐ YES ☒ NO

If NO, delineate the areas where an exemption is being requested on the Operations Map. Describe each location concerning the size of the disturbed area and the type of disturbances. Describe alternate sediment control measures to be utilized if proposed. Demonstrate that siltation structures and alternate sediment control measures (if not proposed) are not necessary for drainage from the disturbed areas to meet effluent limitations and water quality standards. **[1816.46(e)/1817.46(e)]**

Williamson Energy is requesting a sediment pond exemption due to its small area. Silt fence and/or straw bales will be placed along the outside edge of the disturbed areas to minimize sediment loss during site construction. After construction is complete a durable rock surface will be installed or lime stabilization will be completed and all available areas will be seeded during the first planting season after completion of construction.

5.2.2 Will any surface drainage from unaffected areas be intercepted and diverted around the affected mining area. **[1816/1817.43(a)]**

☐ YES ☒ NO

If NO, explain why this is not necessary.

Water will be allowed to sheet flow along the waterline/powerline corridor and the Bleeder site is located such that the unaffected areas will drain away from the Bleeder site.

If YES, based on the definitions of "perennial" and "intermittent" streams as outlined in 62 Ill. Adm. Code 1701.Appendix A, does the Applicant propose to divert a perennial or intermittent stream?

☐ YES ☒ NO

If YES, also complete the appropriate items of Part 6.0: Streams.

5.2.3 Describe the timing in which all construction of the sediment ponds and surface drainage control structures will be completed. Include a discussion of the vegetation stabilization of these structures. **[1816.46(b)(3)/1817.46(b)(3); 1816.49(a)(7)/1817.49(a)(7)]**

N/A

5.3 Conveyance Ditch Design.

5.3.1 Does the Applicant propose to construct or modify any conveyance ditch that collects surface water drainage from affected mining areas and direct it to sediment ponds/treatment facilities? **[1816/1817.45(b)(3)]**

☐ YES ☒ NO

Does the Applicant propose to construct or modify any conveyance ditch that intercepts surface drainage from unaffected areas and direct it around the affected mining area? **[1816/1817.45(b)(4)]**

☐ YES ☒ NO

If either answer above is YES, complete Table 5.3.1: Conveyance Ditch Design Summary and complete the remaining questions through Part 5.3.4. Refer to Technical Guidance Document 2 for clarification.

5.3.1.1 Provide detailed design and construction calculations for the ditches listed in Table 5.3.1 as Attachment 5.3.1.1. **[1816.43/1817.43]**

5.3.1.2 For all ditches listed in Table 5.3.1, indicate the location of each on the Operations Map in relation to the proposed mining operations. Include the drainage area reporting to each segment of conveyance ditch on the Surface Drainage Control Plan Map and/or indicate the drawing(s) that provide the information required and provide a specific reference in the area below. **[1780.14(b)(6)/1784.23(b)(6)]**

5.3.1.3 Provide typical cross-sections for each ditch listed in Table 5.3.1 depicting the bottom width, side slopes, depth based on the appropriate precipitation event, and freeboard depth. (Indicate the drawing(s) that provide the information required and provide a specific reference in the area below.) **[1780.14(b)(6)/1784.23(b)(6)]**

5.3.1.4 Provide profiles for each ditch listed in Table 5.3.1 depicting the flow line slope and the depth based on the appropriate precipitation event. (Indicate the drawing(s) that provide the information required and provide a specific reference in the area below.) **[1780.14(b)(6)/1784.23(b)(6)]**

5.3.1.5 Based on calculated flows, define areas that require supplemental erosion control such as rip rap or dry dams on the Surface Drainage Control Plan Map. Provide details and calculations on the design of additional erosion control features to be employed during the operational life of the ditches. **[1780.14(b)(6)/1784.23(b)(6)]**

5.3.1.6 Describe measures to ensure proper maintenance of diversion ditches, such as methods and frequency of cleaning of ditches that may receive excessive sediments and special equipment to be used for ditches designed with liners. **[1816.43(a)(2)(c)/1817.43(a)(2)(c)]**

5.3.1.7 Provide details of the proposed erosion and sediment control measures to be employed during the construction of the proposed conveyance ditches. **[1816.43(a)(2)/1817.43(a)(2)]**

5.3.2 Are culvert(s) being proposed within the permit area including but not limited to ditches, stream crossings and/or transportation facilities.

☐ YES ☒ NO

If YES, complete Table 5.3.2: Culvert Design Summary and the following:

5.3.2.1 Provide design calculations for each culvert as Attachment 5.3.2.1. **[1816/1817.43(b)(3); 1816/1817.43(c)(3); 1816/1817.151(d)(1)]**

5.3.2.2 Provide a profile for each culvert, depicting appropriate design information including but not limited to length, diameter, slope, inlet and outlet elevations, maximum headwater depth and elevation of roadway or rail crossing. (Indicate the drawing(s) that provide the information required and provide a specific reference in the area below) **[1780/1784.29]**

N/A

5.3.2.3 For culverts being proposed beneath transportation facilities (road/railway), provide measures to be implemented to insure structural capacity under live loads. **[1816/1817.151(d)(4)]**

N/A

5.4 Impoundments. This section refers to modifications or design plans for all impoundments including sediment ponds, freshwater lakes, recirculation lakes (both incised and above grade) other than those covered under Part 3.12 "Coal Refuse Disposal Area". These structures are considered "impoundments" as defined in 62 Ill. Adm. Code 1701.Appendix A. Refer to Technical Guidance Document 2 for clarification. NOT APPLICABLE

5.4.1 Impoundment Design.

5.4.1.1 For all proposed impoundments, complete the Impoundment Design Table 5.4.1: Impoundment Design. **[1816.46(c)/1817.46(c)]**

5.4.1.2 Discuss the design basis for the impoundment calculations. Submit calculations used in spillway designs and determination of inflow volume and pond volume as Attachment 5.4.1.2.

5.4.1.3 Provide construction and maintenance details of dams, spillways, seepage control measures, and erosion control measures for inlets and outlets. Employ maps and cross sections where necessary. **[1816.45/1817.45; 1816.46/1817.46; 1816.49/1817.49]**

5.4.1.4 Submit a typical cross section of the embankment(s), details of the principal and emergency spillways and a plan view of each pond at an appropriate scale showing pond bottom contours and points of inflow. (Indicate the drawing(s) that provide the information required and provide a specific reference in the area below) **[1816.45/1817.45; 1816.46/1817.46; 1816.49/1817.49]**

5.4.1.5 If underground mining has or will occur beneath or adjacent to the proposed impoundment, the plan shall incorporate a technical discussion, survey and evaluation of the potential effect subsidence of the surface and subsurface strata would have on the structure. **[1780.25(a)(1)(D)/1784.16(a)(1)(D)]**

5.4.1.6 Explain what criteria will be used to monitor and determine periodic and/or timely removal of sediments from sediment ponds, to maintain storage volume capacity. If sediment removal becomes necessary to maintain necessary pond treatment volume, explain how the sediment will be removed, where it will be disposed of, and what protective measures will be used to ensure the integrity of clay and/or geosynthetic liners, if applicable. **[1816.46(c)(1)(C)(vi)/1817.46(c)(1)(C)(vi)]**

5.4.1.7 Will pH adjustment be necessary on any of the impoundments in order to meet the applicable State and Federal Standards? **[1780.21(h); 1784.14(g)]**

☐ YES ☐ NO

If YES, discuss in detail, along with detailed basis of design. The basis should include a detailed description of the proposed treatment facilities, process flow diagrams, and design calculations. **[1780.21(h)/1784.14(g)]**

5.4.2 Impoundments Regulated by MSHA.

Are any of the impoundments proposed to be modified or constructed in Part 5.4.1 capable of impounding water or sediment to an elevation of five feet or more above the upstream toe of the structure and can have a storage volume of 20 acre-feet or more?

☐ YES ☐ NO

Are any of the impoundments proposed to be modified or constructed in Part 5.4.1 capable of impounding water or sediment to an elevation of twenty feet or more above the upstream toe of the structure?

☐ YES ☐ NO

If the answer to either above is YES, for each structure meeting or exceeding the size or other criteria of MSHA, 30 CFR 77.216(a), include the following additional information **[1780.25(a)(2)/1784.16(a)(2)]**:

5.4.2.1 The plan required to be submitted to the District Manager of the Mine Safety and Health Administration (MSHA) under 30 CFR 77.216 shall also be submitted to the Department as part of the permit application insofar as the MSHA informational design standard requirements are duplicative of the requirements of 62 Ill. Adm. Code 1780.25/1784.22. This plan shall be included as Attachment 5.4.2.1. **[1816/1817.49(a)(2)]**

5.4.2.2 Any certification issued by MSHA with respect to the design plan shall be included as Attachment 5.4.2.2. **[1816/1817.49(a)(2)]**

5.4.2.3 Provide a geotechnical analysis for stability design and construction specification requirements for the structure as Attachment 5.4.2.3. Include a description of each engineering design assumption and calculation with discussion of each alternative considered in selection design parameters and construction methods. **[1780.25(f); 1784.16(f)]**

5.4.2.4 Describe the operation and maintenance procedures that will be used to ensure the stability of each structure. Include all monitoring instrumentation to be used. **[1780.25(a)(2)(C); 1784.16(a)(2)(C)]**

5.4.3 Impoundment Reclamation.

For permanent impoundments, including sedimentation ponds, provide the following information:

5.4.3.1 Describe the proposed reclamation plans for each structure, including a time table and plans for removal and disposal of material. **[1780.25(a)(2)(D); 1784.16(a)(2)(D)]**

For permanent impoundments, including sedimentation ponds, provide the following information:

5.4.3.2 Provide sufficient design data and calculations to substantiate that the design is in accordance with NRCS Engineering Standard 378 "Ponds" or NRCS Technical Release #60 "Earth Dams and Reservoirs". This information shall be included as Attachment 5.4.3.2. **[1816/1817.49(b)(2)]**

5.4.3.3 Based on the location of the pond relative to existing or proposed surface mining disturbances, and the projected post mining reclamation and post mining land uses, provide an evaluation of the anticipated water quality to assure it will be suitable for the intended use. **[1816.49(b)(2)/1817.49(b)(2)]**

5.4.3.4 Describe the relationship of the impoundment to the post-mining land use. **[1816.49(b)(6)/1817.49(b)(6)]**

5.4.3.5 Describe methods of dropping surface runoff over excavated impoundment side slopes. Discuss design criteria to be employed for downdrain structures and perimeter diversions. **[1816.49(b)(7)/1817.49(b)(7)]**

5.4.3.6 Plans of access roads and other use related facilities. **[1816.49(b)(4)/1817.49(b)(4)]**

PART 6: Streams

The design and construction of all stream channel diversions of perennial and intermittent streams shall be sealed by a qualified registered professional engineer as meeting the performance standards of this Section. **[1780.16(a)(2)(B)/1784.21(a)(2)(B); 1816.97(f)/1817.97(f); 1816.43(a)(3)/1817.43(a)(3)]**

6.1 Disturbance Information. Are surface coal mining operations and/or reclamation activities (including road crossings) or permit boundaries proposed within 100 feet of any stream (ephemeral, intermittent, or perennial)? **[1816.57/1817.57]**

☒ YES ☐ NO

If YES,

- For any stream(s) located outside the proposed permit boundary where disturbance within 100 feet. is proposed go to Part 6.3; and
- For any stream(s) located outside the proposed permit boundary where NO disturbance within 100 feet. will occur go to Part 6.9; and
- For any stream(s) located within the proposed permit boundary where disturbance within 100 feet. is proposed go to Part 6.2.

If NO, go to Part 6.9.

6.2 Stream Information. Provide a Stream Delineation Report and/or Wetland Delineation Report as Attachment 6.2. Information contained in the report(s) shall meet the requirements found at **1780.14/1784.23; 1780.29/1784.29; 1816.43/1817.43 and 1816.97/1817.97.**

6.2.1 Stream Classification. Provide the total number of each type of stream or stream segment or channel reach located within the proposed permit area and continue to Part 6.3.

[2] Ephemeral [5] Intermittent [ ] Perennial

6.3 Stream Buffer Variance. Is a stream buffer variance requested? **[1816.57/1817.57]**

☒ YES ☐ NO

Note, in certain scenarios both YES and NO may be applicable.

If YES,

- For stream(s) located outside the proposed permit boundary go to Part 6.4
- For stream(s) located inside the proposed permit boundary go to Part 6.5.

If NO, provide a justification that each disturbed stream is ephemeral based on both parts of the definition of ephemeral stream found at Section 1701.5 Appendix A. Refer to Operator Memorandum No. 2017-06 for guidance regarding ephemeral stream justification. Briefly describe the disposition of the ephemeral stream(s) during operations and post-mining. Nomenclature of ephemeral streams must be consistent with maps and reports. No further information is required in Part 6 of the application if all streams are ephemeral. **[1816.57/1817.57; 1701.5 Appendix A; 1777.13]**

See delineation report (Attachment 6.2) The surface disturbance was modified to not disturb the

potential wetland identified in the Attachment 6.2.
Both ephemeral streams have a drainage watershed of less than one square mile.
S1 is a small channel which was classified as "ephemeral" based on criteria specified in OMM-LRD Operator Memorandum 2017-06. Specifically, Criterion 1 applies as the soil description for the Bluford silt loam indicates the highest perched water table is 0.5 feet deep with a channel depth of only 0.3 ft. Criterion 2 applies as the stream is a headwater stream. The bed and bank begins about 9 feet upstream of the southern corridor boundary. No other streams flow into S1 upstream of the corridor. Also Criterion 6 applies as there are no meanders, riffles, or pools in the corridor reach. Criterion 7 applies as there are no erosional features such as headcuts. Criterion 9 also applies as soil coloration was 0-1" 10YR 3/3; 1-12" 10YR 4/3, which is not gray enough to meet the criteria for a hydric soil."

S3 is an erosional gully in a soybean field which appears to be growing larger each year as tillage occurs up to the top of slope and headcut erosion is progressing to the south. This feature, although exhibiting bed and bank, may not be a CWA jurisdictional stream but rather an erosional feature. 2017-06 Criteria 6 applies as there are no meanders, riffles, or pools, therefore this feature is classified as "ephemeral"."

6.4 Streams Outside Permit Boundary. For each intermittent and/or perennial stream located outside the permit boundary where a stream buffer variance is requested, provide the name of the stream and describe how the stream channel and its associated riparian vegetation will be restored and how the proposed operations will not adversely affect water quality and quantity. No further information is required in Part 6 of the application for streams outside the proposed permit boundary where buffer zone exemptions are requested. **[1816.57/1817.57]**

There are two intermittent stream segments located adjacent to the proposed IBR area that are not directly associated with the intermittent stream segments proposed to be bored underneath. Quality of riparian vegetation is poor. Neither the channel nor any associated stream bank vegetation associated with these stream segments will be directly impacted by this operation. Water quantity and quality will not be adversely impacted through the use of alternate sediment control measures such as straw bales and silt fence.

6.5 Existing Streams Locations. Provide the Existing Streams Location and Watershed Map meeting the specifications found in the General Mapping Requirements of the Instructions. Additionally, for each intermittent and/or perennial stream located inside the permit boundary where a stream buffer variance is requested, provide the name of the stream and describe how the stream channel and its associated riparian vegetation will be restored and how the proposed operations will not adversely affect water quality and quantity. **[1780.14/1784.23; 1780.29/1784.29; 1816.43/1817.43; 1816.57/1817.57; 1816.97/1817.97]**

- For Temporary Stream Diversions complete Part 6.6.
- For Permanent Stream Diversions, Restorations and Relocations complete Part 6.7.
- For culverts and crossings of non-diverted, temporary, or permanent stream channels complete Part 6.8.

A Stream Buffer Zone Variance is requested by Williamson Energy for all streams to allow for the boring and installation of water and powerline and/or bleeder shaft site. The stream locations and buffer zones for the streams are shown on the Operations Map. Williamson Energy will install silt fence and/or straw bales along the boundary of the construction activities adjacent to the stream segments to protect the stream from having any adverse effect to the water quantity or quality. Construction activities will be carried out over a short period of time and will be temporarily reclaimed immediately after completion of construction and/or boring under the stream segments.

6.6 Temporary Stream Diversions. Temporary diversions shall be removed promptly when no longer needed to achieve the purpose for which they were authorized. **[1816.43/1817.43]**

6.6.1 Temporary Stream Diversion Construction Narrative. For each temporary diversion proposed, discuss the proposed construction practices including the following information: **[1780.29/1784.29]; [1816.43/1817.43;** Memorandum No. 2005-04**]**

6.6.1.1 Estimated diversion construction beginning and ending dates.

6.6.1.2 Erosion control practices during construction to reduce addition of suspended solids to streamflow outside the permit area.

6.6.1.3 Estimated date when erosion control and vegetation will be sufficiently established to allow diversion of water through the temporary channel.

6.6.1.4 Indicate the timing and method of contacting the Department for approval upon stabilization of the stream channel. Department approval is required before water may be diverted through the temporary stream channel.

6.6.1.5 If a sediment pond exemption was requested for diversion channel spoil in Part 5.2.1, then describe methods to prevent channel spoil from impacting the surrounding area and include a discussion of the disposition of channel spoil. If a sediment pond exemption was not requested for diversion channel spoil in Part 5.2.1, then indicate N/A. **[1816.46(e)/1817.46(e)]**

6.6.1.6 Outline a reporting schedule to be submitted to the Department during construction and submit a report to the Department within 30 days after completion of the temporary diversion that has been sealed by a qualified registered professional engineer.

6.6.1.7 Discuss how the activity will comply with the Section 404 of the Federal Water Pollution Control Act of 1972, as amended, and all local ordinances. **[Ill. Rev. Stat. 1991, ch. 19, pars. 52-79; 615 ILCS 5; 30 U.S.C. 1344]**

6.6.2 Temporary Stream Diversion Locations. Provide a Stream Diversion Map meeting the specifications found in the General Mapping Requirements of the Instructions or reference the Surface Drainage Control Plan Map. **[1780.14/1784.23; 1780.29/1784.29; 1816.43/1817.43]**

6.6.3 Temporary Stream Diversion Plan-Profile and Cross-Section. For each temporary stream diversion proposed, provide drawings depicting the following information: **[1780.14/1784.23; 1780.29/1784.29; 1816.43/1817.43]**

6.6.3.1 Cross-sections showing the limits and configuration of the proposed activities, dimensions, channel linings, normal water surfaces, side slopes and inflection points (cut and fill, curves, and straight sections).

6.6.3.2 A profile of the temporary stream diversion depicting the flow line slope and the water level for the 10-year 6-hour storm event.

6.6.3.3 Detailed channel sizing calculations demonstrating the temporary diversion channel is adequate to convey the 10-year 6-hour storm event. The calculations shall include run-off volumes from the drainage area.

6.6.4 Post-Diversion Reclamation. Describe the reclamation of temporary stream diversions after flow has been diverted to the restored or relocated stream channel, provide the following information: **[1816.43(a)(3)/1817.43(a)(3)]**

6.6.4.1 Describe the timing of removal of each temporary stream diversion when the diversion is no longer needed to achieve the purpose for which they were authorized.

6.6.4.2 Discuss any necessary modification or removal of downstream water treatment facilities that were protected by the temporary diversion to prevent overtopping or failure of such facilities.

6.7 Permanent Stream Diversion. The following requirements for a permanent stream diversion must be met: **[1816.43/1817.43]**

6.7.1 Classification. The following information in Part 6.8 contains construction and restoration plan information for (indicate the number of each type):

☐ Permanent Restored Stream(s) ☐ Permanent Relocated Stream(s)

6.7.2 Permanent Stream Channel Construction Narrative. For each permanent diversion or permanent restored stream proposed, discuss the proposed construction practices including the following information: **[1780.29/1784.29; 1816.43/1817.43;** Operator Memorandum No. 2005-04**]**

6.7.2.1 Estimated permanent channel construction beginning and end dates.

6.7.2.2 Erosion control practices during construction to reduce addition of suspended solids to streamflow outside the permit area.

6.7.2.3 Estimated date when erosion control and vegetation will be sufficiently established to allow diversion of water through the permanent channel.

6.7.2.4 Indicate the timing and method of contacting the Department for approval upon stabilization of the stream channel. Department approval is required before water may be diverted through the permanent stream channel.

6.7.2.5 Is a Sediment Pond Exemption requested for diversion channel spoil. **[1816.46(e)/1817.46(e)]**

☐ YES ☐ NO

If NO, explain why an exemption is not required.

If YES, describe methods to prevent diversion channel spoil from impacting surrounding area, including disposition of channel spoil.

6.7.2.6 Discuss how the activity will comply with the Rivers, Lakes, and Streams Act, Section 404 of the Federal Water Pollution Control Act of 1972, as amended, and all local ordinances. **[Ill. Rev. Stat. 1991, ch. 19, pars. 52-79; 615 ILCS 5; 30 U.S.C. 1344]**

6.7.2.7 Outline a reporting schedule to be submitted to the department during construction and submit a report to the Department within 30 days after completion of the permanent stream channel that has been sealed by a qualified registered professional engineer.

6.7.3 Permanent Stream Diversion Locations. Provide a Stream Diversion Map meeting the specifications found in the General Mapping Requirements of the Instructions or reference the Surface Drainage Control Plan Map. **[1780.14/1784.23; 1780.29/1784.29; 1816.43/1817.43]**

6.7.4 Permanent Stream Channel Plan-Profile and Cross-Section. Permanent stream channels shall approximate the original pre-mining stream characteristics. For each permanent stream channel proposed, provide drawings depicting the following information: **[1780.14/1784.23; 1780.29/1784.29; 1816.43/1817.43]**

6.7.4.1 A profile depicting bed slopes, pool-riffle ratios, and normal water surfaces.

6.7.4.2 Plans and drawings for boulder deflectors, check dams, and other instream habitat structures.

6.7.4.3 Cross-sections showing the limits and configuration of the proposed activities, dimensions, channel linings, normal water surfaces, side slopes and inflection points (cut and fill, curves, and straight sections).

6.7.4.4 Include a calculated flow rate (cfs) and velocity (ft/sec) at representative locations for low flow and normal flow and the 100-year flood condition that will allow a freeboard of no less than 0.3 feet.

6.7.4.5 Channel sizing calculations to demonstrate that the proposed stream channel and surrounding flood plain are adequate to convey the 100-year, 6-hour storm event. The calculations shall include run-off volumes from the drainage area.

6.7.5 Permanent Stream Channel Reclamation. Describe the reclamation of permanent stream channels, provide the following: **[1780.18(b)(5)/1784.13(b)(5); 1816.14/1817.43; 1816.116/1817.116; 1816.97/1817.97]**

If all responses to this part are the same as Forest or Fish and Wildlife - Woody post-mining land use information provided in Part 10, indicate such in the space below.

6.7.5.1 Describe proposed soil preparation and a soil testing plan related to reclamation and revegetation procedures. **[1780.18(b)(5)(G)/1784.13(b)(5)(G)]**

6.7.5.2 Describe the methods for the use of temporary seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c); 1816.114/0817.114]**

6.7.5.3 Describe the timing and methods proposed to transition from the temporary vegetation to the permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

6.7.5.4 Provide a permanent species list that will achieve the designated post-mining land use that is diverse, permanent, composed of species native to the area, capable of controlling erosion, compatible with the approved post-mining land use, and capable of self-regeneration.. If non-native species are proposed to achieve the post-mining land use, provide adequate justification that the species are desirable and necessary to achieve the approved post-mining land use. Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates. **[1780.18(b)(5)/1784.13(b)(5); 1816.111 (a) and (b)/1817.111 (a) and (b); 1816.97(g)/1817.97(g)]**

6.7.5.5 If a bat Protection and Enhancement Plan (PEP) is part of the application, the applicant shall ensure consistency between this part and the bat PEP. Describe measures taken to ensure consistency.

6.7.5.6 Describe a periodic measurement plan of the vegetation that will be used to identify if remedial actions are necessary to achieve the approved species and / or post-mining land use vegetation success standards during the applicable period of liability. Refer to Operator Memorandum No. 2017-02 for additional information regarding tree and shrub planting maintenance. Information provided shall also describe a remedial action plan to achieve the approved vegetative species, invasive species management, or post-mining land use success. Remedial actions required may include but are not limited to mowing, burning, undesirable invasive species control, irrigation and pest and disease control. **[1816.116(b)(1)/1817.116(b)(1); 1816.111(a) and (b)/1817.111(a) and (b)]**

6.8 Culverts and Crossing of Non-Diverted, Temporary, and/or Permanent Stream Channels. Where a bridge, road, culvert or other crossing is proposed for any streams, provide the following information: **[1780.37/1784.24]**

NOTE: For design specification requirements, see Part 5.3.2.

6.8.1 Name of stream(s) with nomenclature consistent with names used in maps and reports.

The five intermittent streams will be bored under from outside the riparian zone.

6.8.2 Description of construction methods and sequence including water handling during construction and erosion/sediment control measures for each crossing.

A directional boring machine will be used to bore at least 5 feet underneath the bottom of the stream bed. Silt fence will be used to provide erosion/sediment control around the boring and receiving locations.

6.8.3 Describe how the original stream channel(s) and associated riparian vegetation will be restored.

No riparian vegetation will be disturbed

6.9 Stream Buffer Zone. Discuss how the designated 100 ft. stream buffer zone will be marked for any intermittent and/or perennial stream that will not be disturbed by surface mining activities. Cleary indicate the 100-ft. stream buffer zone on all appropriate maps in the General Mapping Requirements of the Instructions and Part 3.3. If no streams are located within the proposed permit boundary or within 100 ft. of the proposed permit boundary indicate N/A. **[1816.57(b)/1817.57(b) and 1816.11/1817.11]**

Stream Buffer Zone Variance Requested

Attachment 6.2

Wetland & Stream Delineation

Bleeder Shaft IBR Site

Williamson County, Illinois

Prepared for

Williamson Energy

Prepared by

HMG
Engineers • Surveyors
1032 North 6th Street
Murphysboro, Illinois 62966

October 2018

PROJECT DESCRIPTION

HMG Engineers, Inc. (HMG) was contacted Williamson Energy who requested a wetland and stream delineation on a site located in Sections 2, 3, and 10, T8S, R4E in Williamson County, Illinois, located 4 miles south of Thompsonville, Illinois (Figure 1). The delineation area includes rowcrop agricultural land, hayland, and forest. The site includes a corridor approximately 2 miles long and 50 feet wide, and also a trapezoidal tract of 4.4 acres on the east end.

METHODS

HMG conducted a wetland and stream delineation for the assessment area. Results of that investigation are reported herein. Background information was reviewed including aerial photography, topography, soils, floodplain maps, and National Wetland Inventory. A field investigation was conducted on June 20, 2018 and October 16, 2018 by HMG Environmental Scientist William O'Leary. Stream identification utilized COE "bed and bank" criteria. Wetland delineation followed criteria of the 1987 U.S. Army Corps of Engineers Wetlands Delineation Manual, including Regional Supplement, Midwest Version 2.0 (U. S. Army Corps of Engineers [COE] 2010). Global positioning equipment was used to locate features in the field.

BACKGROUND

USGS Topographical Map (see Figures 1 and 3), aerial photography (see Figure 2), soils, National Wetlands Inventory (NWI, Figure 2), and floodplain maps (Figure 2) were reviewed. Aerial photographs and topographical maps identified 3 main stream channels running through and/or adjacent to the corridor. Additionally a number of draws intersected the corridor in which small streams might be present. The area does not lie within any 100 year floodplains; the closest being just across the railroad track from the NE corner (Prairie Creek floodplain). The site includes 7 soil map units, 10C and 10D (Plumfield silty clay loam 5-10% and 10-18% slope), 13B2 (Bluford silt loam 2-5% slope, eroded), 14B and 14C2 (Ava silt loam 2-5% slope and 5-10% slope, eroded), 337A (Creal silt loam 0-2% slope), and 3382A (Belknap silt loam 0-2% slope). None of these soil types are classified as hydric.

FIELD DELINEATION

Field investigation identified that the corridor crosses 7 "bed and bank" channels, which are labeled as S1 through S7 in Figure 4. S1 Is a small channel which was classified as "ephemeral" based on criteria specified in OMM-LRD Operator Memorandum 2017-06. Specifically, Criterion 1 applies as the soil description for the Bluford silt loam indicates the highest perched water table is 0.5 feet deep. Criterion 2 applies as the stream is a headwater stream. The bed and bank begins about 9 feet upstream of the southern corridor boundary. No other streams flow into S1 upstream of the corridor. Also Criterion 6 applies as there are no meanders, riffles, or pools in the corridor reach. Criterion 7 applies as there are no erosional features such as headcuts. Criterion 9 also applies as soil coloration was 0-1" 10YR 3/3; 1-12" 10YR 4/3, which is not gray enough to meet the criteria for a hydric soil.

Stream S2 is identified as an intermittent stream on the USGS topo map. None of the 2017-06 criteria apply, therefore, the intermittent classification was used.

Feature S3 is an erosional gully in a soybean field which appears to be growing larger each year as tillage occurs up to the top of slope and headcut erosion is progressing to the south. This feature, although exhibiting bed and bank, may not be a CWA jurisdictional stream but rather an erosional feature. 2017-06 Criteria 6 applies as there are no meanders, riffles, or pools, therefore this feature is classified as "ephemeral".

Stream S4 has a drainage area greater than 1 square mile and is therefore classified as "intermittent", which is consistent with the USGS designation. This is the largest stream in the corridor. The corridor crosses the meanders of this stream in 3 locations (the reach containing the sample point, a reach just downstream, and a reach near the confluence with S2).

Stream S5 is a draw draining an upland area NW of the corridor. The channel was classified as "intermittent" as none of the 2017-06 criteria apply.

Stream S6 is located where the corridor crosses into a crop field via a culvert. The sample ppint is just downstream of the culvert. This stream is identified as "intermittent" on the USGS topographical map. None of the 2017-06 criteria apply, therefore the "intermittent" designation was used.

The corridor crosses Stream S7 just south of the railroad track. This is a fairly large channel which was classified as "intermittent".

See Figure 4 for overview of jurisdictional features, Figure 6 for more detail on S1 through S4, and Figure 7 for more detail on S5 through S7.

Within the trapezoidal block at the east end of the corridor, no bed and bank streams were observed, although one such channel was observed just off site to the south. A small wetland area is present, a portion of which is located in the SE corner of the trapezoid. The portion of the wetland within the trapezoidal block is 0.04 acres (Figures 4 and 5).

Three other areas along the corridor were tested for either stream or wetland criteria, identified in Figure 4 as points A, B, and C. Point A is located in a draw with likely wetland hydrology. Vegetation was mowed grass which could be reed canary grass (wetland vegetation). Soils, however, tested as 10YR 3/3, not a hydric soil. No bed and bank was present at this location either. At point B, there was no bed and bank. Vegetation was upland species. At point C, there also is no bed and bank. Soils tested as 10YR 4/3, not a wetland soil.

RESULTS

Based on review of available information and the field assessment, 7 streams and 1 wetland were identified. The streams were classified as ephemeral in 2 cases and intermittent in 5 cases. One small emergent wetland (0.04 acre) is present.

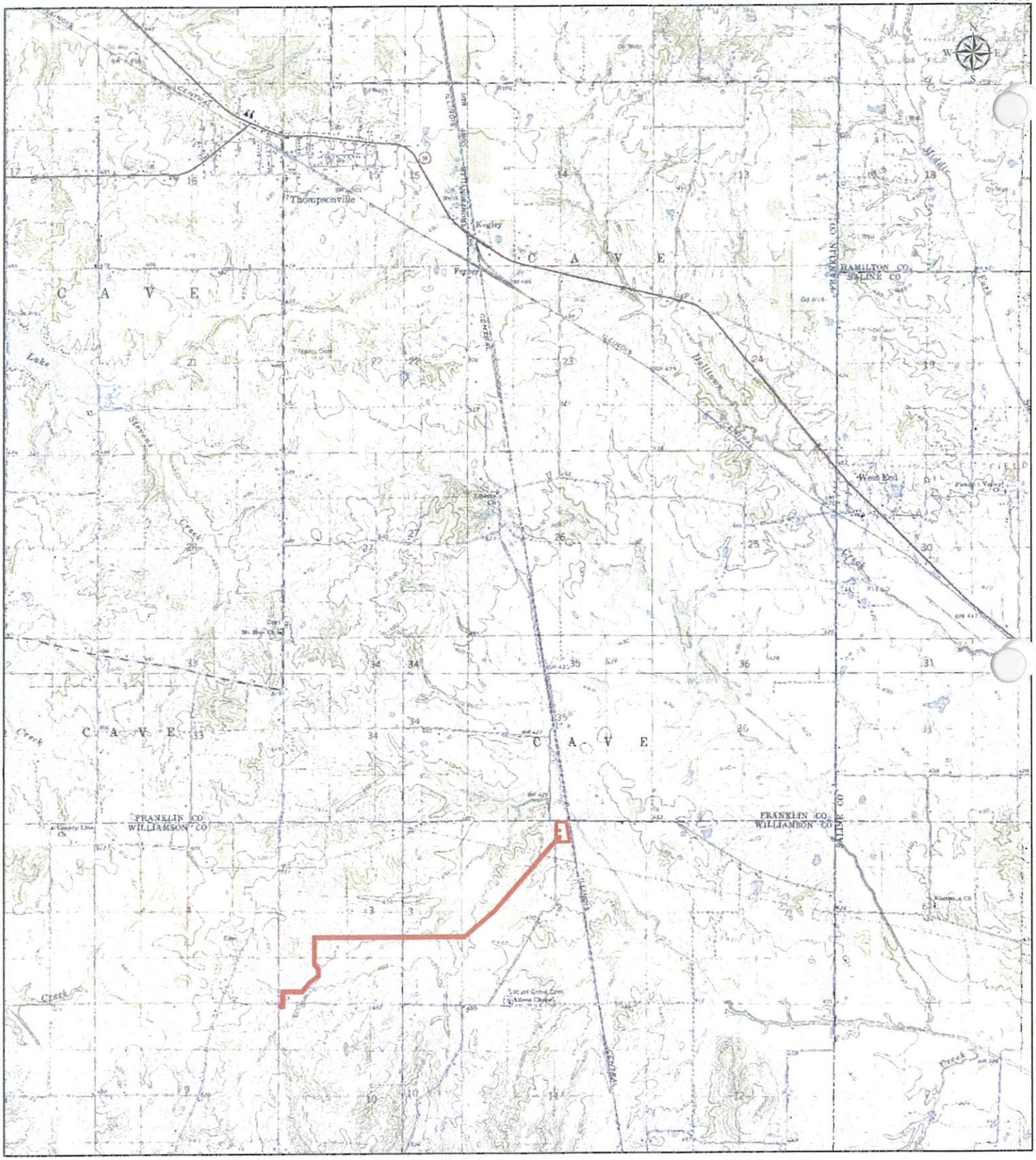
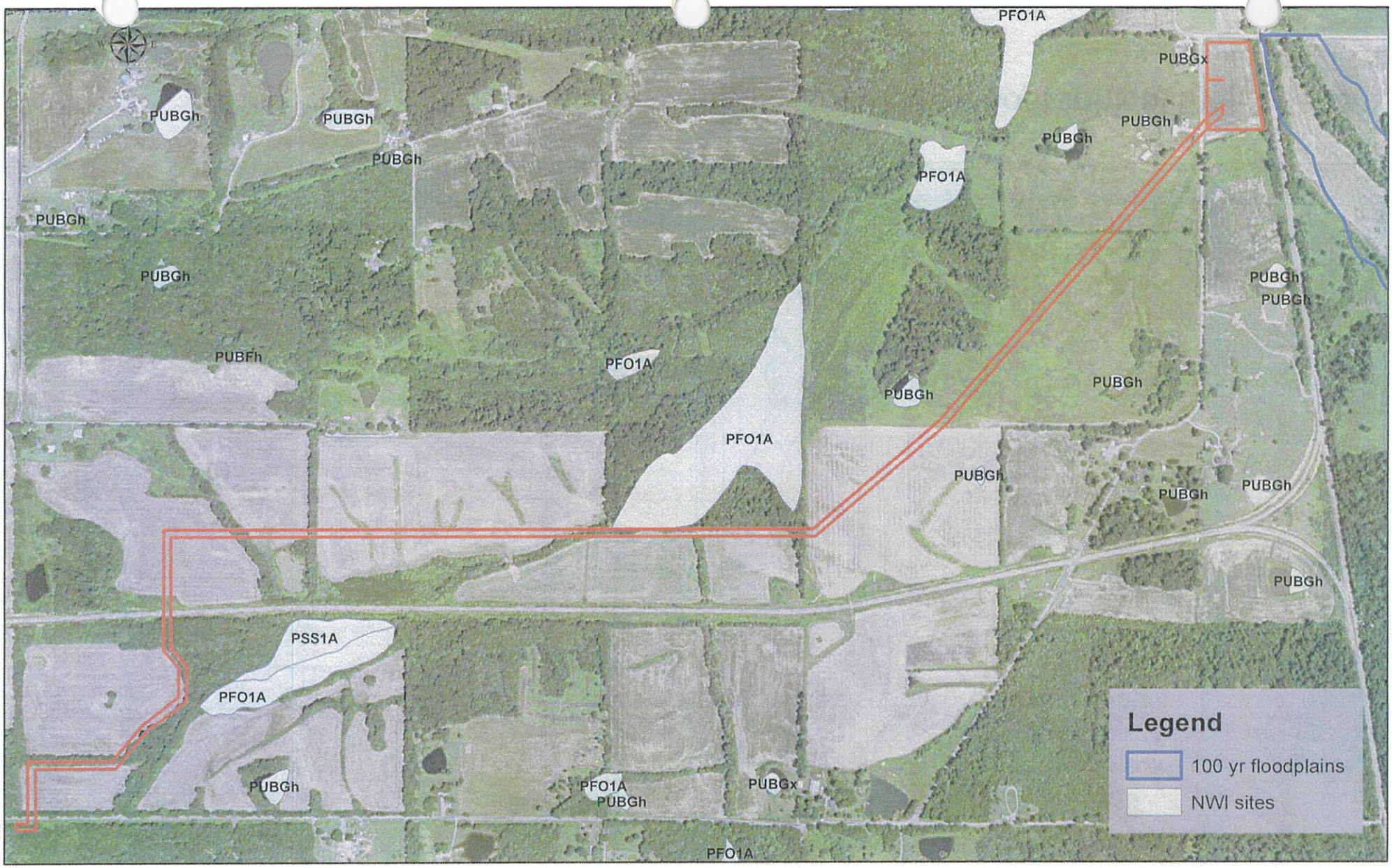


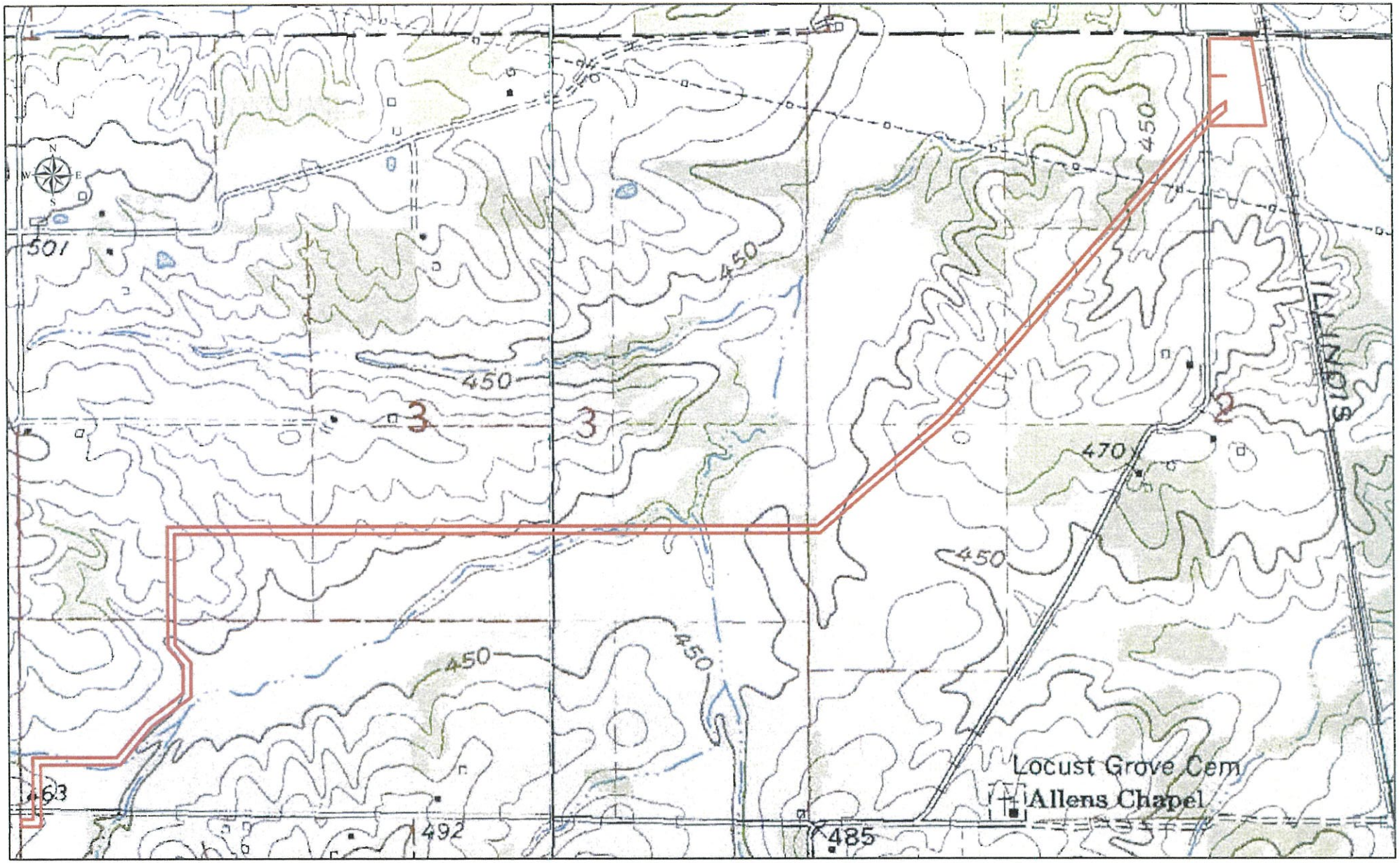
Figure 1. Site location south of Thompsonville, IL.



0 0.25 Miles

Figure 2. Floodplain and National Wetland Inventory sites.

R06406



0 0.25 Miles

Figure 3. USGS topographical map of site.

R06407



0 0.25 Miles

Figure 4. Clean Water Act, Section 404 features within assessment area.

R06408

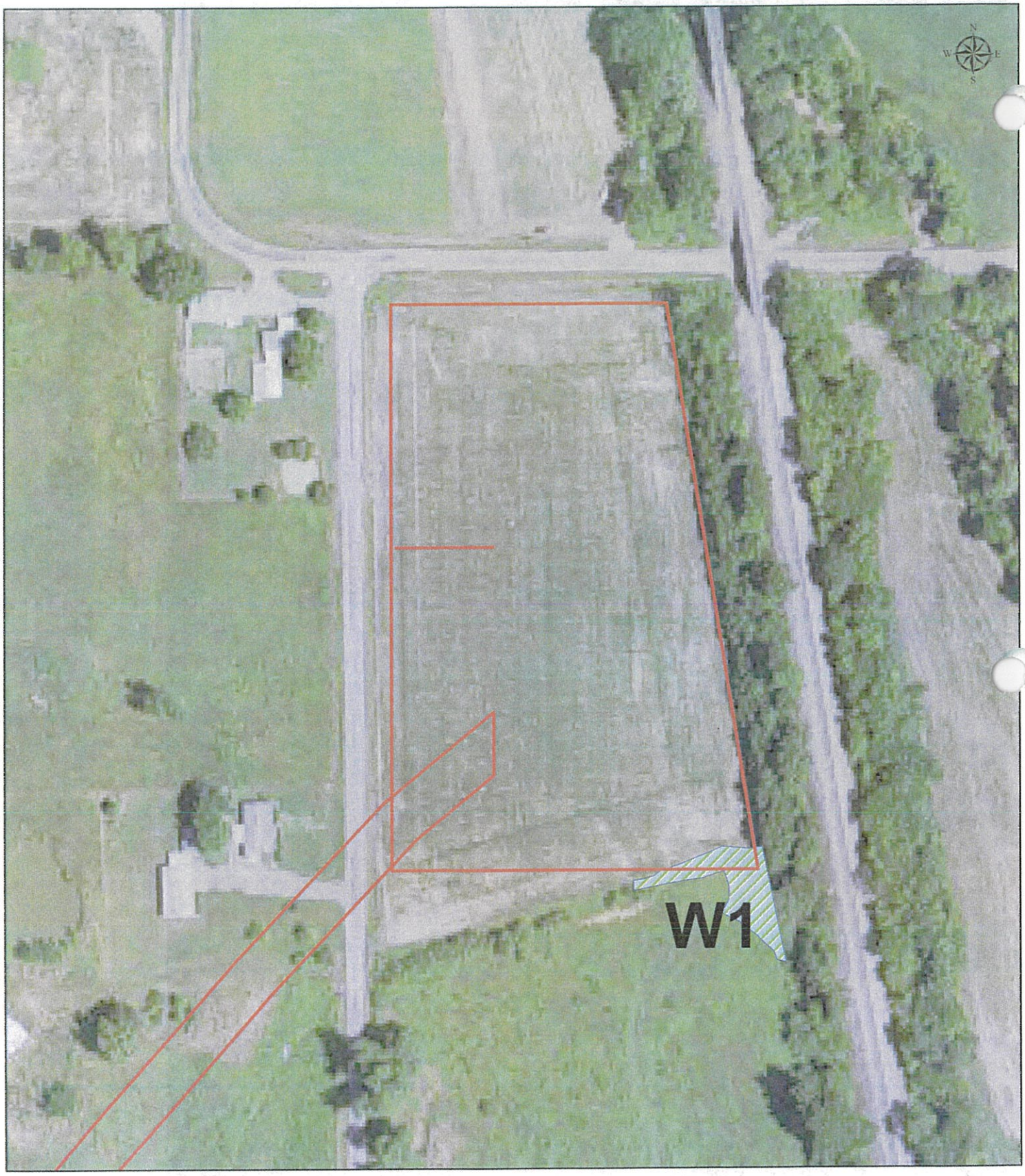


Figure 5. Wetland W1 in SE corner of trapezoidal tract.

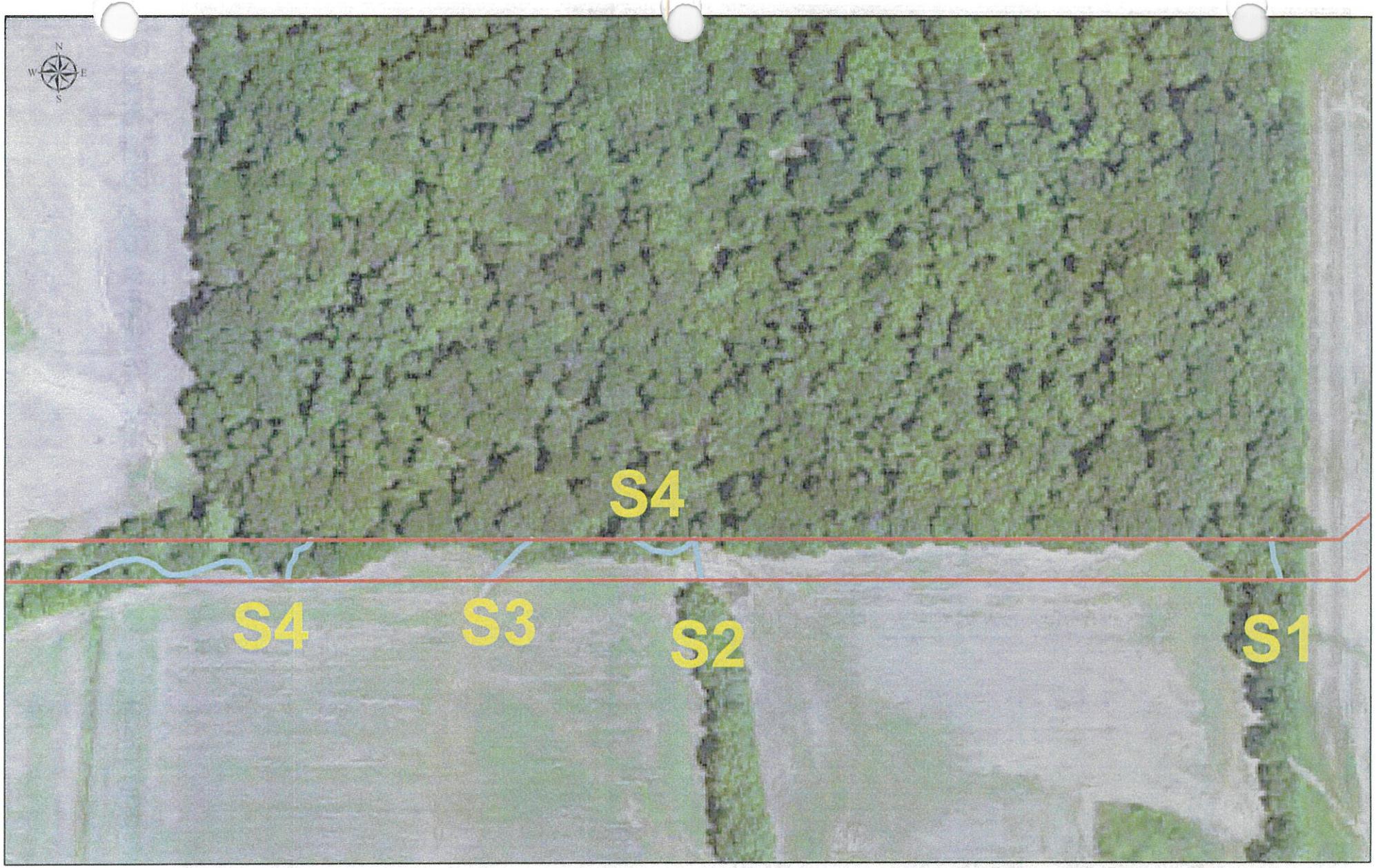


Figure 6. Stream S1, S2, S3, and S4.

R06410



Figure 7. Stream S5, S6, and S7

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME S1	LOCATION NE Williamson County, IL
STATION # _____ RIVERMILE _____	STREAM CLASS ephemeral
LAT 37.85423 LONG -88.74416	RIVER BASIN Middle Fork Saline River
STORET #	AGENCY
INVESTIGATORS William OLeary	
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 11:15 AM PM
REASON FOR SURVEY potential permitting	

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
100 % ☒	%cloud cover	☐ ___ %
☐	clear/sunny	☐

Has there been a heavy rain in the last 7 days? ☐ Yes ☒ No

Air Temperature 45 °C F

Other _____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)

Bankfull width 2.7 ft
Bankfull depth 0.3 ft
Floodprone width 4.9 ft
Terrace width 6.5 ft
Terrace depth 1.2 ft

Photographs were taken facing downstream and upstream.

STREAM CHARACTERIZATION

Stream Subsystem
☐ Perennial ☐ Intermittent ☐ Tidal

Stream Origin
☐ Glacial
☐ Non-glacial montane
☐ Swamp and bog
☐ Spring-fed
☐ Mixture of origins
☒ Other runoff

Stream Type
☐ Coldwater ☒ Warmwater

Catchment Area 5.9 acres

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES

Predominant Surrounding Landuse
☐ Forest ☐ Commercial
☐ Field/Pasture ☐ Industrial
☒ Agricultural ☐ Other _____
☐ Residential

Local Watershed NPS Pollution
☒ No evidence ☐ Some potential sources
☐ Obvious sources

Local Watershed Erosion
☐ None ☒ Moderate ☐ Heavy

RIPARIAN VEGETATION (18 meter buffer)

Indicate the dominant type and record the dominant species present
☒ Trees ☐ Shrubs ☐ Grasses ☐ Herbaceous

dominant species present green ash, shagbark hickory, hackberry

INSTREAM FEATURES

Estimated Reach Length 50 ft X m

Estimated Stream Width _____m

Sampling Reach Area _____m^2

Area in km^2 (m^2x1000) _____km^2

Estimated Stream Depth _____m

Surface Velocity (at thalweg) _____m/sec

Canopy Cover
☐ Partly open ☐ Partly shaded ☒ Shaded

High Water Mark _____m

Proportion of Reach Represented by Stream Morphology Types
☐ Riffle_____% ☒ Run 100 %
☐ Pool_____%

Channelized ☐ Yes ☒ No

Dam Present ☐ Yes ☒ No

LARGE WOODY DEBRIS

LWD _____m^2

Density of LWD _____m^2/km^2 (LWD/ reach area)

AQUATIC VEGETATION

Indicate the dominant type and record the dominant species present
☐ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating
☐ Floating Algae ☐ Attached Algae

dominant species present _____

Portion of the reach with aquatic vegetation 0 %

WATER QUALITY

no water present

Temperature_____° C

Specific Conductance_____

Dissolved Oxygen _____

pH _____

Turbidity _____

WQ Instrument Used _____

Water Odors
☐ Normal/None ☐ Sewage
☐ Petroleum ☐ Chemical
☐ Fishy ☐ Other_____

Water Surface Oils
☐ Slick ☐ Sheen ☐ Globs ☐ Flecks
☐ None ☐ Other_____

Turbidity (if not measured)
☐ Clear ☐ Slightly turbid ☐ Turbid
☐ Opaque ☐ Stained ☐ Other_____

SEDIMENT/ SUBSTRATE

Odors
☒ Normal ☐ Sewage ☐ Petroleum
☐ Chemical ☐ Anaerobic ☐ None
☐ Other_____

Oils
☒ Absent ☐ Slight ☐ Moderate ☐ Profuse

Deposits
☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand
☐ Relict shells ☐ Other_____

Looking at stones which are not deeply embedded, are the undersides black in color? N/A
☐ Yes ☐ No

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	
Gravel	2-64 mm (0.1"-2.5")				
Sand	0.06-2mm (gritty)		Marl	grey, shell fragments	
Silt	0.004-0.06 mm	50			
Clay	< 0.004 mm (slick)	50			

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME S1	LOCATION NE Williamson County, IL	
STATION # _____ RIVERMILE _____	STREAM CLASS ephemeral	
LAT 37.85423 LONG -88.74416	RIVER BASIN Middle Fork Saline River	
STORET #	AGENCY	
INVESTIGATORS William OLeary		
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 11:15 (AM) PM	REASON FOR SURVEY potential permitting

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
11				
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
6				
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
1				
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
6				
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
1				
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 9 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 9 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 9 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 9 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 10 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 4 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 97



S1 facing downstream



S1 facing upstream

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME S2	LOCATION NE Williamson County, IL	
STATION # _____ RIVERMILE _____	STREAM CLASS intermittent	
LAT 37.85421 LONG -88.74660	RIVER BASIN Middle Fork Saline River	
STORET #	AGENCY	
INVESTIGATORS William OLeary		
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 11:30 AM PM	REASON FOR SURVEY potential permitting

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
100 % ☒	%cloud cover	☐ ___ %
☐	clear/sunny	☐

Has there been a heavy rain in the last 7 days? ☐ Yes ☒ No

Air Temperature 45 °C F

Other _____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)

Bankfull width 6.4 ft
Bankfull depth 0.8 ft
Floodprone width 1.4 ft
Terrace width 25.0
Terrace depth 3.5 ft

Photographs were taken facing downstream and upstream.

STREAM CHARACTERIZATION

Stream Subsystem
☐ Perennial ☒ Intermittent ☐ Tidal

Stream Origin
☐ Glacial ☐ Spring-fed
☐ Non-glacial montane ☐ Mixture of origins
☐ Swamp and bog ☒ Other runoff

Stream Type
☐ Coldwater ☒ Warmwater

Catchment Area 0.8 sq miles

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

S2

WATERSHED FEATURES

Predominant Surrounding Landuse
☐ Forest ☐ Commercial
☐ Field/Pasture ☐ Industrial
☒ Agricultural ☐ Other _____
☐ Residential

Local Watershed NPS Pollution
☒ No evidence ☐ Some potential sources
☐ Obvious sources

Local Watershed Erosion
☐ None ☒ Moderate ☐ Heavy

RIPARIAN VEGETATION (18 meter buffer)

Indicate the dominant type and record the dominant species present
Trees ☐ Shrubs ☒ Grasses ☐ Herbaceous
dominant species present barnyard grass, fall panicum

INSTREAM FEATURES

Estimated Reach Length 50 ft X _____m

Estimated Stream Width _____m

Sampling Reach Area _____m^2

Area in km^2 (m^2x1000) _____km^2

Estimated Stream Depth _____m

Surface Velocity (at thalweg) _____m/sec

Canopy Cover
☒ Partly open ☐ Partly shaded ☐ Shaded

High Water Mark _____m

Proportion of Reach Represented by Stream Morphology Types
☐ Riffle ____% ☒ Run 90 %.
☒ Pool 10%

Channelized ☒ Yes ☐ No

Dam Present ☐ Yes ☒ No

LARGE WOODY DEBRIS

LWD _____m^2

Density of LWD _____m^2/km^2 (LWD/ reach area)

AQUATIC VEGETATION

Indicate the dominant type and record the dominant species present
☐ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating
☐ Floating Algae ☐ Attached Algae

dominant species present _____

Portion of the reach with aquatic vegetation 0 %

WATER QUALITY

1 small pool present

Temperature_____° C

Specific Conductance_____

Dissolved Oxygen _____

pH _____

Turbidity _____

WQ Instrument Used _____

Water Odors
☒ Normal/None ☐ Sewage
☐ Petroleum ☐ Chemical
☐ Fishy ☐ Other_____

Water Surface Oils
☐ Slick ☐ Sheen ☐ Globs ☐ Flecks
☒ None ☐ Other_____

Turbidity (if not measured)
☐ Clear ☐ Slightly turbid ☐ Turbid
☒ Opaque ☐ Stained ☐ Other_____

SEDIMENT/ SUBSTRATE

Odors
☒ Normal ☐ Sewage ☐ Petroleum
☐ Chemical ☐ Anaerobic ☐ None
☐ Other_____

Oils
☒ Absent ☐ Slight ☐ Moderate ☐ Profuse

Deposits
☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand
☐ Relict shells ☐ Other_____

Looking at stones which are not deeply embedded, are the undersides black in color?
☒ Yes ☐ No

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	Diameter	% Composition in Sampling Reach	Substrate Type	Characteristic	% Composition in Sampling Area
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	
Gravel	2-64 mm (0.1"-2.5")				
Sand	0.06-2mm (gritty)	10	Marl	grey, shell fragments	
Silt	0.004-0.06 mm	45			
Clay	< 0.004 mm (slick)	45			

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME S2	LOCATION NE Williamson County, IL	
STATION # _____ RIVERMILE _____	STREAM CLASS intermittent	
LAT 37.85421 LONG -88.74660	RIVER BASIN Middle Fork Saline River	
STORET #	AGENCY	
INVESTIGATORS William OLeary		
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 11:30 AM PM	REASON FOR SURVEY potential permitting

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE 7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep, very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE 4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

S2

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
SCORE 6 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 7 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 6 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 7 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE 1 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 1 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 81



S2 facing downstream



S2 facing upstream

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME S3	LOCATION NE Williamson County, IL	
STATION # _____ RIVERMILE _____	STREAM CLASS ephemeral	
LAT 37.85422 LONG -88.74741	RIVER BASIN Middle Fork Saline River	
STORET #	AGENCY	
INVESTIGATORS William OLeary		
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 11:50 AM PM	REASON FOR SURVEY potential permitting

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
100 % ☒	%cloud cover	☐ ___ %
☐	clear/sunny	☐

Has there been a heavy rain in the last 7 days? ☐ Yes ☒ No

Air Temperature 45 ° ~~C~~ F

Other _____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)

Bankfull width 3.6 ft
Bankfull depth 0.3 ft
Floodprone width 7.5 ft
Terrace width 10.5 ft
Terrace depth 2.9 ft

Photographs were taken facing downstream and upstream.

Note: This feature is an erosional gully and as such is probably not a jurisdictional feasture under 404 CWA.

STREAM CHARACTERIZATION

Stream Subsystem
☐ Perennial ☐ Intermittent ☐ Tidal

Stream Origin
☐ Glacial ☐ Spring-fed
☐ Non-glacial montane ☐ Mixture of origins
☐ Swamp and bog ☒ Other runoff

Stream Type
☐ Coldwater ☒ Warmwater

Catchment Area 3.2 acres

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

S3

WATERSHED FEATURES

Predominant Surrounding Landuse
☐ Forest ☐ Commercial
☐ Field/Pasture ☐ Industrial
☒ Agricultural ☐ Other _____
☐ Residential

Local Watershed NPS Pollution
☒ No evidence ☐ Some potential sources
☐ Obvious sources

Local Watershed Erosion
☐ None ☒ Moderate ☐ Heavy

RIPARIAN VEGETATION (18 meter buffer)

Indicate the dominant type and record the dominant species present
Trees ☐ Shrubs ☐ Grasses ☒ Herbaceous
dominant species present Japanese honeysuckle, fall panicum

INSTREAM FEATURES

Estimated Reach Length 50 ft X
Estimated Stream Width _____m
Sampling Reach Area _____m^2
Area in km^2 (m^2x1000) _____km^2
Estimated Stream Depth _____m
Surface Velocity (at thalweg) _____m/sec

Canopy Cover
☒ Partly open ☐ Partly shaded ☐ Shaded

High Water Mark _____m

Proportion of Reach Represented by Stream Morphology Types
☐ Riffle_____% ☒ Run 100 %
☐ Pool_____%

Channelized ☐ Yes ☒ No

Dam Present ☐ Yes ☒ No

LARGE WOODY DEBRIS

LWD _____m^2
Density of LWD _____m^2/km^2 (LWD/ reach area)

AQUATIC VEGETATION

Indicate the dominant type and record the dominant species present
☐ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating
☐ Floating Algae ☐ Attached Algae

dominant species present _____

Portion of the reach with aquatic vegetation 0 %

WATER QUALITY

no water present

Temperature_____° C
Specific Conductance_____
Dissolved Oxygen _____
pH _____
Turbidity _____
WQ Instrument Used _____

Water Odors
☐ Normal/None ☐ Sewage
☐ Petroleum ☐ Chemical
☐ Fishy ☐ Other_____

Water Surface Oils
☐ Slick ☐ Sheen ☐ Globs ☐ Flecks
☐ None ☐ Other_____

Turbidity (if not measured)
☐ Clear ☐ Slightly turbid ☐ Turbid
☐ Opaque ☐ Stained ☐ Other_____

SEDIMENT/ SUBSTRATE

Odors
☒ Normal ☐ Sewage ☐ Petroleum
☐ Chemical ☐ Anaerobic ☐ None
☐ Other_____

Oils
☒ Absent ☐ Slight ☐ Moderate ☐ Profuse

Deposits
☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand
☐ Relict shells ☐ Other_____

Looking at stones which are not deeply embedded, are the undersides black in color? N/A
☐ Yes ☐ No

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	
Gravel	2-64 mm (0.1"-2.5")				
Sand	0.06-2mm (gritty)		Marl	grey, shell fragments	
Silt	0.004-0.06 mm	50			
Clay	< 0.004 mm (slick)	50			

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME S3	LOCATION NE Williamson County, IL	
STATION # _____ RIVERMILE _____	STREAM CLASS ephemeral	
LAT 37.85422 LONG -88.74741	RIVER BASIN Middle Fork Saline River	
STORET #	AGENCY	
INVESTIGATORS William OLeary		
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 11:50 AM PM	REASON FOR SURVEY potential permitting

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 1	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE 7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present	Majority of pools large-deep, very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent
SCORE 1	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed	Very little water in channel and mostly present as standing pools.
SCORE 3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

S3

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 2 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 2 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident, almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented, disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 3 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 3 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE 0 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 0 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 49



S3 facing downstream



S3 facing upstream

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME S4	LOCATION NE Williamson County, IL
STATION # _____ RIVERMILE _____	STREAM CLASS intermittent
LAT 37.85421 LONG -88.74910	RIVER BASIN Middle Fork Saline River
STORET #	AGENCY
INVESTIGATORS William OLeary	
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 12:05 AM (PM)
	REASON FOR SURVEY potential permitting

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
100 %	%cloud cover	☐ ___ %
☐	clear/sunny	☐

Has there been a heavy rain in the last 7 days? ☐ Yes ☒ No

Air Temperature 45 °X F

Other _____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)

Bankfull width 13.0 ft
Bankfull depth 3.2 ft
Floodprone width 20.2 ft
Terrace width 22.2 ft
Terrace depth 7.1 ft

Photographs were taken facing downstream and upstream.

STREAM CHARACTERIZATION

Stream Subsystem
☐ Perennial X Intermittent ☐ Tidal

Stream Type
☐ Coldwater ☒ Warmwater

Stream Origin
☐ Glacial
☐ Non-glacial montane
☐ Swamp and bog
☐ Spring-fed
☐ Mixture of origins
☒ Other runoff

Catchment Area 1.9 sq miles

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

S4

WATERSHED FEATURES

Predominant Surrounding Landuse
☐ Forest ☐ Commercial
☐ Field/Pasture ☐ Industrial
☒ Agricultural ☐ Other _____
☐ Residential

Local Watershed NPS Pollution
☒ No evidence ☐ Some potential sources
☐ Obvious sources

Local Watershed Erosion
☐ None ☒ Moderate ☐ Heavy

RIPARIAN VEGETATION (18 meter buffer)

Indicate the dominant type and record the dominant species present
☒ Trees ☐ Shrubs ☐ Grasses ☐ Herbaceous

dominant species present box elder, green ash, walnut

INSTREAM FEATURES

Estimated Reach Length 50 ft X

Estimated Stream Width _____m

Sampling Reach Area _____m^2

Area in km^2 (m^2x1000) _____km^2

Estimated Stream Depth _____m

Surface Velocity (at thalweg) _____m/sec

Canopy Cover
☒ Partly open ☐ Partly shaded ☐ Shaded

High Water Mark _____m

Proportion of Reach Represented by Stream Morphology Types
☒ Riffle 20 % ☒ Run 20 %
☒ Pool 60 %

Channelized ☐ Yes ☒ No

Dam Present ☐ Yes ☒ No

LARGE WOODY DEBRIS

LWD _____m^2

Density of LWD _____m^2/km^2 (LWD/ reach area)

AQUATIC VEGETATION

Indicate the dominant type and record the dominant species present
☐ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating
☐ Floating Algae ☐ Attached Algae

dominant species present _____

Portion of the reach with aquatic vegetation 0 %

WATER QUALITY

Temperature_____° C

Specific Conductance_____

Dissolved Oxygen _____

pH _____

Turbidity _____

WQ Instrument Used _____

Water Odors
☒ Normal/None ☐ Sewage
☐ Petroleum ☐ Chemical
☐ Fishy ☐ Other_____

Water Surface Oils
☐ Slick ☐ Sheen ☐ Globs ☐ Flecks
☒ None ☐ Other_____

Turbidity (if not measured)
☒ Clear ☐ Slightly turbid ☐ Turbid
☐ Opaque ☐ Stained ☐ Other_____

SEDIMENT/ SUBSTRATE

Odors
☒ Normal ☐ Sewage ☐ Petroleum
☐ Chemical ☐ Anaerobic ☐ None
☐ Other_____

Oils
☒ Absent ☐ Slight ☐ Moderate ☐ Profuse

Deposits
☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand
☐ Relict shells ☐ Other_____

Looking at stones which are not deeply embedded, are the undersides black in color?
☐ Yes ☐ No N/A

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	Diameter	% Composition in Sampling Reach	Substrate Type	Characteristic	% Composition in Sampling Area
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	
Gravel	2-64 mm (0.1"-2.5")	50			
Sand	0.06-2mm (gritty)	50	Marl	grey, shell fragments	
Silt	0.004-0.06 mm				
Clay	< 0.004 mm (slick)				

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME S4	LOCATION NE Williamson County, IL	
STATION # _____ RIVERMILE _____	STREAM CLASS intermittent	
LAT 37.85421 LONG -88.74910	RIVER BASIN Middle Fork Saline River	
STORET #	AGENCY	
INVESTIGATORS William OLeary		
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 12:05 AM (PM)	REASON FOR SURVEY potential permitting

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE 10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep, very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

S4

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks, and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 5 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 4 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 5 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 4 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 2 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 2 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 92



S4 facing downstream



S4 facing upstream

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME S5	LOCATION NE Williamson County, IL	
STATION # _____ RIVERMILE _____	STREAM CLASS intermittent	
LAT 37.85424 LONG -88.75730	RIVER BASIN Middle Fork Saline River	
STORET #	AGENCY	
INVESTIGATORS William OLeary		
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 12:45 AM (PM)	REASON FOR SURVEY potential permitting

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
100 % ☒	%cloud cover	☐ ___ %
☐	clear/sunny	☐

Has there been a heavy rain in the last 7 days? ☐ Yes ☒ No

Air Temperature 45 ° ☒ F

Other _____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)

Bankfull width 4.3 ft
Bankfull depth 1.1 ft
Floodprone width 7.5 ft
Terrace width 12.1 ft
Terrace depth 3.1 ft

Photographs were taken facing downstream and upstream.

STREAM CHARACTERIZATION

Stream Subsystem
☐ Perennial ☒ Intermittent ☐ Tidal

Stream Origin
☐ Glacial ☐ Spring-fed
☐ Non-glacial montane ☐ Mixture of origins
☐ Swamp and bog ☒ Other runoff

Stream Type
☐ Coldwater ☒ Warmwater

Catchment Area 26.1 acres

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

S5

WATERSHED FEATURES

Predominant Surrounding Landuse
☐ Forest ☐ Commercial
☐ Field/Pasture ☐ Industrial
☒ Agricultural ☐ Other _____
☐ Residential

Local Watershed NPS Pollution
☒ No evidence ☐ Some potential sources
☐ Obvious sources

Local Watershed Erosion
☐ None ☒ Moderate ☐ Heavy

RIPARIAN VEGETATION (18 meter buffer)

Indicate the dominant type and record the dominant species present
☒ Trees ☐ Shrubs ☐ Grasses ☐ Herbaceous

dominant species present red maple, American elm, green ash

INSTREAM FEATURES

Estimated Reach Length 50 ft X

Estimated Stream Width _____m

Sampling Reach Area _____m^2

Area in km^2 (m^2x1000) _____km^2

Estimated Stream Depth _____m

Surface Velocity (at thalweg) _____m/sec

Canopy Cover
☐ Partly open ☐ Partly shaded ☒ Shaded

High Water Mark _____m

Proportion of Reach Represented by Stream Morphology Types
☐ Riffle_____% ☒ Run 100 %
☐ Pool_____%

Channelized ☒ Yes ☐ No

Dam Present ☐ Yes ☒ No

LARGE WOODY DEBRIS

LWD _____m^2

Density of LWD _____m^2/km^2 (LWD/ reach area)

AQUATIC VEGETATION

Indicate the dominant type and record the dominant species present
☐ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating
☐ Floating Algae ☐ Attached Algae

dominant species present _____

Portion of the reach with aquatic vegetation 0 %

WATER QUALITY

no water present

Temperature_____° C

Specific Conductance_____

Dissolved Oxygen _____

pH _____

Turbidity _____

WQ Instrument Used _____

Water Odors
☐ Normal/None ☐ Sewage
☐ Petroleum ☐ Chemical
☐ Fishy ☐ Other_____

Water Surface Oils
☐ Slick ☐ Sheen ☐ Globs ☐ Flecks
☐ None ☐ Other_____

Turbidity (if not measured)
☐ Clear ☐ Slightly turbid ☐ Turbid
☐ Opaque ☐ Stained ☐ Other_____

SEDIMENT/ SUBSTRATE

Odors
☒ Normal ☐ Sewage ☐ Petroleum
☐ Chemical ☐ Anaerobic ☐ None
☐ Other_____

Oils
☒ Absent ☐ Slight ☐ Moderate ☐ Profuse

Deposits
☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand
☐ Relict shells ☐ Other_____

Looking at stones which are not deeply embedded, are the undersides black in color?
☐ Yes ☐ No N/A

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	
Gravel	2-64 mm (0.1"-2.5")	50			
Sand	0.06-2mm (gritty)	50	Marl	grey, shell fragments	
Silt	0.004-0.06 mm				
Clay	< 0.004 mm (slick)				

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME S5	LOCATION NE Williamson County, IL	
STATION # _____ RIVERMILE _____	STREAM CLASS intermittent	
LAT 37.85424 LONG -88.75730	RIVER BASIN Middle Fork Saline River	
STORET #	AGENCY	
INVESTIGATORS William OLeary		
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 12:45 AM (PM)	REASON FOR SURVEY potential permitting

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat, well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep, very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE 4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 9	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel, or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 9	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

S5

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 5 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 5 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 5 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 5 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE 2 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 4 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 88



S5 facing downstream



S5 facing upstream

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME S6	LOCATION NE Williamson County, IL	
STATION # _____ RIVERMILE _____	STREAM CLASS intermittent	
LAT 37.84999 LONG -88.75996	RIVER BASIN Middle Fork Saline River	
STORET #	AGENCY	
INVESTIGATORS William OLeary		
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 2:30 AM (PM)	REASON FOR SURVEY potential permitting

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
100 % ☒	%cloud cover	☐ ___ %
☐	clear/sunny	☐

Has there been a heavy rain in the last 7 days? ☐ Yes ☒ No

Air Temperature 45 °C ☒ F

Other _____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)

Bankfull width 5.7 ft
Bankfull depth 1.5 ft
Floodprone width 8.0 ft
Terrace width 11.8 ft
Terrace depth 3.9 ft

Photographs were taken facing downstream and upstream.

STREAM CHARACTERIZATION

Stream Subsystem
☐ Perennial ☒ Intermittent ☐ Tidal

Stream Type
☐ Coldwater ☒ ☐ Warmwater

Stream Origin
☐ Glacial ☐ Spring-fed
☐ Non-glacial montane ☐ Mixture of origins
☐ Swamp and bog ☒ Other runoff

Catchment Area 0.2 sq miles

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

S6

WATERSHED FEATURES

Predominant Surrounding Landuse
☐ Forest ☐ Commercial
☐ Field/Pasture ☐ Industrial
☒ Agricultural ☐ Other _____
☐ Residential

Local Watershed NPS Pollution
☒ No evidence ☐ Some potential sources
☐ Obvious sources

Local Watershed Erosion
☐ None ☒ Moderate ☐ Heavy

RIPARIAN VEGETATION (18 meter buffer)

Indicate the dominant type and record the dominant species present
☒ Trees ☐ Shrubs ☐ Grasses ☐ Herbaceous

dominant species present sycamore, American elm, red maple

INSTREAM FEATURES

Estimated Reach Length 50 ft ~~m~~ X

Estimated Stream Width _____m

Sampling Reach Area _____m^2

Area in km^2 (m^2x1000) _____km^2

Estimated Stream Depth _____m

Surface Velocity (at thalweg) _____m/sec

Canopy Cover
☐ Partly open ☐ Partly shaded ☐ Shaded

High Water Mark _____m

Proportion of Reach Represented by Stream Morphology Types
☒ Riffle 20 % ☒ Run 80 %
☐ Pool _____%

Channelized ☒ Yes ☐ No

Dam Present ☐ Yes ☒ No

LARGE WOODY DEBRIS

LWD _____m^2

Density of LWD _____m^2/km^2 (LWD/ reach area)

AQUATIC VEGETATION

Indicate the dominant type and record the dominant species present
☐ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating
☐ Floating Algae ☐ Attached Algae

dominant species present _____

Portion of the reach with aquatic vegetation 0 %

WATER QUALITY

no water present

Temperature_____° C

Specific Conductance_____

Dissolved Oxygen _____

pH _____

Turbidity _____

WQ Instrument Used _____

Water Odors
☐ Normal/None ☐ Sewage
☐ Petroleum ☐ Chemical
☐ Fishy ☐ Other_____

Water Surface Oils
☐ Slick ☐ Sheen ☐ Globs ☐ Flecks
☐ None ☐ Other_____

Turbidity (if not measured)
☐ Clear ☐ Slightly turbid ☐ Turbid
☐ Opaque ☐ Stained ☐ Other_____

SEDIMENT/ SUBSTRATE

Odors
☒ Normal ☐ Sewage ☐ Petroleum
☐ Chemical ☐ Anaerobic ☐ None
☐ Other_____

Oils
☒ Absent ☐ Slight ☐ Moderate ☐ Profuse

Deposits
☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand
☐ Relict shells ☐ Other_____

Looking at stones which are not deeply embedded, are the undersides black in color?
☒ Yes ☐ No

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	
Gravel	2-64 mm (0.1"-2.5")				
Sand	0.06-2mm (gritty)		Marl	grey, shell fragments	
Silt	0.004-0.06 mm	25			
Clay	< 0.004 mm (slick)	75			

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME S6	LOCATION NE Williamson County, IL	
STATION # _____ RIVERMILE _____	STREAM CLASS intermittent	
LAT 37.84999 LONG -88.75996	RIVER BASIN Middle Fork Saline River	
STORET #	AGENCY	
INVESTIGATORS William OLeary		
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 2:30 AM (PM)	REASON FOR SURVEY potential permitting

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE 13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep, very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE 5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

S6

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal, stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks, and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal, little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion, high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 5 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 6 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 5 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 6 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 2 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 3 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 90



S6 facing downstream



S6 facing upstream

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME S7	LOCATION NE Williamson County, IL	
STATION # _____ RIVERMILE _____	STREAM CLASS intermittent	
LAT 37.85216 LONG -88.75882	RIVER BASIN Middle Fork Saline River	
STORET #	AGENCY	
INVESTIGATORS William OLeary		
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 2:45 AM (PM)	REASON FOR SURVEY potential permitting

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
100 % ☒	%cloud cover	☐ ___ %
☐	clear/sunny	☐

Has there been a heavy rain in the last 7 days? ☐ Yes ☒ No

Air Temperature 45 °X C F

Other _____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)

Bankfull width 12.5 ft
Bankfull depth 1.2 ft
Floodprone width 14.5 ft
Terrace width 16.2 ft
Terrace depth 5.5 ft

Photographs were taken facing downstream and upstream.

STREAM CHARACTERIZATION

Stream Subsystem
☐ Perennial ☒ Intermittent ☐ Tidal

Stream Type
☐ Coldwater ☒ Warmwater

Stream Origin
☐ Glacial ☐ Spring-fed
☐ Non-glacial montane ☐ Mixture of origins
☐ Swamp and bog ☒ Other runoff

Catchment Area 0.06 sq miles

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

S7

WATERSHED FEATURES

Predominant Surrounding Landuse
☐ Forest ☐ Commercial
☐ Field/Pasture ☐ Industrial
☒ Agricultural ☐ Other _____
☐ Residential

Local Watershed NPS Pollution
☒ No evidence ☐ Some potential sources
☐ Obvious sources

Local Watershed Erosion
☐ None ☒ Moderate ☐ Heavy

RIPARIAN VEGETATION (18 meter buffer)

Indicate the dominant type and record the dominant species present
☒ Trees ☐ Shrubs ☐ Grasses ☐ Herbaceous

dominant species present green ash, shagbark hickory, American elm

INSTREAM FEATURES

Estimated Reach Length 50 ft X

Estimated Stream Width _____m

Sampling Reach Area _____m^2

Area in km^2 (m^2x1000) _____km^2

Estimated Stream Depth _____m

Surface Velocity (at thalweg) _____m/sec

Canopy Cover
☐ Partly open ☐ Partly shaded ☒ Shaded

High Water Mark _____m

Proportion of Reach Represented by Stream Morphology Types
☐ Riffle ____% ☒ Run 90%
☒ Pool 10%

Channelized ☐ Yes ☒ No

Dam Present ☐ Yes ☒ No

LARGE WOODY DEBRIS

LWD _____m^2

Density of LWD _____m^2/km^2 (LWD/ reach area)

AQUATIC VEGETATION

Indicate the dominant type and record the dominant species present
☐ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating
☐ Floating Algae ☐ Attached Algae

dominant species present _____

Portion of the reach with aquatic vegetation 0 %

WATER QUALITY

Temperature_____° C

Specific Conductance_____

Dissolved Oxygen _____

pH _____

Turbidity _____

WQ Instrument Used _____

Water Odors
☒ Normal/None ☐ Sewage
☐ Petroleum ☐ Chemical
☐ Fishy ☐ Other_____

Water Surface Oils
☐ Slick ☐ Sheen ☐ Globs ☐ Flecks
☒ None ☐ Other_____

Turbidity (if not measured)
☒ Clear ☐ Slightly turbid ☐ Turbid
☐ Opaque ☐ Stained ☐ Other_____

SEDIMENT/ SUBSTRATE

Odors
☒ Normal ☐ Sewage ☐ Petroleum
☐ Chemical ☐ Anaerobic ☐ None
☐ Other_____

Oils
☒ Absent ☐ Slight ☐ Moderate ☐ Profuse

Deposits
☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand
☐ Relict shells ☐ Other_____

Looking at stones which are not deeply embedded, are the undersides black in color?
☒ Yes ☐ No

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	Diameter	% Composition in Sampling Reach	Substrate Type	Characteristic	% Composition in Sampling Area
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")	5	Muck-Mud	black, very fine organic (FPOM)	
Gravel	2-64 mm (0.1"-2.5")	50			
Sand	0.06-2mm (gritty)	45	Marl	grey, shell fragments	
Silt	0.004-0.06 mm				
Clay	< 0.004 mm (slick)				

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME S7		LOCATION NE Williamson County, IL
STATION # _____ RIVERMILE _____		STREAM CLASS intermittent
LAT 37.85216 LONG -88.75882		RIVER BASIN Middle Fork Saline River
STORET #		AGENCY
INVESTIGATORS William OLeary		
FORM COMPLETED BY WO	DATE 16OCT2018 TIME 2:45 AM (PM)	REASON FOR SURVEY potential permitting

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep, very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE 5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

S7

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks, and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 4 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 4 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 4 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 4 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE 10 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 2 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 94



S7 facing downstream



S7 facing upstream

R06454

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Bleeder Shaft IBR City/County: NE Williamson County Sampling Date: 20JUNE2018

Applicant/Owner: Wiliamson Energy State: IL Sampling Point: W1

Investigator(s): William OLeary Section, Township, Range: 2 T8S R4E

Landform (hillslope, terrace, etc.): flat Local relief (concave, convex, none):

Slope (%): 0-2% Lat: 37.86171 Long: -88.73364 Datum: WGS84

Soil Map Unit Name: 3382A Belknap silt loam 0-2% NWI classification:

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation X, Soil X, or Hydrology X significantly disturbed? Are "Normal Circumstances" present? Yes _____ No see remarks

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No	**Is the Sampled Area within a Wetland?** Yes X No
Hydric Soil Present?	Yes X No	
Wetland Hydrology Present?	Yes X No	

Remarks: Site is a cultivated crop field with a channelized ditch along the southern border. Wetland exists in a portion of the waterway with no defined bed and bank.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
Herb Stratum (Plot size: _____)			
1. *Echinochloa crus-galli*	50	yes	FACW
2. *Panicum dichotomiflorum*	25	yes	FACW
3. *Xanthium strumarium*	25	yes	FAC
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	100 = Total Cover		
Woody Vine Stratum (Plot size: _____)			
1.			
2.			
	= Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x 1 =
FACW species	x 2 =
FAC species	x 3 =
FACU species	x 4 =
UPL species	x 5 =
Column Totals: (A)	(B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

X Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No _____

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: W1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-12	10YR 4/2	50	7.5YR 3/4	50	C	M	silty clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ 2 cm Muck (A10)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 5 cm Mucky Peat or Peat (S3)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- x Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Coast Prairie Redox (A16)
- ___ Iron-Manganese Masses (F12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes x No _____

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ True Aquatic Plants (B14)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Gauge or Well Data (D9)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- x Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- x FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes _____ No x Depth (inches): _____

Water Table Present? Yes _____ No x Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes _____ No x Depth (inches): _____

Wetland Hydrology Present? Yes x No _____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:



Wetland W1



Wetland W1 Soils

PART 7: Fish and Wildlife

7.1 Pre-Mining Fish and Wildlife Resources. Each application shall include fish and wildlife resource information for the permit and adjacent area. Prior to initiating fish and wildlife resource information studies, the applicant shall contact the Department to determine what fish and wildlife resources information will be required. If the applicant has not contacted the Department as described above, an explanation shall be supplied in the space below. **[1780.16(a)/1784.21(a); 1780.16(a)(1)(A)/1784.21(a)(1)(A)]**

See the Pre and Post Mining Land Use Map

7.1.1 Vegetation Map. Provide a Vegetation Map meeting the requirements found in General Mapping Requirements of the Instructions. **[1779.19/1783.19; 1779.24(l)/1783.24(l); 1780.16(a)(2)(B) & (C)/1784.21(a)(2)(B)&(C)]**

See Aerial Photo Map and Pre and Post Mining Land Use Map.

7.1.2 Habitat Descriptions. Provide a description of the habitat types for each listed pre-mining land use category, excluding cropland, within the proposed permit area. Include information for areas categorized as Residential, Industrial/Commercial, Recreational, and Undeveloped that contain trees or other potential habitats of high value for fish and wildlife. Include specific information on pre-mining woody and herbaceous vegetation species. In addition, provide a general description of the habitat found in the adjacent half mile area, specifically addressing any potential habitats of high value. **[1784.15(a)(1)/1780.23(a)(1); 1779.19(a)/1783.19(a);** Operator Memorandum 2015-01**]**

Primary habitat is Cropland, Fish and Wildlife – Woody, Fish and Wildlife Habitat – Herbaceous, Residential and Industrial. Within the half mile buffer the primary land use is cropland and fish and wildlife habitat (herbaceous, woody, and water) with limited areas of residential and industrial/commercial.

7.1.2.1 For wetland resources located within the proposed permit area, discuss how these areas will be avoided or replaced, and enhanced where applicable and provide general information on the steps taken to comply with the Section 404 of the Clean Water Act. If no wetland resources exits within the proposed permit area pre-mining, indicate N/A. **[1780.18(b)(9)/1784.13(b)(9); 1816.97(f)/1817.97(f)]**

N/A.

7.1.3 Other Site Specific Habitats of High Value. Address any habitats of unusually high value for fish and wildlife located within the proposed permit and adjacent half mile area. The following information is required: **[1780.16(a)(2)(B)/1784.21(a)(2)(B); 1816.97(f)/1817.97(f)]**

7.1.3.1 Stream Habitat Characterization. For each intermittent and perennial stream discussed in Part 6, provide a description of the riparian vegetation (if this information is found in Attachment 6.2, referencing that material is acceptable) and a narrative discussing any critical habitat for threatened and endangered aquatic species. Provide a general discussion on how stream habitat will be avoided or replaced, and enhanced where practicable. Provide general information on the steps taken to comply with Section 404 of the Clean Water Act regarding streams and associated riparian areas. If no intermittent or perennial streams were identified in

Part 6 indicate N/A. **[1780.16(a)(2)(B)/1784.21(A)(2)(B); 1816.97(f)/1817.97(f); (1780.18(b)(9)/1784.13(b)(9)]**

The stream intermittent streams will be bored underneath and the riparian vegetation will not be disturbed.

7.1.3.2 Shelter, Protection, and Reproductive Areas. Discuss areas within the proposed permit and adjacent half mile area such as cliffs supporting raptors, caves, migration routes and wintering areas and measures to protect these areas and enhance where practicable. If none of these areas exist indicate N/A. **[1780.16(a)(2)(B)/1784.21(a)(2)(B); 1816.97(f)/1817.97(f)]**

7.1.3.2 Agency Consultation. Discuss any additional habitats of high value identified through other agency consultations as requiring protection by applicable state and federal laws, this may include a larger adjacent area as defined by consultation. If no other habitats of high value were identified through consultation indicate N/A. **[1780.16(a)(2)(C)/1784.21(a)(2)(C); 1780.16(a)(1)(B)(iii)/1784.21(a)(1)(B)(iii)]**

7.2 Threatened and Endangered Species. Information required in this section will ensure that the proposed operations adhere to the Endangered Species Act of 1973, as amended, the Migratory Bird Treaty Act, as amended, the Bald and Golden Eagle Protection Act, as amended and other applicable state and federal laws. **[1773.12; 1780.16/1784.21; 1816.97/1817.97]**

7.2.1 T&E Species List. Provide a complete threatened and endangered species list for both state and federally listed species that are known to occur within the county(ies) of the proposed permit area and half a mile adjacent to the proposed boundary. Applicants should be aware that the adjacent area may be expanded based on the nature of the listed species in the area and/or as defined by consultation. The applicant is encouraged to utilize IPaC - Information for Planning and Conservation system for federal species lists. This information may be provided in Attachment 7.2.1. **[1780.16(a)(1)(B)/1784.21(a)(1)(B); 1780.16(a)(2)(A)/1784.21(a)(2)(A); 1816.97(b)/1817.97(b)]**

Indiana Bat (Myotis Sodalist) and Chuck-Wills-Widow

7.2.1.1 Likely to Occur Determination. For each threatened and endangered species listed in part 7.2.1 provide a determination based on species habitat requirements regarding the likelihood that the species may occur within the proposed permit and, if applicable, the adjacent half mile area. In addition, provide the rationale justifying the determination. If an attachment is provided, it should be titled Attachment 7.2.1.1. If multiple attachments are necessary they should be titled Attachment 7.2.1.1 - 1 of 2 etc. **[1780.16(a)(1)(B)/1784.21(a)(1)(B), 1780.16(a)(2)(A)/1784.21(a)(2)(A); 1816.97(b)/1817.97(b)]**

Williamson Energy, LLC has performed Indiana and Northern Long eared bat survey in this area. No protected bats were caught within this IBR area but the southwest portion of this IBR falls within the 2.5 mile buffer zone of an Indiana Bat roost tree capture during the 2018 bat survey by Alliance Consulting, Inc. Williamson Energy is proposing

to only cut any trees within the buffer zone during the approved Indiana Bat cutting season of October 15 through March 31.

Chuck-Wills-Widow survey was complete by HMG, Inc. (Attachment 7.2.1 2-2). The Chuck-Wills-Widow typically nest in habitat of bare dirt, leaf, or pine needle cover in dense thickets near openings is not present on this proposed IBR area. Given the lack of habitat and the plans not to disturb the surface around the stream corridors, impact to the Chuck-Wills-Widow is unlikely. Chuck-Wills-Widow, typical nesting habitat is namely bare dirt, leaf, or pine needle cover in dense thickets near openings is not present on this proposed IBR area. Given the lack of habitat and the plans not to disturb the surface around the stream corridors, impact to the Chuck-Wills-Widow is unlikely.

7.2.1.2 Format and Contents. The information presented shall be current, clear and concise, filed in the format required by the Department, and contain explicit citations. **Where required by the Department**, relevant portions of the referenced materials shall be presented by photocopying or abstracting. If references to previously approved permits are made, the relevant portions of the permits must be supplied in accordance with Operator Memorandum No. 90-08 or an explanation shall be provided below why this information is not provided. This information may be supplied as Attachment 7.2.1.3 if necessary. **[1777.11(a) and (b)]**

7.2.1.3 Agency Consultation. Discuss any additional species identified through other agency consultations as requiring protection by applicable state and federal laws. If no other species information is required indicate N/A. **[1780.16(a)(2)(C)/1784.21(a)(2)(C); 1780.16(a)(1)(b)(iii)/1784.21(a)(1)(b)(iii)]**

7.2.2 T&E Species Protection and Enhancement Plans.

7.2.2.1 Do any trees exist within the proposed permit area? **[1780.16(b)/1784.21(b)]**

☒ YES ☐ NO

If YES, the applicant shall:

- Provide a Protection and Enhancement Plan and an Incidental Take Authorization request as Attachment 7.2.2 for the Indiana bat meeting the specifications of the "Range-wide Indiana Bat Protection and Enhancement Plan Guidelines" (revised 2013) developed by the U.S. Fish and Wildlife Service and the Office of Surface Mining, or justify why a Protection and Enhancement Plan and Incidental Take authorization request are not required under those guidelines, and;

- Discuss whether or not the project is consistent with the northern long-eared bat Final 4(d) Rule for Federal Actions (January 2016), and if not then provide a Protection and Enhancement Plan and Incidental Take Authorization request consistent with the 2013 Indiana bat guidelines referenced above. This information may be provided in Attachment 7.2.2.

If NO, provide a statement regarding the absence of trees below. If the proposed permit area contains trees but these trees will remain unaffected throughout the life of the permit, this information may be relayed in the space below.

See Attachment 7.2.2 and 7.2.2 A for the Protection and Enhancement Plan, Williamson Energy has performed Indiana and Northern Long eared bat survey in this area. No protected bats were caught within this IBR area but the southern portion of this IBR falls within the 2.5 mile buffer zone of a male Indiana Bat roost tree capture during the 2018 bat survey. Williamson Energy is proposing to only cut any trees within the buffer zone during the approved Indiana Bat cutting season of October 15 through March 31. Tree removal will be limited to the extent practicable during construction of this IBR. Please note if not tree removal is completed on this project because of the boring under the wood patch around the stream, not tree girdling will be completed, but it any trees great than 3" DBH are remove then tree girdling will be completed.

Northern Long-Eared Bat 4(d) Rule Streamlined Consultation Protocol
Does the project occur wholly outside of the WNS Zone? No
Have you contacted the appropriate agency to determine if your project is near known hibernacula or maternity roost trees? Yes
Could the project alter the entrance or interior environment of a known hibernaculum? No
Does the project remove any trees within 0.25 miles of a known hibernaculum at any time of year? No
Would the project cut or destroy known occupied maternity roost trees, or any other trees within a 150-foot radius from the maternity roost tree from June 1 through July 31? No
Base on about no further action is needed to be in compliance with the Northern Long-Eared Bat 4(d) rule.

7.2.2.2 Provide Protection and Enhancement Plans for any additional state or federally listed species that are likely to occur within the proposed permit and adjacent half mile area in Attachment 7.2.2.2. For any additional federally listed threatened or endangered species that are likely to occur in the permit area, provide an Incidental Take Authorization request with the Protection and Enhancement Plan. Indicate N/A if this information is not applicable.

See Attachment 7.2.2 for the Protection and Enhancement Plan

7.2.2.3 If an applicant is in possession of any current Incidental Take Authorizations for state listed threatened or endangered species obtained through the Illinois Department of Natural Resources Office of Resource Conservation, list those species in the space below, otherwise indicate N/A.

See Attachment 7.2.2 for the Protection and Enhancement Plan

7.2.3 Eagles. The applicant shall ensure that mining activity will be conducted in a manner that will not result in the taking of a Bald or Golden Eagle, or any other raptor protected under the Bald Eagle Protection Act, and their nests or eggs. "Take" includes the disturbance of protected eagles to the degree that it substantially interferes with breeding, feeding, or sheltering behavior or results in injury. **[1816.97(c) and (d)/1817.97(c) and (d)]**

7.2.3.1 Provide current and accurate information on distances to known Bald Eagle nests within the proposed permit boundary and within a one mile radius. If none exist, then this should be specifically stated. If nests exist within a one mile radius, a Protection and Enhancement Plan must be supplied. Information should also include any species protected under the Bald Eagle Protection Act as amended and may be provided in Attachment 7.2.3.

The following resource is suggested:

National Bald Eagle Management Guidelines USFWS

N/A

7.2.4 Reporting of Threatened and Endangered and Other Identified Protected Species. Describe the steps and timeframe for reporting to the Department any state or federally listed species or other protected species **as identified through agency consultation**, should the operator become aware of the species existence within the proposed permit area. This may include, but not be limited to bald eagle nest reporting in the permit area or applicable adjacent area. **[1780.16(a)(2)(C)/1784.21(a)(2)(C); 1816.97(b)/1817.97(b)]**

See Attachment 7.2.2 and 7.2.2 A for the Protection and Enhancement Plan

7.3 General Fish and Wildlife Protection and Enhancement Measures. The applicant shall, to the extent possible and with the best technology currently available, minimize disturbances and adverse impacts on fish and wildlife and related environmental values and achieve enhancement of these resources where practicable. **[1780.16(b)/1784.21(b)]; [1816.97(a)/1817.97(a)]**

7.3.1 Protection Measures. Provide information on measures using the best technology currently available how the applicant will protect fish and wildlife and related environmental values. The following information is required: **[1780.16(b)(3)/1784.21(b)(3); 1816.97(e)/1817.97(e)]**

7.3.1.1 Electric Powerlines. If powerlines are proposed to be relocated or constructed at any point during operations, then discuss the measures to ensure electric powerlines are designed and constructed to minimize electrocution hazards and other hazards as identified by agency consultation (potentially including collisions with powerlines) to ensure that the Endangered Species Act, the Bald Eagle Protection Act, and the Migratory Bird Treaty Act have been considered and addressed where applicable. This information may be provided in Attachment 7.3.1.1 if necessary. **[1773.12; 1780.16(b)/1784.21(b); 1816.97(e)(1)/1817.97(e)(1)]**

The following are suggested resources:
"Suggested Practices for Avian Protection from Powerlines: The State of the Art in 2006"

"Reducing Avian Collisions with Power Lines: The State of the Art in 2012"

Any powerline constructed will be constructed per the suggested practice for avian protection for powerlines.

7.3.1.2 Haul and Access Roads. Describe how access and haul roads will be located and operated to avoid or minimize impacts on species protected under the Endangered Species Act, Migratory Bird Treaty Act, and the Bald Eagle Protection Act, or discuss why these protection measures are not applicable. **[1780.16(b)(3)(A)/1784.21(b)(3)(A); 1816.97(e)(2)/1817.97(e)(2)]**

Access road will be minimized length as much as possible.

7.3.1.3 Fences and Overland Conveyers. Describe how fences and overland conveyers and other potential barriers will be designed and constructed to allow passage of large mammals, or discuss why these protection measures are not applicable. **[1780.16(b)(3)(A)/1784.21(b)(3)(A); 1816.97(e)(3)/1817.97(e)(3)]**

N/A

7.3.1.4 Exclusion from Ponds. Provide information on whether or not ponds on site will contain hazardous concentrations of toxic-forming materials and if so, then describe how control measures, management techniques, and monitoring methods will be used to ensure how wildlife protected under the Endangered Species Act, Migratory Bird Treaty Act, and the Bald Eagle Protection Act are excluded from these areas. **[1780.16(b)(3)(A)/1784.21(b)(3)(A); 1816.97(e)(4)/1817.97(e)(4)]**

N/A, no ponds are proposed in this application.

7.3.2 Enhancement Measures. Provide a detailed description of enhancement measures that will be used during the reclamation and post-mining phases of operations to develop aquatic and terrestrial habitats. Measures may include but are not limited to: restoration of streams and wetlands, retention of ponds, establishment of wildlife food and cover, addition of perches or nest boxes, habitat diversification of croplands, and any other management strategies designed to enhance wildlife habitat.
[1780.16(b)(3)(b)/1784.21(b)(3)(b)]

Disturbed areas will be revegetated after the initial disturbance with a cover crop to minimize erosion. The entire disturbed area will be graded for positive drainage.
During the reclamation work, topsoil removed and stored during initial site construction, will be redistributed and graded over the exposed subsoil. The topsoil will be limed, fertilized, prepared and seeded in accordance with the following schedule:

- If the site is reclaimed in the spring season but before normal crop planting, the disturbed area will be straw mulched at 1 ½ tons/acre and seeded with a cover crop of spring oats to protect the soil until the primary planting season is under way. The site will then be planted to row crops as determined by the property owner or tenant farmer.

- If the site is reclaimed in the late fall season, the site will be seeded to a temporary cover crop of winter wheat (+/-) 1.5 Bu./Ac., and the site fertilized, and then mulched at two tons/acre, to protect the soil over the winter season.

- Thereafter, planting of agricultural crops will occur during the first available crop planting period after proper seedbed preparation has been achieved.

Alliance Consulting, Inc.
Engineers • Constructors • Scientists

Attachment 7.2.1 1-2

A SUMMER SURVEY FOR THE FEDERALLY ENDANGERED INDIANA BAT (*MYOTIS SODALIS*) AND THE THREATENED NORTHERN LONG-EARED BAT (*MYOTIS SEPTENTRIONALIS*)

POND CREEK NO. 1 MINE NORTH PANELS
WILLIAMSON COUNTY, ILLINOIS

Prepared for:

WILLIAMSON ENERGY, LLC
WILLIAMSON COUNTY, ILLINOIS

ALLIANCE PROJECT NO. B18-128-1413
REPORT DATE: DECEMBER 2018
SURVEY DATE: JULY 2018

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928 Cross Lanes Drive, Suite 300
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Telephone: (681) 217-2090
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A SUMMER SURVEY FOR THE FEDERALLY ENDANGERED INDIANA BAT (*MYOTIS SODALIS*) AND THE THREATENED NORTHERN LONG-EARED BAT (*MYOTIS SEPTENTRIONALIS*)

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A SUMMER SURVEY FOR THE FEDERALLY ENDANGERED INDIANA BAT (*MYOTIS SODALIS*) AND NORTHERN LONG-EARED BAT (*MYOTIS SEPTENTRIONALIS*)
WILLIAMSON COUNTY, ILLINOIS
WILLIAMSON ENERGY, LLC

1.0 INTRODUCTION

Alliance Consulting, Inc. (Alliance) was contracted by Williamson Energy, LLC (Williamson) to conduct a presence/absence survey of the federally endangered, Indiana bat (*Myotis sodalis*) and federally threatened northern long-eared bat (*Myotis septentrionalis*) (NLEB) at the proposed Pond Creek No. 1 Mine North Panels project area located in Williamson County, Illinois. The project is the Pond Creek No. 1 Mine North Panels (Permit No. 375). The mist net survey site locations are shown on Drawing No. B18-128-B2 contained within this submittal. This report is hereby submitted on behalf of Williamson to fulfill the requirements set forth by the USFWS and IDNR.

The bat survey was conducted by Alliance biologists from July 17-23, 2018, while tracking persisted through July 23, 2018. The bat survey services were completed in accordance with our proposal for professional ecological services and Williamson's subsequent authorization to proceed.

The purpose of the study was to confirm presence/ absence of the federally endangered Indiana bat (*Myotis sodalis*) and the federally threatened NLEB (*Myotis septentrionalis*). The survey was based on Alliance's professional judgment and interpretation of the technical criteria outlined in the USFWS (Region 3) agency document entitled "2018 Range-Wide Indiana Bat Summer Survey Guidelines", dated April 2018.

2.0 SITE LOCATION

The project area is located approximately six miles northeast of Johnston City in Williamson County, Illinois and has its approximate center at Latitude 37.856 and Longitude -88.784. Drawing No. B18-128-B1, found in the Figures Section and entitled "Project Location Map", shows the general area where the study took place.

2.1 Watershed Information

The proposed shadow area and associated facilities lie within the Pond Creek watershed in Illinois. Pond Creek flows into the Big Muddy River. The Big Muddy River, is a perennial stream which flows to the Mississippi River, which are navigable waters of the United States.

3.0 INDIANA BAT INFORMATION

3.1 Species Status and Conservation

The Indiana bat (*Myotis sodalis*) was one of the first bat species in the United States to be



recognized as endangered by the U.S. Fish and Wildlife Service Endangered Species Act (ESA). It was listed as a federally endangered species on March 11, 1967, under the ESA. This listing was largely due to declines recorded at winter hibernation sites in caves, which until very recently were the only known roosts for this species. It is now known that in summer, Indiana bats roost and rear their young under loose bark or in tree hollows. In order to outline habitat requirements, critical habitat, potential causes for the bats' decline, and recovery objectives, the USFWS published a recovery plan in 1983. An agency Draft of a Revised Recovery Plan was distributed by the USFWS in 1999. This document was re-circulated in 2002 for further comments and a first revision was available in 2007. The objectives of the Indiana Bat Recovery Plan include: (1) protect hibernacula, (2) maintain, protect, and restore summer maternity habitat, (3) monitor population trends through winter censusing, (4) educate the public, and (5) continue research. Most recently the USFWS released the "2018 Range-Wide Indiana Bat Summer Survey Guidelines" that outline the specific efforts that should be undertaken during a survey.

The Indiana bat was listed as endangered by the federal government because of declines in their numbers that were documented at seven major hibernacula in the Midwest. At the time of the federal listing, about 85% of the entire population hibernated at only seven sites, and nearly half of the entire population hibernated in only two caves. Populations across the species range (as recorded from counts in hibernacula) have declined since the late 1950s. Human disturbance, collapse, and flooding of hibernacula are considered to be major factors in the bats' population decline. Suspected contributing factors include loss of suitable summer habitat and contamination by pesticides (USFWS, 1999). Since then, steps have been taken to protect most of the major, as well as minor hibernation sites.

3.2 Distribution

The Indiana bat is a migratory species found throughout much of the eastern half of the United States. They are found from Oklahoma, Iowa, Wisconsin east to Vermont, and south to northwestern Florida (Barbour and Davis, 1969). As this species is migratory, this range includes both summer and winter habitat. During winter, the Indiana bat primarily hibernates in caves and abandoned mines. Within these hibernacula, Indiana bats congregate in tightly packed clusters and are easily counted; therefore, winter census data is the most reliable method for documenting population trends range-wide. Consequently, winter distribution of the Indiana bat is well documented. During the summer maternity season, the bats are much more scattered and difficult to locate, so there is much less known about summer distribution. Data on summer distribution may reflect lack of search effort in some areas (USFWS, 1999). Also, even less is known about the migratory habits of the Indiana bat.

3.2.1 Winter Distribution and Habitat

Indiana bats hibernate from October to April, depending on climactic conditions. Specific roost sites in caves or mines that attain temperatures appropriate for hibernation serve as winter habitat for Indiana bats. The preferred hibernacula have temperatures averaging 37 degrees to 43 degrees Fahrenheit in midwinter, and a relative humidity averaging 87 percent. The 2017 winter census estimate of the population was 559,781 individuals (USFWS, 2017). The current



population is less than half the estimated population of 1960, even though there were fewer known hibernacula at that time (USFWS, 2002). However, the populations for the state of Illinois have shown a nearly 16.5% increase in populations since 2015 with the 2017 estimate including approximately 81,444 individuals.

3.2.2 Summer Distribution and Habitat

Reproductive female Indiana bats typically form maternity colonies in trees during the summer. Most records of reproductively active females come from the Midwest: southern Iowa, northern Missouri, northern Illinois, northern Indiana, southern Michigan, and western Ohio (Gardner and Cook, 2002). This area is considered to be the core summer range for the species.

Typically, Indiana bats use the space under exfoliating bark of trees in riparian, bottomland, and upland forest to day roost in the summer. Maternity colonies of females may congregate under this loose tree bark. Because these bats are roosting mainly under exfoliating tree bark, their summer roosts are short-lived. Maternity colonies appear to have at least one "primary roost" that is used by the majority of the colony. Portions of the colony may use over a dozen different "alternate roosts" intermittently.

3.3 Reproduction

Most bats of the United States, including the Indiana bat, mate in the fall. Between early August and mid-September, Indiana bats arrive near their hibernation caves and engage in swarming and mating activity. Swarming at cave entrances continues into mid- or late October. Limited observations indicate that birth and development occur in very small, widely scattered colonies consisting of 25 or so females and their young. Females give birth to a single young in late May to early July. Young Indiana bats are capable of flight within a month of birth, and may mate their first autumn (USFWS, 2002).

3.4 Food Habits

Indiana bats forage in and around the tree canopy of flood plains, riparian areas, and upland forests (USFWS, 1999). They eat a variety of soft-bodied, flying insects found along rivers and lakes in these habitats. Consistently, food habit studies conducted throughout the species range reveal that small moths are important prey items. However, components of diet vary depending on habitat, region, season, and sex or age of the bat. Some researchers have labeled the Indiana bat as a "selective opportunist" feeder due to the abundant occurrence in the diet of one particular insect for brief, unpredictable periods, corresponding with the hatch or mating swarms (Brack and LaVal, 1985).

3.5 Reasons for Current Status

Causes for the overall decline of the Indiana bat are not fully understood or have not been determined. The decline of the species at its current rate is unknown, although it is rapid in certain areas of it range, due the onset of "white-nose syndrome". Originally, cave disturbance



by humans was thought to be the primary reason for the decline, and thought to transmit the fungus that causes "white nose" called *Pseudogymnoascus destructans*. Therefore, habitat protection for these bats has primarily focused on the caves where they hibernate, such as gating of the opening, fencing of the surrounding land, and generally protecting the hibernacula. However, as evidenced by the still-declining population numbers, these measures have not produced the desired result of recovery of the species (USFWS, 1999). Other potential causes for the decline include loss of summer habitat, improper cave gate construction, loss of forest cover, stream channelization, severe weather, and range-wide pesticide poisoning (USFWS, 2002). Presently, white-nose syndrome has devastated bat populations across the eastern United States, not excluding the already endangered Indiana bat (BCI, 2010).

4.0 NORTHERN LONG-EARED BAT INFORMATION

4.1 Species Status and Conservation

The NLEB bat is currently listed as federally threatened under the ESA due to significant population declines throughout the bat's range. This species was proposed for listing in October of 2013, and was added as a threatened species on April 2, 2015. The 4(d) rule was later developed and approved on January 14, 2016. The 4(d) rule prevents the removal of trees within ¼ mile of known hibernaculum, tree removal, or destruction of a known occupied maternity roost tree or any other trees within a 150 foot radius of a maternity roost between June 1 and July 31.

4.2 Distribution

The NLEB has an extensive range, from Canada down to North Carolina, and from the Atlantic coasts to as far west as the Yukon territory in Canada and Montana and Wyoming in the United States.

4.3 Winter Habitat

NLEBs roost over winter in hibernacula including caves and mines. These hibernacula vary from large, with large passages and entrances, to much smaller hibernacula. The hibernacula tend to have relatively constant cool temperatures ranging from 32° - 48° F. NLEBs tend to prefer higher humidity hibernacula than most other species of bats (Federal Register, 2015).

4.4 Summer Habitat

During the summer, NLEBs roost singly or in colonies under loose bark, tree crevices, or man-made structures. They will utilize a wide variety of roosts including dead or live trees, buildings, or even caves. They will utilize areas with abundant canopy cover, as well as areas with less canopy cover, which could be due to their ability to exploit roosts in cluttered environments (Federal Register, 2015).

4.5 Reproduction

Mating occurs from late July to early October. Copulation occurs in early spring, but may also

occur during the winter. They typically produce a single pup in early summer. Females form maternity colonies comprised of adult females and juveniles of up to 30 bats. The colony of females tends to give birth around the same time in late May or early June (Federal Register, 2015).

4.6 Reasons for Current Status

Limited scientific literature exists in relation to the NLEB, including its habitat, reproduction, and foraging activities. The reason for the current listed state of the NLEB is due to white nose syndrome decimating its population in many cases up to 90-100%.

5.0 METHODS

5.1 Level of Survey Effort

The level of survey effort for this project was based upon survey guidelines developed by the Indiana Bat Recovery Team (USFWS, 2018; Appendix A).

5.2 Site Selection

Using a topographic map, aerial photographs, and field reconnaissance of the proposed project area, field personnel identified areas for possible mist net site placement. Alliance corresponded with USFWS for concurrence on these projected mist net sites, prior to implementing the survey (refer to Appendix B). Actual mist net sites for the project were selected during field reconnaissance (Drawing No. B18-128-B2). Field reconnaissance was completed in order to establish mist net sites that would maximize the success of the survey. Additionally, each net site was assessed individually. Photographs were taken (Appendix E) and sketches were made of each net site to show net placement and surrounding habitat features, and habitat characteristics near each net site were recorded (Appendix C).

5.3 Mist Net Survey

Alliance conducted the mist netting survey following the guidelines (Appendix A) outlined in the 2018 Range Wide Indiana Bat Summer Survey Guidelines. Mist nets were composed of 2-ply, 50-denier nylon construction with a mesh size of 38 mm. Mist net sizes were 2.6 to 7.8 m high (approximately 9 to 27 feet) in height, and were 2.6, 6, 9, 12 or 18 m (approximately 9, 20, 30, 36 or 54 feet) in width.

Nine (9) sites were proposed; however, only four (4) sites were operated due to an Indiana bat being captured at Site 01. The three (3) sites were surveyed for endangered bats by Alliance biologists on July 17-23, 2018. Four (4) or five (5) net sets were each operated for two calendar nights at each site. This resulted in a total of 22 net nights of the proposed 81 for the entire survey. A "net night" is defined as the operation of one net set for one night. To the extent possible, nets were placed in a location where they would be bordered on top and sides by vegetation to create a funneling effect to facilitate the capture of bats. Mist nets were deployed at dusk (approximately 20:00 hours) and monitored every 10 minutes for at least five hours.



It is not recommended that Indiana bat surveys be conducted when temperatures drop below 50 degrees Fahrenheit or during rainy, foggy, or windy conditions (USFWS, 2018). To ensure that surveys were not conducted during inclement weather, temperature, wind speed, percent cloud cover, rainfall and moon phase were monitored and recorded during the survey (Appendix C).

Captured bats were carefully removed from the nets and then identified. The age, sex, reproductive condition, weight, and forearm length were then determined and recorded for all bats. Any notable bands, parasites or deformities were also recorded. After all information had been collected, the bats were released at the site of capture.

5.4 Telemetry

Alliance biologists used Lotek PicoPip Ag337 (Bat) transmitters in the 172 MHz range. Each transmitter weighed 0.3 grams or less and had a transmitter life expectancy of 8 days. When an endangered bat was captured the transmitter was activated by removing the magnetic switch and tested for signal quality at 500 meters. Field Marshall 1000 telemetry receivers paired with folding 3 element Yagi directional antennas from Marshall Telemetry were used to locate and track the activated transmitters. The active and tested transmitter was then affixed to the back of the bat using Perma-Type Surgical Cement. Once the adhesive was dry the bat was released in a relative open area so the biologist could ensure that the bat flew unimpeded.

Once a transmitted bat was released the biologist monitored its activity to obtain a direction of flight from the release point and to ensure that the bat was active. Following release of a transmitted bat and upon verification that the bat was flying unimpeded, a telemetry crew of 2 to 4 biologists would search for the transmitter frequency. Once the transmitter frequency was located its general position was triangulated using a compass and handheld gps unit.

The biologist then proceeded to hone in on the transmitter frequency until they found the exact tree that the radio signal was coming from. The determination of the roost tree was confirmed by circling the tree and approaching the tree from multiple angles with the telemetry receivers. If the transmitter frequency was not located, the telemetry crew would begin searching for the bats and continue for a minimum of four hours.

5.5 Roost Tree Emergence Survey

Once a roost tree was identified and its location was recorded with a sub-meter gps unit the biologists would record the tree DBH, height, percent of exfoliating bark, approximate location on the tree of the transmitter, species of tree, and solar exposure. The biologists would then leave the area to keep disturbance to a minimum around the roost tree. The biologists would then return to the roost tree approximately half an hour before sunset. They would approach quietly to the general area of the roost tree and check that the radio signal was still present. The biologists would then find a place where they could see the most actual roosting locations on the tree with the sky as a backdrop. If multiple roosting locations or debris were encountered then the biologists would split up to cover multiple angles of observation.



Each biologist watched the roost tree to document the total number of bats that emerged, as well as when the first bat emerged, when the transmitted bat emerged, and when the final bat emerged. The biologists stayed in position until they could no longer see the roost tree due to darkness.

Each transmitted bat was tracked for a minimum of seven days. Each identified roost tree was surveyed for a minimum of two evenings.

6.0 RESULTS

6.1 Summer Habitat Survey

From July 17-23, 2018, Alliance biologists evaluated the project area for potential Indiana bat summer habitat. The forested areas were dominated by an overstory of box elder (*Acer negundo*), American sycamore (*Platanus occidentalis*), and silver maple (*Acer saccharinum*). The area is covered with a mixed mesophytic forest of primarily second or third growth timber and several large snags including potential and known roost trees.

6.2 Mist Net Survey

Mist nets were set primarily along stream channels through forested areas, as well as forest/field interfaces and ponds. Old roads and stream corridors provide foraging areas or travel corridors for bats as they move between roosts and feeding areas. Streams and ponds attract insects and provide drinking areas as well. The forest/field interfaces offer some protection for the bats while flying from field to field, as well as providing foraging areas.

6.3 Pond Creek No. 1 Mine North Panels Results

A total of 31 bats of three species were captured during the 22 net nights of effort for the Pond Creek No. 1 Mine North Panels. Two federally listed endangered Indiana bats were captured during survey efforts. The eastern red bat (*Lasiurus borealis*) was the species most commonly encountered, making up 80.6 percent of the total capture (Table No. 1). Other species captured included the tri-colored bat (*Perimyotis subflavus*) and the Indiana bat (*Myotis sodalis*). Refer to Table No. 1. Bat survey forms were completed for each night of mist netting and can be found in Appendix E. Representative photographs of bat species caught in the project area and representative photographs at the bat roosts are located in Appendix D.

Table No. 1 – Pond Creek No. 1 Mine North Panels

Site	Eastern Red Bat	Tri-colored Bat	Indiana Bat	Total
1	5	4	1	10
2	5	0	1	6
3*	0	0	0	0

Site	Eastern Red Bat	Tri-colored Bat	Indiana Bat	Total
4*	0	0	0	0
5*	0	0	0	0
6*	0	0	0	0
7	8	0	0	8
8	7	0	0	7
9*	0	0	0	0
Total	***25***	***4***	***2***	***31***
% Total	***80.6***	***12.9***	***6.5***	

*Site not operated due to it being within a 2.5 mile Indiana bat buffer.

6.5 Telemetry and Tracking

The mist net surveys for the Pond Creek No. 1 Mine North Panels project that Alliance conducted included the capture of two Indiana bats (Table No. 2). One of the captured bats was an adult lactating female and another was an adult non-reproductive male. A radio transmitter was affixed on the captured Indiana bats. Both of the captured bats were banded (Table No. 2). The frequency of the radio transmitter utilized is included in Table No. 2.

Table No. 2 Tracking Summary

Species	Age/Sex/Condition	Transmitter Frequency	Capture Site	Band Number
Myotis sodalis	Adult/Female/ Lactating	172.413	01	A0024
Myotis sodalis	Adult/Male/Non-Reproductive	172.636	02	A0026

Bat 172.413 was captured and tracked from July 15 through July 23, 2018. The first night it was tracked, Alliance biologist tracked all night until they could no longer locate the bat. On July 16th, the bat could not be located during the day, but was located at night and tracked to its roost on July 17th (Roost 01). It was located in the same roost on July 18th (Roost 01). It was located in a new roost on July 19th (Roost 02). On July 20th, the bat was located in the same roost as the previous night (Roost 02). On July 21st, Bat 172.413 was located in a third roost (Roost 03). On July 23rd, the bat could not be located.

Bat 172.636 was captured and tracked on July 18, 2018. It was tracked from July 18th through July 24th. On July 18th, the bat was tracked through the night, and its roost was identified on July 19th (Roost 01). On July 20th, it was located in a new roost (Roost 02). On July 21st, the bat was located back in its first roost (Roost 01). Bat 172.636 remained in the same tree until July 24th, when tracking concluded.

6.6 Roost Emergence

The tracking efforts for Bat 172.413 were carried out from July 15, 2018 through July 23, 2018. Bat 172.413 used three different roosts over that time. Roost 01 was watched on July 17th and 18th. Roost 02 was watched on July 19th and 20th, and Roost 03 was watched on July 21st and 23rd. The results of the emergence counts for Bat 172.413 have been summarized in Table No. 3 below. Roost and emergence data sheets can be found in Appendix D. Photographs of the roosts can be found in Appendix D as well. Locations of the roosts can be found in the Figures section (Drawing No. B18-128-B3).

The tracking efforts for Bat 172.636 were carried out from July 18, 2018 through July 24, 2018. Bat 172.636 used two different roosts during that time. Roost 01 was watched on July 19th and 21st, and Roost 02 was watched on July 20th and July 21st. The results of the emergence counts for Bat 172.636 have been summarized in Table No. 4 below. Roost and emergence data sheets can be found in Appendix D. Photographs of the roosts can be found in Appendix D as well. Locations of the roosts can be found in the Figures section (Drawing No. B18-128-B3).

Table No. 3 Bat 172.413 Emergence Counts

Date:	Roost 01	Roost 02	Roost 03
7/17/2018	56	--	--
7/18/2018	52	--	--
7/19/2018	--	27	--
7/20/2018	--	43	--
7/21/2018	--	--	47
7/23/2018	--	--	40
Average:	54	33.5	43.5

Table No. 4 Bat 172.636 Emergence Counts

Date:	Roost 01	Roost 02
7/19/2018	1	--
7/20/2018	--	1
7/21/2018	1	0
Average:	1	1

7.0 DISCUSSION

7.1 Bats Captured

Weather conditions at the project area were within the limits to conduct an Indiana bat survey. The eastern red bat was the most common species captured during survey efforts. Other bats captured included the tri-colored bat and the Indiana bat.

The eastern red bat (*Lasiurus borealis*) was the most abundant species of bat captured during the survey when evaluated cumulatively (80.6%). Its distribution includes southern Canada, the eastern United States (except the Florida peninsula), and northeastern Mexico (Harvey et al.,



1999). In colder parts of their range, they are known to migrate south in winter or hibernate in hollow trees or leaf litter. The eastern red bat is common throughout most of its range.

Tri-colored bats (*Perimyotis subflavus*) were also captured in the project area. These are one of the most common bats within their range, which includes eastern Canada, most of the eastern United States, and southward through eastern Mexico to Central America (Harvey et al., 1999).

Myotis sodalis, the Indiana bat, was also captured within the project area. The Indiana bat was one of the first bat species in the United States to be recognized as endangered by the U.S. Fish and Wildlife Service Endangered Species Act (ESA). This bat spends the winter at hibernation sites in caves, which, until very recently, were the only known roosts for this species. It is now known that in summer, Indiana bats roost and rear their young under loose bark or in tree hollows. Indiana bats forage in and around the tree canopy of flood plains, riparian areas, and upland forests (USFWS, 1999). They eat a variety of soft-bodied, flying insects found along rivers and lakes in these habitats. Consistently, food habit studies conducted throughout the species range reveal that small moths are important prey items. However, components of diet vary depending on habitat, region, season, and sex or age of the bat.

It should be noted that no NLEBs (*Myotis septentrionalis*) were captured during this project. The NLEB has been listed as threatened.

No open mine portals or other potential hibernacula were observed in the proposed project area by Alliance or reported by Williamson personnel.

In preparing this document, our professional services have been performed with the care and skill ordinarily exercised by reputable members of the profession practicing under similar conditions at the same time and the same or similar locality. No warranty, expressed or implied, is made or intended by rendition of these consulting services or by furnishing oral or written reports of the findings made. We reserve the right to revise or amend our opinion in this report in the event new information, documentation or evidence becomes available.

Respectfully submitted,

ALLIANCE CONSULTING, INC.

Alex J. Patterson
Staff Scientist

Braden A. Hoffman
Senior Project Manager

AJP/BAH:kjs

File: \\Aci-zeus\projects\Projects\Williamson Energy (1413)\2018\B18-128-1413\Bat Report\Report.doc

8.0 LITERATURE CITED

Barbour, R.W. and W.H. Davis. 1969. Bats of America. University Press Kentucky, Lexington. 286 pp.

BCI (Bat Conservation International). 2007. Species profiles. http://batcon.org.

BCI (Bat Conservation International). 2010. What We DO/White-Nose Syndrome. http://batcon.org.

Brack, W., Jr., and R.K. LaVal. 1985. Food habits of the Indiana bat in Missouri. Journal of Mammalogy. 66:308-315.

Braun, E.L. 1950. Deciduous forests of eastern North America. The Blackburn Press, Caldwell, New Jersey. 596 pp.

Federal Register. 2015. Endangered and Threatened Wildlife and Plants: Threatened Species Status for the Norther Long-Eared Bat with 4(d) Rule. Accessed December 3, 2018. http://www.federalregister.gov.

Gardner and Cook. 2002. Seasonal and geographic distribution and quantification of potential summer habitat. Bat Conservation International. Austin, Texas.

Harvey, M.J., J.S. Altenbach, and T.L. Best. 1999. Bats of the United States. Arkansas Game & Fish Commission. 64 pp.

U.S. Fish and Wildlife Service (USFWS). 1999. Agency Draft: Indiana Bat (*Myotis sodalis*) Revised Recovery Plan. Region 3 U.S. Fish and Wildlife Service, Ft. Snelling, Minnesota. March 1999.

U.S. Fish and Wildlife Service (USFWS). 2002. Indiana bat (*Myotis sodalis*) revised recovery plan, Agency Draft. Ft. Snelling, Minnesota. 69 pp.

U.S. Fish and Wildlife Service (USFWS). 2007. Indiana Bat (*Myotis sodalis*) Draft Recovery Plan: First Revision. Region 3 U.S. Fish and Wildlife Service. Fort Snelling, Minnesota. 258 pp.

U.S. Fish and Wildlife Service (USFWS). 2014. 2014 Rangewide Indiana Bat Summer Survey Guidelines. http://www.fws.gov/northeast/virginiafield/pdf/endspecies/2014_IBat_Summer_Survey_Guidelines.pdf

U.S. Fish and Wildlife Service (USFWS). 2018. 2018 Rangewide Population Estimate for the Indiana Bat (*Myotis sodalis*) by USFWS Region. Accessed December 5, 2018 at www.fws.gov.

USGS. 2006. *Indiana bats.*
http://biology.usgs.gov/s+t/frame/c164.htm#10816 accessed July 24, 2006.

APPENDIX A

MIST NETTING GUIDELINES RATIONALE

(AS CONTAINED WITHIN APPENDIX B OF 2018 INDIANA BAT SUMMER SURVEY GUIDANCE)

APPENDIX B: PHASE 2 or 3 MIST-NETTING

Mist-netting can be used as a presence/probable absence method (Phase 2 surveys) or it can be conducted for the purpose of attempting to capture Indiana bats after detection during acoustic presence/probable absence surveys (Phase 3 surveys). The same recommendations (e.g., season, personnel, equipment, net placement, checking nets) apply for either use of mist-netting surveys.

SUMMER MIST-NETTING SEASON: May 15[29] – August 15[30]

Capture of reproductive adult females (i.e., pregnant, lactating, or post-lactating) and/or young of the year during May 15 – August 15 confirms the presence of a maternity colony in the area. Since adult males and non-reproductive females have commonly been found summering with maternity colonies, radio-tracking results will be relied upon to help determine the presence or absence of a maternity colony or large concentrations of bats in the area when only males and/or non-reproductive females are captured.

PERSONNEL

A qualified biologist(s)[31] must (1) select/approve mist-net set-ups in areas that are most suitable for capturing Indiana bats, (2) be physically present at each mist-net site throughout the survey period, and (3) confirm all bat species identifications. This biologist may oversee other biological technicians and manage mist-net set-ups in close proximity to one another as long as the net-check timing (i.e., every 10 minutes) can be maintained while **walking** between nets.

COORDINATION WITH USFWS FO(s)

If not already required by federal permit, we recommend that applicants submit a draft study plan for all survey phases to the USFWS FO(s) for review and approval. Study plans should include a map/aerial photo identifying the proposed project area boundaries, suitable bat habitats and acreages within the project area, and the proposed number and tentative locations of net sites.

EQUIPMENT

Use the finest, lowest visibility mesh mist-nets commercially available, as practicable. Currently, the finest net on the market is 75 denier, 2 ply, denoted 75/2 (Arndt and Schaetz 2009); however, the 50 denier nets are still acceptable for use at this time. The finest mesh size available is approximately 1½ inches (38 millimeters).

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[29] Due to concerns with transmission of white-nose syndrome, some USFWS FO(s) and state natural resource agencies have delayed the start of the Indiana bat summer field survey season/mist-netting until June 1. Surveyors/applicants should always coordinate with local USFWS FO(s) and state natural resource agencies before beginning surveys.

[30] With prior USFWS FO approval, a survey may be completed after August 15 if it was initiated in time to be completed by August 15 and extenuating weather circumstances resulted in delaying completion. Delays as a result of not meeting the acceptable weather requirements are the ONLY valid justification for surveying after August 15.

[31] A qualified biologist is an individual who holds a USFWS Recovery Permit (Federal Fish and Wildlife Permit) for Indiana bats in the state/region in which they are surveying and/or has been authorized by the appropriate state agency to net and handle Indiana bats. Several USFWS offices maintain lists of qualified bat surveyors, and if working in one of those states with authorizations in lieu of a Recovery Permits, the individual will either need to be on that list or submit qualifications to receive USFWS approval prior to conducting any field work.

APPENDIX B: PHASE 2 or 3 MIST-NETTING

No specific hardware is required. There are many suitable systems of ropes and/or poles to hold nets. The system of Gardner et al. (1989) has been widely used. See NET PLACEMENT for minimum net heights, habitats, and other netting requirements that affect the choice of hardware.

To minimize potential for disease transmission, any equipment that comes in contact with bats should be kept clean and disinfected, following approved protocols; this is particularly a concern relative to white-nose syndrome (WNS). Disinfection of equipment to avoid disease transmission (e.g., WNS) is required; protocols are posted at http://www.whitenosesyndrome.org/. Federal and state permits may also have specific equipment restrictions and disinfection requirements.

MINIMUM PRESENCE/ABSENCE MIST-NETTING LEVEL OF EFFORT (PHASE 2)

The level of netting survey effort required for a non-linear project will be dependent upon the overall acreage of suitable habitat that may be impacted by the action (directly or indirectly). To determine the survey effort, quantify the amount of suitable summer habitat within the project area. **NOTE**: for projects where other impacts than tree removal are likely (e.g., collision), ensure that presence/probable absence surveys are designed to cover all suitable habitat within the entire project area (where exposure to any kind of impacts may be anticipated) and NOT just the locations where tree removal is planned. Additional guidance for linear project is in Appendix F.

Conduct Mist-Netting Surveys following Recovery Unit-based protocols[32] (See Figures 1 and 2)

Northeast and Appalachian Recovery Units (CT, DE, MA, MD, NC, NJ, NY, PA, eastern TN, WV, VA, VT):

Linear projects: a minimum of 3 net nights per km (0.6 miles) of suitable summer habitat (see Appendix F).

Non-linear projects: a minimum of 42 net nights per 123 acres[33] (0.5 km^2) of suitable summer habitat.

For example:

- 7 sites[34], 2 nets[35]/site for 3 calendar nights = 42 net nights
- 7 sites, 3 nets/site for 2 calendar nights = 42 net nights
- 3 sites, 2 nets/site for 7 calendar nights* = 42 net nights

[32] The Indiana bat populations in the Northeast and Appalachian Recovery Units (RUs) have been more heavily impacted by white-nose syndrome; therefore, we recommend higher survey effort in these RUs than the Midwest and Ozark-Central RUs.

[33] We have no recommendations for reducing the minimum level of effort required to demonstrate probable absence for projects <123 acres in size. Detection probabilities and occupancy estimates were derived from past survey efforts that used the same acreage threshold (see Niver et al. 2013).

[34] A site is defined as a geographic area to be sampled. It can include one or more nets that can be managed by one Qualified Biologist.

[35] A net is defined as any combination of individual panels and poles (e.g., single, double, triple high) to fill the area (e.g., corridor) being sampled.

APPENDIX B: PHASE 2 or 3 MIST-NETTING

Maximum of 3 nights of consecutive netting at any given net location. After 3 consecutive nights of netting at the same location, you must change net locations or wait at least 2 calendar nights before resuming netting at the same location.

a) If no capture of Indiana bats, then no further summer surveys are necessary[36].
b) If capture of Indiana bat(s), then stop or proceed to **Phase 4** as previously decided in coordination with the FO(s).

Midwest and Ozark-Central Recovery Units (AL, AR, GA, IA, IL, IN, KY, MI, MO, MS, OH, OK, and central & western TN):

Linear projects: a minimum of 2 net nights per km (0.6 miles) of suitable summer habitat (see Appendix F).

Non-linear projects: a minimum of 9 net nights per 123 acres (0.5 km^2) of suitable summer habitat.

- 3 sites, 1 net/site for 3 calendar nights = 9 net nights
- 1 site, 3 nets/site for 3 calendar nights = 9 net nights

Maximum of 3 nights of consecutive netting at any given net location. After 3 consecutive nights of netting at the same location, you must change net locations or wait at least 2 calendar nights before resuming netting at the same location.

a) If no capture of Indiana bats, then no further summer surveys are necessary.
b) If capture of Indiana bat(s), then stop or proceed to **Phase 4** as previously decided in coordination with the FO(s).

MIST-NETTING SURVEYS TO CAPTURE INDIANA BATS AFTER ACOUSTICS WERE USED AS P/A METHOD (PHASE 3)

If netting was not conducted as the P/A method, then netting may be conducted to capture and characterize (e.g., sex, age, reproductive condition) the Indiana bats (documented through the Phase 2 acoustic P/A survey) present in an area and to facilitate radio-tracking (Phase 4) efforts. We encourage working with the FO(s) to develop Phase 3 netting plans based on best available information (e.g., positive acoustic locations). There are no minimum requirements for this phase as this is not a P/A phase.

a) If no Indiana bats are captured, then coordinate with the USFWS FO.
b) If Indiana bats are captured, then proceed to **Phase 4** as previously decided in coordination with the FO(s).

[36] NOTE: For Phase 2 Presence/Absence Surveys, wherever the phrase "no further summer surveys are necessary" occurs within this document, the USFWS FO(s) is in affect assuming probable absence of Indiana bats during the summer.

APPENDIX B: PHASE 2 or 3 MIST-NETTING

NET PLACEMENT

Potential travel corridors (e.g., streams, logging trails) typically are the most effective places to net (although other places may also be productive; see Carroll et al. 2002). Place nets approximately perpendicular across the corridor. Nets should fill the corridor from side to side, extending beyond the corridor boundaries when possible, and from stream (or ground) level up to the overhanging canopy. Nets of varying widths and heights may be used as the situation dictates. A typical set is at least 5 m to 9 m high consisting of two or more nets stacked on top one another and from 6 m to 18 m wide. If netting over water, ensure there is enough space between the net and the water so that captured bats will not get wet.

Occasionally it may be necessary or desirable to net where a suitable corridor is lacking. The typical equipment described in the section above may be inadequate for these situations, requiring innovation on the part of the surveyor (see Humphrey et al. 1968). See Kiser and MacGregor (2005) for additional discussion about net placement.

Although no minimum spacing between mist-nets is being specified, surveyors should attempt to evenly distribute net set-ups throughout suitable habitat and must provide written justification in their report if net set-ups were not distributed throughout suitable habitat (i.e., why were they clumped?). Net set-ups can be repeatedly sampled throughout the project, but generally no more than 2-3 nights at a single location is recommended. In addition, changing locations within a project area may improve capture success (see Robbins et al. 2008; Winhold and Kurta 2008). Photo-document placement of nets.

SURVEY PERIOD

The survey period for each net shall begin at sunset[37] and continue for at least 5 hours (longer survey periods may also improve success).

CHECKING NETS

Each net set-up should be checked approximately every 10 minutes (Gannon et al. 2007). If surveyors monitor nets continuously, take care to minimize noise, lights and movement near the nets. Monitoring the net set-up continuously with a bat detector (ideally using ear phones to avoid alerting bats) can be beneficial: (a) bats can be detected immediately when they are captured, (b) prompt removal from the net decreases stress on the bat and potential for the bat to escape (MacCarthy et al. 2006), and (c) monitoring with a bat detector also allows the biologist to assess the effectiveness of each net placement (i.e., if bats are active near the net set-up but avoiding capture), which may allow for adjustments that will increase netting success on subsequent nights. There should be no other disturbance near the nets, other than to check nets and remove bats. Biologists should be prepared to cut the net if a bat is severely entangled and cannot be safely extracted within 3 or 4 minutes (CCAC 2003; Kunz et al. 2009).

[37] Surveys may need to start a little earlier or later than official sunset times (i.e., at "dusk") in some settings such as a deep/dark forested valleys or ridge tops to avoid missing early-flying bats or capturing late-flying birds, respectively. Sunset tables for the location of survey can be found at: http://aa.usno.navy.mil/data/docs/RS_OneYear.php.

APPENDIX B: PHASE 2 or 3 MIST-NETTING

Capture and handling are stressful for bats. Emphasis should be on minimizing handling and holding bats to as short a time as possible to achieve field study objectives. Indiana bats should not be held for more than 30 minutes after capture, unless the individual is targeted for radio-tracking. Bats targeted for radio-tracking should be released as quickly as possible, but no longer than 30 minutes[38] after capture, or as allowed in federal and state permits. See Kunz and Kurta (1988) for general recommendations for holding bats.

WEATHER, LIGHTING, AND OTHER ENVIRONMENTAL CONDITIONS

Severe weather adversely affects capture of bats. Some Indiana bats may remain active despite inclement weather and may still be captured while others in the same area become inactive. Therefore, negative surveys combined with any of the following weather conditions throughout all or most of a sampling period are likely to require an additional night of mist-netting[39]: (a) temperatures that fall below 50°F (10°C)[40]; (b) precipitation, including rain and/or heavy fog, that exceeds 30 minutes or continues intermittently during the survey period; and (c) sustained wind speeds greater than 9 miles/hour (4 meters/seconds; 3 on Beaufort scale) for 30 or more minutes.

NOTE: Provided that nets are not dripping wet, surveyors can resume netting to meet the minimum 5-hour requirement after short periods of adverse weather. If nets are under good cover, light rain may not alter bat behavior. However, if no bats are being captured during marginal weather, coordinate with the USFWS FO(s).

It is typically best to place net set-ups under the canopy where they are out of moonlight, particularly when the moon is half-full or greater. Net set-ups illuminated by artificial light sources should also be avoided.

The shining of lights, and noise should be kept to a minimum with no smoking around the survey sites. In addition, the use of radios, campfires, running vehicles, punk sticks, citronella candles and other disturbances will not be permitted within 300 feet of mist nets (or acoustic detectors) during surveys.

DOCUMENTATION OF INDIANA BAT CAPTURES

If an Indiana bat(s) is captured during mist-netting, protocols for radio-tracking and emergence survey requirements, as provided in Appendix D and E, respectively, should be followed. In addition, the appropriate USFWS FO(s) must be notified of the capture within 48 hours (or in accordance with permit conditions), and the sex and reproductive condition of the bat and GPS coordinates of the capture site should be provided. Ensure GPS coordinates are recorded for each individual net set on datasheets.

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[38] Current standard federal Section 10 bat permit conditions require prior written approval from the Field Supervisor in the USFWS FO(s) if capture times may exceed 30 minutes.

[39] With prior USFWS FO approval, a survey may be completed after August 15 if it was initiated in time to be completed by August 15 and extenuating weather circumstances resulted in delaying completion. Delays as a result of not meeting the acceptable weather requirements are the ONLY valid justification for surveying after August 15.

[40] If using this guidance for NLEB: Overnight survey temperatures may be lower in northern portions of the NLEB range, please coordinate with the local USFWS FO in the northern portion of the range for any variation in temperature requirements.

APPENDIX B: PHASE 2 or 3 MIST-NETTING

Several species of bats from the genus *Myotis* share common features which can make identification difficult; Indiana bats and little brown bats (*Myotis lucifugus)* can be particularly difficult to distinguish. Photo-documentation of all bats captured and identified as Indiana bats and the first 10 little brown bats per project are requested to verify the identifications made in the field.

Photo-documentation should include diagnostic characteristics:

- a ¾-view of face showing ear, tragus, and muzzle
- view of calcar showing presence/absence of keel
- a transverse view of toes showing extent of toe hairs

If a bat from the genus *Myotis* is captured during mist netting that cannot be readily identified to the species level, then species verification may be attempted through fecal DNA analysis. Collect one or more fecal pellets (i.e., guano) from the bat in question by placing it temporarily in a holding bag (15 minutes is usually sufficient, no more than 30 minutes is recommended). The pellet (or pellets) collected should be placed in a small vial (e.g., 1.5 ml) with silica gel desiccant; pellets from each individual bat should be stored in separate vials and out of direct light. Fees charged by independent laboratories for sequencing fecal DNA samples is generally inexpensive (approx. $50 per guano sample), however, it has been challenging to identify labs willing to consistently conduct these analyses. Any additional information and a list of available laboratories will be made available on the Indiana bat webpage on the USFWS's Region 3 website (http://www.fws.gov/midwest/Endangered/mammals/inba/index.html).

SUBMISSION OF MIST-NETTING RESULTS

Provide results of netting surveys to the appropriate USFWS FO(s) in accordance with previously agreed upon[41] timeframes and formats[42]. If Indiana bats are captured, this report should also include the results of subsequent radio-tracking and emergence counts. Reports should include the following:

1. Copy of prior phase reports (if not previously provided).
2. Explanation of any modifications from original survey plan (e.g., altered net locations).[43]
3. Description of net locations (including site diagrams), net set-ups (include net heights), survey dates, duration of surveys, weather conditions, and a summary of findings.
4. Map identifying netting locations and information regarding net set-ups, including lat/long or UTM, individual net placement, net spacing (i.e., include mist-netting

[41] As discussed in the Introduction, we encourage coordination with USFWS FO(s) prior to implementation of any surveys to ensure that all parties agree upon the need for surveys, the methods proposed, and the decisions from various survey results.

[42] In 2016, the USFWS implemented a new standardized approach for reporting of bat survey data. In addition to a traditional written report, federal permit holders are now required to submit their survey data using the standardized permit reporting spreadsheets available on the R3 Indiana Bat Summer Survey Guidance webpage (http://www.fws.gov/midwest/Endangered/mammals/inba/inbasummersurveyguidance.html).

[43] If the USFWS previously agreed upon the study plan we need to understand whether the revised work still accomplished the agreed upon methods

equipment in photographs of net locations), and adequate justification if net set-ups are not evenly distributed across suitable habitat within the project area.

5. Full names of mist-netting personnel attending each mist-net site during an operation, including the federally-permitted/qualified biologist present at each mist-net site. Indicate on the field data sheet the full name of person who identified bats each night at each site.
6. Legible copies of all original mist-netting datasheets (see example datasheet below) and a summary table with information on all bats captured during the survey including, but not limited to: capture site, date of capture, time of capture, sex, reproductive condition, age, weight, right forearm measurement, band number and type (if applicable), and Reichard's wing damage index score (Reichard and Kunz. 2009).
7. Photographs of all net set-ups, as well as **all** Indiana bats and the first 10 little brown bats captured from each project, so that the placement of netting equipment and identification of species can be verified. Photographs of bats should include all diagnostic characteristics that resulted in the identification of the bat to the species level.
8. Any other information requested by the local USFWS FO(s) related to the project.

REFERENCES

Arndt, R.J. and B.A. Schaetz. 2009. A tale of two deniers: nylon versus polyester mist nets. Bat Research News 50(3):57.

Carroll, S.K., T.C. Carter, and G.A. Feldhamer. 2002. Placement of nets for bats: effects on perceived fauna. Southeastern Naturalist 1:193-198.

Canadian Council on Animal Care (CCAC). 2003. CCAC species-specific recommendations on bats. 9pp. Available at: http://www.ccac.ca/en/CCAC_Programs/Guidelines_Policies/GDLINES/BatsFinal20May03.htm (Accessed October 30, 2008).

Gannon, W.L., R.S. Sikes, and the Animal Care and Use Committee of the American Society of Mammologists. 2007. Guidelines of the American Society of Mammologists for the use of wild mammals in research. Journal of Mammalogy 88:809-823.

Gardner, J. E., J.D. Garner, and J.E. Hofmann. 1989. A portable mist-netting system for capturing bats with emphasis on *Myotis sodalis* (Indiana bat). Bat Research News 30:1-8.

Humphrey, P.S., D. Bridge, and T.E. Lovejoy. 1968. A technique for mist-netting in the forest canopy. Bird-Banding 39(1): 43-50.

Kiser, J.D. and J.R. MacGregor. 2005. Indiana bat (*Myotis sodalis*) mist net surveys for coal mining activities. Pp. 169-172 *in* K.C. Vories and A. Harrington (eds.), The Proceedings of the Indiana bat and coal mining: a technical interactive forum Office of Surface Mining, U.S.

Department of the Interior, Alton, IL. Available at: http://www.mcrcc.osmre.gov/MCR/Resources/bats/pdf/Indiana_Bat_and_Coal_Mining.pdf. (Accessed October 06, 2011).

Kunz, T.H. and A. Kurta. 1988. Capture methods and holding devices. Pp. 1-29 *in* T.H. Kunz (ed.), Ecological and behavioral methods for the study of bats. Smithsonian Institution Press, Washington, D.C.

Kunz, T.H., R. Hodgkison, and C.D. Weise. 2009. Methods of capturing and handling bats. Pp. 3-35 *in* T.H. Kunz and S. Parsons (eds.), Ecological and behavioral methods for the study of bats, second edition. The Johns Hopkins University Press, Baltimore, Maryland.

MacCarthy, K.A., T.C. Carter, B.J. Steffen, and G.A. Feldhamer. 2006. Efficacy of the mist-net protocol for Indiana bats: A video analysis. Northeastern Naturalist 13:25-28.

Reichard, J.D., and T.H. Kunz. 2009. White-nose syndrome inflicts lasting injuries to the wings of little brown myotis (Myotis lucifugus). Acta Chiropterologica 11: 457-464.

Robbins, L.W., K.L. Murray, and P.M. McKenzie. 2008. Evaluating the effectiveness of the standard mist-netting protocol for the endangered Indiana bat (*Myotis sodalis*). Northeastern Naturalist 15:275-282.

Winhold, L. and A. Kurta. 2008. Netting surveys for bats in the Northeast: differences associated with habitat, duration of netting, and use of consecutive nights. Northeastern Naturalist 15:263-274.

APPENDIX B

REQUIRED PERMITS

NATIVE ENDANGERED & THREATENED SP. RECOVERY
ENDANGERED & THREATENED WILDLIFE

Permit Number: TE06801A-5

Effective: 03/29/2018 Expires: 12/31/2018

Issuing Office:

Department of the Interior
U.S. FISH & WILDLIFE SERVICE
Endangered Species Permit Office
5600 American Boulevard, West, Suite 990
Bloomington, MN 55437-1458
permitsR3ES@fws.gov

Laura J. Rogers
Acting
CHIEF - ENDANGERED SPECIES

Permittee:

PITTSBURGH WILDLIFE & ENVIRONMENTAL, INC.
dba PWE
853 BEAGLE CLUB ROAD
MCDONALD, PA 15057
U.S.A.

Name and Title of Principal Officer:
NEIL R. BOSSART - PRESIDENT

Authority: Statutes and Regulations: 16 USC 1539(a), 16 USC 1533(d); 50 CFR 17.22, 50 CFR 17.32, 50 CFR 13.

Location where authorized activity may be conducted:
'N LANDS SPECIFIED IN THE CONDITIONS AND AUTHORIZATIONS

Reporting requirements:
ANNUAL REPORT DUE: 01/31
See permit conditions for reporting requirements

Authorizations and Conditions:

A. General Conditions set out in Subpart B of 50 CFR 13, and specific Conditions contained in Federal regulations cited above, are hereby made a part of this permit. All activities authorized herein must be carried out in accord with and for the purposes described in the application submitted. Continued validity, or renewal of this permit is subject to complete and timely compliance with all applicable Conditions, including the filing of all required information and reports.

B. The validity of this permit is also conditioned upon strict observance of all applicable foreign, state, local, tribal, or other Federal law.

C. Valid for use by those identified in the List of Authorized Individuals.

C.1. Authorized Individuals:

Only individuals on the attached List of Authorized Individuals (LAI) are authorized to conduct activities pursuant to this permit. The LAI, printed on U.S. Fish and Wildlife Service (USFWS) letterhead, and signed and dated by the Region 3 permit issuing office or a Region 3 lead species Field Office Supervisor, may identify special Conditions or circumstances under which individuals can conduct authorized activities and it must be retained with these Conditions and Authorizations. Each named

individual shall be responsible for compliance with the Conditions and Authorizations of this permit.

Trained assistants not named on the attached LAI may work on permitted activities under the direct and on-site supervision of the individuals named on the LAI. "On-site supervision" is defined as having the Permittee at a distance close enough to enable immediate assistance to a supervised individual, as needed, while the supervised individual conducts an authorized activity. Trained assistants may not work independently at a site.

Permittee/Principal Officer shall replace outdated LAIs and attach the subsequent current updated version of the LAI to this recovery permit upon receipt. **This permit will be considered invalid without a current attached LAI.**

C.2. To request changes to the LAI, the Permittee/Principal Officer shall submit written requests to the USFWS Midwest Region (Region 3) Permit Coordinator identified in Condition L. The request shall be submitted at least 30 days prior to the desired effective date. The request should indicate the desired effective date, must include the $50 application processing fee unless fee exempt (see 50 CFR 13.11 (d)), must be signed and dated by the Permittee/Principal Officer, and include the following information:

a. The name of each individual (first name, middle initial, last name) to be added to the LAI and indicate the species they will be working with and the activities they will be conducting;

b. The resume/qualifications of each person, including specific information on previous professional experience working with the species/activity affected by the request. Information should include: the approximate number of hours of focused activity with each species in occupied habitat; approximate numbers of each species the applicant has worked with at each site (e.g., how many birds at a specific site(s) or specific activity(ies); names, dates, and location of areas surveyed; and experience with similar species;

c. For each individual: the names, titles, organizations, emails, and telephone numbers of a minimum of two references who can verify experience with the species (reference letters are preferred and always appreciated); and

d. The names of any individuals to be deleted from the LAI.

Note: This procedure is **only** for personnel changes to the LAI. For requests to renew/amend this permit, a complete application and appropriate application processing fee must be submitted to the Region 3 Recovery Permits Coordinator. The application Form 3-200-55 may be obtained at: https://www.fws.gov/endangered/permits/how-to-apply.html.

D. Acceptance of this permit serves as evidence that the Permittee and its authorized agents understand and agree to abide by the terms of this permit and all sections of Title 50 Code of Federal Regulations, Parts 13 and 17, pertinent to issued permits (https://www.fws.gov/permits/ltr/ltr.html). Section 11 of the Endangered Species Act of 1973, as amended, provides for civil and criminal penalties for failure to comply with permit Conditions.

E. Permittee is authorized to take (capture with mist-nets or harp traps, handle, identify, radio-tag, band, collect non-intrusive measurements, enter hibernacula or maternity roost caves, and release) Indiana bat (*Myotis sodalis*), gray bat (*M. grisescens*), and northern long-eared bat (*M. septentrionalis*) for scientific research aimed at recovery of the species: presence/absence surveys, studies to document habitat use, population monitoring, and to evaluate potential impacts. This permit does **not** authorize the collection of voucher specimens.

F. Activities are authorized at the following locations:

F.1. Location within Region 2 of the USFWS: Oklahoma upon receipt of written concurrence from the Field Supervisor, and upon coordination with Ozark Plateau National Wildlife Refuge prior to 1) surveys of caves known to be used by federally-listed bats, and 2) examinations of caves suspected of containing federally-listed bat species (some presence/absence surveys may require the presence of a USFWS Biologist), and as outlined in Condition G.

F.2. Locations within Region 3 of the USFWS: Illinois, Indiana, Iowa, Michigan, Missouri, Ohio, and Wisconsin upon receipt of written concurrence from the Field Supervisor, as outlined in Condition G.

F.3. Locations within Region 4 of the USFWS: Alabama, Arkansas, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee, upon receipt of written concurrence from the Field Supervisor, as outlined in Condition G.

F.4. Locations within Region 5 of the USFWS: New Jersey, New York, Pennsylvania, Virginia and West Virginia, upon receipt of written concurrence from the Field Supervisor, as outlined in Condition G.

F.5. Locations within Region 6 of the USFWS: Kansas, upon receipt of written concurrence from the Field Supervisor, as outlined in Condition G.

G. Permittee shall notify the USFWS Field Supervisor in the state in which activities are proposed to occur at least 15 days prior to conducting any activities. Contact information is available at: https://www.fws.gov/midwest/endangered/permits/index.html. Your request for this site-specific approval must be in writing and must indicate:

G.1. Species for which proposed activities are being conducted.

G.2. Location of proposed activities, including project site (legal description and lat/long), county, and state.

G.3. The purpose and a description of the proposed activities (e.g., surveys, radio telemetry studies, etc.).

G.4. Dates when the project is proposed to take place.

G.5. Evidence that Permittee has received any required contracts to complete the activities.

G.6. Whether all annual reporting requirements have been fulfilled.

G.7. You may proceed with activities only upon receipt of written concurrence from the USFWS Field Supervisor. ***Your concurrence letter must be carried with this permit to authorize site-specific activities.***

H. Permittee shall adhere to the following Conditions involving capture and handling of bats:

H.1. Bats may be captured with mist nets following the protocol included in the Range-wide Indiana Bat Summer Survey Guidelines. Guidelines are available at: https://www.fws.gov/midwest/endangered/mammals/inba/inbasummersurveyguidance.html. Note: You must use the most up-to-date version of the Summer Survey Guidelines, available on the USFWS website page, for your summer surveys. The monitoring interval for mist nets is +/- 10 minutes and may not exceed 15 minutes. Captured bats may be held for a maximum of 30 minutes, unless injured. In extenuating circumstances, bats shall be held for no longer than 45 minutes.

H.2. Bats may be captured with harp traps with written concurrence from the Field Supervisor in the state in which trapping is proposed. Harp traps must be continually monitored. Captured bats may be held for a maximum of 30 minutes, unless injured. In extenuating circumstances, bats shall be held for no longer than 45 minutes.

H.3. Permittee shall carry out non-intrusive measurements on all captured bats. Data shall be recorded for all bats captured and include, but not be limited to, the data requested in any automated or species specific data sheet provided by the USFWS (e.g., Bat Reporting Spreadsheet). Handling should be limited to the maximum extent practicable and should cease immediately at signs of undue stress (e.g., bat becoming unresponsive, etc.). Bats that appear stressed from handling should be placed in a dark, quiet location away from activity where it can safely fly away after recovery, and should be checked to ensure successful recovery before leaving the study site. Photographs of the identifying characteristics for each individual federally-listed species captured are encouraged. The Permittee may be requested to provide individual photographs after submittal of annual reporting data.

H.4. Lipped metal bands having a unique identifier may be applied to the forearm of captured bats prior to release. No more than one band per bat may be used. Bands should be applied to the forearm of captured bats prior to release. Position the band on the wing so that when the bat is hanging upside down, the band numbers are right-side up. A single band should be placed on the right forearm of each male and the left forearm of each female bat.

H.5. Radio transmitters may be applied during spring, summer, and fall roosting and migration periods via nontoxic skin bond adhesive. The total weight of the transmitter may not exceed 5% of the bat's body weight and the total weight of the package (transmitter and adhesive) may not exceed 6% of the bat's body weight. The lightest package (both transmitter and adhesive) capable of accomplishing the required task should be used, especially with pregnant females and newly volant juveniles. Bats carrying transmitters must be monitored daily for at least three days, or until the transmitter falls off, whichever occurs first. ***Although not required as a Condition of this permit, in order to gather needed information to promote the conservation of the northern long-eared bat, it is recommended that the permittee radio-track female and juvenile northern long-eared bats captured when conducting mist-netting and radio-tracking of Indiana bats within the white-nose syndrome zone of the range of the northern long-eared bat. Specifics on the number of females and juvenile bats to be tracked will be determined in coordination with the appropriate Field Office, as specified in Condition G.***

H.6. No trapping activities shall occur within 20 meters of a known Indiana bat maternity roost site, either natural or artificial roosts, unless Permittee receives prior written approval from the USFWS Field Supervisor for the state in which the activities are proposed to occur.

H.7. Caves, mines, or other suitable hibernation sites may be quietly searched in a manner that minimizes disturbance by utilizing the minimum number of people and time required to complete the survey. Surveys should not be repeated more often than once every other year in any given hibernaculum that is occupied by endangered or threatened bats. Where hibernacula area and safety conditions allow, individuals entering caves are recommended to utilize night vision goggles or red-filtered light and to remain in the cave no more than 90 minutes to complete the work.

H.8. For the Ozark big-eared bat (*Corynorhinus townsendii ingens*), Virginia big-eared bat (*C. t. virginianus*) [***all authorized individuals***], and gray bat (*M. grisescens*) [***Genavie Veron and Ethan Okon***], Permittee is authorized to take (capture and release) only in the event that the species is captured accidental to lawful survey activities directed at other permitted species. This permit does not authorize any activities for the specific purpose of capture of gray bat, Ozark or Virginia big-eared bats. Should incidental/accidental capture of gray bat, Ozark or Virginia big-eared bats occur, you must document the

capture and collect data (weight, sex, and age) on the captured animal. Permittee must also document the discovery with a photograph. Gray bat, Ozark and Virginia big-eared bats must be released immediately following the data collection. Captured bats may be held for a maximum of 30 minutes, unless injured. Handling should be limited to the maximum extent practicable and should cease immediately at signs of undue stress (e.g., bat becoming unresponsive, etc.). Bats that appear stressed from handling should be placed in a dark, quiet location away from activity, where they can safely fly away after recovery, and should be checked to ensure successful recovery before leaving the study site. Ozark and Virginia big-eared bats shall not be held in paper bags. Within 48 hours, you must notify the USFWS in the state in which you are working of the accidental capture (see https://www.fws.gov/midwest/endangered/permits/index.html).

H.9. Equipment used to capture and handle bats shall be cleaned and decontaminated, including personal gear such as boots and gloves, using products cited in decontamination guidelines and in compliance with label directions. The most recent decontamination guidance is found on the web at: https://www.whitenosesyndrome.org/topics/decontamination.

I. Upon determination that endangered or threatened bats are present at previously undocumented sites, Permittee shall notify the following offices within 48 hours: the USFWS Region 3 Office (Condition L.), the Species Recovery Lead (Condition M.), and the USFWS Field Office within the geographic location of study areas (https://www.fws.gov/midwest/endangered/permits/index.html).

J. Accidental injury or mortality may not exceed two (2) specimens. In the event that any accidental injury or mortality occurs, all activities must cease. The Permittee must immediately report any bat mortality or serious injury to the applicable USFWS Field Office in the state in which the incident occurred (contact information provided at: https://www.fws.gov/midwest/endangered/permits/index.html). Written notification must also be made within 24 hours to the Midwest Regional Permits Coordinator (see Condition L.), the Species Recovery Lead (Condition M.), and the applicable USFWS Field Office in the state in which the incident occurred (Condition N.). The Permittee's statement must document the cause of the injury or mortality, and identify all remedial measures employed by the Permittee to eliminate future mortality or injury events. Based on consultation between the USFWS offices, decisions will be made regarding remedial measures that will be implemented and whether and/or when any of the authorized activities may continue. The Species Recovery Lead Office will provide a decision within five (5) business days concerning the disposition of any injured or dead specimen. Dead or moribund bats may be retained for further study only with the written permission of the USFWS. Any bats that are not authorized for retention are to be chilled and promptly transferred to the USFWS Species Recovery Lead for potential necropsy and/or contaminants analysis. Permitted activities may resume upon receipt of written approval from the Species Recovery Lead Office.

K. An Annual Report of all activities conducted under the authority of this permit is due by January 31 following each year this permit is in effect. In addition, copies of all publications and reports resulting from work conducted under this permit must be submitted as they become available. Failure to furnish any reports required by this permit is cause for permit revocation and/or denial of future permit applications. At a minimum, your report shall include:

K.1. The date, time, geographic locations (including datum and projection information), species, age, sex, and weight of all bats encountered.

K.2. A description of locations surveyed where no bats were encountered.

K.3. Band numbers of all bats banded.

K.4. Information on any injuries and/or mortalities and disposition of specimens.

K.5. Location and characteristics of roost trees and bat colonies.

K.6. Copies of any separate reports and/or publications resulting from work conducted under the authority of this permit.

K.7. A completed data collection form as found in the Summer Survey Guidelines, Appendix B, cited in Condition H.1.

K.8. Data shall be submitted for all bats captured and include, but not be limited to, the data requested in any automated or species-specific data sheet provided by the USFWS (e.g., the data collection sheets found on the current Rangewide Indiana Bat Summer Survey Guidelines website page cited in Condition H.1., or other species specific data sheets). Photographs of the identifying characteristics for each individual federally-listed species captured are encouraged. The Permittee may be requested to provide individual photographs after submittal of annual reporting data.

K.9. Copies of all site-specific authorization letters required under Condition G.

IF NO ACTIVITIES OCCURRED OVER THE COURSE OF THE YEAR, INDICATION OF SUCH SHALL BE SUBMITTED AS AN ANNUAL REPORT.

L. **Copies of your reports shall be sent to the offices listed below.** When possible, electronic copies shall be submitted in lieu of hard copies in MS Word, Portable Document Format, Rich Text Format, or other file format that is compatible with the receiving office.

L.1. Regional Recovery Permits Coordinator
U.S. Fish and Wildlife Service - Midwest Region (Region 3)
Ecological Services - Endangered Species
5600 American Blvd. W., Suite 990
Bloomington, Minnesota 55437-1458
(612/713-5343; fax 612/713-5292)
permitsR3ES@fws.gov

L.2. Regional Recovery Permits Coordinator
U.S. Fish and Wildlife Service - Southwest Region (Region 2)
Division of Classification & Recovery Permits
P.O. Box 1306
Albuquerque, New Mexico 87103-1306
(505/248-6420; fax 505/248-6788)
permitsR2ES@fws.gov

L.3. Regional Recovery Permits Coordinator
U.S. Fish and Wildlife Service - Southeast Region (Region 4)
Endangered Species Permits Office
1875 Century Blvd.
Atlanta, Georgia 30345-3301
(404/679-7097; fax 404/679-7081)
permitsR4ES@fws.gov

L.4. Regional Recovery Permits Coordinator

U.S. Fish and Wildlife Service - Northeast Region (Region 5)
Endangered Species Division
300 Westgate Center Drive
Hadley, Massachusetts 01035-9589
(413/253-8795; fax 413/253-8482)
permitsR5ES@fws.gov

L.5. ESA Assistant Recovery Coordinator & Permit Coordinator
U.S. Fish and Wildlife Service - Mountain-Prairie Region (Region 6)
Endangered Species Permits Office
Denver Federal Center, P.O. Box 25486
Denver, Colorado 80225-0489
(303-236-4224; fax 303/236-0027)
permitsR6ES@fws.gov

M. Additionally, based on species, reports and publications shall be submitted to the following:

M.1. ***For studies involving Indiana bat:***
Lori Pruitt
U.S. Fish and Wildlife Service
Ecological Services Field Office
620 S. Walker Street
Bloomington, Indiana 47403-2121
(812/334-4261 x1213; fax 812/334-4273)

M.2. ***For studies involving northern long-eared bat:***
Jill Utrup
U.S. Fish and Wildlife Service
Ecological Services Field Office
4104 American Blvd. E.
Bloomington, Minnesota 55425-1665
(952/252-0092; fax 952/646-2873)

M.3. ***For studies involving gray bat:***
Shauna Marquardt
U.S. Fish and Wildlife Service
Ecological Services Field Office
101 Park DeVille Drive, Suite A
Columbia, Missouri 65203-0007
(573/234-2132; fax 573/234-2181)

M.4. ***For studies involving Ozark big-eared bat:***
Richard Stark
U.S. Fish and Wildlife Service
Ozark Plateau National Wildlife Refuge
9014 East 21st Street
Tulsa, Oklahoma 74129
(918/382-4520; fax 918/581-7467)

M.5. ***For studies involving Virginia big-eared bat:***
Barbara Douglas

U.S. Fish and Wildlife Service
Ecological Services Field Office
694 Beverly Pike
Elkins, West Virginia 26241
(304/636-6586 x19; fax 304/636-7824)

N. Additionally, based on geographic areas, reports and publications shall be submitted to the offices under Field Office Contact Information, located at: https://www.fws.gov/midwest/endangered/permits/index.html.

cc: FWS/Regions 2, 4, 5, and 6 (Attn: Regional Recovery Permits Coordinator)
FWS, TE Coordinator: Illinois/Iowa, Indiana, Michigan, Minnesota/Wisconsin, Missouri, Ohio
DNR/DOC, TE Coordinator: Illinois, Indiana, Iowa, Michigan, Missouri, Ohio, Wisconsin

END

9109-19
Part 3 of 3

R06497

United States Department of the Interior

FISH AND WILDLIFE SERVICE

5600 American Boulevard West, Suite 990
Bloomington, Minnesota 55437-1458

IN REPLY REFER TO:

FWS/AES-TE

LIST OF AUTHORIZED INDIVIDUALS
TE06801A-5
Pittsburgh Wildlife & Environmental, Inc.
Neil R. Bossart (Principal Officer)

C.1. Individuals authorized to independently conduct activities under this permit:

For all species/all activities: Neil R. Bossart and Jennifer L. Dreibelbis.

For all activities with Indiana bat and northern long-eared bat, other than entering hibernacula and maternity roost caves: Genavie Veron and Ethan D. Okon.

Trained assistants may conduct activities pursuant to this permit only under the direct and on-site supervision of an above-named individual. "On-site supervision" is defined as having the Permittee at a distance close enough to enable immediate assistance to a supervised individual, as needed, while the supervised individual conducts an authorized activity. **At least one named Permittee must remain present at each mist-net site while it is being operated.**

Acting Chief, Division of Endangered Species

March 29, 2018
Date

This List of Authorized Individuals (LAI) is valid only when it is dated on or after the permit issuance date. Federal Permit TE06801A-5 will be considered invalid without this LAI.

APPENDIX C

COMPLETED BAT SURVEY DATA FORMS

PWE Bat Survey Data Form

Project: Pond Creek No. 1 Mine North Panels | Site #: 01 | Night: 01 | Date: 7/15/18

State: IL | County: Williamson | Township: N/A

Quad: Pittsburg | Lat/UTM: 37.85570° | Long/UTM: -88.82660° | Datum: WGS 84

Identifier: E. Okon | Tech(s): J. Brooke | Bat activity time: 20:35

Site Description: Forested stream through ag fields and woodlots

Dominant Tree Species: Black walnut, shagbark hickory, box elder

Other Wildlife Observed: Song birds, frogs, water snakes, deer, barred owl | Whip-Poor-Wills: 0

Comments: Closed early due to Indiana bat capture, tracked bat all night

Sunrise: 05:44 | Sunset: 20:17 | Moonrise: 08:39 | Moonset: 22:32 | Illumination: 5%

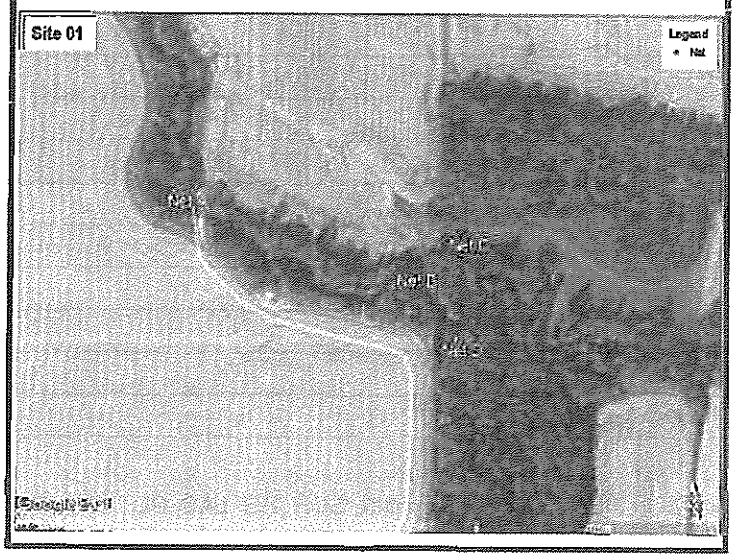
Nets/Traps/Detectors | **Time Open: 20:30** | **Time Closed: 23:30**

Name	Type	L(m)	x	H(m)	Lat/UTM	Long/UTM	Habitat
A	Mist Net	12	x	7.8	37.85606°	-88.82902°	Stream
B	Mist Net	9	x	7.8	37.85544°	-88.82675°	Stream
C	Mist Net	18	x	7.8	37.85572°	-88.82623°	Corridor
D	Mist Net	4	x	2.6	37.85490°	-88.82630°	Stream
			x				

Weather

Time	Temp(C)	% Cloud	Wind (mph)
20:30	24.1 °	100	1-4
21:30	23.8 °	80	1-4
22:30	23.5 °	50	1-4
23:30	23.7 °	85	1-4
	°		
	°		
	°		

Site Drawing/Imagery



PWE Bat Survey Data Form

Project: Pond Creek No. 1 Mine North Panels						Site #: 01			Night: 01		Date: 7/15/18
	Time	Species of Bat	Age	Sex	Rep	Wt (g)	RFA (mm)	Ht in Net	Net	WNS	Band #	Comments: Transmitter/Parasite/Photo
1	21:55	Eastern Red bat	J	M	NR			18	C	UNK		Released
2	21:55	Tricolor bat	A	F	LAC	6.4	34.0	12	A	0		
3	22:00	Tricolor bat	A	F	LAC	7.6	35.0	3	B	0		
4	22:35	Indiana bat	A	F	LAC	7.5	37.5	8	A	0	R3FWS A0024	Freq. 172.413
5												
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7												
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30												

Additional Notes/Comments:

Age=A,J Sex=M,F Rep=NR, SCR, PG, LAC, PL RFA=Right Forearm Height in Net=Feet

PWE Bat Survey Data Form

Project: Pond Creek No. 1 Mine North Panels Site #: 01 Night: 02 Date: 7/17/18

State: IL County: Williamson Township: N/A

Quad: Pittsburg Lat/UTM: 37.85570° Long/UTM: -88.82660° Datum: WGS 84

Identifier: E. Okon Tech(s): J. Brooke, A. Patterson, T. Wilson Bat activity time: 20:45

Site Description: Forested stream through ag fields and woodlots

Dominant Tree Species: Black walnut, shagbark hickory, box elder

Other Wildlife Observed: Song birds, frogs, water snakes, deer, barred owl Whip-Poor-Wills: 0

Comments:

Sunrise: 05:46 Sunset: 20:16 Moonrise: 10:58 Moonset: 23:44 Illumination: 30%

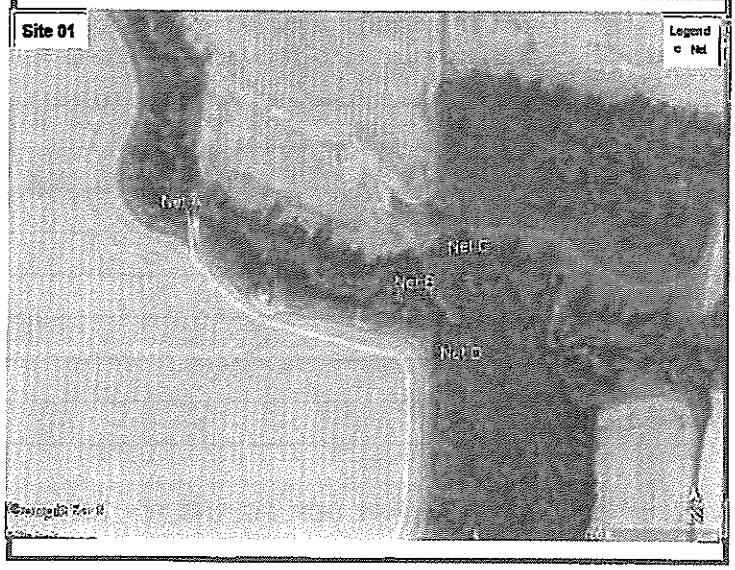
Nets/Traps/Detectors | **Time Open: 20:30** | **Time Closed: 01:30**

Name	Type	L(m)	x	H(m)	Lat/UTM	Long/UTM	Habitat
A	Mist Net	12	x	7.8	37.85606°	-88.82902°	Stream
B	Mist Net	9	x	7.8	37.85544°	-88.82675°	Stream
C	Mist Net	18	x	7.8	37.85572°	-88.82623°	Corridor
D	Mist Net	4	x	2.6	37.85490°	-88.82630°	Stream
			x				

Weather

Time	Temp(C)	% Cloud	Wind (mph)
20:30	24.2 °	60	0
21:30	22.8 °	90	0
22:30	21.9 °	50	0
23:30	20.8 °	10	0
00:30	20.7 °	20	1-4
01:30	20.1 °	25	1-4
	°		

Site Drawing/Imagery



PWE Bat Survey Data Form

Project: Pond Creek No. 1 Mine North Panels | **Site #:** 01 | **Night:** 02 | **Date:** 7/17/18

	Time	Species of Bat	Age	Sex	Rep	Wt (g)	RFA (mm)	Ht in Net	Net	WNS	Band #	Comments: Transmitter/Parasite/Photo
1	21:50	Tricolor bat	A	F	LAC	7.1	35.0	8	B	0		
2	22:50	Tricolor bat	J	M	NR	5.3	31.0	4	B	0		
3	23:25	Eastern Red bat	UNK	UNK	UNK				B	UNK		Escaped
4	23:25	Eastern Red bat	J	M	NR	7.8	38.5	14	C	0		
5	00:45	Eastern Red bat	J	M	NR			12	B	0		Released
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7												
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27												
28												
29												
30												

Additional Notes/Comments:

Age=A,J Sex=M,F Rep=NR, SCR, PG, LAC, PL RFA=Right Forearm Height in Net=Feet

PWE Bat Survey Data Form

Project: Pond Creek No. 1 Mine North Panels Site #: 01 Night: 03 Date: 7/18/18

State: IL County: Williamson Township: N/A

Quad: Pittsburg Lat/UTM: 37.85570° Long/UTM: -88.82660° Datum: WGS 84

Identifier: E. Okon Tech(s): J. Brooke Bat activity time: 20:50

Site Description: Forested stream through ag fields and woodlots

Dominant Tree Species: Black walnut, shagbark hickory, box elder

Other Wildlife Observed: Song birds, frogs, water snakes, deer, barred owl Whip-Poor-Wills: 0

Comments: Closed site due to Indiana bat capture at nearby site.

Sunrise: 05:46 Sunset: 20:16 Moonrise: 12:03 Moonset: Illumination: 40%

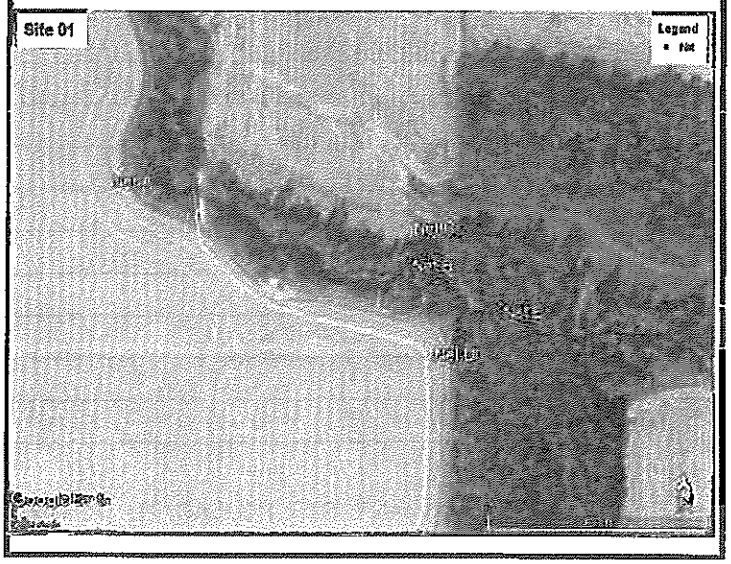
Nets/Traps/Detectors | **Time Open:** 20:30 | **Time Closed:** 22:30

Name	Type	L(m)	x	H(m)	Lat/UTM	Long/UTM	Habitat
A	Mist Net	12	x	7.8	37.85606°	-88.82902°	Stream
B	Mist Net	9	x	7.8	37.85544°	-88.82675°	Stream
C	Mist Net	18	x	7.8	37.85572°	-88.82623°	Corridor
D	Mist Net	4	x	2.6	37.85490°	-88.82630°	Stream
E	Mist Net	6	x	5.2	37.85511°	-88.82591°	Stream

Weather

Time	Temp(C)	% Cloud	Wind (mph)
20:30	22.3 °	55	0
21:30	21.9 °	50	0
22:30	20.1 °	30	1-4
	°		
	°		
	°		
	°		

Site Drawing/Imagery



PWE Bat Survey Data Form

	Project: Pond Creek No. 1 Mine North Panels						Site #: 01		Night: 03		Date: 7/18/18
	Time	Species of Bat	Age	Sex	Rep	Wt (g)	RFA (mm)	Ht in Net	Net	WNS	Band #	Comments: Transmitter/Parasite/Photo
1	21:20	Eastern Red bat	J	M	NR			15	B	0		Released
2												
3												
4												
5												
6												
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28												
29												
30												

Additional Notes/Comments:

Age=A,J Sex=M,F Rep=NR, SCR, PG, LAC, PL RFA=Right Forearm Height in Net=Feet

Bat Survey Data Form

Project: Pond Creek No. 1 North Panels Site #: 02 Night: 01 Date: 7/18/18

State: IL County: Williamson Township:

Quad: Corinth Lat/UTM: 37.85250° Long/UTM: -88.80231° Datum: NAD 27

Identifier: E. Okon Tech(s): Alex Patterson , Tim Wilson Bat activity time: 20:30

Site Description: Pond creek with surrounding ag fields

Dominant Tree Species: boxelder, red maple

Other Wildlife Observed: deer Whip-Poor-Wills:

Comments:

Sunrise: 05:46 Sunset: 20:16 Moonrise: 12:03 Moonset: Illumination: 40%

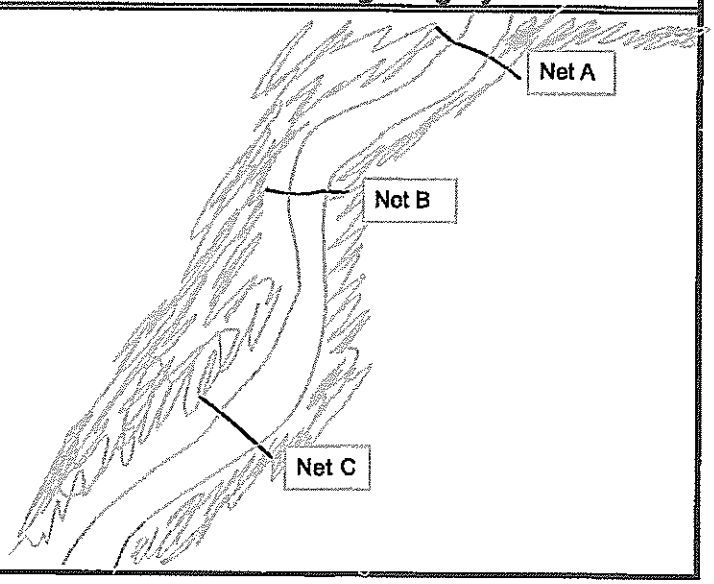
Nets/Traps/Detectors | **Time Open: 20:30** | **Time Closed: 21:00**

Name	Type	L(m)	x	H(m)	Lat/UTM	Long/UTM	Habitat
A	Mist Net	9	x	7.8	37.85245°	-88.80321°	Stream
B	Mist Net	12	x	7.8	37.85245	-88.80250°	Stream
C	Mist Net	6	x	7.8	37.85163°	-88.80117°	Stream
			x				
			x				

Weather

Time	Temp(C)	% Cloud	Wind (mph)
20:30	25.3 °	0	0
	°		
	°		
	°		
	°		
	°		
	°		

Site Drawing/Imagery



Bat Survey Data Form

	Project: Pond Creek No. 1 North Panels						Site #: 02		Night: 01		Date: 7/18/18
	Time	Species of Bat	Age	Sex	Rep	Wt (g)	RFA (mm)	Ht in Net	Net	WNS	Band #	Comments: Transmitter/Parasite/Photo
1	00:30	Eastern Red bat	A	F	LAC	12.2	40.0	12	C	0		
2	00:30	Eastern Red bat	A	F	LAC	12.2	43.0	10	B	0		
3	00:30	Eastern Red bat	A	F	LAC	11.8	40.0	8	A	0		
4	21:00	Eastern Red bat	A	F	LAC	11.8	39.0	10	B	0		
5	21:00	Eastern Red bat	J	M	NR	8.8	37.0	10	C	0		
6	21:00	Indiana bat	A	M	NR	6.5	40.0	16	B	0	A0026	Frequency 172.636
7												
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30												

Additional Notes/Comments:

Age=A,J Sex=M,F Rep=NR, SCR, PG, LAC, PL RFA=Right Forearm Height in Net=Feet

PWE Bat Survey Data Form

Project: Pond Creek No. 1 Mine North Panels Site #: 07 Night: 01 Date: 7/21/18

State: IL County: Williamson Township: N/A

Quad: Harco Lat/UTM: 37.85739° Long/UTM: -88.74174° Datum: WGS 84

Identifier: E. Okon Tech(s): J. Brooke Bat activity time: 21:10

Site Description: ATV tralls through young forested woodlot and small pond

Dominant Tree Species: Shagbark hickory, white oak, red elm

Other Wildlife Observed: Song birds, deer Whip-Poor-Wills: 0

Comments:

Sunrise: 05:48 Sunset: 20:13 Moonrise: 15:07 Moonset: 01:21 Illumination: 60%

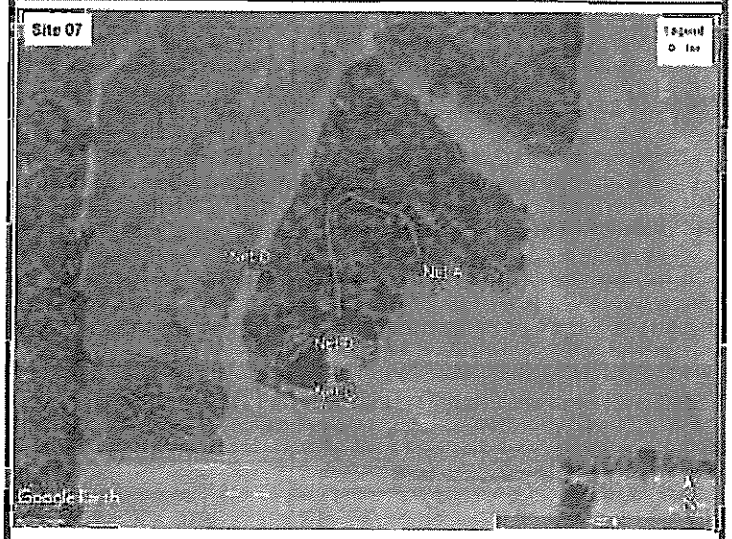
Nets/Traps/Detectors | **Time Open: 20:30** | **Time Closed: 01:30**

Name	Type	L(m)	x	H(m)	Lat/UTM	Long/UTM	Habitat
A	Mist Net	12	x	7.8	37.85772°	-88.74074°	Corridor
B	Mist Net	9	x	7.8	37.85729°	-88.74148°	Corridor
C	Mist Net	18	x	5.2	37.85692°	-88.74147°	Pond
D	Mist Net	18	x	7.8	37.85775°	-88.74229°	Corridor
			x				

Weather

Time	Temp(C)	% Cloud	Wind (mph)
20:30	22.7 °	0	1-4
21:30	22.5 °	0	0
22:30	22.2 °	0	1-4
23:30	21.7 °	0	1-4
00:30	21.2 °	0	1-4
01:30	21.0 °	0	1-4
	°		

Site Drawing/Imagery



PWE Bat Survey Data Form

	Project: Pond Creek No. 1 Mine North Panels					Site #: 07			Night: 01		Date: 7/21/18
	Time	Species of Bat	Age	Sex	Rep	Wt (g)	RFA (mm)	Ht in Net	Net	WNS	Band #	Comments: Transmitter/Parasite/Photo
1	21:10	Eastern Red bat	J	F	NR	10.3	42.0	15	D	0		
2	21:25	Eastern Red bat	J	M	NR	8.7	38.5	16	B	0		
3	22:05	Eastern Red bat	UNK	M	UNK			12	B	UNK		Escaped
4	00:10	Eastern Red bat	J	M	NR	7.6	36.5	10	D	0		Small bat
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30												

Additional Notes/Comments:

Age=A,J Sex=M,F Rep=NR, SCR, PG, LAC, PL RFA=Right Forearm Height in Net=Feet

PWE Bat Survey Data Form

Project: Pond Creek No. 1 Mine North Panels Site #: 07 Night: 02 Date: 7/23/18

State: IL County: Williamson Township: N/A

Quad: Harco Lat/UTM: 37.85739° Long/UTM: -88.74174° Datum: WGS 84

Identifier: E. Okon Tech(s): J. Brooke Bat activity time: 20:35

Site Description: ATV trails through young forested woodlot and small pond

Dominant Tree Species: Shagbark hickory, white oak, red elm

Other Wildlife Observed: Song birds, deer, northern bobwhite, barred owl, coyotes Whip-Poor-Wills: 0

Comments:

Sunrise: 05:50 Sunset: 20:12 Moonrise: 17:01 Moonset: 02:33 Illumination: 75%

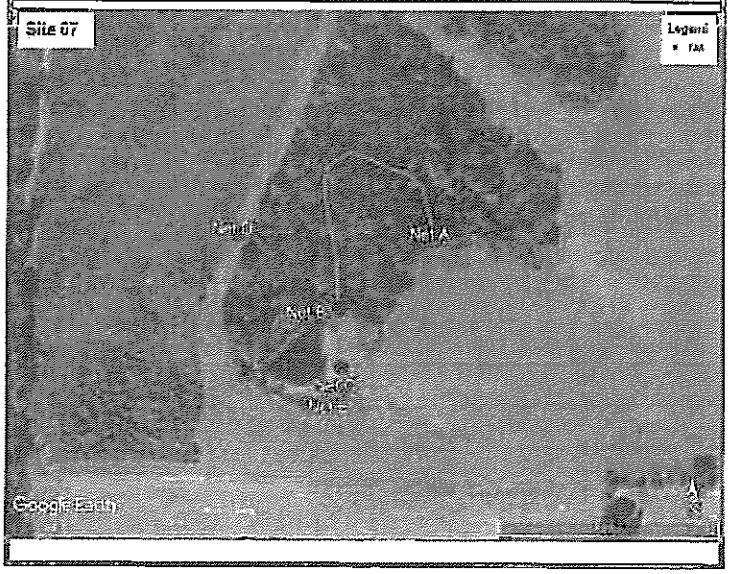
Nets/Traps/Detectors | **Time Open: 20:30** | **Time Closed: 01:30**

Name	Type	L(m)	x	H(m)	Lat/UTM	Long/UTM	Habitat
A	Mist Net	12	x	7.8	37.85772°	-88.74074°	Corridor
B	Mist Net	9	x	7.8	37.85729°	-88.74148°	Corridor
C	Mist Net	18	x	5.2	37.85692°	-88.74147°	Pond
D	Mist Net	18	x	7.8	37.85775°	-88.74229°	Corridor
E	Mist Net	6	x	2.6	37.85669°	-88.74174°	Pond

Weather

Time	Temp(C)	% Cloud	Wind (mph)
20:30	22.1 °	15	0
21:30	20.7 °	0	1-4
22:30	19.6 °	0	1-4
23:30	18.9 °	10	1-4
00:30	18.6 °	5	0
01:30	17.9 °	0	0
	°		

Site Drawing/Imagery



PWE Bat Survey Data Form

	Project: Pond Creek No. 1 Mine North Panels					Site #: 07			Night: 02		Date: 7/23/18
	Time	Species of Bat	Age	Sex	Rep	Wt (g)	RFA (mm)	Ht in Net	Net	WNS	Band #	Comments: Transmitter/Parasite/Photo
1	22:20	Eastern Red bat	J	F	NR	9.8	39.5	10	C	0		
2	22:45	Eastern Red bat	J	M	NR	9.7	40.0	16	D	0		
3	22:45	Eastern Red bat	UNK	UNK	UNK			16	D	UNK		Escaped
4	01:25	Eastern Red bat	J	F	NR	10.6	40.5	18	B	0		
5												
6												
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Additional Notes/Comments:

Age=A,J Sex=M,F Rep=NR, SCR, PG, LAC, PL RFA=Right Forearm Height in Net=Feet

PWE Bat Survey Data Form

Project: Pond Creek No. 1 Mine North Panels Site #: 08 Night: 01 Date: 7/19/18

State: IL County: Williamson Township: N/A

Quad: Harco Lat/UTM: 37.85128° Long/UTM: -88.73420° Datum: WGS 84

Identifier: E. Okon Tech(s): J. Brooke Bat activity time: 20:30

Site Description: Old atv trails through young forest

Dominant Tree Species: Black cherry, red maple, mockernut hickory

Other Wildlife Observed: Song birds, deer, barred owl, black rat snake Whip-Poor-Wills: 0

Comments:

Sunrise: 05:47 Sunset: 20:15 Moonrise: 13:06 Moonset: Illumination: 50%

Nets/Traps/Detectors | **Time Open: 20:30** | **Time Closed: 01:30**

Name	Type	L(m) x H(m)	Lat/UTM	Long/UTM	Habitat
A	Mist Net	12 x 7.8	37.85139°	-88.73391°	Corridor
B	Mist Net	9 x 7.8	37.85145°	-88.73329°	Corridor
C	Mist Net	12 x 7.8	37.85109°	-88.73349°	Corridor
D	Mist Net	9 x 5.2	37.85105°	-88.73452°	Corridor
		x			

Weather

Time	Temp(C)	% Cloud	Wind (mph)
20:30	24.9 °	40	0
21:30	23.0 °	60	0
22:30	22.6 °	55	0
23:30	22.3 °	10	0
00:30	22.1 °	0	0
01:30	21.9 °	0	0
	°		

Site Drawing/Imagery



PWE Bat Survey Data Form

	Project: Pond Creek No. 1 Mine North Panels						Site #: 08		Night: 01		Date: 7/19/18
	Time	Species of Bat	Age	Sex	Rep	Wt (g)	RFA (mm)	Ht in Net	Net	WNS	Band #	Comments: Transmitter/Parasite/Photo
1	20:35	Eastern Red bat	A	F	LAC	14.4	41.5	4	D	0		
2	23:15	Eastern Red bat	J	F	NR	11.3	41.5	10	A	0		
3	23:15	Eastern Red bat	J	F	NR	10.9	43.0	15	A	0		
4	01:30	Eastern Red bat	J	F	NR	10.6	41.0	12	A	0		
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Additional Notes/Comments:

Age=A,J Sex=M,F Rep=NR, SCR, PG, LAC, PL RFA=Right Forearm Height in Net=Feet

PWE Bat Survey Data Form

Project: Pond Creek No. 1 Mine North Panels Site #: 08 Night: 02 Date: 7/20/18

State: IL County: Williamson Township: N/A

Quad: Harco Lat/UTM: 37.85128° Long/UTM: -88.73420° Datum: WGS 84

Identifier: E. Okon Tech(s): J. Brooke Bat activity time: 20:35

Site Description: Old atv trails through young forest

Dominant Tree Species: Black cherry, red maple, mockernut hickory

Other Wildlife Observed: Song birds, deer, barred owl, black rat snake Whip-Poor-Wills: 0

Comments:

Sunrise: 05:47 Sunset: 20:14 Moonrise: 14:07 Moonset: 00:59 Illumination: 55%

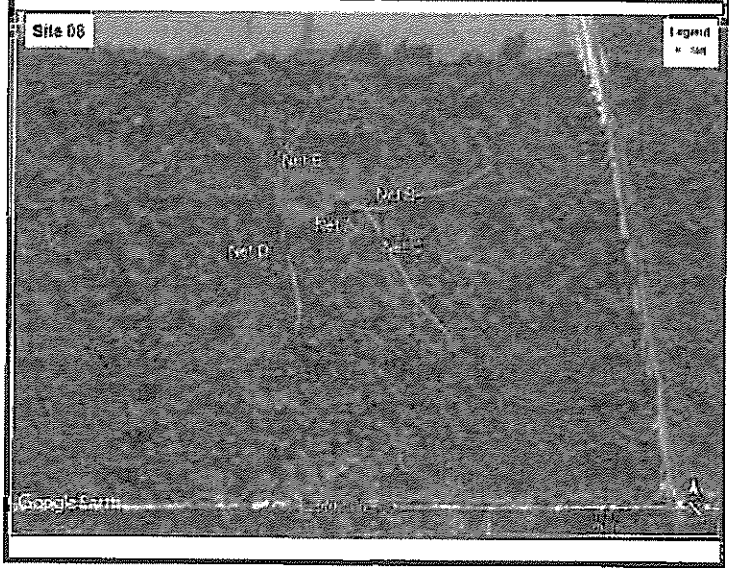
Nets/Traps/Detectors | **Time Open: 20:30** | **Time Closed: 01:30**

Name	Type	L(m)	x	H(m)	Lat/UTM	Long/UTM	Habitat
A	Mist Net	12	x	7.8	37.85139°	-88.73391°	Corridor
B	Mist Net	9	x	7.8	37.85145°	-88.73329°	Corridor
C	Mist Net	12	x	7.8	37.85109°	-88.73349°	Corridor
D	Mist Net	9	x	5.2	37.85105°	-88.73452°	Corridor
E	Mist Net	6	x	2.6	37.85181°	-88.73454°	Corridor

Weather

Time	Temp(C)	% Cloud	Wind (mph)
20:30	26.2 °	50	0
21:30	26.1 °	35	0
22:30	24.6 °	0	0
23:30	23.8 °	0	1-4
00:30	22.3 °	0	0
01:30	21.6 °	0	1-4
	°		

Site Drawing/Imagery



PWE Bat Survey Data Form

Project: Pond Creek No. 1 Mine North Panels						Site #: 08			Night: 02		Date: 7/20/18
	Time	Species of Bat	Age	Sex	Rep	Wt (g)	RFA (mm)	Ht in Net	Net	WNS	Band #	Comments: Transmitter/Parasite/Photo
1	20:35	Eastern Red bat	UNK	UNK	UNK			16	A	UNK		Escaped
2	01:00	Eastern Red bat	J	F	NR	11.3	41.5	20	A	0		
3	01:30	Eastern Red bat	J	M	NR	9.9	40.5	4	D	0		
4												
5												
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30												

Additional Notes/Comments:

Age=A,J Sex=M,F Rep=NR, SCR, PG, LAC, PL RFA=Right Forearm Height in Net=Feet

APPENDIX D

ROOST PHOTOGRAPHS AND ROOST AND EMERGENCE DATA SHEETS

Project No. B18-128-1413

PHOTOGRAPHS OF ROOST TREES WITHIN POND CREEK NO. 1 MINE NORTH PANELS



Roost 01 Bat 172.636



Roost 02 Bat 172.413

Project No. B18-128-1413

PHOTOGRAPHS OF ROOST TREES WITHIN POND CREEK NO. 1 MINE NORTH PANELS



Roost 02 Bat 172.636



Roost 03 Bat 172.413

Project No. B18-128-1413

PHOTOGRAPHS OF ROOST TREES WITHIN POND CREEK NO. 1 MINE NORTH PANELS



North Panels 172.413 Roost Tree 01

APPENDIX D: PHASE 4 RADIO-TRACKING

USFWS INDIANA BAT ROOST DATASHEET

Biologists (Full Name): Alex Patterson **Date:** 7-17-18

UTM: Zone_____ **Easting**_____ **Northing**_____ ***OR***

LAT 37.84780° **LONG** -88.09230°

Property Owner:_____ **Phone#**_____

State Illinois **County** Williamson **Site #** 01

Roost # 01 **Roost Name:** Roost 01 Bat 172.413

Roost Tree Data

Species: Silver maple **Live** __ **Snag** X **Other** __

(if other, explain) _____

DBH (in or cm) 17.5 in **Total Height (ft or m)** 75 ft

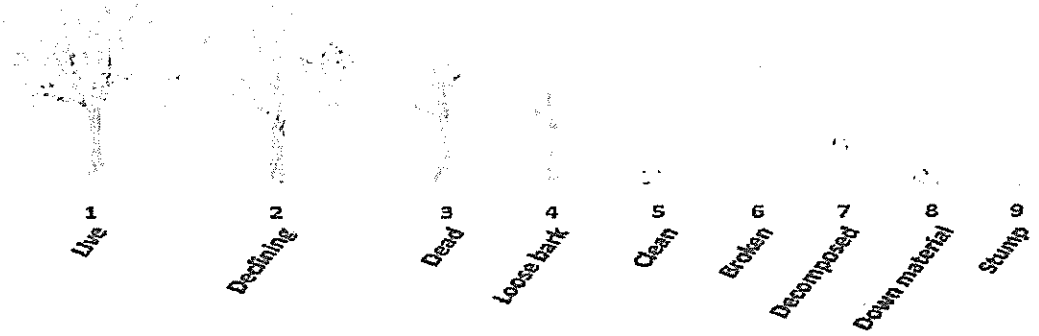
Height of roost area (if known)_____ **Dist. from capture site** 1.96 miles

Roost position aspect (deg)_____

Exfoliating bark on bole (%) 90 **Describe: sloughing** X **platy**__ **tight**__

Cavities present? ____ **If so, describe:**_____

Roost Decay State: 1 2 3 (4) 5 6 7 8 9 Other



APPENDIX D: PHASE 4 RADIO-TRACKING

Roost tree or snag canopy position: Dominant X Co-Dominant __ Suppressed __

Surrounding Habitat Condition

Canopy closure at roost (%) 20%

Approximate woodlot size (ac or ha) 100 **Distance to non-forest (ft or m)** 645 Ft

Describe forest/woodlot current condition (mature, partially cut-over, burned, insect damage, etc.)
The roost Roost 01 was located in a swamp within a woodlot. The woodlot had copious mature trees, as well as dense understory brush. The swamp had many dead or dying trees making suitable habitat.

Additional Comments

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

USFWS BAT EMERGENCE SURVEY DATASHEET

Date: 7-17-18 **Surveyor(s) Full Name:** Alex Patterson

State: IL **County:** Williamson **Project Name:** Mach North Panels Bat Survey

Site Name/#: a1 **Roost Name/#** Roost 01 **Bat #:** 172, 413

Lat/Long or UTM of Roost: 37.84750°, -88.79230

Description of Roost/Habitat Feature Surveyed: The roost is along dead silver maple

Bat Species Known to be using this Roost/Feature (if not known, leave blank): Myotis sodalis

Other Suspected Bat Species (explain):

Weather Conditions during Survey (temperature, precipitation, wind speed): warm and clear

Survey Start Time: 19:45 **Time of Sunset:** 20:45 **Survey End Time:** 20:52

NOTE: Emergence surveys should begin ½ hour before sunset and continue until at least one hour after sunset or until it is otherwise too dark to see emerging bats. The surveyor(s) should position him or herself so that emerging bats will be silhouetted against the sky as they exit the roost. Tallies of emerging bats should be recorded every few minutes or as natural breaks in bat activity allow. Please ensure that surveyor(s) are close enough to the roost to observe all exiting/returning bats, but not close enough to influence emergence (i.e., do not stand directly beneath the roost and do not make unnecessary noise and/or conversation, and minimize use of lights other than a small flashlight to record data, if necessary). Do not shine a light on the roost tree crevice/cave/mine entrance itself as this may prevent or delay bats from emerging. If available, use of an infra-red, night vision, or thermal-imaging video camera or spotting scope and an ultrasonic bat detector are strongly recommended but not required.

Time	Number of Bats Leaving Roost*	Comments / Notes
20:33	1	First bat
20:43	1	Bat 172, 413
20:46	1	Last Bat

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

Site Name/#: Roost 01 Bat 1724 **Roost Name/#:** Roost 01

Time	Number of Bats Leaving Roost*	Comments / Notes
Total Number of Bats Observed Emerging from the Roost/Feature During the Survey:	56	

* If any bats return to the roost during the survey, then they should be subtracted from the tally.

Describe Emergence: Did bats emerge simultaneously, fly off in the same direction, loiter, circle, disperse, etc. If a radio-tagged bat was roosting in the tree, at what time did it emerge?

Bats emerged at different times, sometimes bats would loiter and circle the roost.

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

USFWS BAT EMERGENCE SURVEY DATASHEET

Date: 7-18-2018 **Surveyor(s) Full Name:** Alex Patterson

State: IL **County:** Williamson **Project Name:** Bond Creek Wa. 1 Mine North Pauls

Site Name/#: 01 **Roost Name/#** Roost 01 **Bat #:** 172.413

Lat/Long or UTM of Roost: 37.84350, -88.79230

Description of Roost/Habitat Feature Surveyed: The roost is a long, dead silver maple

Bat Species Known to be using this Roost/Feature (if not known, leave blank):
Myotis sodalis

Other Suspected Bat Species (explain): _____

Weather Conditions during Survey (temperature, precipitation, wind speed):
Warm and clear

Survey Start Time: 19:45 **Time of Sunset:** 20:45 **Survey End Time:** 20:56

NOTE: Emergence surveys should begin ½ hour before sunset and continue until at least one hour after sunset or until it is otherwise too dark to see emerging bats. The surveyor(s) should position him or herself so that emerging bats will be silhouetted against the sky as they exit the roost. Tallies of emerging bats should be recorded every few minutes or as natural breaks in bat activity allow. Please ensure that surveyor(s) are close enough to the roost to observe all exiting/returning bats, but not close enough to influence emergence (i.e., do not stand directly beneath the roost and do not make unnecessary noise and/or conversation, and minimize use of lights other than a small flashlight to record data, if necessary). Do not shine a light on the roost tree crevice/cave/mine entrance itself as this may prevent or delay bats from emerging. If available, use of an infra-red, night vision, or thermal-imaging video camera or spotting scope and an ultrasonic bat detector are strongly recommended but not required.

Time	Number of Bats Leaving Roost*	Comments / Notes
20:25	1	First bat
20:40	1	Bat 172.413
20:50	1	Last bat

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

Site Name/#: 01 **Roost Name/#:** Roost 01 Bat 172.413

Time	Number of Bats Leaving Roost*	Comments / Notes
Total Number of Bats Observed Emerging from the Roost/Feature During the Survey:	52	

* If any bats return to the roost during the survey, then they should be subtracted from the tally.

Describe Emergence: Did bats emerge simultaneously, fly off in the same direction, loiter, circle, disperse, etc. If a radio-tagged bat was roosting in the tree, at what time did it emerge?

Bats were observed circling the roosts after emergence.

APPENDIX D: PHASE 4 RADIO-TRACKING

USFWS INDIANA BAT ROOST DATASHEET

Biologists (Full Name): Alex Patterson **Date:** 7-19-2018

UTM: Zone_____ **Easting** _____ **Northing**_____ ***OR***

LAT 37.8468337 **LONG** -88.7881944

Property Owner:_____ **Phone#**_____

State Illinois **County** Williamson **Site #** 01

Roost # 02 **Roost Name:** Bat 172.463 Roost 02

Roost Tree Data

Species: American elm **Live** __ **Snag** X **Other** __

(if other, explain) _____

DBH (in or cm) 18 inches **Total Height (ft or m)** 35ft

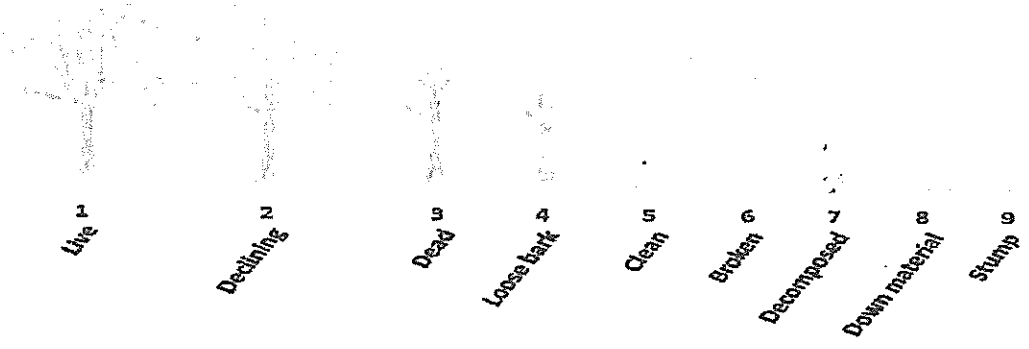
Height of roost area (if known)_____ **Dist. from capture site** ≈ 2 miles

Roost position aspect (deg)_____

Exfoliating bark on bole (%) 30% **Describe: sloughing** X **platy**__ **tight**__

Cavities present? ____ **If so, describe:**_____

Roost Decay State: 1 2 3 (4) 5 6 7 8 9 Other



APPENDIX D: PHASE 4 RADIO-TRACKING

Roost tree or snag canopy position: Dominant X **Co-Dominant** __ **Suppressed** __

Surrounding Habitat Condition

Canopy closure at roost (%) 0%

Approximate woodlot size (ac or ha) 100 **Distance to non-forest (ft or m)** 500 Ft

Describe forest/woodlot current condition (mature, partially cut-over, burned, insect damage, etc.)
The Roost 02 for Bat 172.413 was located within a swamp surrounded by a mature forest. Roost 02 was in the same swamp as the First roost.

Additional Comments

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

USFWS BAT EMERGENCE SURVEY DATASHEET

Date: 7-19-18 **Surveyor(s) Full Name:** Braden Hoffman
State: IL **County:** Williamson **Project Name:** Pond Creek No. 1 North Panels
Site Name/#: 01 **Roost Name/#** Roost 02 **Bat #:** 172.413
Lat/Long or UTM of Roost: 37.8468337, -88.7881444
Description of Roost/Habitat Feature Surveyed: Large dead elm

Bat Species Known to be using this Roost/Feature (if not known, leave blank):
Myotis sodalis
Other Suspected Bat Species (explain):
Weather Conditions during Survey (temperature, precipitation, wind speed):
warm and clear
Survey Start Time: 19:45 **Time of Sunset:** 20:45 **Survey End Time:** 20:59

NOTE: Emergence surveys should begin ½ hour before sunset and continue until at least one hour after sunset or until it is otherwise too dark to see emerging bats. The surveyor(s) should position him or herself so that emerging bats will be silhouetted against the sky as they exit the roost. Tallies of emerging bats should be recorded every few minutes or as natural breaks in bat activity allow. Please ensure that surveyor(s) are close enough to the roost to observe all exiting/returning bats, but not close enough to influence emergence (i.e., do not stand directly beneath the roost and do not make unnecessary noise and/or conversation, and minimize use of lights other than a small flashlight to record data, if necessary). Do not shine a light on the roost tree crevice/cave/mine entrance itself as this may prevent or delay bats from emerging. If available, use of an infra-red, night vision, or thermal-imaging video camera or spotting scope and an ultrasonic bat detector are strongly recommended but not required.

Time	Number of Bats Leaving Roost*	Comments / Notes
20:30	1	First Bat
20:40	1	Bat 172.413
20:50	1	Last Bat

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

Site Name/#: 01 **Roost Name/#:** 02

Time	Number of Bats Leaving Roost*	Comments / Notes
Total Number of Bats Observed Emerging from the Roost/Feature During the Survey:	27	

* If any bats return to the roost during the survey, then they should be subtracted from the tally.

Describe Emergence: Did bats emerge simultaneously, fly off in the same direction, loiter, circle, disperse, etc. If a radio-tagged bat was roosting in the tree, at what time did it emerge?

Bats would emerge from the roost and circle the try before leaving for the night.

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

USFWS BAT EMERGENCE SURVEY DATASHEET

Date: 7-20-18 **Surveyor(s) Full Name:** Braden Hoffman
State: IL **County:** Williamson **Project Name:** Ford Creek No. 1 North Panels
Site Name/#: 01 **Roost Name/#** 02 **Bat #:** 122, 413
Lat/Long or UTM of Roost: 37.8468332, -88.7881444
Description of Roost/Habitat Feature Surveyed: Large dead elm.

Bat Species Known to be using this Roost/Feature (if not known, leave blank):
Myotis sodalis
Other Suspected Bat Species (explain):
Weather Conditions during Survey (temperature, precipitation, wind speed):
Warm and clear
Survey Start Time: 19:45 **Time of Sunset:** 20:45 **Survey End Time:** 20:59

NOTE: Emergence surveys should begin ½ hour before sunset and continue until at least one hour after sunset or until it is otherwise too dark to see emerging bats. The surveyor(s) should position him or herself so that emerging bats will be silhouetted against the sky as they exit the roost. Tallies of emerging bats should be recorded every few minutes or as natural breaks in bat activity allow. Please ensure that surveyor(s) are close enough to the roost to observe all exiting/returning bats, but not close enough to influence emergence (i.e., do not stand directly beneath the roost and do not make unnecessary noise and/or conversation, and minimize use of lights other than a small flashlight to record data, if necessary). Do not shine a light on the roost tree crevice/cave/mine entrance itself as this may prevent or delay bats from emerging. If available, use of an infra-red, night vision, or thermal-imaging video camera or spotting scope and an ultrasonic bat detector are strongly recommended but not required.

Time	Number of Bats Leaving Roost*	Comments / Notes
20:29	1	First Bat
20:48	1	Last Bat

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

Site Name/#: 01 **Roost Name/#:** Roost 02

Time	Number of Bats Leaving Roost*	Comments / Notes
Total Number of Bats Observed Emerging from the Roost/Feature During the Survey:	43	

* If any bats return to the roost during the survey, then they should be subtracted from the tally.

Describe Emergence: Did bats emerge simultaneously, fly off in the same direction, loiter, circle, disperse, etc. If a radio-tagged bat was roosting in the tree, at what time did it emerge?

Bats were observed leaving the roost and circling before leaving for the night

APPENDIX D: PHASE 4 RADIO-TRACKING

USFWS INDIANA BAT ROOST DATASHEET

Biologists (Full Name): Brady Hoffman Date: 7-21-18

UTM: Zone_____ Easting_____ Northing_____ *OR*

LAT 37.8461495 LONG -88.7880787

Property Owner:_____ Phone#_____

State Illinois County Williamson Site # 01

Roost # 03 Roost Name: Bat 172.413 Roost 03

Roost Tree Data

Species: Fraxinus spp Live__ Snag X Other__

(if other, explain) _____

DBH (in or cm) 12 in Total Height (ft or m) 50 ft

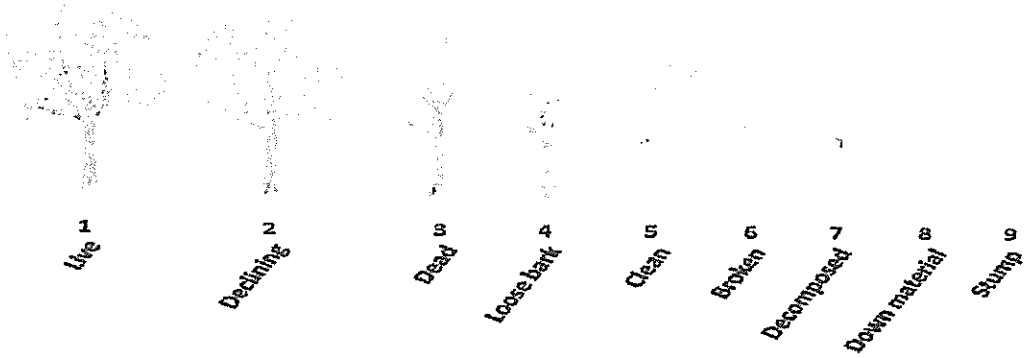
Height of roost area (if known)_____ Dist. from capture site ≈ 2 miles

Roost position aspect (deg)_____

Exfoliating bark on bole (%) 25% Describe: sloughing X platy__ tight__

Cavities present? ____ If so, describe:_____

Roost Decay State: 1 2 3 (4) 5 6 7 8 9 Other



APPENDIX D: PHASE 4 RADIO-TRACKING

Roost tree or snag canopy position: Dominant X **Co-Dominant** __ **Suppressed** __

Surrounding Habitat Condition

Canopy closure at roost (%) 0

Approximate woodlot size (ac or ha) 100 **Distance to non-forest (ft or m)** 500 Ft

Describe forest/woodlot current condition (mature, partially cut-over, burned, insect damage, etc.)
The roost was located in a swamp surrounded by a mature woodlot.

Additional Comments

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

USFWS BAT EMERGENCE SURVEY DATASHEET

Date: 7-21-18 **Surveyor(s) Full Name:** Braden Hoffman
State: IL **County:** Williamson **Project Name:** Pond Creek No. 1 North Panels
Site Name/#: 01 **Roost Name/#** 03 **Bat #:** 172.413
Lat/Long or UTM of Roost: 37.846149S, -88.788078
Description of Roost/Habitat Feature Surveyed: Large dead ash tree.

Bat Species Known to be using this Roost/Feature (if not known, leave blank):
Myotis sodalis
Other Suspected Bat Species (explain):
Weather Conditions during Survey (temperature, precipitation, wind speed):
Warm and clear
Survey Start Time: 19:45 **Time of Sunset:** 20:45 **Survey End Time:** 20:58

NOTE: Emergence surveys should begin ½ hour before sunset and continue until at least one hour after sunset or until it is otherwise too dark to see emerging bats. The surveyor(s) should position him or herself so that emerging bats will be silhouetted against the sky as they exit the roost. Tallies of emerging bats should be recorded every few minutes or as natural breaks in bat activity allow. Please ensure that surveyor(s) are close enough to the roost to observe all exiting/returning bats, but not close enough to influence emergence (i.e., do not stand directly beneath the roost and do not make unnecessary noise and/or conversation, and minimize use of lights other than a small flashlight to record data, if necessary). Do not shine a light on the roost tree crevice/cave/mine entrance itself as this may prevent or delay bats from emerging. If available, use of an infra-red, night vision, or thermal-imaging video camera or spotting scope and an ultrasonic bat detector are strongly recommended but not required.

Time	Number of Bats Leaving Roost*	Comments / Notes
20:36	1	First bat
20:45	1	Bat 172.413
20:48	1	Last bat

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

Site Name/#: 01 **Roost Name/#:** Roost 03 Bat 172.413

Time	Number of Bats Leaving Roost*	Comments / Notes
Total Number of Bats Observed Emerging from the Roost/Feature During the Survey:	47	

* If any bats return to the roost during the survey, then they should be subtracted from the tally.

Describe Emergence: Did bats emerge simultaneously, fly off in the same direction, loiter, circle, disperse, etc. If a radio-tagged bat was roosting in the tree, at what time did it emerge?

Bats emerged randomly and circle the tree before leaving for the night.

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

USFWS BAT EMERGENCE SURVEY DATASHEET

Date: 7-23-18 **Surveyor(s) Full Name:** Alex Patterson
State: IL **County:** Williamson **Project Name:** Pond Creek No. 1 North Panel 1
Site Name/#: G1 **Roost Name/#** Roost 03 **Bat #:** 172, 417
Lat/Long or UTM of Roost: 37.8461495, -88.7880787
Description of Roost/Habitat Feature Surveyed: Large dead ash tree

Bat Species Known to be using this Roost/Feature (if not known, leave blank):
Myotis sodalis
Other Suspected Bat Species (explain):
Weather Conditions during Survey (temperature, precipitation, wind speed):
Warm and clear
Survey Start Time: 19:45 **Time of Sunset:** 20:45 **Survey End Time:** 20:59

NOTE: Emergence surveys should begin ½ hour before sunset and continue until at least one hour after sunset or until it is otherwise too dark to see emerging bats. The surveyor(s) should position him or herself so that emerging bats will be silhouetted against the sky as they exit the roost. Tallies of emerging bats should be recorded every few minutes or as natural breaks in bat activity allow. Please ensure that surveyor(s) are close enough to the roost to observe all exiting/returning bats, but not close enough to influence emergence (i.e., do not stand directly beneath the roost and do not make unnecessary noise and/or conversation, and minimize use of lights other than a small flashlight to record data, if necessary). Do not shine a light on the roost tree crevice/cave/mine entrance itself as this may prevent or delay bats from emerging. If available, use of an infra-red, night vision, or thermal-imaging video camera or spotting scope and an ultrasonic bat detector are strongly recommended but not required.

Time	Number of Bats Leaving Roost*	Comments / Notes
20:34	1	First Bat
20:55	1	Last Bat

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

Site Name/#: 01 **Roost Name/#:** Roost 03 Bat 172, 413

Time	Number of Bats Leaving Roost*	Comments / Notes
Total Number of Bats Observed Emerging from the Roost/Feature During the Survey:	40	

* If any bats return to the roost during the survey, then they should be subtracted from the tally.

Describe Emergence: Did bats emerge simultaneously, fly off in the same direction, loiter, circle, disperse, etc. If a radio-tagged bat was roosting in the tree, at what time did it emerge?

Bats emerged and circled the tree before leaving for the night. Bat 172, 413 could not be heard on this day.

APPENDIX D: PHASE 4 RADIO-TRACKING

USFWS INDIANA BAT ROOST DATASHEET

Biologists (Full Name): Brady Hoffman **Date:** 7-19-18

UTM: Zone_____ **Easting** _____ **Northing**_____ ***OR***

LAT 37.84592 **LONG** -88.78396

Property Owner:_____ **Phone#**_____

State Illinois **County** Williamson **Site #** 03

Roost # 01 **Roost Name:** Bat 172.636 Roost 01

Roost Tree Data

Species: common huckberry **Live** __ **Snag** X **Other** __

(if other, explain) _____

DBH (in or cm) 14in **Total Height (ft or m)** 45 Ft

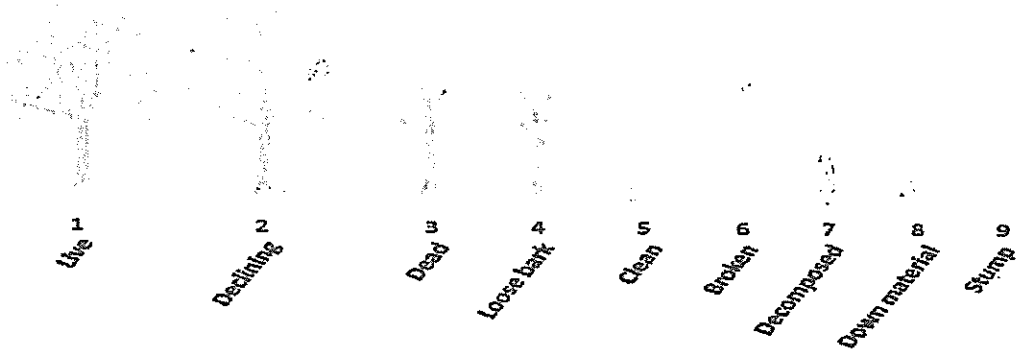
Height of roost area (if known)_____ **Dist. from capture site** ≈ 1.5 miles

Roost position aspect (deg)_____

Exfoliating bark on bole (%) 75 **Describe: sloughing** X **platy**__ **tight**__

Cavities present? ____ **If so, describe:**_____

Roost Decay State: 1 2 3 (4) 5 6 7 8 9 Other



APPENDIX D: PHASE 4 RADIO-TRACKING

Roost tree or snag canopy position: Dominant __ Co-Dominant X Suppressed __

Surrounding Habitat Condition

Canopy closure at roost (%) 0%

Approximate woodlot size (ac or ha) 100 **Distance to non-forest (ft or m)** 500ft

Describe forest/woodlot current condition (mature, partially cut-over, burned, insect damage, etc.)
Roost is located with a swamp. The swamp is within a woodlot which is comprised primarily of mature trees with some areas of underbrush.

Additional Comments

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

USFWS BAT EMERGENCE SURVEY DATASHEET

Date: 7-19-18 **Surveyor(s) Full Name:** Braden Huffman
State: IL **County:** Williamson **Project Name:** Pond Creek No. 1 North Panels
Site Name/#: 02 **Roost Name/#** Roost 01 **Bat #:** 172.635
Lat/Long or UTM of Roost: 37.84592°, -88.78796°
Description of Roost/Habitat Feature Surveyed: Dead common hackberry

Bat Species Known to be using this Roost/Feature (if not known, leave blank):
Myotis sodalis
Other Suspected Bat Species (explain):
Weather Conditions during Survey (temperature, precipitation, wind speed):
Warm and clear
Survey Start Time: 19:45 **Time of Sunset:** 20:45 **Survey End Time:** 20:59

NOTE: Emergence surveys should begin ½ hour before sunset and continue until at least one hour after sunset or until it is otherwise too dark to see emerging bats. The surveyor(s) should position him or herself so that emerging bats will be silhouetted against the sky as they exit the roost. Tallies of emerging bats should be recorded every few minutes or as natural breaks in bat activity allow. Please ensure that surveyor(s) are close enough to the roost to observe all exiting/returning bats, but not close enough to influence emergence (i.e., do not stand directly beneath the roost and do not make unnecessary noise and/or conversation, and minimize use of lights other than a small flashlight to record data, if necessary). Do not shine a light on the roost tree crevice/cave/mine entrance itself as this may prevent or delay bats from emerging. If available, use of an infra-red, night vision, or thermal-imaging video camera or spotting scope and an ultrasonic bat detector are strongly recommended but not required.

Time	Number of Bats Leaving Roost*	Comments / Notes
20:38	1	Only bat, Bat 172.636

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

Site Name/#: 02 **Roost Name/#:** Roost of Bat 172,636

Time	Number of Bats Leaving Roost*	Comments / Notes
Total Number of Bats Observed Emerging from the Roost/Feature During the Survey:	1	

* If any bats return to the roost during the survey, then they should be subtracted from the tally.

Describe Emergence: Did bats emerge simultaneously, fly off in the same direction, loiter, circle, disperse, etc. If a radio-tagged bat was roosting in the tree, at what time did it emerge?

Bat left the roost and did not remain in the area

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

USFWS BAT EMERGENCE SURVEY DATASHEET

Date: 7-21-18 **Surveyor(s) Full Name:** Braden Huffman

State: TN **County:** Williamson **Project Name:** Pond Creek No. 1 North Panels

Site Name/#: 02 **Roost Name/#** Roost 02 **Bat #:** 172.636

Lat/Long or UTM of Roost: 37.84592, -88.78796

Description of Roost/Habitat Feature Surveyed: Dead common hackberry

Bat Species Known to be using this Roost/Feature (if not known, leave blank):
Myotis sodalis

Other Suspected Bat Species (explain): _____

Weather Conditions during Survey (temperature, precipitation, wind speed):
Warm and clear

Survey Start Time: 19:45 **Time of Sunset:** 20:45 **Survey End Time:** 20:55

NOTE: Emergence surveys should begin ½ hour before sunset and continue until at least one hour after sunset or until it is otherwise too dark to see emerging bats. The surveyor(s) should position him or herself so that emerging bats will be silhouetted against the sky as they exit the roost. Tallies of emerging bats should be recorded every few minutes or as natural breaks in bat activity allow. Please ensure that surveyor(s) are close enough to the roost to observe all exiting/returning bats, but not close enough to influence emergence (i.e., do not stand directly beneath the roost and do not make unnecessary noise and/or conversation, and minimize use of lights other than a small flashlight to record data, if necessary). Do not shine a light on the roost tree crevice/cave/mine entrance itself as this may prevent or delay bats from emerging. If available, use of an infra-red, night vision, or thermal-imaging video camera or spotting scope and an ultrasonic bat detector are strongly recommended but not required.

Time	Number of Bats Leaving Roost*	Comments / Notes
20:55	1	Only bat, But 172.636

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

Site Name/#: 02 **Roost Name/#:** Roost 01 Bat 172.636

Time	Number of Bats Leaving Roost*	Comments / Notes
Total Number of Bats Observed Emerging from the Roost/Feature During the Survey:	1	

* If any bats return to the roost during the survey, then they should be subtracted from the tally.

Describe Emergence: Did bats emerge simultaneously, fly off in the same direction, loiter, circle, disperse, etc. If a radio-tagged bat was roosting in the tree, at what time did it emerge?

Bat emerged and left the area.

APPENDIX D: PHASE 4 RADIO-TRACKING

USFWS INDIANA BAT ROOST DATASHEET

Biologists (Full Name): Braden Hoffman **Date:** 7-20-18

UTM: Zone_____ **Easting** _____ **Northing**_____ ***OR***

LAT 37.8464514 **LONG** -88.7883335

Property Owner:_____ **Phone#**_____

State Illinois **County** Williamson **Site #** 02

Roost # 02 **Roost Name:** Roost02 Bat172,636

Roost Tree Data

Species: American elm **Live** __ **Snag** X **Other** __

(if other, explain) _____

DBH (in or cm) 14 in **Total Height (ft or m)** 30Ft

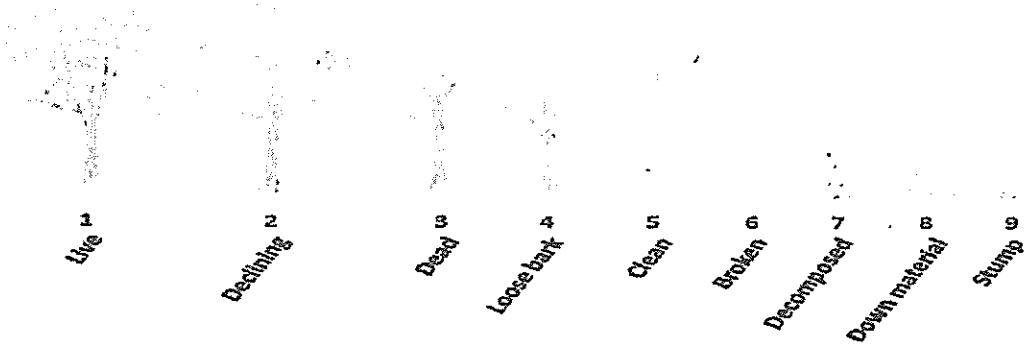
Height of roost area (if known)_____ **Dist. from capture site** ≈ 2 miles

Roost position aspect (deg)_____

Exfoliating bark on bole (%) 30 **Describe: sloughing** X **platy** __ **tight** __

Cavities present? ____ **If so, describe:**_____

Roost Decay State: 1 2 3 (4) 5 6 7 8 9 Other



APPENDIX D: PHASE 4 RADIO-TRACKING

Roost tree or snag canopy position: Dominant __ Co-Dominant X Suppressed __

Surrounding Habitat Condition

Canopy closure at roost (%) 0

Approximate woodlot size (ac or ha) 100 **Distance to non-forest (ft or m)** 500 Ft

Describe forest/woodlot current condition (mature, partially cut-over, burned, insect damage, etc.)
Roost tree was in a swamp that was within a woodlot. The woodlot was comprised mainly of mature trees with some sections of low under brush.

Additional Comments

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

USFWS BAT EMERGENCE SURVEY DATASHEET

Date: 7-20-18 **Surveyor(s) Full Name:** Braden Hoffman
State: TN **County:** Williamson **Project Name:** Sand Creek Dev. North Parcels
Site Name/#: 02 **Roost Name/#** 02 **Bat #:** 172.636
Lat/Long or UTM of Roost: 35.846454, -86.788333
Description of Roost/Habitat Feature Surveyed: Large dead American elm tree

Bat Species Known to be using this Roost/Feature (if not known, leave blank):
Myotis sodalis
Other Suspected Bat Species (explain):
Weather Conditions during Survey (temperature, precipitation, wind speed):
Warm and clear
Survey Start Time: 19:45 **Time of Sunset:** 20:45 **Survey End Time:** 20:59

NOTE: Emergence surveys should begin ½ hour before sunset and continue until at least one hour after sunset or until it is otherwise too dark to see emerging bats. The surveyor(s) should position him or herself so that emerging bats will be silhouetted against the sky as they exit the roost. Tallies of emerging bats should be recorded every few minutes or as natural breaks in bat activity allow. Please ensure that surveyor(s) are close enough to the roost to observe all exiting/returning bats, but not close enough to influence emergence (i.e., do not stand directly beneath the roost and do not make unnecessary noise and/or conversation, and minimize use of lights other than a small flashlight to record data, if necessary). Do not shine a light on the roost tree crevice/cave/mine entrance itself as this may prevent or delay bats from emerging. If available, use of an infra-red, night vision, or thermal-imaging video camera or spotting scope and an ultrasonic bat detector are strongly recommended but not required.

Time	Number of Bats Leaving Roost*	Comments / Notes
20:37	1	Baby bat, bat 172.636

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

Site Name/#: 07 **Roost Name/#:** Roost 02 Bat 172.636

Time	Number of Bats Leaving Roost*	Comments / Notes
Total Number of Bats Observed Emerging from the Roost/Feature During the Survey:	1	

* If any bats return to the roost during the survey, then they should be subtracted from the tally.

Describe Emergence: Did bats emerge simultaneously, fly off in the same direction, loiter, circle, disperse, etc. If a radio-tagged bat was roosting in the tree, at what time did it emerge?

Bat emerged on 2 left the area.

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

USFWS BAT EMERGENCE SURVEY DATASHEET

Date: 7-21-18 Surveyor(s) Full Name: Braden Hoffman

State: IL County: Williamson Project Name: Bad Creek No. 1 North Panels

Site Name/#: 02 Roost Name/# Roost 02 Bat #: 172.636

Lat/Long or UTM of Roost: 37.8464574, -88.7883335

Description of Roost/Habitat Feature Surveyed: Large dead American elm.

Bat Species Known to be using this Roost/Feature (if not known, leave blank):
Myotis sodalis

Other Suspected Bat Species (explain):

Weather Conditions during Survey (temperature, precipitation, wind speed):
Warm and clear

Survey Start Time: 19:45 Time of Sunset: 20:45 Survey End Time: 20:59

NOTE: Emergence surveys should begin ½ hour before sunset and continue until at least one hour after sunset or until it is otherwise too dark to see emerging bats. The surveyor(s) should position him or herself so that emerging bats will be silhouetted against the sky as they exit the roost. Tallies of emerging bats should be recorded every few minutes or as natural breaks in bat activity allow. Please ensure that surveyor(s) are close enough to the roost to observe all exiting/returning bats, but not close enough to influence emergence (i.e., do not stand directly beneath the roost and do not make unnecessary noise and/or conversation, and minimize use of lights other than a small flashlight to record data, if necessary). Do not shine a light on the roost tree crevice/cave/mine entrance itself as this may prevent or delay bats from emerging. If available, use of an infra-red, night vision, or thermal-imaging video camera or spotting scope and an ultrasonic bat detector are strongly recommended but not required.

Time	Number of Bats Leaving Roost*	Comments / Notes
		No bats

APPENDIX E: PHASE 4 EMERGENCE SURVEYS

Site Name/#: 07 **Roost Name/#:** Roost 07 Bat 172,636

Time	Number of Bats Leaving Roost*	Comments / Notes
Total Number of Bats Observed Emerging from the Roost/Feature During the Survey:	0	

* If any bats return to the roost during the survey, then they should be subtracted from the tally.

Describe Emergence: Did bats emerge simultaneously, fly off in the same direction, loiter, circle, disperse, etc. If a radio-tagged bat was roosting in the tree, at what time did it emerge?

No bats

APPENDIX E

PHOTOGRAPHS OF MIST NET SITES AND REPRESENTATIVE BAT SPECIES CAPTURED WITHIN THE PROJECT AREA

Project No. B18-128-1413

PHOTOGRAPHS OF MIST NET SITES AND REPRESENTATIVE BAT SPECIES CAPTURED WITHIN POND CREEK NO. 1 MINE NORTH PANELS



Site 1, Net A



Site 1, Net B

Project No. B18-128-1413

PHOTOGRAPHS OF MIST NET SITES AND REPRESENTATIVE BAT SPECIES CAPTURED WITHIN POND CREEK NO. 1 MINE NORTH PANELS



Site 1, Net C



Site 1, Net D

Project No. B18-128-1413

PHOTOGRAPHS OF MIST NET SITES AND REPRESENTATIVE BAT SPECIES CAPTURED WITHIN POND CREEK NO. 1 MINE NORTH PANELS



Site 1, Net E



Site 2, Net A

Project No. B18-128-1413

PHOTOGRAPHS OF MIST NET SITES AND REPRESENTATIVE BAT SPECIES CAPTURED WITHIN POND CREEK NO. 1 MINE NORTH PANELS



Site 2, Net B



Site 2, Net C

Project No. B18-128-1413

PHOTOGRAPHS OF MIST NET SITES AND REPRESENTATIVE BAT SPECIES CAPTURED WITHIN POND CREEK NO. 1 MINE NORTH PANELS



Site 7, Net A



Site 7, Net B

Project No. B18-128-1413

PHOTOGRAPHS OF MIST NET SITES AND REPRESENTATIVE BAT SPECIES CAPTURED WITHIN POND CREEK NO. 1 MINE NORTH PANELS



Site 7, Net C



Site 7, Net D

Project No. B18-128-1413

PHOTOGRAPHS OF MIST NET SITES AND REPRESENTATIVE BAT SPECIES CAPTURED WITHIN POND CREEK NO. 1 MINE NORTH PANELS



Site 7, Net E



Site 8, Net A

Project No. B18-128-1413

PHOTOGRAPHS OF MIST NET SITES AND REPRESENTATIVE BAT SPECIES CAPTURED WITHIN POND CREEK NO. 1 MINE NORTH PANELS



Site 8, Net B



Site 8, Net C

Project No. B18-128-1413

PHOTOGRAPHS OF MIST NET SITES AND REPRESENTATIVE BAT SPECIES CAPTURED WITHIN POND CREEK NO. 1 MINE NORTH PANELS



Site 8, Net D



Site 8, Net E

Project No. B18-128-1413

PHOTOGRAPHS OF MIST NET SITES AND REPRESENTATIVE BAT SPECIES CAPTURED WITHIN POND CREEK NO. 1 MINE NORTH PANELS



Eastern Red Bat (*Lasiurus borealis*)



Indiana Bat (*Myotis sodalis*)

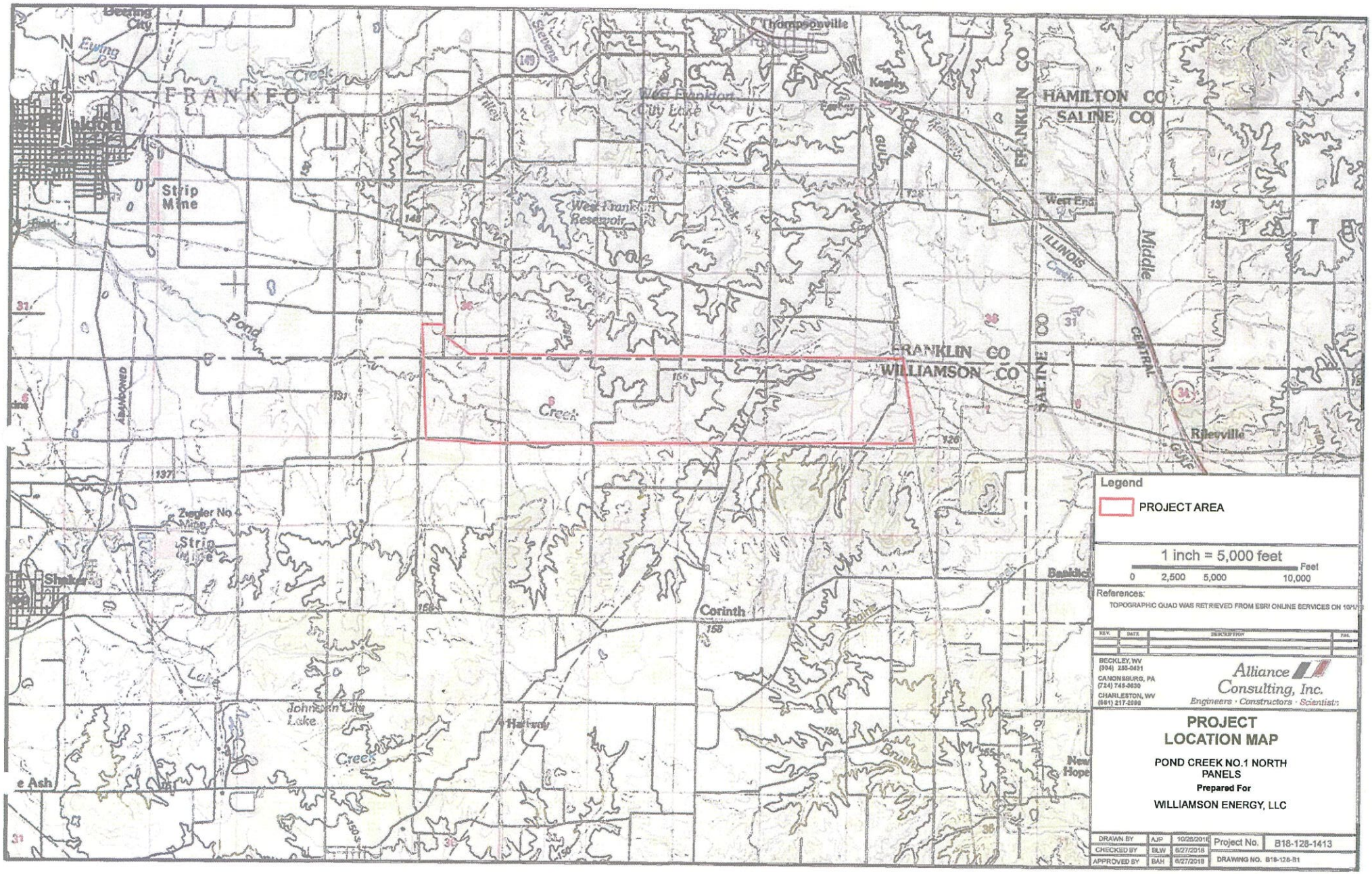
Project No. B18-128-1413

PHOTOGRAPHS OF MIST NET SITES AND REPRESENTATIVE BAT SPECIES CAPTURED WITHIN POND CREEK NO. 1 MINE NORTH PANELS

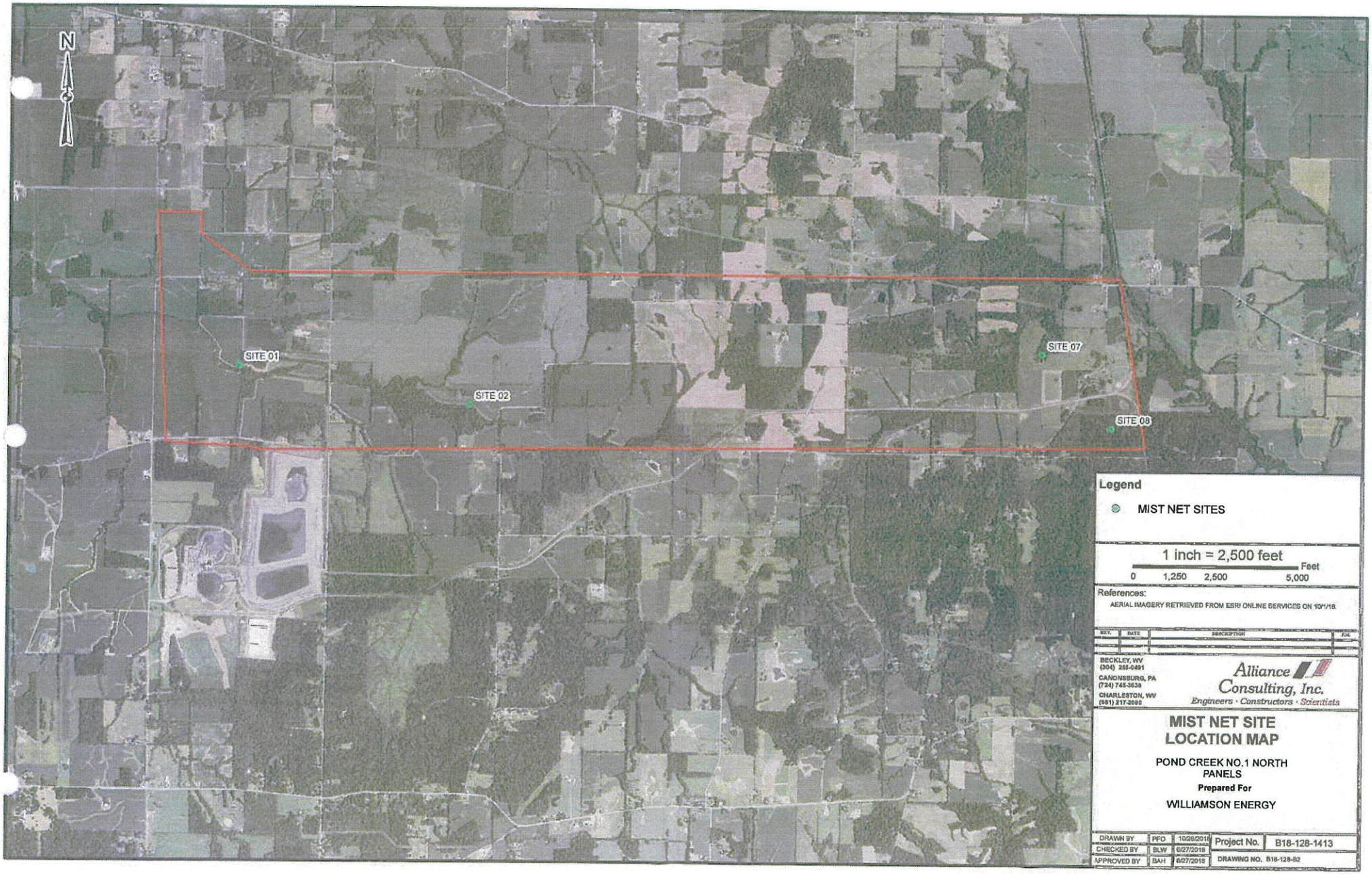


Tri-Colored Bat (*Perimyotis subflavus*)

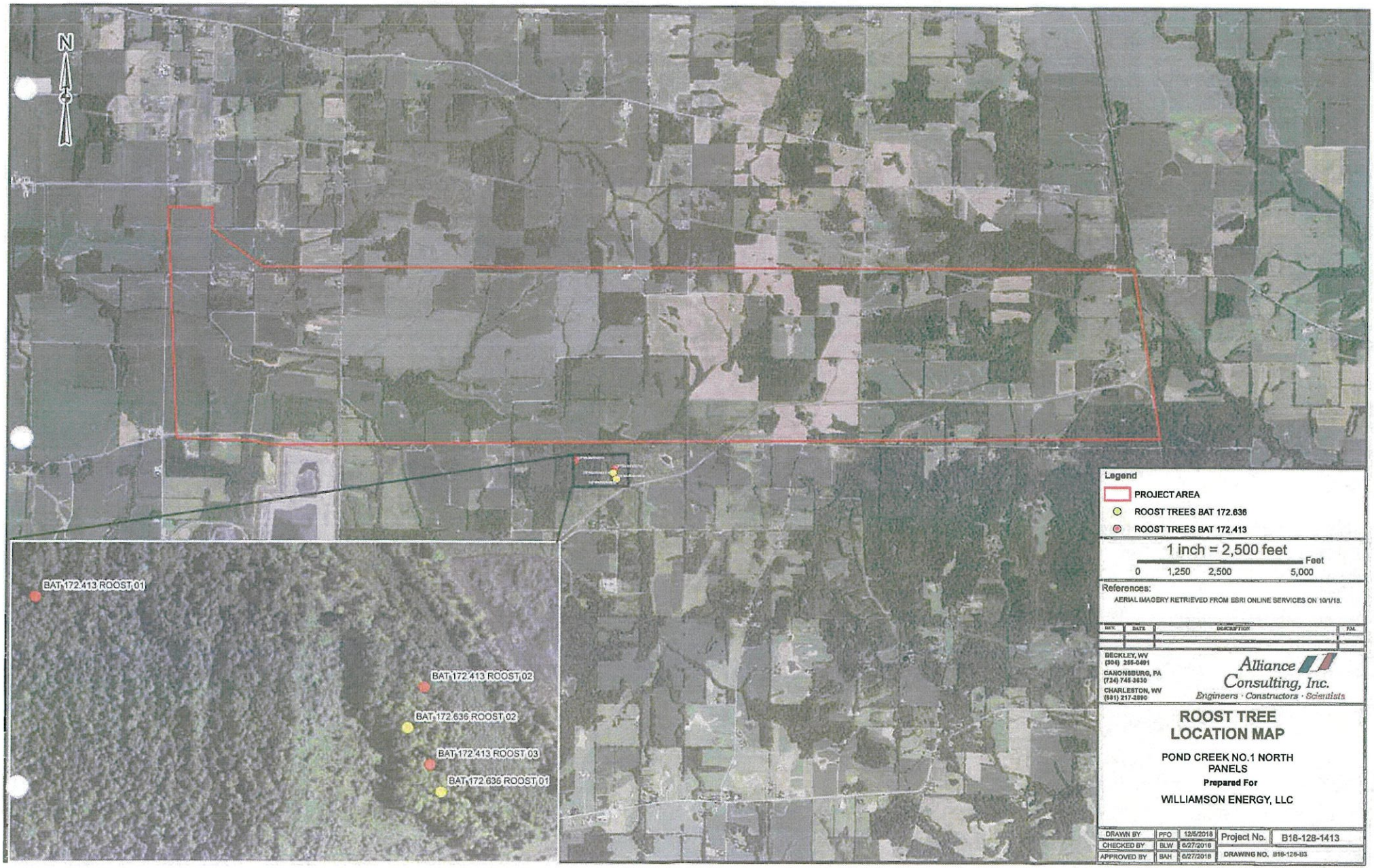
FIGURES


FRANKFORT
Strip Mine
West Frankfort City Lake
West Frankfort Reservoir
Thompsonville
HAMILTON CO
SALINE CO
FRANKLIN CO
WILLIAMSON CO
Rileyville
Corinth
Johnston City Lake
Zeigler No 9 Mine
Strip Mine
Legend
PROJECT AREA
1 inch = 5,000 feet
0 2,500 5,000 10,000 Feet
References:
TOPOGRAPHIC QUAD WAS RETRIEVED FROM ESRI ONLINE SERVICES ON 10/1/18
REV. DATE DESCRIPTION PM
BECKLEY, WV (304) 255-0491
CANONSBURG, PA (724) 745-3630
CHARLESTON, WV (681) 217-2090
Alliance Consulting, Inc.
Engineers · Constructors · Scientists
PROJECT LOCATION MAP
POND CREEK NO.1 NORTH PANELS
Prepared For
WILLIAMSON ENERGY, LLC
DRAWN BY AJP 10/26/2018
CHECKED BY BLW 6/27/2018
APPROVED BY BAH 6/27/2018
Project No. B18-128-1413
DRAWING NO. B18-128-R1

R06562


N
SITE 01
SITE 02
SITE 07
SITE 08
Legend
MIST NET SITES
1 inch = 2,500 feet
Feet
0
1,250
2,500
5,000
References:
AERIAL IMAGERY RETRIEVED FROM ESRI ONLINE SERVICES ON 10/1/18.
REV.
DATE
DESCRIPTION
APP.
BECKLEY, WV
(304) 255-0491
CANONSBURG, PA
(724) 745-3638
CHARLESTON, WV
(681) 217-2080
Alliance Consulting, Inc.
Engineers · Constructors · Scientists
MIST NET SITE LOCATION MAP
POND CREEK NO.1 NORTH PANELS
Prepared For
WILLIAMSON ENERGY
DRAWN BY
PFO
10/26/2018
CHECKED BY
BLW
6/27/2018
APPROVED BY
BAH
6/27/2018
Project No.
B18-128-1413
DRAWING NO. B18-128-B2

R06563


N
BAT 172.413 ROOST 01
BAT 172.413 ROOST 02
BAT 172.636 ROOST 02
BAT 172.413 ROOST 03
BAT 172.636 ROOST 01
Legend
PROJECT AREA
ROOST TREES BAT 172.636
ROOST TREES BAT 172.413
1 inch = 2,500 feet
Feet
0 1,250 2,500 5,000
References:
AERIAL IMAGERY RETRIEVED FROM ESRI ONLINE SERVICES ON 10/1/18.
REV. DATE DESCRIPTION P.M.
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CANONSBURG, PA (724) 745-3630
CHARLESTON, WV (681) 217-2990
Alliance Consulting, Inc.
Engineers · Constructors · Scientists
ROOST TREE LOCATION MAP
POND CREEK NO.1 NORTH PANELS
Prepared For
WILLIAMSON ENERGY, LLC
DRAWN BY PFO 12/5/2018
CHECKED BY BLW 6/27/2018
APPROVED BY SAH 6/27/2018
Project No. B18-128-1413
DRAWING NO. B18-128-B3

R06564

Chuck-Wills-Widow Nesting Habitat Assessment

North District Shaft IBR Site

Pond Creek Mine

Williamson County, IL

Prepared for:

Williamson Energy, LLC

Prepared by:

William O'Leary, M.S.

HMG Engineers, Inc.

1032 N. 6th Street

Murphysboro, Illinois 62966

January 2019

INTRODUCTION

HMG Engineers, Inc. (HMG) was contacted by Williamson Energy, LLC seeking assistance in assessing the likelihood of the presence of Chuck-Wills-Widow nesting habitat associated with a corridor and shaft site located in Williamson County 4 miles south of Thompsonville, IL. The site includes a corridor 2 miles long and 50 feet wide and also a trapezoidal shaped tract 4.4 acres on the east end (Figure 1).

Williamson Energy, LLC informed HMG of a concern regarding Chuck-Wills-Widows (*Caprimulgus carolinensis)*, a listed (threatened) bird species in Illinois. Chuck-Wills-Widows reportedly nest on the ground among dead leaves, pine needles, or bare dirt in dense thickets near openings. State biologists were wanting more information regarding the liklihood that Chuck-Wills-Widow nesting habitat occurs in the proposed IBR area.

METHODS

The entire proposed IBR area including both the corridor and the 4.4 acre tract were visually inspected. Habitat features including vegetation composition were noted and compared with the reported preferred nesting habitat for the Chuck-Wills-Widow.

RESULTS

The most prevalent vegetation cover in the proposed IBR area is soy bean stubble. The next most prevalent is cool season grassland. Neither of these vegetation regimes has any woody vegetation. These two cover types account for approximately 95% of the proposed IBR area. The remaining 5 % includes stream channels with narrow wooded margins. These margins include thick understory vegetation composed largely of Japanese honeysuckle, multiflora rose, and blackberry. This habitat type is not the type as described for nesting Chuck-Wills-Widow. It is also noted that in areas where the corridor will be crossing the streams, the company plans to bore under the stream corridors and not disturb the surface.

CONCLUSIONS

The typical nesting habitat of the Chuck-Wills-Widow, namely bare dirt, leaf, or pine needle cover in dense thickets near openings is not present on the proposed IBR area. Given the lack of habitat and the company's plans not to disturb the surface around stream corridors, impacts to the Chuck-Wills-Widow is unlikely.

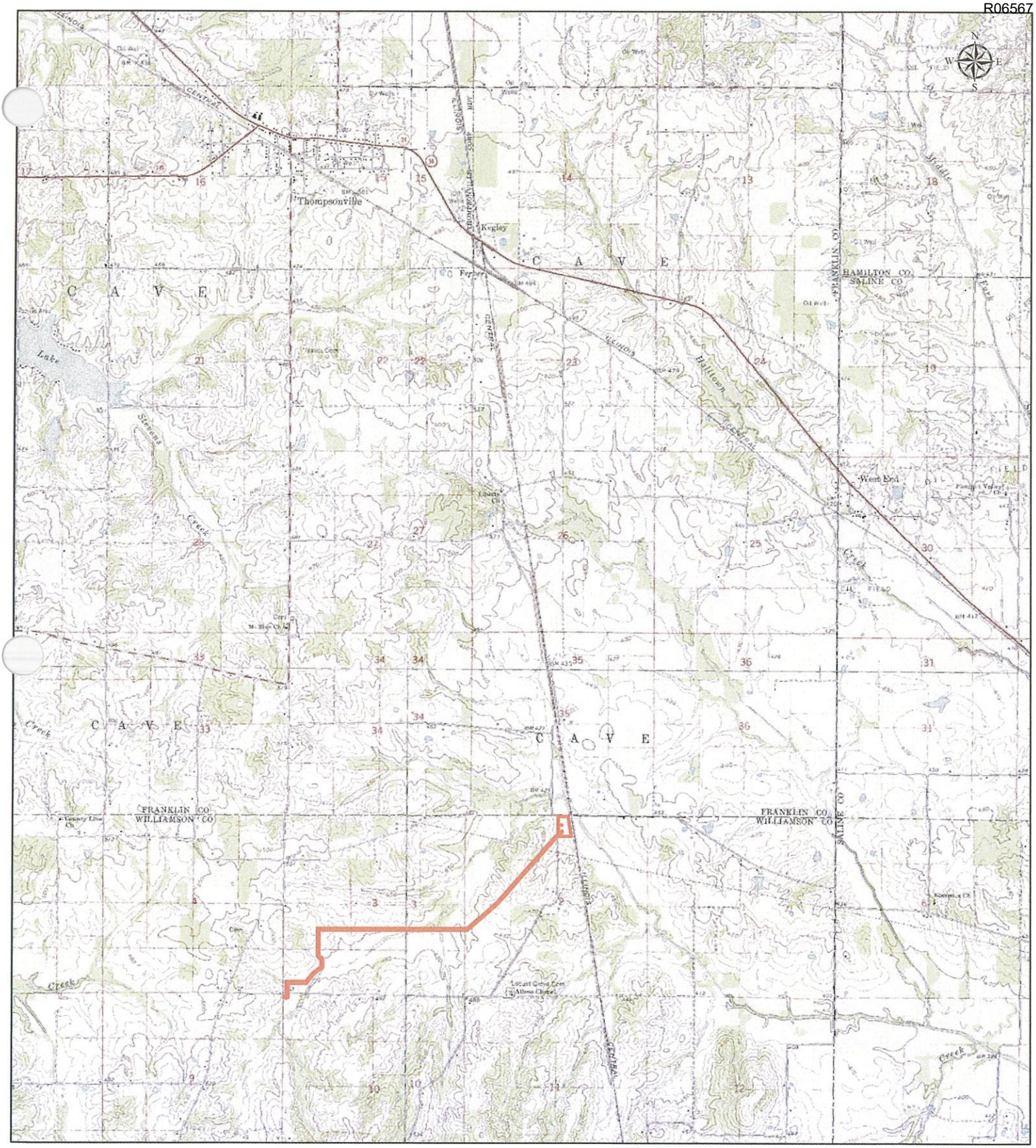


Figure 1. Site location south of Thompsonville, IL.

Attachment 7.2.2

Protection and Enhancement Plan
Indiana Bat (Myotis sodalis)

North Bleeder Shaft IBR

Williamson County, IL

Prepared for:
Williamson Energy, LLC
P.O. Box 99
Johnston City, IL 62951

Prepared by:
Decota Consulting Company, Inc.
4984 West Washington street
Cross Lanes, WV 25313

January, 2019

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APPENDIX A

Indiana Bat Incidental Take Table

INTRODUCTION

Williamson Energy, LLC has proposed to permit an area for a Bleeder Shaft Site along with a water line and powerline corridor to connect the Bleeder Shaft Site to the existing Permit 375 area. The proposed North Bleeder Shaft IBR permit area consist of approximately 17.0 acres, of which approximately 8.4 acres are within know habitat and only 1.0 acres contain suitable forested habitat to be considered habitat for Threatened and Endangered bat species. The proposed permit area is located approximately 2.8 miles northwest of Corinth, Illinois. The approximate project center is at Latitude 37.85 and Longitude 88.74 (Exhibit A).

Coal mining operations may affect the Indiana bat in situations where the proposed surface disturbance area is located near documented Indiana bat habitat, or when forested areas which could provide Indiana bat habitat are cleared to facilitate the mining activity (USFWS 2009). Indiana bats are known to occur in several counties in Illinois, including Williamson County. Coal mining activities may result in clearing of forested habitat or alteration of potential hibernacula like old mine portals and caves that serve as potential habitat for the Indiana bat. The potential for altering bat travel corridors, feeding and watering locations, and sheltering and hibernating locations exists due to the potential tree clearing and hibernacula closing or alteration. In July 2009, the "Range-wide Indiana Bat Protection and Enhancement Plan Guidelines" (hereafter referred to as "the guidelines") were established in order to set minimum standards for determining the presence of Indiana bat habitat and developing Indiana bat Protection and Enhancement Plans. The guidelines were updated in February 2013. The following Plan was prepared in accordance with these guidelines.

In 2018, two Indiana bats were captured and tracked to roost locations. Based upon the roost tree locations for the two bats (Bats 172.413 and 172.636), portions of the proposed North Bleeder Shaft IBR fall within the Indiana Bat buffer and making it "known habitat". No Northern long-eared bats (NLEB) were captured in the vicinity of the permit area; therefore, it is assumed to be absent. As a result, a Protection and Enhancement Plan (PEP) is required and is included below. It is important to note that one mist net site was run within the IBR area in 2018 and no endangered bats were captured in the vicinity of the project area.

The project area itself totals 17.0 acres in its entirety, of which a total of 8.4 acres exists within a 2.5 mile known habitat buffer, and of the 8.4 acres within the known habitat buffer, only 1.0 acres is sufficiently forested to be considered bat habitat at all. The remainder of the project area within the known habitat buffer consists of primarily of agricultural fields that do not meet the FWS definition of suitable habitat. The remaining 8.6 acres outside of known habitat buffer was surveyed for T/E species in 2018 with negative results and therefore will not be considered in this PEP. The areas covered by the proposed PEP are shown on the Aerial Map (Exhibit B)

POTENTIAL INDIANA BAT HABITAT

Known Habitat

Known habitat is defined as "habitat occupied by Indiana bats based on capture records, survey information, or other sources" (USFWS 2013).

There are no documented caves or other underground openings where Indiana bats have been recorded within the proposed permit area.

The nearest capture site for a female or juvenile is located approximately 4.7 miles West of the proposed project area. The nearest known maternity roost tree is located 2.5 miles southwest of the proposed permit area. The nearest capture site for a male is located 3.4 miles West of the proposed permit area. Based on these distances, portions of the proposed permit area do meet the criteria to be considered "known summer habitat" (USFWS 2013).

Based on available information and the results of field surveys, the proposed permit area does not meet the criteria to be considered "known winter habitat" (USFWS 2013) as no portals or other karst features exist within the project area.

Potential Summer Habitat

Suitable/potential habitat is defined as habitat that is "within the range of the species and is either (a) currently suitable for habitation by Indiana bats but for which no survey or other data is available showing that Indiana bats are present or (b) may be suitable pending a definitive analysis of its suitability for Indiana bat use, which is especially relevant for potential winter habitat" (USFWS 2013).

A mist net survey for Indiana bats and NLEBs was conducted in the summer of 2018 by Alliance Consulting, Inc. for the area that surrounds the permit area associated with the North Bleeder Shaft IBR. During this survey, two (2) Indiana bats were captured, and both of them were found to be roosting approximately 2.5 miles southwest of the proposed IBR area which resulted in the creation of a 2.5 mile buffer. Of the 17.0 acre permit area, a total of 8.4 acres is within known habitat buffers and the remainder is located within an area of assumed absence for both the Indiana and NLEB. Due to the permit area existing within an Indiana bat buffer, the 1.0 wooded acres is considered to be known habitat. No NLEBs were captured during the mist net survey; therefore, they are assumed to be absent within the permit area and will not be further discussed. Additionally, the 8.6 acres of the proposed IBR area outside of the buffer is also in an assumed absence area based on survey results, and is not considered under this PEP.

MINIMIZING POTENTIAL TAKE OF AN INDIANA BAT

Avoidance of Potential Summer and/or Winter Habitat

Due to the nature of this project, it will not be possible to avoid impacts to known summer habitat. The forested areas within the proposed permit area will be cleared to facilitate mining activity. As previously mentioned, the project will only impact 1.0 forested acres.

No potential winter hibernacula exist within the project area; therefore, no buffering of caves or abandoned mines is proposed. There are no known caves within 2.5 miles of the proposed IBR area.

Tree Clearing Restrictions

By avoiding tree clearing during Indiana bat occupancy periods, potential adverse effects to these species can be effectively minimized. As discussed above, the habitat in the proposed permit area does contain 1.0 acres of known summer habitat for the Indiana bat. Tree clearing operations will only occur from October 15 to March 31, unless otherwise authorized by the Illinois Department of Natural Resources and the U.S. Fish and Wildlife Service. However, given permit authorization time frames and the necessity of this facility, it is likely that authorization to clear this 1.0 acres will be requested outside the normal tree clearing window.

Protection of Aquatic Resources

No stream crossings are proposed by this project. However, the project will include five (5) borings underneath intermittent stream segments. The borings will be conducted such that the Riparian vegetation will be left in-tact to the extent practicable. The stream segments subject to the borings and the adjacent aquatic resources will be protected by the erosion and sediment control plan for the facility.

SHORT-TERM HABITAT REPLACEMENT

The applicant proposes to girdle three (3) trees within the proposed IBR area. Trees will be girdled outside of the limits of disturbance but within the proposed permit area. According to the guidelines, a tree must be girdled for every 500 feet of project perimeter. The perimeter of forested project area within the known habitat area is approximately 1,530 linear feet.

Short-term Habitat Measures

As part of the PEP, the forested areas above and below the proposed contouring operations in the affected watersheds will be evaluated for the existence of sufficient trees/snags and availability of suitable girdling trees. This evaluation will be conducted once the permit has been approved, prior to or concurrent with the clearing during the initial winter clearing season. Based upon the findings, additional measures, such as Bat Boxes may be utilized to provide sufficient suitable roosting habitat adjacent to the proposed permit area.

Flooded Timber

Flooded timber is not proposed for this project due to the abundance of potential roosting, watering and feeding habitat around the proposed IBR area.

Tree Girdling

Tree girdling is proposed for the project at an adjacent location due to the 1.0 acres being cleared. A total of three (3) trees will be girdled within the proposed IBR area.

Staged Tree Removal

The proposed facility will only require the potential clearing of approximately 1.0 forested acres. During the construction operations associated with the proposed IBR, removal of trees >3 dbh will be limited to the extent practicable. However, the applicant does not intend to stage tree removal given the limited and fragmented amount of forested habitat to be lost (Exhibit B).

Minimization of disturbed areas

The operation will only disturb areas necessary for the facilitation of mining and will only result in the potential clearing of 1.0 forested acres within the know habitat area (Exhibit B).

Long Term Habitat Measures

Appropriate Herbaceous Ground Cover

Reestablishment of appropriate herbaceous ground cover species within the proposed IBR area is important to ensure erosion control while preventing competition with planted trees. The applicant will use herbaceous species or other species which have proven to be effective in controlling erosion while minimizing competition with growing seedlings for nutrients and sunlight. Table 1 lists the herbaceous ground cover mix for woody planting areas.

Table 1 - Herbaceous Wildlife Area and Woody Wildlife Areas (Cool Season Seed Mix Augmented with Warm Season Species)

Plant Species*	Seeding Rate PLS	Method of Application
Redtop	10 lbs/acre	Broadcast
Partridge Pea	5 lbs/acre	Broadcast
Orchard Grass	10 lbs/acre	Broadcast
Indian Grass	2 lbs/acre	Broadcast
Spring Oats (Spring Seeding)	50 lbs/acre	Broadcast
Winter Wheat (Fall Seeding)	40 lbs/acre	Broadcast
Much (Straw or Mixed Hay)	2 tons/acre	Broadcast

* Some of the above species area non-native. Although they are non-native, their use in grass establishment is necessary to achieve the desired post mining land use. The oats and wheat are easy and fast to establish and provide temporary erosion control. The oats and wheat are annuals that are not persistent and will be replaced by the native grasses.

Travel Corridors

No travel corridors are proposed for planting at this time. However, the forested areas affected by the proposed IBR are largely segmented.

Tree Species Selection and Performance Criteria

The PEP guidelines provide a list of tree species that should be used for Indiana bat habitat. This list is included below (Table 2). The reforestation area will include a minimum of six different species from the list. In particular, four of those species must be those identified as "exfoliating bark species". At the request of the IDNR, ash species (Fraxinus sp.) will not be planted as part of the reforestation. The exfoliating bark species must equal at least 40 percent of the minimum stems per acre. Since a total of 1.0 acres of forested habitat exists within the project, a minimum of 0.7 acres (70%) will be reforested with an appropriate mix of the species below.

Table 2 - Tree Species Appropriate for Establishing Indiana Bat Habitat

Exfoliating Bark Species	
Acer. saccharinum	Suger Maple
Carya cordiformis	Bitternut Hickory
Carya glabra	Pignut Hickory
Carya laciniosa	Shellbark Hickory
Carya ovate	Shagbark Hickory
Carya. tomentosa	Mockernut Hickory
Fraximus americana	White Ash
Fraximus pennsylvania	Green Ash
Oxydendron arboreum	Sourwood
Pinus echinata	Shortleaf Pine
Populus detloides	Cottonwood
Quercus. alba	White Oak
Quercus coccinea	Scarlet Oak
Quercus falcate	Southern Red Oak
Quercus imbricaria	Shingle Oak
Quercus prinus	Chestnut Oak
Quercus rubra	Northern Red Oak
Quercus stellata	Post Oak
Quercus velutina	Black Oak
Sassafras albidum	Sassafras
Ulmus americana	American Elm
Ulmus rubra	Slippery Elm
Nitrogen Fixing Trees	
Cercis Canadensis	Redbud
Robinia pseudoacacia	Black Locust
Other Trees	
Cornus florida	Flowering Dogwood
Diospyros virginiana	Persimmon
Morus rubra	Red Mulberry
Prunus serotina	Wild Black Cherry

Watering Areas

The intermittent stream segments that fall within the proposed IBR area will be bored underneath to minimize any potential impact to the stream segments. These stream segments and the multiple farm ponds, intermittent and perennial stream segments that exist within one mile of the proposed IBR area currently provide drinking areas; therefore, no water areas are proposed.

Other Long-Term Habitat Replacement: Reforestation

Currently there are 1.0 acres of forest habitat in the proposed IBR area that is located within known habitat which will potentially be disturbed. During construction activities associated with the proposed IBR, the applicant will limit tree removal within the forested segments of the known habitat area to the extent practicable. Additionally, according to the guidelines, the applicant must replant a minimum of 70% of the forested acres that is disturbed (USFWS 2013).

SUMMARY

The first objective of the PEP is to avoid the potential take of Indiana bats by avoiding or minimizing disturbance to known or potential habitat areas. While the applicant will not disturb any areas that are not critical to the facilitation of mining, there are 1.0 acres of known Indiana bat summer habitat that will potentially be cleared. This forested habitat will be cleared between the dates of October 15 and March 31 to effectively minimize adverse effects to the bat population, unless otherwise approved by the USFWS and IDNR. However, Williamson Energy, LLC reserves the right to consult with the USFWS and IDNR to explore other options, which may allow them to clear outside these dates, if necessary.

The second objective of the PEP is to minimize the potential take of Indiana bats by providing short-term habitat measures. The forested habitat cleared during mining operations will be supplemented in the short-term by girdling trees. There are also large amounts of forested habitat adjacent to the project area to provide additional roosting/foraging habitat for any displaced bats.

The third objective of the PEP is to provide long-term habitat measures for the Indiana bats in the post-mine reclamation plan. The applicant will provide long-term habitat post-mining by planting appropriate herbaceous ground cover, and reforesting the area. These measures will regenerate 70% of the potential summer bat habitat that existed on the project prior to disturbance.

Given the minimization efforts to be used and the long-term habitat improvement post-mining, the Indiana bat populations should not be affected by the proposed project. Additionally, the Indiana Bat Incidental Take Table for the project has been included within Appendix A of this document.

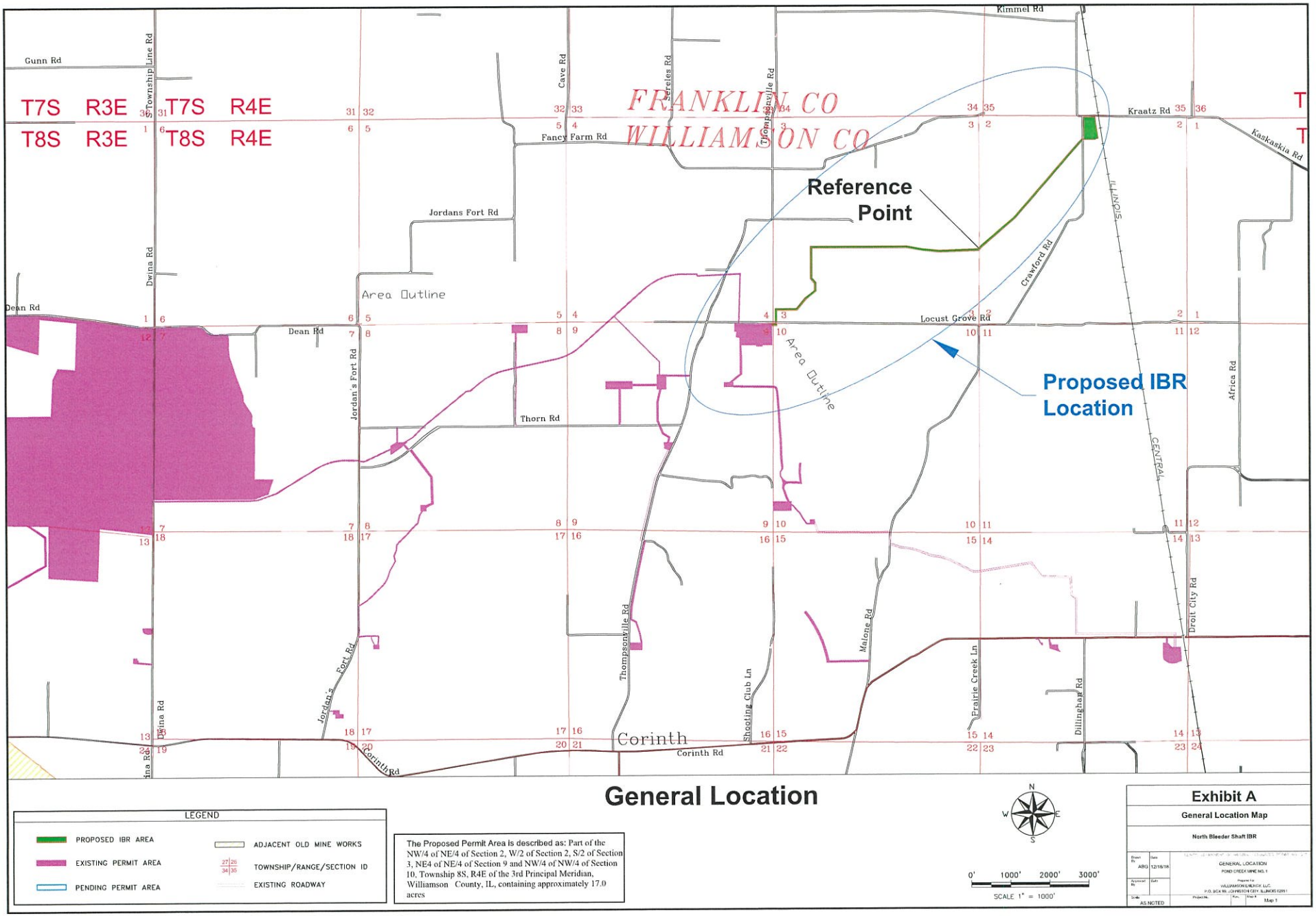
LITERATURE CITED

U.S. Fish and Wildlife Service. 2007. Indiana Bat (Myotis sodalis) Draft Recovery Plan: First Revision. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota. 258 pp.

U.S. Fish and Wildlife Service (USFWS). 2009 (Revised 2013). Range-wide Indiana Bat Protection and Enhancement Plan Guidelines.

U.S. Fish and Wildlife Service (USFWS). 2014. Accessed September 2, 2014. http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A0JE

EXHIBITS



General Location

LEGEND

- PROPOSED IBR AREA
- EXISTING PERMIT AREA
- PENDING PERMIT AREA
- ADJACENT OLD MINE WORKS
- 27|26 / 34|35 TOWNSHIP/RANGE/SECTION ID
- EXISTING ROADWAY

The Proposed Permit Area is described as: Part of the NW/4 of NE/4 of Section 2, W/2 of Section 2, S/2 of Section 3, NE4 of NE/4 of Section 9 and NW/4 of NW/4 of Section 10, Township 8S, R4E of the 3rd Principal Meridian, Williamson County, IL, containing approximately 17.0 acres

N W E S

0' 1000' 2000' 3000'

SCALE 1" = 1000'

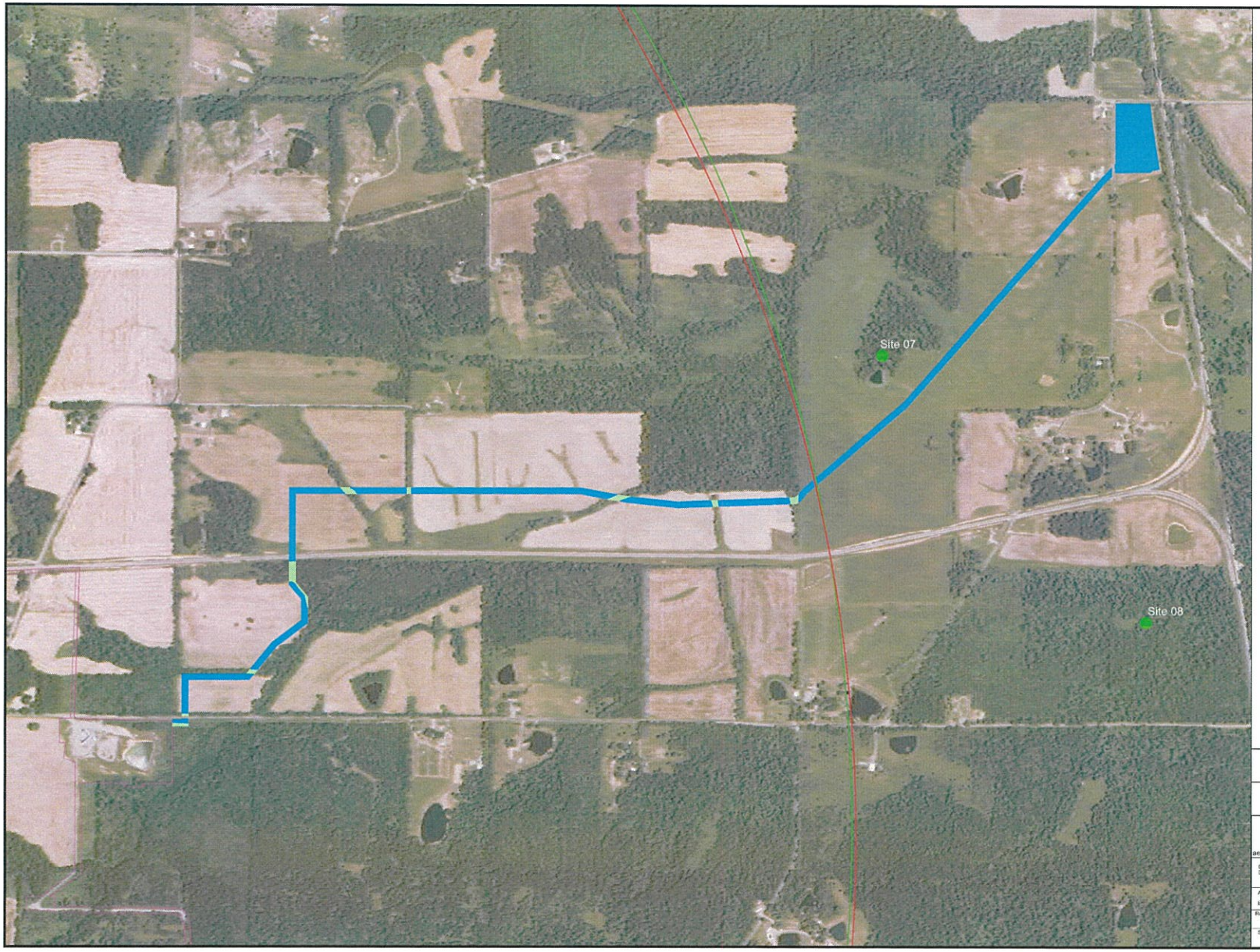
Exhibit A

General Location Map

North Bleeder Shaft IBR

Drawn By: ARG	Date: 12/18/18	GENERAL LOCATION POND CREEK MINE NO. 1
Approved By:	Date:	Prepared For: WILLIAMSON ENERGY, LLC. P.O. BOX 99 - CHRISTOPHER, ILLINOIS 62822
Scale: AS NOTED	Project No.	Map # Map 1

R06578



N

LEGEND

- Mist Net Site
- Project Area Subject to PEP
- Areas Not Subject to PEP or Non-Habitat
- 2018 Male Indiana Bat Roost Buffer
- 2018 Lactating Female Indiana Bat Roost Buffer

0' 800' 1600'

SCALE 1" = 800'

EXHIBIT B

Aerial Map

North Bleeder Shaft IBR

aerial - pep.dwg

Drawn By	Date
ABG	12/18/18
Approved By	Date
Revised:	
Scale	
AS NOTED	

ILLINOIS DEPARTMENT OF NATURAL RESOURCES PERMIT NO. 375

AERIAL MAP

POND CREEK MINE NO. 1

Prepared For

WILLIAMSON ENERGY, LLC.

P.O. BOX 99, JOHNSTON CITY, ILLINOIS 62951

Project No.	Rev.	Map #
		Map 4

R06579

APPENDIX A

INDIANA BAT INCIDENTAL TAKE TABLE

Type and amount of incidental take resulting from SMCRA permits issued by the Ill. Dept. of Natural Resources, Mines & Minerals Division, Land Reclamation Division for the 2018 year reporting period.

Permit No. [c]	Forest Habitat [d] (# acres)			Roost Trees [e] (# trees)		Hibernacula [f] (# hibernacula)	Individual Bats [g] (# bats)	Maternity Colonies [h] (# colonies)
	Known	Potential	Proposed PMLU [i]	Known	Potential			
	1.0	0	0.7 (minimum)	NA	0	0	NA	NA
Annual Totals:	1.0	0	0.7 (minimum)	NA	0	0	NA	NA

[a] Enter the name of the RA that compiled the data for the table in place of "[RA]".
[b] Enter the year or other period of time for which the table was prepared in place of "[Year or reporting period]".
[c] Enter the permit number for all permits (including amendments and revisions) where Indiana bat incidental take was expected and used based on known occurrence or when Indiana bat presence is assumed. Additional rows should be added to the table as necessary to include all permits where incidental take occurred in a given year.
[d] Enter the number of acres of known and/or potential habitat that will be cleared, removed, or destroyed by the permitted action. Potential habitat (e.g., assumed habitat) and known habitat must be accounted for separately in the table. Most permits will have at least one acreage entry for Forest Habitat and some permits may have entries for both. Indeterminable entries should be marked as "NA" in the table.
[e] Enter the number of known and/or potential roost trees that will be removed by the permitted action. Potential roost trees and known roost trees must be accounted for separately in the table. Indeterminable entries should be marked as N/A."
[f] Enter the number of known hibernacula that will be impacted (e.g., changes in air flow, etc.) or destroyed (e.g., mined-through or entrances closed). Indeterminable entries should be marked as "Unknown" in the table.
[g] Enter the number of individual Indiana bats that were adversely affected by the permitted mining activity. For most permits, and especially those permits where Indiana bat presence was assumed, this number will not be known, because sufficient demographic data is unavailable. If no specific information or data is available regarding the number of Indiana bats that were adversely affected, this entry should be marked as "NA", which will mean that the number of individuals was indeterminable.
[h] Enter the number of maternity colonies that were adversely affected by the permitted mining activity. For most permits, and especially those permits where Indiana bat presence was assumed, this number will not be known because sufficient demographic data was unavailable. If no specific information or data is available regarding the number of Indiana bat maternity colonies that were adversely affected, this entry should be marked as "NA", which will mean that the number of maternity colonies was indeterminable.
[i] Enter the acreage of the proposed Post Mining Forest land use.

R06581

Attachment 7.2.2 A

Chuck-Wills-Widow Nesting Habitat Assessment

North District Shaft IBR Site

Pond Creek Mine

Williamson County, IL

Prepared for:

Williamson Energy, LLC

Prepared by:

William O'Leary, M.S.

HMG Engineers, Inc.

1032 N. 6th Street

Murphysboro, Illinois 62966

January 2019

INTRODUCTION

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Williamson Energy, LLC informed HMG of a concern regarding Chuck-Wills-Widows (*Caprimulgus carolinensis)*, a listed (threatened) bird species in Illinois. Chuck-Wills-Widows reportedly nest on the ground among dead leaves, pine needles, or bare dirt in dense thickets near openings. State biologists were wanting more information regarding the liklihood that Chuck-Wills-Widow nesting habitat occurs in the proposed IBR area.

METHODS

The entire proposed IBR area including both the corridor and the 4.4 acre tract were visually inspected. Habitat features including vegetation composition were noted and compared with the reported preferred nesting habitat for the Chuck-Wills-Widow.

RESULTS

The most prevalent vegetation cover in the proposed IBR area is soy bean stubble. The next most prevalent is cool season grassland. Neither of these vegetation regimes has any woody vegetation. These two cover types account for approximately 95% of the proposed IBR area. The remaining 5 % includes stream channels with narrow wooded margins. These margins include thick understory vegetation composed largely of Japanese honeysuckle, multiflora rose, and blackberry. This habitat type is not the type as described for nesting Chuck-Wills-Widow. It is also noted that in areas where the corridor will be crossing the streams, the company plans to bore under the stream corridors and not disturb the surface.

CONCLUSIONS

The typical nesting habitat of the Chuck-Wills-Widow, namely bare dirt, leaf, or pine needle cover in dense thickets near openings is not present on the proposed IBR area. Given the lack of habitat and the company's plans not to disturb the surface around stream corridors, impacts to the Chuck-Wills-Widow is unlikely.

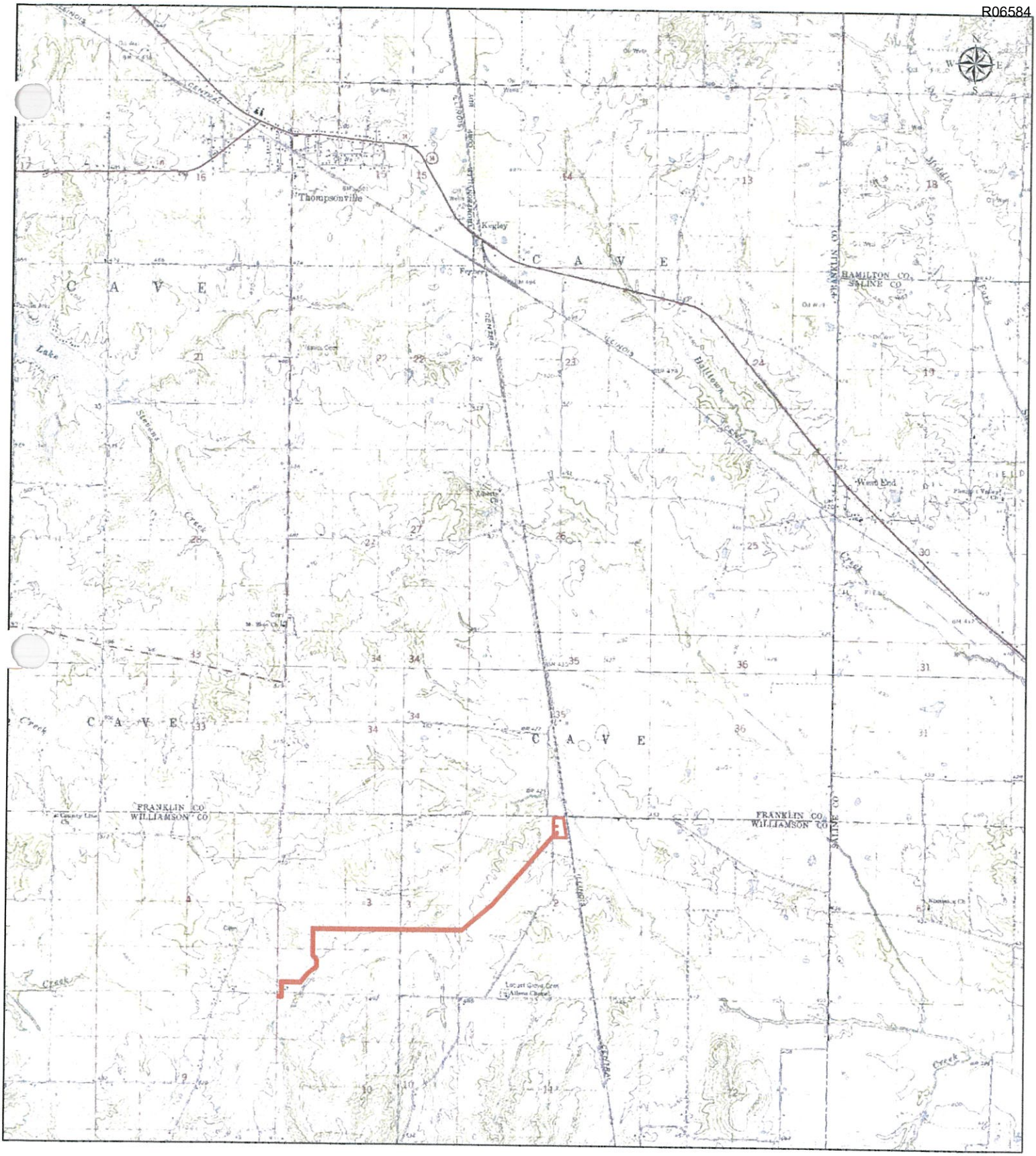


Figure 1. Site location south of Thompsonville, IL.

PART 8: Cropland Capability Soils

8.1 High Capability Post-Mining Land Use.

8.1.1 Discuss planned final graded slopes of the replaced high capability areas. Include a discussion of slope lengths and slope steepness. **[1825.14(c)]**

All slopes will be graded to original contour.

8.1.2 Discuss planned replacement of soil horizons with respect to horizon thickness and total root zone (mention thickness of each horizon).

Topsoil will be redistributed evening across the site. Topsoil will be replaced to ~7-14 inches thick. Subsoil will be replaced to pre-mining condition.

a) The topsoil replacement thickness will be __ inches. **[1823.14]**

b) The root medium replacement thickness will be ___ inches **[1825.14**

8.1.3 Discuss how excessive compaction will be avoided. If excessive compaction cannot be avoided, provided a compaction alleviation plan. **[1825.14(e)]**

Minimal passes will be required to distribute topsoil. Therefore, compaction will be minimized.

8.1.4 Discuss how wind and water erosion will be minimized. Include discussions of construction, timing, seeding, seeding equipment to be used and erosion control structures to be used. **[1825.14(f)]**

Topsoil will be removed and redistributed during dry ground conditions.

8.1.5 Discuss the management of these areas including crop rotations, green manuring, and levels of fertility. **[1780.18(b)/1784.13(b)]**

Soil will be sampled at the time of starting crop rotation and appropriate fertilize will be added.

8.1.6 Discuss planned timing of the construction and removal, if applicable, of the erosion control structures. If erosion control design and construction is to be coordinated with the Natural Resources Conservation Service, please discuss. **[1825.14(f)]**

Site will be reclaimed within one year after the plugging of the boreholes and shaft.

8.1.7 Discuss the management of positive surface drainage with respect to differential settling. **[1825.14]**

Topsoil will be distributed evening across the site and will be graded back to original contours.

8.1.8 Discuss the methods of mulching to be used with respect to seasonal variation. **[1780.18(b)/1784.13(b)]**

Immediately after topsoil replacement, the topsoil will be seeded with a quick-growing nurse crop such as wheat or oats. The area will then be planted to row crops during the next row-cropping season.

8.1.9 If the post-mining acreage of high capability land is proposed to be reduced for any individual landowner in the permit area other than the applicant, provide a letter of consultation and response, if received, from those landowners.**[1780.23 (b) and (c)/1784.15(b) and (c)]**

N/A

8.2 Pre-Mining Prime Farmland Soils. The following information must be given, in order for the regulatory authority to evaluate whether the applicant has the technological capability to restore mined prime farmland to equivalent or greater productivity within a reasonable time. The applicant shall use the Soils Map and Soil Information Chart provided in Part 2.3.9 of the application. The applicant may also choose to include references to the Custom Soil Survey referenced in Part 2.3.

8.2.1 Pre-Mining Soil Profile. The applicant must include a description of the original undisturbed soil profile. The description must discuss the following parameters for each soil horizon that collectively constitutes the root zone unless specific depths or horizons are requested. **[1785.17(c)]**

See Soil Report

8.2.1.1 Depth and thickness of each horizon (range and average).

Topsoil is 7-14 inches thick.

8.2.1.2 Moist bulk density of each major horizon (use USDA approved method or reference).

8.2.1.3 Present pH and state of fertility (P&K) (A horizon only).

8.2.1.4 Texture analysis of each horizon (use USDA texture classification).

8.2.1.5 If B&C horizons are proposed to be mixed, submit evidence to support proposal.

8.2.2 Pre-Mining Soil Samples. Soil samples must be taken on the permit site to obtain the material necessary for the above-required information. Sample site locations must be indicated on the soils map. NRCS established values on bulk density may be used in lieu of field investigation. Use of soil information from related permits may be considered if they are representative of the proposed application area. Underground mine surface disturbances which are not exempt from prime farmland restoration requirements and which propose to leave the subsoil in place, may submit the information provided in a Custom Soil Survey except that onsite samples must be taken to provide the information required for A horizon thickness.

Soil description is as found in the County Soil Survey. No sample was taken.

8.2.2.1 The applicant shall discuss the history of previous productivity and cropping practices on the prime farmland, if known, or may reference the productivity information from Bulletin 811, provided in response to Part 2.3.1. **[1785.17(c)(4)]**

8.2.2.2 The applicant shall provide references or copies of available agricultural school studies, company data or other scientific data for comparable areas to demonstrate that the applicant, using their proposed method of reclamation will achieve, within a reasonable time, equivalent or higher levels of yield after mining as existed before mining. **[1785.17(c)(3)]**

8.3 Prime Farmland Soil Handling.

8.3.1 Describe the equipment to be used in the removal and replacement of each soil horizon. **[1785.17(c)(2)]**

Topsoil will be picked up and stockpiled by small scrapers and redistributed similarly.

8.3.2 Discuss how excessive compaction will be avoided. **[1823.14(c)].** If excessive compaction cannot be avoided, provide a compaction alleviation plan. **[1823.14(d)]**

Minimal passes will be required to distribute topsoil. Therefore, compaction will be minimized.

8.3.3 Discuss the timing of the removal and replacement of the horizons with regards to seasons, weather, and regulatory authority testing approval. **[1823.12, 1823.14(b) and (e)]**

Topsoil will be removed and redistributed during dry ground conditions. Topsoil stockpiles will remain in place for at least 5 years prior to be redistributed over the site.

8.3.4 Discuss how mining operation will impact prime farmlands where the B and/or C horizons are to be left in place and how these soils layers will be protected or restored to their original capability **[1823.12]**

B and C horizons will be deep-ripped if deemed necessary.

8.3.5 Discuss how the prime farmland will be identified in the field in order to avoid contamination with non-prime farmland soils. **[1823.12]**

Prime farmland will be identified according to the Soils map.

8.3.6 Are prime farmland topsoil or subsoils to be mixed with non-prime soils?

☐ YES ☒ NO

If YES, provide evidence showing how combining will not affect the permittee's ability to restore the pre-mining prime farmland productivity. **[1823.14(e)]**

8.3.7 Discuss whether stockpiles will be used or direct placement will be used. If stockpiling will be used, discuss. Locate on Operations Map. **[1823.13]**

Stockpiles will be used. See Operations Map.

8.3.8 Discuss length of time stockpiles are to be in place. **[1823.13]**

Stockpiles will be in place for approximately six years.

8.3.9 Discuss how prime land stockpiles are to be identified in the field in terms of different horizons and prime versus non-prime farmland piles. **[1823.13]**

The prime farmland topsoils will be in the stockpiles on IBR Site.

8.3.10 Discuss any intermittent stockpile relocations as to how, when and why. **[1823.13]**

N/A

8.3.11 Discuss temporary and/or permanent seeding and revegetation to prevent wind and water erosion. **[1823.13]**

Immediately after topsoil replacement, the topsoil will be seeded with a quick-growing nurse crop such as wheat or oats. The area will then be planted to row crops during the next row-cropping season.

8.3.12 Discuss how contamination by other soil horizons or by fly rock will be prevented. **[1823.13]**

Temporary subsoil pile from drilling pit construction and shaft development material will be kept in separate stockpiles from topsoil stockpiles throughout the remainder of the IBR site, thus preventing contamination of the topsoil.

8.4 Prime Farmland Reclamation Plan and Map.

8.4.1 Locate on the Post-Mining Land Use/Capability Reclamation Map the location of the replaced prime farmland. Give acreage totals in Table 11.1. If the post mining acreage of prime farmland is proposed to be reduced for any individual landowner in the permit area other than the applicant, provide a letter of consent from those landowners. **[1785.17 (e)(5)]**

See Pre and Post Mine Land Use Map.

8.4.2 Discuss how wind and water erosion will be minimized. Include discussions of construction, timing, seeding, seeding equipment to be involved and erosion control structures to be used. **[1823.14(e)]**

Erosion will be minimized by using nurse crops and normal farming practices.

8.4.3 Discuss the management of these areas including crop rotations, green manuring, levels of fertility and personnel responsible for management. Discuss the fertility management. Also, discuss the management in relation to any land leveling needed. **[1823.14(f)]**

The area will be subject to crop rotation (normally corn and soybeans) along with the rest of the adjacent crop field.

8.4.4 Discuss the timing of the construction of the erosion control structures and the criteria used to determine the need for and construction design of erosion control systems. If erosion control design and construction is to be coordinated with the Natural Resources Conservation Service, please discuss. **[1823.14(g)]**

N/A

8.4.5 Discuss the final graded slopes of the replaced prime farmland areas. Include a discussion of slope lengths. **[1816.102(a)/1817.102(a); 1823.14]**

Slopes will be reconstructed to the pre-mining slopes.

8.4.6 Discuss the management of positive surface drainage with respect to differential settling. **[1823.14]**

N/A as the area is small.

8.4.7 Discuss the replacement of soil horizons with respect to horizon thickness and the total root zone.

Topsoil will be replaced to ~7-14 inches thick. Subsoil will be replaced to pre-mining condition.

a) The topsoil replacement thickness will be ___ inches. **[1823.14(e)]**

b) The root medium replacement thickness will be ___ inches **[1823.14(a)(1)]**

8.4.8 Include any other relevant information in support of a possible finding by the regulatory authority that the operator has the technological capability to restore prime farmland areas, within a reasonable time, to equivalent or higher levels of yield, as determined by the regulatory authority. **[1785.17(e)]**

N/A

PART 9: Reclamation Plan

9.1 Post-Mining Land Use.

9.1.1 Provide a Post-Mining Land Use/Capability Reclamation Map as required by the General Mapping Requirements.

Provide a detailed description of proposed post-mining land uses and capabilities employing land use and capability categories listed in Table 9.1: Post-Mining Land Use Capability. Complete acreage figures for each post-mining land use proposed and designate its capability classification. This information shall be broken down by landowner in addition to the composite land uses and capabilities. In addition, the applicant shall complete Table 9.1 – GRAND TOTAL: Post-Mining Land Use Capability Summary. This table is a compilation of all Post-Mining Land Use Capability tables filled out for each individual land owner.

For IBR applications complete Table 9.1: Post-Mining Land Use Capability for each landowner and update Table 9.1 – GRAND TOTAL Post-Mining Land Use Capability Summary.

*NOTE: For Post-Mining Land Use change IPRs and Significant Revisions see Guidance Document TGD#4 and **complete ONLY** Tables 9.1.1 and 9.1.2*

For surface mines, acreage figures for post-mining land use must differentiate between mined and surface disturbance areas based on the mining line used in Part 2.2.3 of the application. **[1777.11(a)(3)]**

The pre-mining land use of the proposed permit area is Cropland, Industrial, Fish and Wildlife (woody and herbaceous) and Residential. Stockpile areas will be revegetated after the initial disturbance with a cover crop to minimize erosion. The entire disturbed area will be graded for positive drainage.
During the reclamation work, topsoil removed and stored during initial site construction, will be redistributed and graded over the exposed subsoil. The topsoil will be limed, fertilized, prepared and seeded in accordance with the following schedule: If the site is reclaimed in the spring season but before normal crop planting, the disturbed area will be straw mulched at 1 ½ tons/acre and seeded with a cover crop of spring oats to protect the soil until the primary planting season is under way. The IBR areas will be returned to their original land use. Where applicable, the IBR areas will then be planted to row crops as determined by the property owner or tenant farmer. If the site is reclaimed in the late fall season, the site will be seeded to a temporary cover crop of winter wheat (+/-) 1.5 Bu./Ac., and the site fertilized, and then mulched at two tons/acre, to protect the soil over the winter season.

Thereafter, planting of agricultural crops will occur during the first available crop planting period after proper seedbed preparation has been achieved.

9.1.2 Where a post-mining land use different from a pre-mining land use is proposed, provide:

a) A discussion explaining the consideration which has been given to making all the proposed surface mining activities consistent with surface owner plans and applicable state and local land use plans and programs. **[1780.23/1784.15]**

N/A

b) A copy of the comments from the owner of the surface concerning the proposed land use of the proposed permit area and from the state or local government agencies which would have to initiate, implement, approve or authorize the proposed uses of the land following reclamation. In the event the surface land owner does not provide comments; the applicant shall provide proof of mailing to the surface owner soliciting comments to show that a good faith effort was made to provide the surface owner with the opportunity to comment. **[1780.23/1784.15]**

9.1.3 Provide a detailed timetable for completion for each major step in the proposed reclamation plan. The time table shall include for: **[1780.18(b)(1)/1784.13(b)(1)]**

9.1.3.1 Surface mine mining areas: **NOT APPLICABLE**

9.1.3.1.1 The timing of the rough grading, root medium, and topsoil during active mining to meet the standards of Section 1816.101(b)(1).

Note: If the plan proposes to reduce the time frames or distance to less than that allowed, it must be stated here and in the reclamation cost estimate section.

9.1.3.1.2 The timing of the planting of initial and permanent vegetation after final grading as it relates to the proposed land use.

9.1.3.2 Surface and underground mines, support areas, including refuse disposal areas:

9.1.3.2.1 The timing of the rough grading, root medium, and topsoil during active mining to meet the standards of Section 1816.101/1817.101

All grading will be completed within 12 months of cessation of active use.

9.1.3.2.2 The timing of the planting of initial and permanent vegetation after final grading as it relates to the proposed land use.

Temporary seeding will take place immediately after topsoil replacement. Cropping will be initiated with the next normal cropping season.

9.1.3.2.3 Any other reclamation proposed activities during the mining to minimize reclamation liability and its associated costs.

N/A

9.2 Backfilling and Grading.

9.2.1 Describe the methods to be used for backfilling and grading the proposed permit area, including soil stabilization and compaction practices in accordance with 62 Ill. Adm. Codes 1816.102/1817.102 through 1816.107/1817.107.

See responses above.

9.2.1.1 Provide appropriate cross-sections to illustrate and define the proposed post-mining configuration of the permit area. These cross-sections shall be referenced on the Post-Mining Land Use/Capability Reclamation Map **[1780.18(b)(3)/1784.13(b)(3)]**

The area will be restored to pre-mining conditions.

9.2.2 To achieve the proposed post-mining configuration including cover requirements for refuse disposal areas, the Applicant shall provide soil balancing calculations to ensure an adequate quantity of material is available. These calculations shall include soil shrinkage and swell factors consistent with sound engineering practices as approved by the Department. **[1780.23(b)(1)/1784.15(b)(1)]**

NOTE: This information may be supplied as Attachment 9.2.2.

N/A

9.2.2.1 Are borrow areas being proposed to provide a sufficient amount of material to achieve the post-mining configuration?

☐ YES ☒ NO

If YES, delineate the locations of the borrow areas on the Post-Mining Land Use/Capability Reclamation Map and complete the appropriate items included in Part 5.0: Drainage Control.

9.2.3 For surface mines, does the proposed surface coal mining and reclamation operation require disposal of excess spoil?

☐ YES ☐ NO ☒ N/A

If YES, provide the following:

9.2.3.1 Each application shall contain descriptions, including appropriate maps and cross-section drawings, of the proposed disposal site and design of the spoil disposal structures according to **62 Ill. Adm. Code 1816.71 through 1816.74**. These plans shall describe the geotechnical investigation, design, construction, operation, maintenance, and removal, if appropriate, of the site and structures. **[1780.35(a)]**

9.2.3.2 Each application shall contain the results of a geotechnical investigation of the proposed disposal site that include the information outlined in **62 Ill. Adm. Code 1780.35(b)**.

9.2.3.3 If, under 62 Ill. Adm. Code 1816.71(l), rocktoe buttresses or key-way cuts are required, the application shall include information as outlined in **62 Ill. Adm. 1780.35(c).**

If NO, will the spoil and other waste materials available from the entire permit area be insufficient to restore the disturbed area to its approximate original contour as addressed in **62 Ill. Adm. Code 1816.104**?

9.2.4 Describe the timing in which all grading and the construction and removal or renovation of water and erosion control structures will be complete and the sequence for accomplishing the work in relation to seasonal weather conditions. **[1780.25(a)/1784.16(a)]**

9.3 Shaft, Slope and Borehole Sealing. Each shaft, drift, adit, tunnel, exploratory hole, entryway, or other opening to the surface from underground shall be capped, sealed, backfilled, or otherwise properly managed, as required by the Department, in accordance with **62 Ill. Adm. Code Section 1816.13/1817.13**, Operator Memorandum No. 00-01, Operator Memorandum No. 2015-02, Operator Memorandum No. 17-09, consistent with **30 CFR 75.1711**, and provide the following: **[1816.15/1817.15]**

9.3.1 Temporary Seals. In the event the mine is temporarily closed or abandoned, provide information on temporary seals to be constructed for prevention of entry to all mine openings. Include an appropriate timetable for construction of these seals. **[1816.14/1817.14]**

All openings will be covered with a perforated metal cap to prevent access to the mine workings by people, livestock, fish and wildlife, and machinery. The surface casing will be high enough above ground to prevent drainage from entering hole and to keep acid or other toxic drainage from entering ground water or surface water.

9.3.2 Permanent Sealing Plans.

9.3.2.1 Provide a description, including appropriate cross-sections and plan views, of the measures to be used to seal or manage mine openings, and to plug, case, or manage exploration holes, other boreholes, wells, and other openings within the proposed permit area, in accordance with **62 Ill. Adm. Code 1816.13/1817.13 through 1816.15/1817.15** and shall reflect the following concerns:

- Completion using a combination of backfilling and sealing.
- The type and grade of materials to be used for backfilling and the intervals in which they will be used.
- Sections of casing, entry linings, or collar to be demolished.
- Design of hydraulic seals, including construction material, reinforcing, method of placement, design thickness, and method of anchoring.
- Design of gas ventilation piping that will be incorporated in seal design.
- Finished grading at land surface.
- A description of a permanent monument marker identifying the seal as a mine opening.
- A description of the location of all sealed shafts, slopes, or other entrance tunnels to be recorded with the appropriate recorder of deeds. This is in Operator Memorandum 00-01 as a RECOMMENDATION.

9.3.2.2 For any deviation from the established guidelines for sealing, backfilling, and capping, provide an engineering and hydrologic justification. **[1780.18(b)(8)/1784.13(b)(8);** Operator Memorandum 00-01**;** Operator Memorandum 17-09**]**

The shaft and any boreholes will be plugged from top to bottom according to all MSHA and IDNR regulatory standards after they are no longer needed. Any steel casings will be cut off five feet below natural soil level and the void filled with subsoil, and then covered with topsoil, mulched and seeded. Shaft hole will be filled with stockpile shaft material/rip rap and have at least one foot of concrete reinforced cap. All utility

boreholes will be plugged and filled with neat cement. The shaft will be surveyed and filed in the Williamson County Courthouse as required by Operation Memorandum 00-01.

9.4 Abandonment and Closure of Refuse Disposal Areas. NOT APPLICABLE

9.4.1 Describe proposed reclamation for all coal refuse disposal areas in accordance with **62 Ill Adm. Code 1780.18(b)/1784.13(b)**. The proposed reclamation plan shall include the following information:

- Timing of final coverage
- Cross sections of final cover and configuration.
- Type and amount of material proposed to be used for cover, including any coarse refuse used to provide a base over slurry prior to soil cover.
- Construction details of cover and caps, including the proposed soil depths and long-term groundwater protection measures.
- Design details of all proposed downdrain, terraces, benches or any other permanent surface drainage structure.
- Relationship of the refuse disposal area to the post-mining land use.
- Any plans of access roads and other use related facilities.

NOTE: This information shall be provided as Attachment 9.4.1.

9.5 Bond Estimation.

9.5.1 Provide a detailed estimate of the cost of reclamation for the proposed operation required to be covered by a performance bond. Provide calculations and/or drawings, cross sections, etc., to support the reclamation cost estimate. Provide extra calculations for multiple pits or refuse areas. Complete the appropriate Table 9.5 sections. At a minimum, delineate all buildings, reinforced concrete structures and pavement/gravel areas to be reclaimed on the Bond Calculation Map. **[1780.18(b)(2)/1784.13(b)(2); 1800.14]**

The estimate of the cost of reclamation shall be based on:

- Bond Calculation Acreage *(Table 9.5.1.1)*
- Surface Mining Soil Reclamation *(Table 9.5.1.2)*
- Interior Grading *((Table 9.5.1.3)*
- Boxcut Outslope Grading *(Table 9.5.1.4)*
- Incline/Highwall Reclamation *(Table 9.5.1.5)*
- Gob Pile/Gob Impounding Structure/Slurry Reclamation *(Table 9.5.1.6)*
- Incised Slurry Pond or Refuse Reclamation *(Table 9.5.1.7)*
- Support Area Reclamation *(Table 9.5.1.8)*
- Building Reclamation *(Table 9.5.1.9)*
- Reinforced Concrete Structure Reclamation *(Table 9.5.1.10)*
- Pavement/Gravel Area Reclamation *(Table 9.5.1.11)*
- Borehole/Monitoring Well Backfilling *(Table 9.5.1.12)*
- Shaft/Slope Backfilling *(Table 9.5.1.13)*
- Public Road Reclamation *(Table 9.5.1.14)*

NOTE: If incremental bonding is requested, provide a Bond Increment Map as required by the General Mapping Requirements of the Instructions and complete all appropriate Tables of this part.

9.5.2 If applicable, provide the location of buried volatile material storage facilities on the Bond Calculation Map and list the size of each facility. **[1800.14]**

Table 9.1
Post-Mining Land Use Capability

Revised 1/9/2019

Land Owner: *David M. & Karen Y. Mandrel*

DISTURB CATEGORY	LAND CAPABILITY	POST-MINE LAND USE ACREAGE														Subtotal
		Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	
Mining Area	Prime															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unaffected (Optional)	Prime	1.10														1.10
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10
Support	Prime	3.30														3.30
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	3.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.30
Total Area	Prime	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.40
	Neg. Det.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	High Cap.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Limited Capability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Subtotal	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.40

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06596

Table 9.1
Post-Mining Land Use Capability

Revised 1/9/2019

Land Owner: *Williamson Energy, LLC*

DISTURB CATEGORY	LAND CAPABILITY	POST-MINE LAND USE ACREAGE														Subtotal
		Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	
Mining Area	Prime															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unaffected (Optional)	Prime															0.00
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Support	Prime															0.00
	High Cap.								0.06							0.06
	Limited Capability				0.67				0.28							0.95
	Subtotal	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	1.01
Total Area	Prime	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Neg. Det.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	High Cap.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.06
	Limited Capability	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.95
	Subtotal	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	1.01

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06597

Table 9.1
Post-Mining Land Use Capability

Revised 1/9/2019

Land Owner: *Ameren Illinois Company*

DISTURB CATEGORY	LAND CAPABILITY	POST-MINE LAND USE ACREAGE														Subtotal
		Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	
Mining Area	Prime															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unaffected (Optional)	Prime															0.00
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Support	Prime															0.00
	High Cap.															0.00
	Limited Capability				0.12											0.12
	Subtotal	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Total Area	Prime	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Neg. Det.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	High Cap.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Limited Capability	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
	Subtotal	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06598

Table 9.1
Post-Mining Land Use Capability

Revised 1/9/2019

Land Owner: *Joyce L King*

DISTURB CATEGORY	LAND CAPABILITY	POST-MINE LAND USE ACREAGE														Subtotal
		Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	
Mining Area	Prime															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unaffected (Optional)	Prime															0.00
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Support	Prime															0.00
	High Cap.				1.00											1.00
	Limited Capability				1.08											1.08
	Subtotal	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08
Total Area	Prime	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Neg. Det.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	High Cap.	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
	Limited Capability	0.00	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.08
	Subtotal	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06599

Table 9.1
Post-Mining Land Use Capability

Revised 1/9/2019

Land Owner: *Robert Wayne Wilkas*

DISTURB CATEGORY	LAND CAPABILITY	POST-MINE LAND USE ACREAGE														Subtotal
		Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	
Mining Area	Prime															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unaffected (Optional)	Prime															0.00
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Support	Prime															0.00
	High Cap.				1.31											1.31
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.31
Total Area	Prime	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Neg. Det.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	High Cap.	0.00	0.00	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.31
	Limited Capability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Subtotal	0.00	0.00	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.31

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06600

Table 9.1
Post-Mining Land Use Capability

Revised 1/9/2019

Land Owner: *New River Royalty, LLC*

DISTURB CATEGORY	LAND CAPABILITY	POST-MINE LAND USE ACREAGE														Subtotal
		Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	
Mining Area	Prime															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unaffected (Optional)	Prime															0.00
	Neg. Det.															0.00
	High Cap.															0.00
	Limited Capability															0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Support	Prime	3.96														3.96
	High Cap.	0.06			0.21	0.70										0.97
	Limited Capability	2.50			0.28	0.33				0.05						3.16
	Subtotal	6.52	0.00	0.00	0.49	1.03	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	8.09
Total Area	Prime	3.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.96
	Neg. Det.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	High Cap.	0.06	0.00	0.00	0.21	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97
	Limited Capability	2.50	0.00	0.00	0.28	0.33	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	3.16
	Subtotal	6.52	0.00	0.00	0.49	1.03	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	8.09

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06601

Table 9.1 - Grand Total
Post-mining Land Use Capability Summary

Revised 1/9/2019

NOTE: This table must reflect the summary of all individual Pre-mining Land Use Capability tables

DISTURB CATEGORY	LAND CAPABILITY	POST-MINE LAND USE ACREAGE														Subtotal
		Cropland	Pasture	Forest	Wildlife - Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	
Mining Area	Prime	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	High Cap.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Limited Capability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unaffected (Optional)	Prime	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10
	Neg. Det.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	High Cap.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Limited Capability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Subtotal	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10
Support	Prime	7.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.26
	High Cap.	0.06	0.00	0.00	2.52	0.70	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	3.34
	Limited Capability	2.50	0.00	0.00	2.15	0.33	0.00	0.00	0.28	0.05	0.00	0.00	0.00	0.00	0.00	5.31
	Subtotal	9.82	0.00	0.00	4.67	1.03	0.00	0.00	0.34	0.05	0.00	0.00	0.00	0.00	0.00	15.91
Total Area	Prime	8.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.36
	Neg. Det.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	High Cap.	0.06	0.00	0.00	2.52	0.70	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	3.34
	Limited Capability	2.50	0.00	0.00	2.15	0.33	0.00	0.00	0.28	0.05	0.00	0.00	0.00	0.00	0.00	5.31
	Subtotal	10.92	0.00	0.00	4.67	1.03	0.00	0.00	0.34	0.05	0.00	0.00	0.00	0.00	0.00	17.01

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.xx)

R06602

Table 9.5.1.1
Bond Calculation Acreages

Revised 1/9/2019

Land Use/Operation	Acres	Cost
Prime Farmland (surface mined)		**$0.00**
High Capability (surface mined)		**$0.00**
Non-Cropland Capability (surface mined)		**$0.00**
Incline/Highwall Slopes (surface mined)		**$0.00**
Boxcut Spoil Area (surface mined)		**$0.00**
Water		**$0.00**
Support Facilities	17.01	**$0.00**
Refuse Disposal Area* (above grade)		**$0.00**
Refuse Disposal Area (below grade)		**$0.00**
Placeland/Unaffected		**$0.00**
Roads (to remain)		**$0.00**
Total (should equal Permitted acres)	17.01	**$0.00**

*Includes slurry inside refuse area

NOTE: All acreage numbers must be reported to the tenth of an acre (xx.x)

Table 9.5.1.10
Reinforced Concrete Structure Reclamation

Note: All reinforced concrete structures must be located on the Bond Calculation Map

Structure *(name/ID)*: Bleeder Shaft Pad

Structure Type	Height (ft)	Length (ft)	Width (ft)	Concrete Floor Thickness (in.)	Cost
Pads		82	29.7	48	**$0.00**
Footings					**$0.00**
Concrete Structures					**$0.00**

Structure *(name/ID)*: Borehole B Pad

Structure Type	Height (ft)	Length (ft)	Width (ft)	Concrete Floor Thickness (in.)	Cost
Pads		10	10	12	**$0.00**
Footings					**$0.00**
Concrete Structures					**$0.00**

Structure *(name/ID)*: Borehole C Pad

Structure Type	Height (ft)	Length (ft)	Width (ft)	Concrete Floor Thickness (in.)	Cost
Pads		10	10	12	**$0.00**
Footings					**$0.00**
Concrete Structures					**$0.00**

Structure *(name/ID)*: Borehole D Pad

Structure Type	Height (ft)	Length (ft)	Width (ft)	Concrete Floor Thickness (in.)	Cost
Pads		10	10	12	**$0.00**
Footings					**$0.00**
Concrete Structures					**$0.00**

Structure *(name/ID)*: Borehole E Pad

Structure Type	Height (ft)	Length (ft)	Width (ft)	Concrete Floor Thickness (in.)	Cost
Pads		10	10	12	**$0.00**
Footings					**$0.00**
Concrete Structures					**$0.00**

Table 9.5.1.10
Reinforced Concrete Structure Reclamation

Note: All reinforced concrete structures must be located on the Bond Calculation Map

Structure *(name/ID)*: Borehole F Pad

Structure Type	Height (ft)	Length (ft)	Width (ft)	Concrete Floor Thickness (in.)	Cost
Pads		10	10	12	**$0.00**
Footings					**$0.00**
Concrete Structures					**$0.00**

Structure *(name/ID)*: Borehole G Pad

Structure Type	Height (ft)	Length (ft)	Width (ft)	Concrete Floor Thickness (in.)	Cost
Pads		10	10	12	**$0.00**
Footings					**$0.00**
Concrete Structures					**$0.00**

Structure *(name/ID)*: Transformer Pad

Structure Type	Height (ft)	Length (ft)	Width (ft)	Concrete Floor Thickness (in.)	Cost
Pads		10	8	12	**$0.00**
Footings					**$0.00**
Concrete Structures					**$0.00**

Silos / Thickeners

Type	Height (ft)	Outside Diameter (ft)	Wall Thickness (ft)	Concrete Floor Thickness (in.)	Cost
					$0.00
					$0.00
					$0.00
					$0.00

Table 9.5.1.11
Pavement / Gravel Area Reclamation

Note: All pavement/gravel areas must be located on the Bond Calculation Map

Name/ID: Bleeder Shaft Site/Work Yard

Type: *(Concrete/Asphalt/Gravel)*	Thickness (in)	Length (ft)	Width (ft)	Cost
Gravel	12	315	373	**$0.00**

Name/ID: _____

Type: *(Concrete/Asphalt/Gravel)*	Thickness (in)	Length (ft)	Width (ft)	Cost
Gravel				**$0.00**

Name/ID: _____

Type: *(Concrete/Asphalt/Gravel)*	Thickness (in)	Length (ft)	Width (ft)	Cost
				$0.00

Name/ID: _____

Type: *(Concrete/Asphalt/Gravel)*	Thickness (in)	Length (ft)	Width (ft)	Cost
				$0.00

Name/ID: _____

Type: *(Concrete/Asphalt/Gravel)*	Thickness (in)	Length (ft)	Width (ft)	Cost
				$0.00

Name/ID: _____

Type: *(Concrete/Asphalt/Gravel)*	Thickness (in)	Length (ft)	Width (ft)	Cost
				$0.00

Name/ID: _____

Type: *(Concrete/Asphalt/Gravel)*	Thickness (in)	Length (ft)	Width (ft)	Cost
				$0.00

Name/ID: _____

TOTAL COST: $0.00

Table 9.5.1.12
Borehole/Monitoring Well Backfilling

Quantity	Name / ID	Type	Radius (inches)	Depth (feet)
1	Borehole B - Dist#4-1Turbine	Turbine	8	500
1	Borehole C - Dist#4-2Service	Service Borehole	4.3125	500
1	Borehole D - Dist#4-3Service	Service Borehole	6.375	500
1	Borehole E - Dist#4-4Service	Service Borehole	6.375	500
1	Borehole F - Dist#4-5Service	Service Borehole	6.375	500
1	Borehole G - Dist#4-6Service	Service Borehole	12	500

TOTAL COST: **$0.00**

Table 9.5.1.13
Shaft / Slope Backfilling

Shaft Name/ID:	District#4BleederShaft					
Is MSHA acceptable fill available on site?		Yes	[X]	No	[ ]	
Depth of removal of concrete below grade:		5	feet			
Depth of shaft/slope:		500	feet			
If round:	Diameter:	16.5	feet			
If rectangular, provide	Length:		feet	Width:		feet
				COST:	**$0.00**	

Shaft Name/ID:						
Is MSHA acceptable fill available on site?		Yes	[ ]	No	[ ]	
Depth of removal of concrete below grade:			feet			
Depth of shaft/slope:			feet			
If round:	Diameter:		feet			
If rectangular, provide	Length:		feet	Width:		feet
				COST:	**$0.00**	

Shaft Name/ID:						
Is MSHA acceptable fill available on site?		Yes	[ ]	No	[ ]	
Depth of removal of concrete below grade:			feet			
Depth of shaft/slope:			feet			
If round:	Diameter:		feet			
If rectangular, provide	Length:		feet	Width:		feet
				COST:	**$0.00**	

Slope Name/ID:						
Is MSHA acceptable fill available on site?		Yes	[ ]	No	[ ]	
Percentage (%) slope:			%			
Distance from Surface to Toe of Seal:			feet			
If round:	Diameter:		feet			
If rectangular, provide	Height:		feet	Width:		feet
				COST:	**$0.00**	

PART 10: Revegetation *(Excluding Cropland and Streams)*

10.1 Revegetation of Drainage Control Ditches. Describe plans for revegetation of ditches associated with construction of roads, conveyer systems, rail systems, and associated with controlling overland flow drainage. For responses that are identical to other parts, "see response to question number X" is acceptable. The following information is required: **[1780.18(b)(5)/1784.13(b)(5; 1816.43/1817.43; 1816.45/1817.45; 1816.111/1817.111; 1816.114/1817.114]**

10.1.1 Describe the methods for the use of temporary seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c); 1816.114/0817.114; 1780.18(b)(5)/1784.13(b)(5)]**

N/A

10.1.2 Describe the timing and methods proposed to transition from the temporary vegetation to the semi-permanent or permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

N/A

10.1.3 Provide a semi-permanent or permanent grass and forbs species list that is diverse, native, capable of controlling erosion, and capable of self-regeneration. If non-native species are proposed, provide adequate justification that the species are desirable, necessary to achieve the approved post-mining land use, and are required to control erosion. **[1816.111 (a) and (b)/1817.111 (a) and (b); 1816.111(c)/1817.111(c)]**

N/A

10.1.4 Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates for the semi-permanent or permanent grass and forbs list. **[1780.18(b)(5)/1784.13(b)(5)]**

N/A

10.2 Revegetation of Faces of Embankments. Describe plans for revegetation of faces of embankments of sediment ponds and other water structures. For responses that are identical to other parts, "see response to question number X" is acceptable. The following information is required: **[1780.18(b)(5)/1784.13(b)(5); 1816.46(b)(1) and (4)/1817.46(b)(1) and (4); 1816.49(a)(8)/1817.49(a)(8); 1816.111/1817.111]**

10.2.1 Describe the methods for the use of temporary seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c); 1816.114/0817.114; 1780.18(b)(5)/1784.13(b)(5)]**

N/A – No embankment sediment ponds are proposed by this IBR

10.2.2 Describe the timing and methods proposed to transition from the temporary vegetation to the semi-permanent or permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

N/A

10.2.3 Provide a semi-permanent or permanent grass and forbs species list that is diverse, native, capable of controlling erosion, and capable of self-regeneration. If non-native species are proposed, provide adequate justification that the species are desirable, necessary to achieve the approved post-mining land

use, and are required to control erosion. **[1816.111 (a) and (b)/1817.111 (a) and (b); 1816.111(c)/1817.111(c)]**

N/A

10.2.4 Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates for the semi-permanent or permanent grass and forbs list. **[1780.18(b)(5)/1784.13(b)(5)]**

N/A

10.3 Revegetation of Soil Stockpiles. Describe plans for revegetation of subsoil and topsoil stockpiles. For responses that are identical to other parts, "see response to question number X" is acceptable. The following information is required: **[1780.18(b)(5)/1784.13(b)(5; 1816.22(c)(2)(C)/1817.22(c)(2)(C); 1816.111/1817.111]**

10.3.1 Describe the methods for the use of temporary seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c); 1816.114/1817.114; 1780.18(b)(5)/1784.13(b)(5)]**

Spring Oats(Spring Seeding) 50 lbs./acre and Winter Wheat (Fall Seeding) 40 lbs./acre are proposed as temporary cover crop , Ryegrass (annual) 20.0 lbs./acre, German Millet 20.0 lbs./acre, (Fall Planting), Ryegrass (perennial) 20.0 lbs./acre, 1.5 tons mulch/acre straw broadcast.

10.3.2 Describe the timing and methods proposed to transition from the temporary vegetation to the semi-permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

Permanent vegetation will be planted during final reclamation.

10.3.3 Provide a semi-permanent grass and forbs species list that is capable of controlling erosion and capable of self-regeneration. If non-native species are proposed, provide adequate justification that the species are desirable and necessary to control erosion. **[1816.111 (a) and (b)/1817.111 (a) and (b); 1816.111(c)/1817.111(c)]**

See 10.3.1

10.3.4 Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates for the semi-permanent grass and forbs list. **[1780.18(b)(5)/1784.13(b)(5)]**

See 10.3.1.

10.4 Revegetation of Refuse Disposal Facilities. Describe plans for revegetation of refuse disposal facilities. The revegetation plan must conform to the standards of success outlined in the regulations and adhere to the Illinois Noxious Weed Law. For responses that are identical to other parts, "see response to question number X" is acceptable. The following information is required: **[1780.18(b)(5)/1784.13(b)(5); 1816.22(c)(2)(C)/1817.22(c)(2)(C); 1816.111/1817.111]**

10.4.1 Provide the proposed post-mining land use designation for refuse disposal facilities and a justification for the necessity of that land use. **[1780.23(b)/1784.15(b)]**

10.4.2 Describe proposed soil preparation and a soil testing plan related to reclamation and re-vegetation procedures. **[1780.18(b)(5)(G)/1784.13(b)(5)(G)]**

10.4.3 Describe the methods for the use of temporary seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c); 1816.114/0817.114]**

10.4.4 Describe the timing and methods proposed to transition from the temporary vegetation to the permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

10.4.5 Provide a permanent grass and forbs species list that is diverse, native, capable of controlling erosion, and capable of self-regeneration. If non-native species are proposed to achieve the post-mining land use, provide adequate justification that the species are desirable, necessary to achieve the approved post-mining land use, and are required to control erosion. Specify if the proposed seed mix contains different species for the slopes and the top of the structure. Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates. **[1780.18(b)(5)/1784.13(b)(5); 1816.111(a) and (b)/1817.111(a) and (b); 1816.111(a)(2)/1817.111(a)(2); 1816.97(g)/1817.97(g)]**

10.4.6 Describe a periodic measurement plan of the vegetation that will be used to identify if remedial actions are necessary to achieve the approved species and / or post-mining land use vegetation success standards during the applicable period of liability. Information provided shall also describe a remedial action plan to achieve the approved vegetative species, invasive species management, or post-Mining Land Use success. Remedial actions may include but are not limited to mowing, burning, undesirable invasive species control, irrigation and pest and disease control. **[1816.116(b)(1)/1817.116(b)(1); 1816.111(a) and (b)/1817.111(a) and (b)]**

10.5 Pasture Reclamation Plan. Describe plans for reclamation and revegetation of Pasture. The revegetation plan must conform to the standards of success outlined in the regulations and adhere to the Illinois Noxious Weed Law. For responses that are identical to other parts, "see response to question number X" is acceptable. The following information is required: **[1780.18(b)(5)/1784.13(b)(5); 1816.111/1817.111; 1816.116/1817.116]**

10.5.1 Describe proposed soil preparation and a soil testing plan related to reclamation and re-vegetation procedures. **[1780.18(b)(5)(G)/1784.13(b)(5)(G)]**

10.5.2 Describe the methods for the use of temporary seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c); 1816.114/0817.114]**

10.5.3 Describe the timing and methods proposed to transition from the temporary vegetation to the permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

10.5.4 Provide a permanent pasture grass species list, describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates. **[1780.13(b)(5)/1784.18(b)(5)]**

10.5.5 Describe a periodic measurement plan of the vegetation that will be used to identify if remedial actions are necessary to achieve the approved species and / or post-mining land use vegetation success standards during the applicable period of liability. Information provided shall also describe a remedial action plan to achieve the approved vegetative species, invasive species management, or post-Mining Land Use success. Remedial actions may include but are not limited to mowing, burning, undesirable invasive species control, irrigation and pest and disease control. **[1816.116(b)(1)/1817.116(b)(1); 1816.111(a) and (b)/1817.111(a) and (b)]**

10.6 Fish and Wildlife-Herbaceous Reclamation Plan. Describe plans for reclamation and revegetation of Wildlife Herbaceous areas. The revegetation plan must conform to the standards of success outlined in the regulations and adhere to the Illinois Noxious Weed Law. For responses that are identical to other parts, "see response to question number X" is acceptable. The following information is required:
[1780.18(b)(5)/1784.13(b)(5); 1816.111/1817.111; 1816.97/1817.97; 1816.116/1817.116; 1816.117/1817.117]

10.6.1 Describe proposed soil preparation and a soil testing plan related to reclamation and revegetation procedures. **[1780.18(b)(5)(G)/1784.13(b)(5)(G)]**

Topsoil will be redistributed evenly across the site.

10.6.2 Describe the methods for the use of temporary seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch.
[1816.111(c)/1817.111(c); 1816.114/0817.114]

Spring Oats(Spring Seeding) 50 lbs./acre and Winter Wheat (Fall Seeding) 40 lbs./acre are proposed as temporary cover crop, Redtop 10 lbs./acre, Perennial Ryegrass 5 lbs./acre, Orchard Grass 10 lbs./acre, White Dutch Clover 5 lbs./acre, Red Clover 8 lbs./acre, Partridge Pea 1 lb./acre. and 1.5 tons/acre of straw mulch broadcast.

10.6.3 Describe the timing and methods proposed to transition from the temporary vegetation to the permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

Planted during final reclamation.

10.6.4 Provide a permanent grass and forbs species list that is diverse, native, capable of controlling erosion, and capable of self-regeneration. If non-native species are proposed to achieve the post-mining land use, provide adequate justification that the species are desirable, necessary to achieve the approved post-mining land use, and are required to control erosion. Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates. **[1780.18(b)(5)/1784.13(b)(5); 1816.111(a) and (b)/1817.111(a) and (b); 1816.111(a)(2)/1817.111(a)(2); 1816.97(g)/1817.97(g)]**

See 10.6.2

10.6.5 Describe a periodic measurement plan of the vegetation that will be used to identify if remedial actions are necessary to achieve the approved species and / or post-mining land use vegetation success standards during the applicable period of liability. Information provided shall also describe a remedial action plan to achieve the approved vegetative species, invasive species management, or post-mining land

use success. Remedial actions may include but are not limited to mowing, burning, undesirable invasive species control, irrigation and pest and disease control. **[1816.116(b)(1)/1817.116(b)(1); 1816.111(a) and (b)/1817.111(a) and (b)]**

Areas will be inspected routinely until 70% uniformed vegetative cover has been obtained over the disturbed area.

10.7 Fish and Wildlife-Woody Reclamation Plan. Describe plans for reclamation and revegetation of Wildlife Woody areas. The revegetation plan must conform to the standards of success outlined in the regulations and adhere to the Illinois Noxious Weed Law. If a bat Protection and Enhancement Plan (PEP) is part of the application, the applicant shall ensure consistency between this part and the bat PEP. For responses that are identical to other parts, "see response to question number X" is acceptable. The following information is required: **[1780.18(b)(5)/1784.13(b)(5; 1816.111/1817.111; 1816.97/1817.97; 1816.116/1817.116; 1816.117/1817.117;** OSM Directives TSR-16 Directive 931**]**

10.7.1 Describe proposed soil preparation and a soil testing plan related to reclamation and revegetation procedures. **[1780.18(b)(5)(G)/1784.13(b)(5)(G)]**

10.7.2 Describe the methods for the use of temporary seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c); 1816.114/0817.114]**

Redtop 10 lbs/acre, Partridge Pea 5 lbs/acre, Orchard Grass 10 lbs/acre, Indian Grass 2 lbs/acre, Spring Oats (Spring Seeding) 50 lbs/acre, Winter Wheat (Fall Seeding), 40 lbs/acre Mulch (Straw or Mixed Hay) 2 tons/acre Broadcast

10.7.3 Describe the timing and methods proposed to transition from the temporary vegetation to the permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

Tree will be planted after water line is no longer needed.

10.7.4 Provide a permanent herbaceous ground cover species list and a woody species list that is diverse, native, capable of controlling erosion, capable of self-regeneration, and that has growth habits compatible with woody species success. If non-native species are proposed to achieve the post-mining land use, provide adequate justification that the species are desirable, necessary to achieve the approved post-mining land use, and are required to control erosion. Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates. **[1780.18(b)(5)/1784.13(b)(5); 1816.111(a) and (b)/1817.111(a) and (b); 1816.111(a)(2)/1817.111(a)(2); 1816.97(g)/1817.97(g);** Operator Memorandum No. 2017-02**]**

Acer. saccharinum Suger Maple, Carya cordiformis Bitternut Hickory, Carya glabra Pignut Hickory, Carya laciniosa Shellbark Hickory, Carya ovate Shagbark Hickory, Carya. tomentosa Mockernut Hickory, Fraximus americana White Ash, Fraximus pennsylvania Green Ash, Oxydendron arboreum Sourwood, Pinus echinata Shortleaf Pine, Populus detloides Cottonwood, Quercus. alba White Oak, Quercus coccinea Scarlet Oak, Quercus falcate Southern Red Oak, Quercus imbricaria Shingle Oak, Quercus prinus Chestnut Oak, Quercus rubra Northern Red Oak, Quercus stellata Post Oak, Quercus velutina Black Oak, Sassafras albidum Sassafras, Ulmus americana American Elm, Ulmus rubra Slippery Elm, Cercis Canadensis Redbud, Robinia pseudoacacia Black Locust, Cornus florida Flowering Dogwood, Diospyros virginiana

Persimmon, Morus rubra Red Mulberry, Prunus serotina Wild Black Cherry

10.7.5 Describe a periodic measurement plan of the vegetation that will be used to identify if remedial actions are necessary to achieve the approved species and / or post-mining land use vegetation success standards during the applicable period of liability. Refer to Operator Memorandum No. 2017-02 for additional information regarding tree and shrub planting maintenance. Information provided shall also describe a remedial action plan to achieve the approved vegetative species, invasive species management, or post-mining land use success. Remedial actions may include but are not limited to mowing, burning, undesirable invasive species control, irrigation and pest and disease control.
[1816.116(b)(1)/1817.116(b)(1); 1816.111(a) and (b)/1817.111(a) and (b)]

During final reclamation, an attempted will be made to remove all invasive species through the use of cutting and herbicides. Vegetation will be routinely monitored after final planting to ensure the approved vegetative species are present.

10.8 Fish and Wildlife-Wetland Reclamation Plan. Describe plans for reclamation and revegetation of Wildlife Wetland areas. The revegetation plan must conform to the standards of success outlined in the regulations and adhere to the Illinois Noxious Weed Law. The following information is required: **[1701.5; 1816.111/1817.111; 1816.97/1817.97; 1816.116/1817.116; 1816.117/1817.117; 1816.102(h)/1817.102(h);** OSM Directives System TSR-14 Directive 828**]**

10.8.1 Is the wetland a managed, engineered area that functions as part of a drainage control plan, a sediment control plan, or is not a fully incised wetland?

☐ YES ☐ NO

If NO, complete Part 10.8.2, If YES, the following information is required:

10.8.1.1 Describe how the soil type(s) in the proposed wetland area will support hydrophytic vegetation. If hydric soils are not present, describe how the area will function as a wetland without this wetland parameter. **[1701.5 Appendix A]**

10.8.1.2 Discuss the potential for the area to be inundated or saturated by surface or groundwater at a frequency to support hydrophytic vegetation on at least 30% of the surface acres of the wetland. **[1701.5 Appendix A]**

10.8.1.3 Provide a permanent wetland vegetation species list that is compatible with the Corp of Engineers Wetland Delineation Manual as described in the regulations. The species list must also be diverse, capable of controlling erosion, and capable of self-regeneration. If non-native species are proposed to achieve the post-mining land use, provide adequate justification that the species are desirable, necessary to achieve the approved post-mining land use, and are required to control erosion.
[1816.116(a)(5)(A)/1817.116(a)(5)(A); 1816.111 (a) and (b)/1817.111 (a) and (b); 1816.97(g)/1817.97(g)]

10.8.1.4 Provide a description of how the requirements for permanent impoundments will be met. **[1816.49(b)/1817.49(b)]**

10.8.2 Is the wetland a depression created by removal of soil for the purposes of a borrow area or enhancement of wildlife habitat and not an engineered portion of a drainage control plan or sediment control plan?

☐ YES ☐ NO

If YES, the following information is required:

10.8.2.1 Describe how the soil type(s) in the proposed will support hydrophytic vegetation. If hydric soils are not present, describe how the area will function as a wetland without this wetland parameter. **[1701.5 Appendix A]**

10.8.2.2 Discuss the potential for the area to be inundated or saturated by surface or groundwater at a frequency to support hydrophytic vegetation on at least 30% of the surface acres of the wetland. **[1701.5 Appendix A]**

10.8.2.3 Provide a permanent wetland vegetation species list that is compatible with the Corp of Engineers Wetland Delineation Manual as described in the regulations. The species list must also be diverse, capable of controlling erosion, and capable of self-regeneration. Adequate justification that the species are desirable, necessary to achieve the approved post-mining land use, and are required to control erosion. **[1816.116(a)(5)(A)/1817.116(a)(5)(A); 1816.111 (a) and (b)/1817.111 (a) and (b); 1816.97(g)/1817.97(g)]**

10.9 Fish and Wildlife-Water and/or Developed Water Resources Reclamation Plan. Describe plans for reclamation and revegetation of Wildlife Water and/or Developed Water Resources areas. The revegetation plan must conform to the standards of success outlined in the regulations and adhere to the Illinois Noxious Weed Law. The following information is required: **[1816.49(b)/1817.49(b); 1816.56/1817.56; 1816.97/1817.97]**

10.9.1 For Developed Water Resources, provide a description of the future quality of the impounded water including the following: assurance that it will meet water quality standards, it will not degrade the quality of the receiving water, and it will not diminish the quality/quantity of water utilized by adjacent land owners. **[1816.49(b)/1817.49(b)]**

10.9.2 For Fish and Wildlife - Water, discuss how the area will support and enhance fish and wildlife habitat, describe the future water quality, and describe how the water level will be capable of supporting the intended use. **[1816.49(b)/1817.49(b); 1816.97/1817.97]**

10.10 Forest Reclamation Plan. Describe plans for reclamation and revegetation of Forest areas. The revegetation plan must conform to the standards of success outlined in the regulations and adhere to the Illinois

Noxious Weed Law. If a bat Protection and Enhancement Plan (PEP) is part of the application, the applicant shall ensure consistency between this part and the bat PEP. For responses that are identical to other parts, "see response to question number X" is acceptable. The following information is required: **[1816.111/1817.111; 1816.97/1817.97; 1816.116/1817.116; 1816.117/1817.117;** OSM Directives TSR-16 Directive 931**]**

10.10.1 Describe proposed soil preparation and a soil testing plan related to reclamation and revegetation procedures. **[1780.18(b)(5)(G)/1784.13(b)(5)(G)]**

10.10.2 Describe the methods for the use of temporary seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c); 1816.114/1817.114]**

10.10.3 Describe the timing and methods proposed to transition from the temporary herbaceous cover vegetation to the permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

10.10.4 Provide a permanent herbaceous ground cover species list and a woody species list that is diverse, native, capable of controlling erosion, capable of self-regeneration, and that has growth habits compatible with woody species success. If non-native species are proposed to achieve the post-mining land use, provide adequate justification that the species are desirable, necessary to achieve the approved post-mining land use, and are required to control erosion. Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates. **[1780.18(b)(5)/1784.13(b)(5); 1816.111(a) and (b)/1817.111(a) and (b); 1816.111(a)(2)/1817.111(a)(2); 1816.97(g)/1817.97(g);** Operator Memorandum No. 2017-02**]**

10.10.5 Describe a periodic measurement plan of the vegetation that will be used to identify if remedial actions are necessary to achieve the approved species and / or post-mining land use vegetation success standards during the applicable period of liability. Refer to Operator Memorandum No. 2017-02 for additional information regarding tree and shrub planting maintenance. Information provided shall also describe a remedial action plan to achieve the approved vegetative species, invasive species management, or post-mining land use success. Remedial actions may include but are not limited to mowing, burning, undesirable invasive species control, irrigation and pest and disease control. **[1816.116(b)(1)/1817.116(b)(1); 1816.111(a) and (b)/1817.111(a) and (b)]**

10.11 Industrial/Commercial Reclamation Plan. Describe plans for reclamation and revegetation of Industrial/Commercial areas. The revegetation plan must conform to the standards of success outlined in the regulations and adhere to the Illinois Noxious Weed Law. For responses that are identical to other parts, "see response to question number X" is acceptable. The following information is required: **[1816.111/1817.111; 1816.97/1817.97; 1816.116/1817.116; 1816.117/1817.117]**

10.11.1 Describe plans for utilization of the area for Industrial or Commercial purposes at the time of bond release.

The existing rail will continue to operate as it did prior to IBR construction.

10.11.2 Provide a ground cover species list and a woody species list, if applicable that is diverse, native, capable of controlling erosion, and capable of self-regeneration. If non-native species are proposed to achieve the post-mining land use, provide adequate justification that the species are desirable, necessary to achieve the approved post-mining land use, and are required to control erosion. **[1816.111 (a) and (b)/1817.111 (a) and (b); 1816.97(i)/1817.97(i)]**

Seeding around vegetated area will comply with the Fish and Wildlife – Herbaceous requirements above in Part 10.6

10.12 Recreation Reclamation Plan. Describe plans for reclamation and revegetation of Recreation areas. The revegetation plan must conform to the standards of success outlined in the regulations and adhere to the Illinois Noxious Weed Law. For responses that are identical to other parts, "see response to question number X" is acceptable. The following information is required: **[1816.111/1817.111; 1816.97/1817.97; 1816.116/1817.116; 1816.117/1817.117]**

10.12.1 Describe plans for utilization of the area for recreational purposes at the time of bond release.

N/A

10.12.2 Provide a ground cover species list and a woody species list, if applicable that is diverse, native, capable of controlling erosion, and capable of self-regeneration. If non-native species are proposed to achieve the post-mining land use, provide adequate justification that the species are desirable, necessary to achieve the approved post-mining land use, and are required to control erosion **[1816.111 (a) and (b)/1817.111 (a) and (b); 1816.97(i)/1817.97(i)]**

N/A

10.13 Habitat Diversification in Cropland. Describe plans to intersperse crop fields with trees, hedges, conservation drainage ways, or fence rows that will break up crop monocultures and diversify habitat, where appropriate and compatible with crop management and wildlife management practices. **[1816.97(h)/1817.97(h); 1816.111/1817.111]**

PART 12: Shaft, Slope and Miscellaneous Borehole Construction

12.1 Shafts and/or Slopes.

12.1.1 For the shafts and/or slopes being proposed, describe the measures to be implemented to minimize disturbance to the prevailing hydrologic balance and to ensure the safety of people, livestock, fish and wildlife, and machinery in the permit area and adjacent area. **[1816.13/1817.13]**

The 16.5 feet concrete finished shaft will have all necessary fencing require to comply with 1816.13/1817.13. The shafts will be fully grouted into place to protect prevailing hydrologic balance.

12.1.2 For each shaft and/or slope, provide a drawing showing those features which are relevant to protecting the hydrologic balance. The drawing shall include:

- The physical dimensions of excavations and entry lining material;
- The type of entry lining material;
- The measures which will be used to seal the annulus between the entry lining and adjacent rock;
- Water rings and conductor pipes;
- Elevation of land surface, coal seam, and any other mine workings penetrated by the structure; and
- Provide the latitude and longitude (in decimal degrees) for each shaft and/or slope.

Provide reference to each drawing below.

A raise bore shaft construction of a 16.5 feet diameter finished cement with water collection rings as required (Typical location for the water ring in a raise bore shaft in the bottom 40 feet). Concrete collar will be excavated and keyed into bedrock to ensure not surface water is intermixed with ground water. Surface Elevation is approximately 421 and the bottom of the shaft will be the Herrin #6 at 500 feet deep. (Lat 37.8623, Long 88.7338). The top of the Illinois #6 coal is at approximately elevation -79.(District#4BleederShaft)

12.1.3 Will the Applicant be conducting any surface blasting activities incidental to underground mining, including, but not limited to, initial rounds of slopes and/or shafts that are within 50 vertical feet of the original ground surface? **[1817.61(a)]**

☐ YES ☒ NO

If YES, complete the appropriate items in Part 11: Blasting.

12.2 Miscellaneous Boreholes.

12.2.1 For each borehole or group of boreholes being proposed, describe the measures to be implemented to minimize disturbance to the prevailing hydrologic balance and ensure the safety of people, livestock, fish and wildlife, and machinery in the permit area and adjacent area. **[1816.13/1817.13]**

Six (6) holes will be drilled. Each hole will be fully cased with steel pipe and fully grouted in place. All open will be covered with a perforated metal cap to prevent access

to the mine workings by people, livestock, fish and wildlife, and machinery. The surface casing will be high enough above ground to prevent drainage from entering hole and to keep acid or other toxic drainage from entering ground water or surface water. The boreholes will be permanently sealed within 60 days of when the borehole becomes inactive. Each hole drilled will be plugged during reclamation by filling with neat cement to the top and the casing will be cut off at least five feet below grade.

12.2.2 For each borehole or group of boreholes which will be constructed in a similar manner, provide a borehole log with the following: [Operator Memorandum 2017-01]

- The depth (or depth range) and diameter of each drill hole;
- The depth (or depth range) and diameter of each casing string, type and thickness of casing material in each string, and spacing of collars and any centralizers;
- Intervals to be cemented, grouted, or otherwise sealed and the method of placement;
- Any geophysical logging which is proposed;
- The names and numbers of boreholes to which the sketch applies; and
- Provide the latitude and longitude (in decimal degrees) for each borehole.

Provide reference to each borehole log below.

1 – 16" diameter ¼" Steel cased fully grouted hole approximately ~500 feet deep, No geophysical logging proposed at ~ LAT: ~37.8619° LON: ~88.7339° (Borehole B - Dist#4-1Turbine)

1 – 8 5/8" diameter ¼" Steel cased fully grouted hole approximately ~500 feet deep, No geophysical logging proposed at ~ LAT: ~37.8627° LON: ~88.7341° (Borehole C - Dist#4-2Service)

1 – 12 3/4" diameter ¼" Steel cased fully grouted holes approximately ~500 feet deep, No geophysical logging proposed at ~ LAT: ~37.8627° LON: ~88.7341° (Borehole D - Dist#4-3Service)

1 – 12 3/4" diameter ¼" Steel cased fully grouted holes approximately ~500 feet deep, No geophysical logging proposed at ~ LAT: ~37.8627° LON: ~88.7340° (Borehole E - Dist#4-4Service)

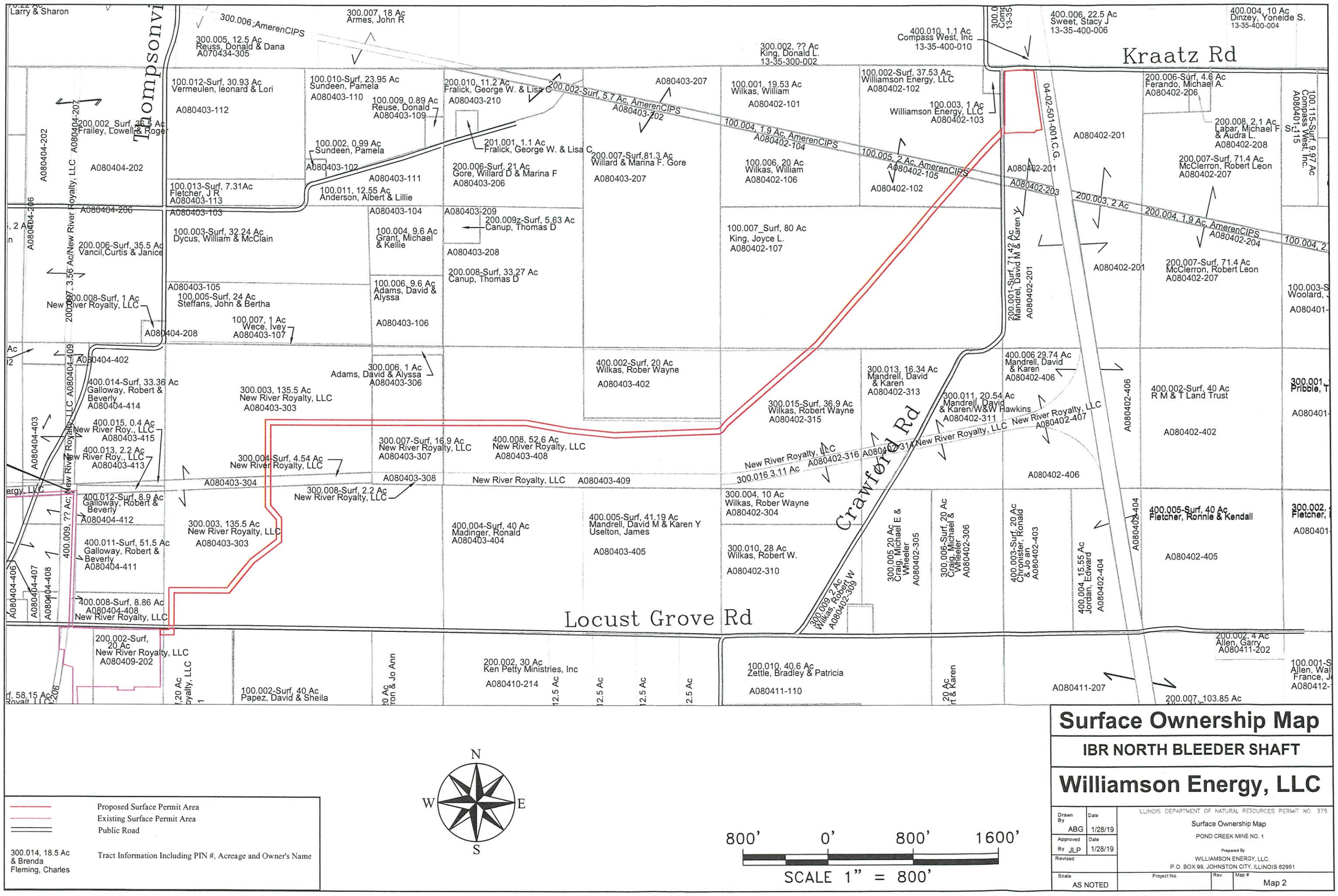
1 – 12 3/4" diameter ¼" Steel cased fully grouted holes approximately ~500 feet deep, No geophysical logging proposed at ~ LAT: ~37.8627° LON: ~88.7340° (Borehole F - Dist#4-5Service)

1 – 24" diameter ¼" Steel cased fully grouted hole approximately ~500 feet deep, No geophysical logging proposed at ~ LAT: ~37.8627° LON: ~88.7339° (Borehole G - Dist#4-6Service)

The boreholes will be permanently sealed within 60 days of when the borehole becomes inactive. Each hole drilled will be plugged during reclamation by filling with neat

cement to the top and the casing will be cut off at least five feet below grade.

R06621



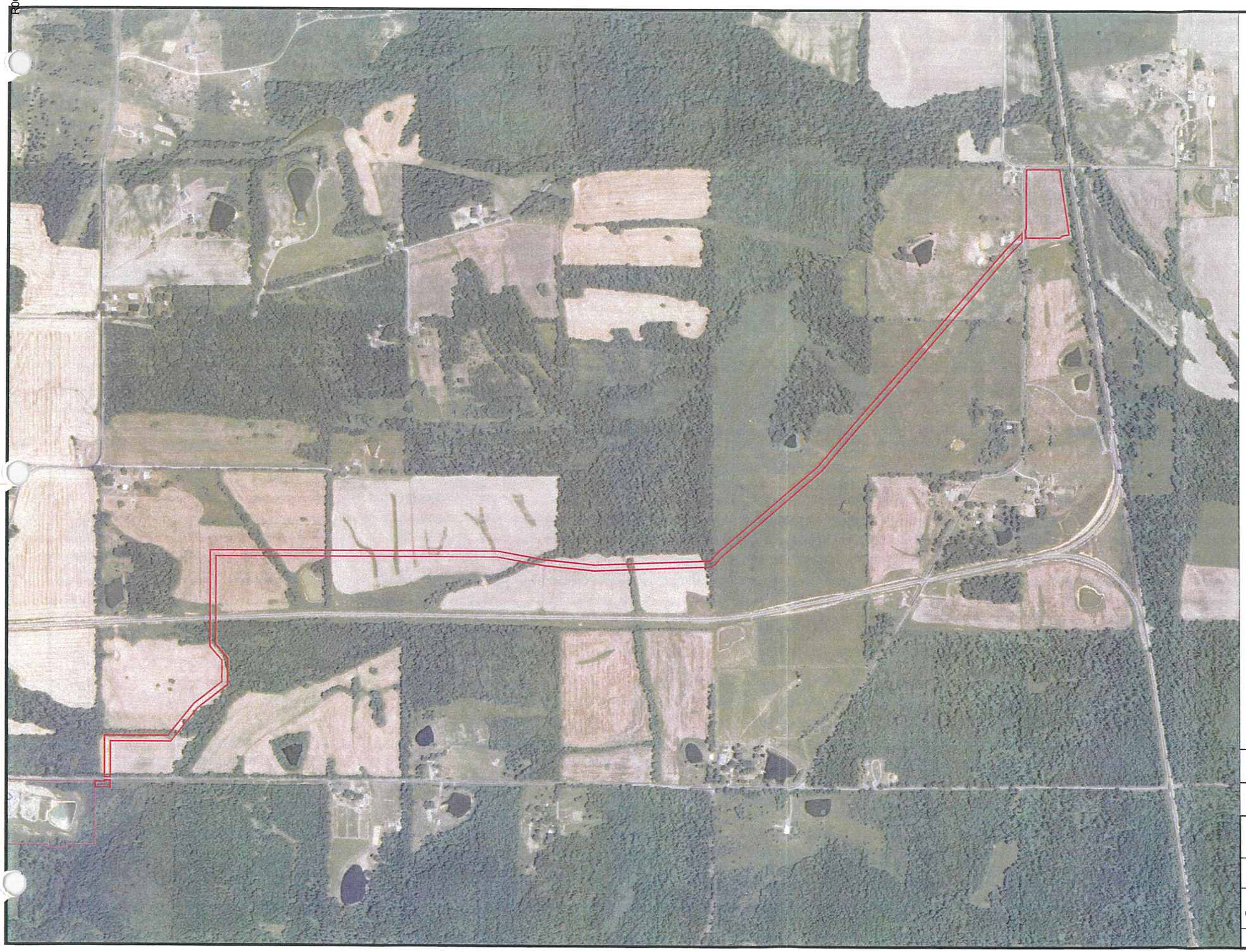
Surface Ownership Map

IBR NORTH BLEEDER SHAFT

Williamson Energy, LLC

Drawn By ABG	Date 1/28/19	ILLINOIS DEPARTMENT OF NATURAL RESOURCES PERMIT NO. 375
Approved By JLP	Date 1/28/19	Surface Ownership Map
Revised:		POND CREEK MINE NO. 1
		Prepared By WILLIAMSON ENERGY, LLC. P.O. BOX 99, JOHNSTON CITY, ILLINOIS 62951
Scale AS NOTED	Project No.	Rev. / Map # Map 2

R06622



N

0' 800' 1600'

SCALE 1" = 800'

Aerial Map

IBR NORTH BLEEDER SHAFT

Drawn By: ABG	Date: 1/28/19	ILLINOIS DEPARTMENT OF NATURAL RESOURCES PERMIT NO. 375
Approved By:	Date:	Pre & Post Mine Land Use Map
Revised:		POND CREEK MINE NO. 1
		Prepared For: WILLIAMSON ENERGY, LLC. P.O. BOX 99, JOHNSTON CITY, ILLINOIS 62951
Scale: AS NOTED	Project No.: land use map - ibr.dwg	Rev.
		Map #: Map 4

R06623

N

LEGEND

Cropland	Fish and Wildlife (Water)
Residential	Industrial/Commercial
Fish & Wildlife (woody)	Proposed IBR Boundary
Fish & Wildlife (herbaceous)	Occupied Structure
	Unoccupied Structure
	1000 feet offset

0' 800' 1600'

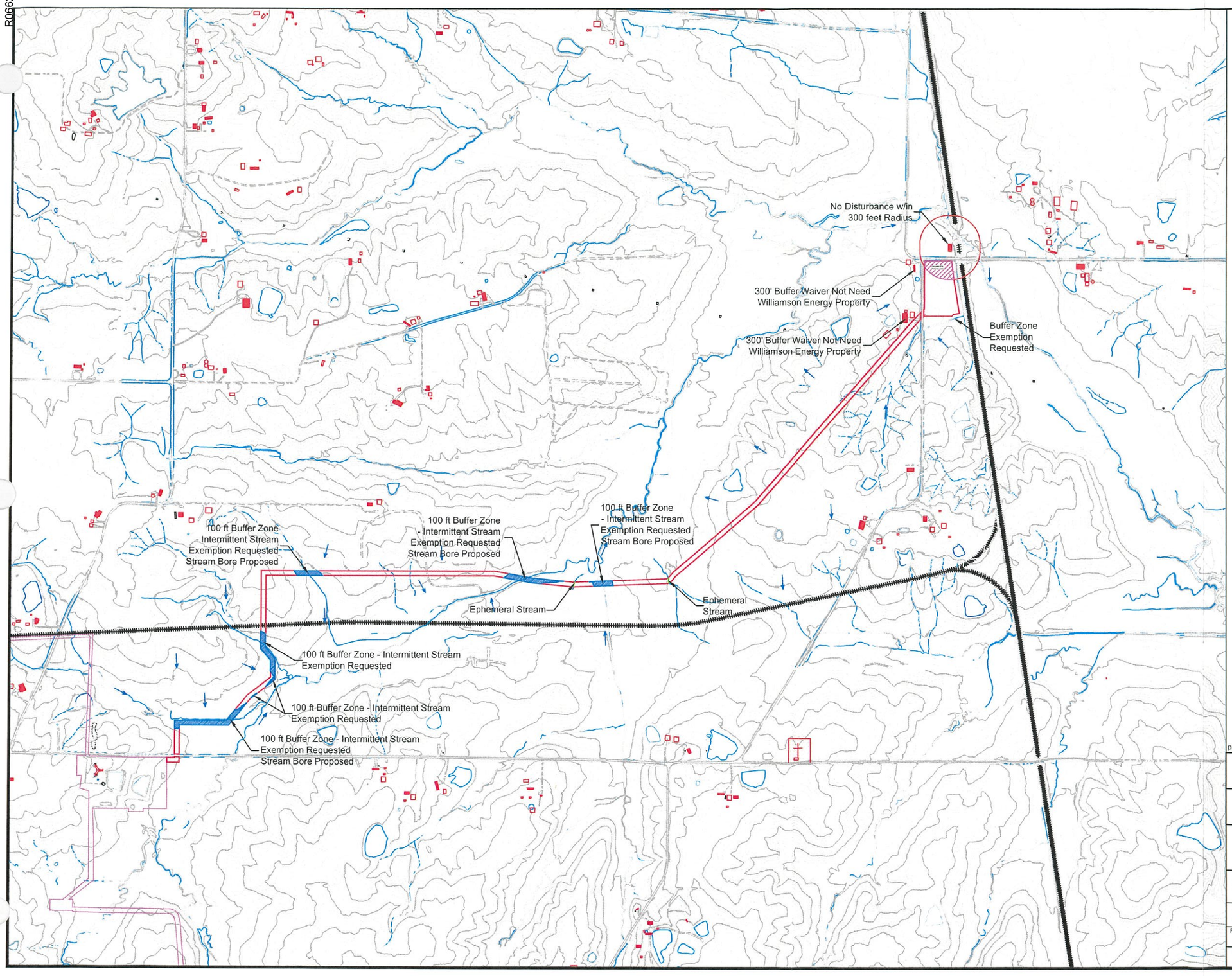
SCALE 1" = 800'

Pre & Post Mine Land Use

IBR NORTH BLEEDER SHAFT

Drawn By: ABG	Date: 1/28/19	ILLINOIS DEPARTMENT OF NATURAL RESOURCES PERMIT NO. 375
Approved By:	Date:	Pre & Post Mine Land Use Map
Revised:		POND CREEK MINE NO. 1
		Prepared For: WILLIAMSON ENERGY, LLC. P.O. BOX 99, JOHNSTON CITY, ILLINOIS 62951
Scale: AS NOTED	Project No.: land use map - ibr.dwg	Rev.:
		Map #: Map 4

R06624



N
W E
S

Legend

- Permit 375
- Proposed IBR Boundary
- Roads
- Surface Drainage
- 10 Ft. Contour Line
- 2 Ft. Contour Line
- Drainage Flow
- Occupied Structure
- Un-Occupied Structure
- 100' Stream Buffer Zone

1000' 0' 1000' 2000'

SCALE 1" = 1000'

pre-post topo map - ibr north bleeder.dwg

Pre and Post Topo Map

IBR North Bleeder Shaft

Williamson Energy, LLC

Drawn By ABG	Date 12/18/18	ILLINOIS DEPARTMENT OF NATURAL RESOURCES PERMIT NO. 375
Approved By JLP	Date 12/18/18	Pre & Post Topo Map POND CREEK MINE NO. 1
Revised:		Prepared By WILLIAMSON ENERGY, LLC. P.O. BOX 99, JOHNSTON CITY, ILLINOIS 62951
Scale AS NOTED	Project No.	Rev. / Map # Map 5

R06626

1" = 100'

Permitted But
Not Disturbed

30' Site Entrance

C D E F G

Temp Drill Pit

Sub Soil

Temp Drill Pit

Top Soil Pile

Jennchem Plant

Bleeder Fan

VFD trailer

A

12'x8'x1' Concrete Pad

Transformer pad

Temp Drill Pit

B Concrete 10'x10'x1'

Gravel ~2.70 Acres

No Disturbance w/in
300 feet Radius

300' Buffer Waiver Not Need
Williamson Energy Property

300' Buffer Waiver Not Need
Williamson Energy Property

Buffer Zone
Exemption
Requested

Crawford Road Bore

100 ft Buffer Zone
- Intermittent Stream
Exemption Requested
Stream Bore Proposed

100 ft Buffer Zone
- Intermittent Stream
Exemption Requested
Stream Bore Proposed

100 ft Buffer Zone
- Intermittent Stream
Exemption Requested
Stream Bore Proposed

Rail Raod Bore

Ephemeral Stream

Ephemeral
Stream

100 ft Buffer Zone - Intermittent Stream
Exemption Requested

Waterline connects to
existing waterline

100 ft Buffer Zone - Intermittent Stream
Exemption Requested

100 ft Buffer Zone - Intermittent Stream
Exemption Requested
Stream Bore Proposed

Locust Grove
Road Bore

N

W E

S

Legend

- Permit 375
- Proposed IBR Boundary
- Roads
- Surface Drainage
- 10 Ft. Contour Line
- 2 Ft. Contour Line
- Drainage Flow
- Occupied Structure
- Un-Occupied Structure
- 100' Stream Buffer Zone
- Indiana Bat 172.413
  2.5 Mile Buffer Radius
- Indiana Bat 172.636
  2.5 Mile Buffer Radius

800' 0' 800' 1600'

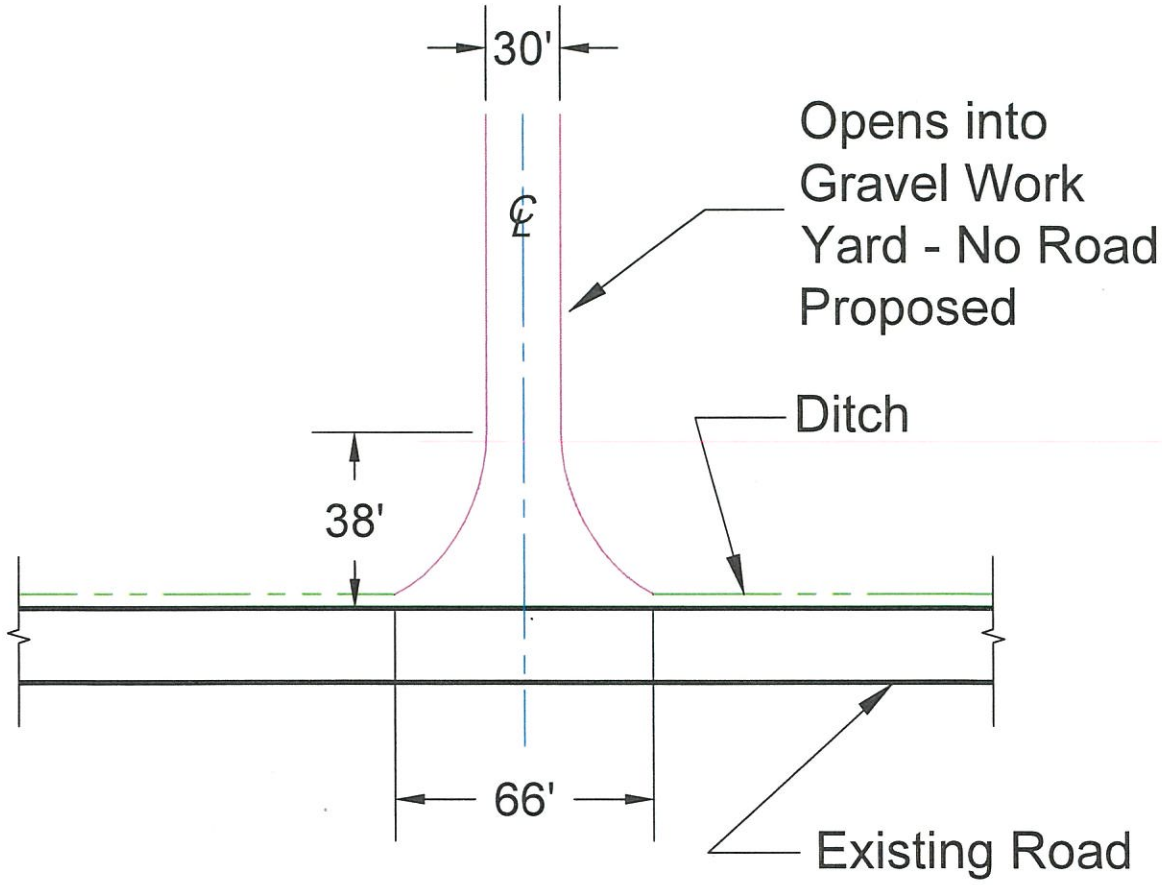
SCALE 1" = 800'

Operations Map

IBR North Bleeder Shaft

Williamson Energy, LLC

Drawn By ABG	Date 1/28/19	ILLINOIS DEPARTMENT OF NATURAL RESOURCES PERMIT NO. 375
Approved By JLP	Date 1/28/19	Operations Map
Revised:		POND CREEK MINE NO. 1
		Prepared By WILLIAMSON ENERGY, LLC. P.O. BOX 99, JOHNSTON CITY, ILLINOIS 62951
Scale AS NOTED	Project No. op map - ibr north bleeder.dwg	Rev. / Map # Map 6



For Crawford Road Entrance

Entrance Plan (Typical)

Scale-NTS

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951

Revisions						IBR North Bleeder Shaft	
No	Date	By	No.	Date	By	Drawn By:	ABG
1			6			Checked By:	JLP
2			7			Approved By:	JLP
3			8			Date:	1/28/19
4			9			Scale:	NTS
5			10			Drawing #:	ibr north bleeder shaft entrance-typical
File Location							

DOCUMENT 29

STATE OF ILLINOIS

ENVIRONMENTAL PROTECTION AGENCY

Subject: Williamson Energy, LLC – Pond Creek Mine No. 1

Data: Log No. 9082-19

Reviewed by: I. Ward **Date:** 06/10/19

Log No. 9082-19 ⇒IBR No. 78 to OMM Permit No. 375.

Log No. 9082-19

- IBR to OMM Permit No. 375 requests the addition of 1.0 acre.
- IBR area is located in Section 13, Township 8 South, Range 3 East, Williamson County.
- IBR is for a buried four-inch waterline to be installed.
- Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

* Action: Reference Log Nos. 9082-19 in CA as additional permit acreage.

9082 / 19
Issue date: 3-29-19
R06630

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Illinois Department of
Natural Resources

One Natural Resources Way Springfield, Illinois 62702-1271
www.dnr.illinois.gov

Bruce Rauner, Governor
Wayne A. Rosenthal, Director

December 22, 2017

Mr. Carson Pollastro
Williamson Energy, LLC
P.O. Box 99
Johnston City, IL 62951

RECEIVED
DEC 26 2017
IL Environmental Protection Agency
MARION REGIONAL OFFICE

Re: Permit No. 375
Insignificant Revision No. 55
Incidental Boundary Revision No. 78

Dear Mr. Pollastro:

The appropriate Department technical staff has reviewed the proposed change dated October 30, 2017, and the supplemental information dated December 11, 2017, submitted by the permittee for the Pond Creek No. 1 Mine. The permittee has requested approval to add 1.0 acre to the permitted area and utilize the areas of the previously approved incidental boundary revisions (IBRs) number 37 and 41. The 1.0-acre area will be used for installation of a four-inch underground waterline to convey mine water from the borehole in IBR No. 41 to the perimeter ditch on Permit No. 417. Also, IBR No. 37 will be utilized for horizontal boring and placement of the waterline.

Since this operation is not currently approved, it will constitute a change to the approved plan. Insignificant permit revisions (IPR's) and incidental boundary revisions (IBR's) are allowed under 62 Ill. Adm. Code Sections 1774.13(b)(2) and (d), respectively.

Section 1774.13: The Department has determined the proposed alteration will have no significant potential adverse impact on the achievement of final reclamation plans or upon the surrounding area, is in compliance with 62 Ill. Adm. Code 1700 – 1850 and is insignificant, and therefore exempts the permittee from submitting a significant permit revision application in accordance with Section 1774.13(b).

Further, the Department finds the permittee has demonstrated in its request, and field inspections by the Department's field representative have confirmed, that these areas meet the requirements for an incidental boundary revision, as outlined in 62 Ill. Adm. Code 1774.13(d). Section 1774.13(d)(6) publication requirements have been met. Section 1774.13(c) findings are below.

a. The disturbed drainage area within the total disturbed area is small; and

b. Alternate sediment control measures as described in Section 1817.45(b) are used in lieu of a siltation structure, and the permittee demonstrates that siltation structures are not necessary for drainage from the disturbed area to meet the effluent limitations and water quality standards for the receiving waters set forth in Section 1817.42

The Department has determined that the area for which a sediment pond exemption is requested meets the criteria established in Section 1817.46(e) and hereby grants an exemption from the use of a sedimentation pond for this area.

Section 1817.57(a)(1): The applicant has requested a stream buffer zone variance for an area as delineated in the application. In accordance with Section 1817.57(a)(1), the Department finds that:

a. The original stream channel and its associated riparian vegetation will be restored;

b. Surface mining activities will not cause or contribute to a violation of Section 1817.42 and will not adversely affect the water quantity and quality or other environmental resources of the stream.

Therefore, the Department authorizes surface mining activities closer than one hundred (100) feet of the top of the bank of the normal channel of the perennial or intermittent stream or through the stream.

Section 1817.97(b): Based on the 17 Ill. Adm. Code Part 1075 consultation, the Department has determined that the operations, as approved, will neither affect the continued existence of endangered or threatened species nor result in the destruction or adverse modification of their critical habitats, as determined under the Endangered Species Act of 1973 (16 USC 1531, et seq.).

FEE AND BOND

Section 1777.17(c): The total fee for this operation will be $25.00. The fee is comprised of $25.00 for non-surface mining permit area ($5/acre x 1.0 acre x the 5 years the bond is in force).

Section 1800.15(d): The bond for the area will be $5,500.00.

PERMIT CONDITIONS

1. Pursuant to 62 Ill. Adm. Code 1780.16 (b)(3)(A) and 1816.97 (b) surface disturbance activities within the IBR boundary shall only be conducted within the Chuck-Will's-

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020 Fax: 618-983-3017

Williamson Energy, LLC

Permit 375
Dwina Road Water Line

IBR # 78 and
IPR to IBR #37 and #41

October 30, 2017

R06633

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020 Fax: 618-983-3017

October 30, 2017

Mr. Scott Fowler
Illinois Department of Natural Resources
Land Reclamation Division
One Natural Resources Way.
Springfield, IL 62702

RE: IBR to Permit No. 375, Williamson Energy, LLC: **1.0-acre IBR and IPR for IBR #37 and #41 for a Dwina Road Water Line.**

Dear Mr. Fowler:

An application (2 Copies) for the above-referenced IBR is enclosed for Williamson Energy, LLC

A Cultural Resources Survey will be completed and submitted at the end of the written text.

One copy was hand delivered to Williams Gillespie at the IDNR office in Benton, IL.

Please let me know if you have any questions or need further information.

Sincerely,

James Plumley

James Plumley
Permit Coordinator—Foresight Energy, LLC

enclosure
Cc: Chris Skelton
Williams Gillespie

RECEIVED
FEB 14 2019
IL Environmental Protection Agency
MARION REGIONAL OFFICE

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020 Fax: 618-983-3017

October 30, 2017

Mr. Williams Gillespie
Illinois Department of Natural Resources
Land Reclamation Division
503 E. Main St.
Benton, Il. 62812

RE: IBR to Permit No. 375, Williamson Energy, LLC: **1.0-acre IBR and IPR for IBR 37 and 41 for a Dwina Water Line**

Dear Mr. Gillespie:

An application for the above-referenced IBR is enclosed for Williamson Energy, LLC.

A Cultural Resources Survey is included with this submittal and had been already forward to Dawn Cobb.

Please let me know if you have any questions or need further information.

Sincerely,

James Plumley
Permit Coordinator—Foresight Energy, LLC

enclosure
Cc: Chris Skelton

State of Illinois Department of
Natural Resources Office of
Mines and Minerals Land
Reclamation Division
One Natural Resources Way
Springfield, IL 62702-1271

APPLICATION FOR SURFACE COAL MINING AND RECLAMATION OPERATIONS
INCIDENTAL BOUNDARY REVISION IBR-1

PART I DATE: **October 30, 2017**

NOTICE: This state agency is requesting disclosure of information that is necessary to accomplish the statutory purpose as outlined under Ill. Rev. Stat. 1987 Ch. 96 1/2, par. 7901.01 et seq. Disclosure of this information is voluntary, however failure to comply may result in this form not being processed. This form has been approved by the Forms Management Center.

1) A) General Information
(I)(We)(The) **Williamson Energy, LLC**
(Name of Company, Corporation, Partnership or Individual)

PO Box 99 Johnston City, IL 62951 **618-983-3020**
(Address) (Telephone Number)

hereby submit application for an Incidental Boundary Revision to Permit 375

Name of Mine **Pond Creek Mine No. 1, LLC**.

MSHA No. **11-03141**

I, Mark Schuerger under penalty
(Vice President or his duly authorized representative under the existing permit)

of perjury declare that all information provided in this application is true and correct to the best of my knowledge.

Mark Schuerger
Authorized Person

ADDITIONAL ACRES REQUESTED **1.0** EXISTING PERMIT ACREAGE **742.1**

(I) (We) **Mark Schuerger**
(Individual or Individuals)

under penalty of perjury declare on behalf of the applicant, Williamson Energy, LLC, that said applicant has valid documents which bestow upon the applicant a legal right to enter and commence surface coal mining and reclamation operations upon lands contained in the proposed IBR area, and such legal right is not in any way the subject of pending court litigation.

Dated this 30th day of October, 2017.

Signature / Authorized Person

ENGINEERING CEERTIFICATION

I hereby certify the engineering design used in preparation of this application, attachments, and supplements was done by me or under my direct supervision.

I further certify to the best of my knowledge all such design is in accordance with all applicable local, state and federal laws, rules and regulations. I have placed an "X" in the box below if that item is relevant.

N/A	Whereas the Reclamation Plan calls for an alternative land use, I also certify the plans to conform to applicable accepted standards for adequate land stability, drainage, vegetative cover, and aesthetic design appropriate for the post-mining use of the site.
N/A	Whereas the operation proposes disposal of spoil or waste materials in areas other than mining workings or excavations, I also certify such fills are designed in accordance with recognized professional standards and all applicable laws.
N/A	Certification of Illinois Environmental Protection Agency-35 Ill. Adm. Code 405.104(a) Permit. In my professional judgment, the plans and specifications submitted as part of this application describe an operation which will meet all applicable effluent and water quality standards. I certify that I am familiar with all of the plans, specifications, reports, and maps submitted as part of this application and that said plans, etc. are accurate insofar as they represent existing conditions.

James Plumley
Name

067610
Illinois Registration Number (Seal)

Foresight Energy, LLC
Firm

618-983-3020
Phone Number

16824 Liberty School Road, Marion, IL 62959
Address

JAMES L. PLUMLEY 067610 LICENSED PROFESSIONAL ENGINEER STATE OF ILLINOIS

James Plumley
Signature

October 30, 2017
Date

B) Indicate the type of disturbance and associated acreage.

Type of Disturbance	Existing	Permit IBR	Total
Area Stripping	20.1	0.0	20.1
Mine Waste Areas	277.4	0.0	277.4
Processing Areas & Support Facilities	4.7	1.0	5.7
Access, Haul Roads & Transport Facilities	181.2	0.0	181.2
Soil Storage Areas	28.9	0.0	28.9
Diversions	87.5	0.0	87.5
Coal Recovery (Gob & Slurry)	32.8	0.0	32.8
Other (shaft site/fan pad, etc.)	50.8	0.0	50.8
Not to be Disturbed	38.8	0.0	38.8
Total	722.2	1.0	723.2

2) A) Provide name and address of every legal or equitable owner of record of the IBR area.

RESPONSE: **The IBR surface area is owned by:**
Williamson County Highway Department, 1817 North Court St., Marion, IL 62959

B) Provide name and address of the owner of record for all surface and subsurface areas contiguous to any part of the proposed IBR area.

RESPONSE: **Please see the Surface Ownership Map (Map 2) and the corresponding Property Rights Summary sheet at the end of this Part I of the application.**

C) Show location of owners of record of those lands, both surface and subsurface, included in or contiguous to the IBR area on premining land use map or another map, if necessary.

RESPONSE: **See Surface Ownership Map (Map 2) in map section and corresponding Property Rights Summary sheet at the end of this Part I of the application.**

3) Provide name and address of any holder of record of leasehold interest for the IBR area.

RESPONSE: **Williamson Energy, LLC (applicant) has leasehold interest in the surface and coal.**

4) Affidavits, Certifications

A) Complete affidavit regarding applicant's legal right to enter and begin surface coal mining and reclamation operations in the IBR area and whether that right is the subject of pending litigation. Identify the documents upon which affidavit is based by type and date of execution and identify specific lands to which each document pertains and explain the legal rights claimed by the applicant (1778.15(a)). If the private mineral estate to be mined has been severed from the private surface estate, provide copies of the documents required under Section 1778.15(B)(1)-(3). On the permit map or other designated map show the boundaries of land within the permit area upon which the applicant has the legal right to enter and begin surface mining activities.

B) Complete certification for engineering aspects of the application. In addition to the general certification, three specific certifications are included which are applicable only if the box in front of each is marked. The first two cover special permit requirements and should be marked only when they occur for the proposed permit. The third certification covers the Illinois Environmental Protection Agency permit requirements. In most cases, an Illinois registered engineer will be required to certify IEPA permit requirements. Except as otherwise provided all maps, plans and cross-sections included in the permit application shall be prepared by, or under the direction of, and sealed by a qualified registered professional engineer licensed under the Illinois Professional Engineering Act, a qualified registered structural engineer licensed under the Illinois Structural Engineering Act or if authorized by state law, a qualified registered professional land surveyor licensed under the Illinois Land Surveyors Act with assistance from experts in related fields.

RESPONSE: **The Affidavit at the end of this Part.**

5) Areas Designated Unsuitable for Mining

A) Does proposed IBR area include -

(1) Lands within boundaries of the National Park System, National Wildlife Refuge System, National Recreation Areas, etc. [Section 1761.11(a)]?

Yes ____ No **X**

(2) National forest land?

Yes ____ No **X**

(3) Any land which will adversely affect any publicly-owned park or places included in or eligible for listing in the National Register of Historic places, etc. [per 62 Ill. Adm. Code 1761.11(a)(3) or Section 10, (B)(C) of the SCM-1?
Yes ____ No **X**

If yes, complete Part II, Section 10, (B) & (C) of the SCM-1 or theUCM-1

Application.

(4) Any public roads which are to be removed, relocated or temporarily closed?

Yes ____ No __X__

Indicate on the pre-mining land use map or other designated map the location of the public roads and attach a copy of the written agreement from the appropriate authority authorizing the relocation, removal or temporary closure.

Describe the measures to be used to insure that the interest of the public and land owners affected will be protected.

B) Will proposed IBR area be located --

(1) Within 100 feet of the right-of-way line of any public road?

Yes __X__ No _____

If yes, explain proposed procedure for complying with regulation section 1761.11(d), including request for variance, if relevant. Provide location of public roads on pre-mining land use map or other designated map. Describe the measures to be used to insure that the interest of the public and land owners affected will be protected.

RESPONSE: **The new four inch waterline will parallel Dwina road for ~4,000 feet (Dwina Road Please see Operation PLAN Map. (Map 5 S.F.)) Williamson Energy, LLC has a written agreement with Williamson County Highway department to ensure the interest of the public is protected. Per our agreement, Williamson Energy will ensure one-way traffic be maintained during the period of construction and adequate protections for safety of the public be provided. All work shall be constructed to satisfaction of the county engineer. All work performed so as not to permanently impair the existing road, and that any damage to the said road that might be done during the time of construction shall be repaired to the satisfaction of the County Engineer.**

(2) Within 300 feet measured horizontally from any occupied dwelling?

Yes __X__ No ___

If so, is waiver provided meeting requirements of Section 1761.15?

RESPONSE: **IBR will be within 300 feet of an occupied dwelling. See attached 300 feet waivers.**

(3) Within 300 feet measured horizontally of any public building, school, church, community or institutional building or public park?

Yes ____ No X

(4) Within 100 feet measured horizontally of a cemetery?

Yes____ No X

C) Are valid existing rights (per 1761.11) claimed for any part of the IBR area?

Yes ____ No X

If yes, provide documentation to substantiate claim.

D) Provide a draft copy of the proposed newspaper notice and name of local newspaper of general circulation in which advertisement of the application will be published, per 62 Ill. Adm. Code 1774.13(d)(6). Certification of publication is to be furnished to the Department and must be received prior to Department approval of the IBR.

RESPONSE: **A draft copy of the Public Notice is at the end of this Part I of the application. It will be published in the Marion, Illinois Daily Republican newspaper.**

PUBLIC NOTICE

Pursuant to the Surface Coal Mining Land Conservation and Reclamation Act (PA-81-1015, as amended) and the Rules and Regulations of the Act, Williamson Energy, LLC, P. O. Box 99, Johnston City, IL 62951, hereby gives notice that a request for a 1.0-acre Incidental Boundary Revision (IBR) was submitted to the Illinois Department of Natural Resources, Office of Mines and Minerals, Land Reclamation Division under the provisions of Section 1774.13 (d) (2 to install a four inch HDPE waterline inside the Dwina Road ROW at one location the four inch HDPE waterline will be bored underneath Dwina Road.

The Proposed Permit Area is described as: Part of the E/2 of Section 13 of Township 8S, R3E of the 3rd Principal and Part of W/2, NW/4 of Section 18 and Part of SW/4, SW/4 of Section 7 Township 8S, R4E of the 3rd Principal Meridian, Williamson County, IL.

The physical location is on Dwina Road and approximately 2060 feet north of the Corinth Road intersection in Williamson County, Illinois.

Approval is also requested to operate within 100 feet of the outside right-of-way of public roads which are located as follows: Dwina Road along East side of Section 13 of Township 8S, R3E of the 3rd Principal and Part of W/2, NW/4 of Section 18 and Part of SW/4, SW/4 of Section 7 Township 8S, R4E.

Activities to be conducted within 100 feet of the outside right-of-way of public roads can include but not be limited to construction/installation of a waterline.

Copies of the application are on file for inspection at the following office, and written comments may be addressed to: Illinois Department of Natural Resources, Office of Mines & Minerals, Land Reclamation Div., One Natural Resources Way, Springfield, IL 62702-1271.

The closing date of the comment period for this IBR is fourteen (14) days from the date of this Public Notice.

R06643

Tract 13
04-07-300-007
No Structure

Tract 12
04-07-300-004
No Structure

A080407-304

Tract 11
04-07-300-005
No Structure

A080407-305

Tract 10
03-13-200-002
Structure
1
A080313-202

Tract 9
03-13-200-003
No Structure
A080313-203

A080313-204

Tract 8
03-13-200-004
No Structure

Tract 7
03-13-200-006
Structure
1
A080313-206

Tract 6
03-13-200-007
Structure
4
1
A080313-207

A080313-210

Tract 5
03-13-200-008
Structure
1
A080313-208

Tract 3
03-13-200-009
No Structure
A080313-209

A080313-211

A080313-426

A080313-402
5

Tract 2
03-13-400-002
Structure
1

A080313-427

A080313-429

A080313-417

Tract 1
03-13-400-017
No Structure

A080313-425

A080313-423

A080313-416

A080313-403

A080418-101

Tract 4
04-18-100-001
No Structure

A080418-102

1
A080418-301
4
5

Williamson County
Road ROW

A080418-317

A080418-307
1
A080418-307
3

A080418-302

N
W
E
S

400' 0' 400' 800'
SCALE 1" = 400'

Description

The Proposed Permit Area is described as: Part of the E/2 of Section 13 of Township 8S, R3E of the 3rd Principal and Part of W/2, NW/4 of Section 18 and Part of SW/4, SW/4 of Section 7 Township 8S, R4E of the 3rd Principal Meridian, Williamson County, IL, containing approximately 1.0 acres

Proposed Surface Permit Area

Existing Surface Permit Area
Public Road

300.014,
12-36-300-002
Tract Information Including PIN #

Surface Ownership Map

Dwina Water Line

Williamson Energy, LLC

Drawn By JLP	Date 9/5/17	ILLINOIS DEPARTMENT OF NATURAL RESOURCES PERMIT NO. 375
Approved By JLP	Date 9/5/17	Surface Ownership Map
Revised:		POND CREEK MINE NO. 1
		Prepared By WILLIAMSON ENERGY, LLC. P.O. BOX 99, JOHNSTON CITY, ILLINOIS 62951
Scale AS NOTED	Project No.	Rev. / Map # Map 2

PROPERTY RIGHTS SUMMARY

For: Williamson Energy– Dwina Water Line

SURFACE OWNERSHIP OF PROPOSED PERMIT AREA

Williamson County Highway Rite of Way Marion, IL 62959

CONTIGUOUS SURFACE OWNERSHIP / CONTROL

New River Royalty, LLC	A080313-417	PO Box 609, Benton, IL 62812
New River Royalty, LLC	A080313-403	PO Box 609, Benton, IL 62812
New River Royalty, LLC	A080313-402	PO Box 609, Benton, IL 62812
New River Royalty, LLC	A080313-209	PO Box 609, Benton, IL 62812
New River Royalty, LLC	A080313-208	PO Box 609, Benton, IL 62812
New River Royalty, LLC	A080313-207	PO Box 609, Benton, IL 62812
New River Royalty, LLC	A080313-206	PO Box 609, Benton, IL 62812
New River Royalty, LLC	A080313-204	PO Box 609, Benton, IL 62812
New River Royalty, LLC	A080313-203	PO Box 609, Benton, IL 62812
Colt, LLC	A080313-202	PO Box 609, Benton, IL 62812
Williamson Energy, LLC	A080312-404	PO Box 99, Johnston City, IL 62951
Williamson Energy, LLC	A080407-306	PO Box 99, Johnston City, IL 62951
New River Royalty, LLC	A080407-302	PO Box 609, Benton, IL 62812
New River Royalty, LLC	A080407-304	PO Box 609, Benton, IL 62812
New River Royalty, LLC	A080407-307	PO Box 609, Benton, IL 62812
New River Royalty, LLC	A080407-305	PO Box 609, Benton, IL 62812
New River Royalty, LLC	A080418-101	PO Box 609, Benton, IL 62812
Allan D & Terri L Thompson	A080418-301	15862 Dwina Rd, Marion IL 62959
Allan D & Terri L Thompson	A080419-317	PO Box 332, Energy, IL 62933

SUB-SURFACE OWNERSHIP WITHIN PROPOSED PERMIT AREA

WPP, LLC leased to Williamson Energy, LLC, with an address at 3801 PGA Blvd. Suite 903, Palm Beach Gardens, Florida 33410

NOTE: Applicant has leasehold interest to the coal under the proposed permit area.

SUB-SURFACE OWNERSHIP CONTIGUOUS TO PROPOSED PERMIT AREA

WPP, LLC leased to Williamson Energy, LLC, with an address at 3801 PGA Blvd. Suite 903, Palm Beach Gardens, Florida 33410

RIGHTS CLAIMED BY APPLICANT:

The right to conduct mining and reclamation operations within the approved and proposed areas of coal mining. See Mining Affidavit in PART I.

SURFACE WAIVER AND CONSENT

Prepared by:
Williamson Energy, LLC
P. O. Box 99
Johnston City, IL 62951

SURFACE WAIVER AND CONSENT

This surface waiver and consent (herein this "Waiver and Consent") is made this 10th day of August, 2017, from NEW RIVER ROYALTY, LLC, a Delaware Limited Liability Company, authorized to conduct business in the State of Illinois, with and address of 402 N Main Street, Benton, Illinois 62812, (herein the "Grantor"), in favor of Williamson Energy, LLC with and address at P.O. Box 99, Johnston City, Illinois 62951, (herein the "Grantee").

WHEREAS, Grantee desires to install a water line within the existing Dwina Road right-of-way pursuant to the Williamson County Highway Department Permit issued July 31, 2017, and attached hereto as Exhibit A.

WHEREAS, the Grantor is the owner of occupied dwellings located upon the following described real property (herein the "Dwellings"):

New River Royalty, LLC's deed source of title:

Tract 1: S/2 NE/4 NE/4, 13-8-3
Book/Page: 330/922
Tax Parcel No.: 03-13-400-017

Tract 2: N/2 NE/4 NE/4, 13-8-3
Book/Page: 330/922
Tax Parcel No.: 03-13-400-002

Tract 3: S/2 SE/4 SE/4, 13-8-3
Book/Page: 486/889
Tax Parcel No.: 03-13-200-009

Tract 4: W/2, 18-8-4
Book/Page: 486/966
Tax Parcel No.: 04-18-100-001

Tract 5: N/2 SE/4 SE/4, 13-8-3
Book/Page: 487/722
Tax Parcel No.: 03-13-200-008

Tract 6: S/2 NE/4 SE/4, 13-8-3
Book/Page: 487/111
Tax Parcel No.: 03-13-200-007

Tract 7: N/2 NE/4 SE/4, 13-8-3
Book/Page: 330/922
Tax Parcel No.: 03-13-200-006

Tract 8: S part NE/4 except NE/4, 13-8-3
Book/Page: 486/966
Tax Parcel No.: 03-13-200-004

Tract 9: S 5A of N 10A of E/2 NE/4, 13-8-3
Book/Page: 486/967
Tax Parcel No.: 03-13-200-003

Tract 10: E 5A of N 10A of NE/4, 13-8-3
Book/Page: 489/441
Tax Parcel No.: 03-13-200-002

Tract 11: S/2 S/2 SW/4, 7-8-4
Book/Page: 330/922
Tax Parcel No.: 04-07-300-005

Tract 12: N/2 S/2 SW/4, 7-8-4
Book/Page: 330-922
Tax Parcel No.: 04-07-300-004

WHEREAS, Grantee owner or leases the coal rights as to the real property corresponding to the Dwellings and will be conducting surface coal mining operations with respect to the coal rights; and,

WHEREAS, the surface coal mining operations of Grantee will be conducted within 300 feet, measured horizontally, of the Dwellings; and,

WHEREAS, Grantor and Grantee acknowledge that Grantor, as owner of the Dwellings, has the legal right to deny surface coal mining operations within said 300 feet; and,

WHEREAS, notwithstanding Grantor's legal right to deny mining, Grantor desires to waive this right and consent to surface coal mining operations, consisting only of the installation of a single four-inch water pipeline within the existing Dwina Road Williamson County Right of Way, within 300 feet, measured horizontally, of the Dwellings; and,

WHEREAS, Grantor desires to execute this Waiver and Consent waiving said right and consenting to said operations.

NOW, THEREFORE, for and in consideration of the foregoing recitals, the mutual benefits to be derived therefrom, and Two Thousand Five Hundred Dollars ($2,500.00) and other valuable consideration, Grantor agrees, waives, and consents as

follows:

1. Waives the right to deny Grantee the right to conduct surface coal mining operations, consisting only of the installation of a single four-inch water pipeline within the existing Dwina Road Williamson County Right of Way, within 300 feet, measured horizontally, of the Dwellings.

2. Consents to the conducting of surface coal mining operations, consisting only of the installation of a single four-inch water pipeline within the existing Dwina Road Williamson County Right of Way, by Grantee closer than 300 feet, measured horizontally, of the Dwellings.

3. Waives and consents as set forth in paragraphs 1 and 2 above knowing that as the owner of the Dwellings, Grantor has the right to deny such surface coal mining operations.

4. Consents to the recording of this Waiver and Consent in the County Clerk and Recorder's Office in the county where the Dwellings are located.

5. Waives all rights under and by virtue of the homestead exemption laws of the State of Illinois.

6. Agrees that this Waiver and Consent shall be binding upon and inure to the benefit of the Grantor and Grantee together with their successors and assigns.

7. Agrees that this Waiver and Consent is executed pursuant to 62 Ill.Adm. Code 1761.15(b).

DATED the day and year above written.

GRANTOR

NEW RIVER ROYALTY, LLC

By: Robert Keith Varney

Its: Vice President

STATE OF ~~ILLINOIS~~ Florida)
) SS.
COUNTY OF Palm Beach)

I, the undersigned Notary Public, in and for said County in the State aforesaid, do hereby certify that Robert Keith Varney its Vice President personally known to me to be a duly authorized person for NEW RIVER ROYALTY, LLC, a Delaware Limited Liability Company, and personally known to me to be the same person whose name is subscribed to the foregoing instrument, appeared before me this day in person, and acknowledged that he signed, sealed and delivered the said instrument as such authorized person pursuant authority given by the Members of said limited liability company, as their free and voluntary act, and as the free and voluntary act and deed of said Company, for the uses and purposes therein set forth.

Given under my hand and seal this 10th day of August, 2017.

Samantha Lea Wright
Notary Public

Seal:

SAMANTHA LEA WRIGHT
MY COMMISSION # FF983995
EXPIRES August 06, 2020
(407) 398-0153 FloridaNotaryService.com

GREGORY S. SMOTHERS
COUNTY ENGINEER

SCOTT BARGER
DESIGN ENGINEER

YVONNE RICHERT
OFFICE MANAGER

WILLIAMSON COUNTY
HIGHWAY DEPARTMENT
MARION, ILLINOIS 62959

1817 NORTH COURT ST.
MARION, ILLINOIS 62959

TELEPHONE 618-998-2145

EXHIBIT "A" to Surface Waiver and Consent

PERMIT REQUEST TO INSTALL WATER LINE

WHEREAS, **Williamson Energy, LLC**, Williamson County, Illinois, has requested permission to construct a water line under a road in Williamson County which is subject to the jurisdiction and authority of said County and its officers.

WHEREAS, the proposed construction consists of 4000 feet of 4" HDPE waterline to be installed along and under **Dwina Road (TR 544), in Section 13, T8S, R3E, and Sections 7 & 18, T8S, R4E of the 3rd P.M.** in Williamson County.

THEREFORE, be it permitted and granted by the County Engineer of Williamson County, Illinois, that permission be granted to proceed with said construction, subject to the following conditions:

1. That the petitioner shall furnish all materials, do all work and pay all costs of such work.

2. That one-way traffic be maintained during the period of construction and adequate protection for the safety of the public be provided.

3. That the petitioner or his assigns shall assume all risks and liability for accidents and damages that may occur to persons or property on account of said work.

4. That this permit is effective insofar only as the County has jurisdiction and does not presume to release the petitioner from compliance with the provisions of any existing statute relative to the work involved.

5. That the said work shall be constructed to the satisfaction of the County Engineer.

6. That the work shall be performed so as not to permanently impair the existing road, and that any damage to the said road that might be done during the time of construction shall be repaired to the satisfaction of the County Engineer.

7. That the waterline shall be a minimum of three (3) feet below the present grade of the road where the waterline crosses the roadway or two feet below the existing ground line if located outside of the roadbed but within the R.O.W. The said water line shall be placed in the back slope of the ditch.

8. That the waterline shall be relocated at no expense to the County if such a move is needed for maintenance or construction work on the road at any time in the future.

9. Open cutting of the road surface will not be allowed. Directional boring will be required.

PERMIT REQUESTED BY _____

IN WITNESS WHEREOF, I have hereunto set my hand and seal as the County Engineer of Williamson County, Illinois, this 31ST day of JULY, 2017

Gregory S. Smothers
County Engineer
Williamson County Highway Dept.

PART II PREMINING INFORMATION

Premining information is to be displayed on premining land use map unless otherwise indicated.

1) Describe how the IBR area perimeter will be marked and discuss the method or system employed to locate permit area perimeter and set markers along it. Designate a reference point outside the IBR area if different than the original permit. Provide a description of the reference point and a sketch relating the reference point to the IBR area perimeter.

   RESPONSE: **The permit boundary will be marked at each end of the waterline with permit sign. The waterline will be installed in the back slope of the road ditch. No markers will be place along the proposed route due to routine maintenance of the Right of Way by the Williamson County Highway Department. For permit reference point, the physical location is approx. 2070 feet north of the intersection of Dwina Road and Cornith Road in Williamson County, Illinois. This reference point is noted on the General Location Map.**

2) Explain and locate areas where the IBR is contiguous to an existing permit.

   RESPONSE: **Please see the General Location Map and the other maps included with this application.**

2) Post Mining Land Use

A) Provide a detailed description of proposed post-mining land uses and capabilities employing land use and capability categories listed below. Provide acreage figures for each post-mining land use proposed for the existing permit, the IBR area and total permit after inclusion of the IBR acreage and designate the post-mining land uses on the Post Mining Land Use Map. Acreage figures for post-mining land use must differentiate between mined and surface disturbance areas based on the mining line used in the premining section of the application.

	Existing Permit (ac)			IBR (ac)			Total Permit (ac)		
Land Use	Prime	Hcap	NCrop	Prime	Hcap	NCrop	Prime	Hcap	NCrop
Cropland	13.0	8.7	2.5				13.0	8.7	2.5
Pasture Land	0.0	0.8	5.5				0.0	0.8	5.5
Grazing Land	0.0	0.0	0.0				0.0	0.0	0.0
Forestry	0.0	0.0	14.3				0.0	0.0	14.3
Residential	0.0	0.0	1.5			0.1	0.0	0.0	1.6
Industrial/Commercial	0.3	0.0	0.0				0.3	0.0	0.0
Recreation	0.0	0.0	0.0				0.0	0.0	0.0
Fish & Wildlife Habitat (Herbaceous)	5.5	22.8	46.0		0.5 *	0.4 *	5.5	23.3	46.4
Fish & Wildlife Habitat (Woody)	0.0	0.8	571.8				0.0	0.8	571.8
Fish & Wildlife Habitat (Wetland)	0.0	0.0	0.2				0.0	0.0	0.2
Fish & Wildlife Habitat (Water)	0.0	0.0	9.2				0.0	0.0	9.2
Developed Water Resources	0.0	0.0	19.3				0.0	0.0	19.3
Undeveloped Land	0.0	0.0	0.0				0.0	0.0	0.0
Total	18.8	33.1	670.3	0.0	0.5	0.5	18.8	33.6	670.8

Prime: Prime farmland

HCap: High Capability - meeting productivity requirements of 62 Ill. Adm. Code 1825.

NonCrop: Non-Cropland - All soils which do not qualify as prime farmland or high capability

* = "Negative Determination" Acres

4) Soils Information Map

A) Does the submitted soils map represent a map developed by the National Resources Conservation Service (NRCS)?

Yes X No ___. If no, explain.

B) Delineate on the soils map(s) the area which will incur actual mining (removal of overburden and/or deposition of overburden for the extraction of coal).

RESPONSE: **No mining will be conducted on this site.**

C) Are any of the identified map units correlated as prime farmland by NRCS criteria?

Yes X No ____

If yes, explain and provide documentation to meet the requirements of Section 1785.17, if a determination for grandfathering and/or negative determination is sought. If prime farmlands exist which will not meet the exemption criteria described above, the approved prime farmlands restoration plan must be followed.

RESPONSE: **None of the prime farmland units identified by the NRCS are currently in crop projection therefore, were a negative determination on these acres.**

D) Submit, by completing soils information chart, acreage totals of each map unit (soil type and slope classification) and land use capability classes in the IBR area and the percent slope range of each lettered slope classification used on the soil map.

RESPONSE: **See Soils Information Chart at the end of this Part II.**

E) Provide, by completing soil information chart, acreage for each of the map units of high capability land (including grandfathered and negatively determined prime farmland) and non-cropland capability land with respect to areas which will be mined and areas which will incur other forms of disturbance (i.e., roads, ditches, etc.). Identify and provide map unit acreage values, if any, for areas which will not be disturbed.

RESPONSE: **See Soils Information Chart at the end of this Part along with Soils Map.**

F) Are selected overburden materials proposed to be used in lieu of or as a supplement to the A-horizon?

Yes ____ No X If yes, provide the appropriate information required under 1780.18(b)(4)/1784.13(b)(4).

Williamson Energy, LLC Dwina Road Waterline

SOIL INFORMATION CHART

					Actual Surface Mining Areas (Acres)					Support Areas					
					Prime Farmlands Soils			High Cap. Soils	Other	Prime Farmlands Soils			High Cap. Soils	Other	Total
Soil Type	Names	Slope Class	Land Use Cap.	Productivity Index Circular 1156	Prime Soils	Neg Determ.	Grand-Fathered			Prime Soils	Neg. Determ.	Grand-Fathered			
10D	Plumfield silty clay loam	10 to 18%	6e	71										0.1	0.1
13B2	Bluford silt loam	2 to 5%	2e	82							0.0				0.0
14C2	Ava silt loam	5 to 10%	3e	90									0.1		0.1
301B	Grantsburg silt loam	2 to 5%	2e	95							0.5				0.5
340D2	Zanesville silt loam	10 to 18%	4e	76										0.1	0.1
340D3	Zanesville silt loam	10 to 18%	6e	76										0.2	0.2
															0.0
															0.0
															0.0
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															0.0
															0.0
															0.0
															0.0
	Total				0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.1	0.4	1.0

R06655

United States Department of Agriculture

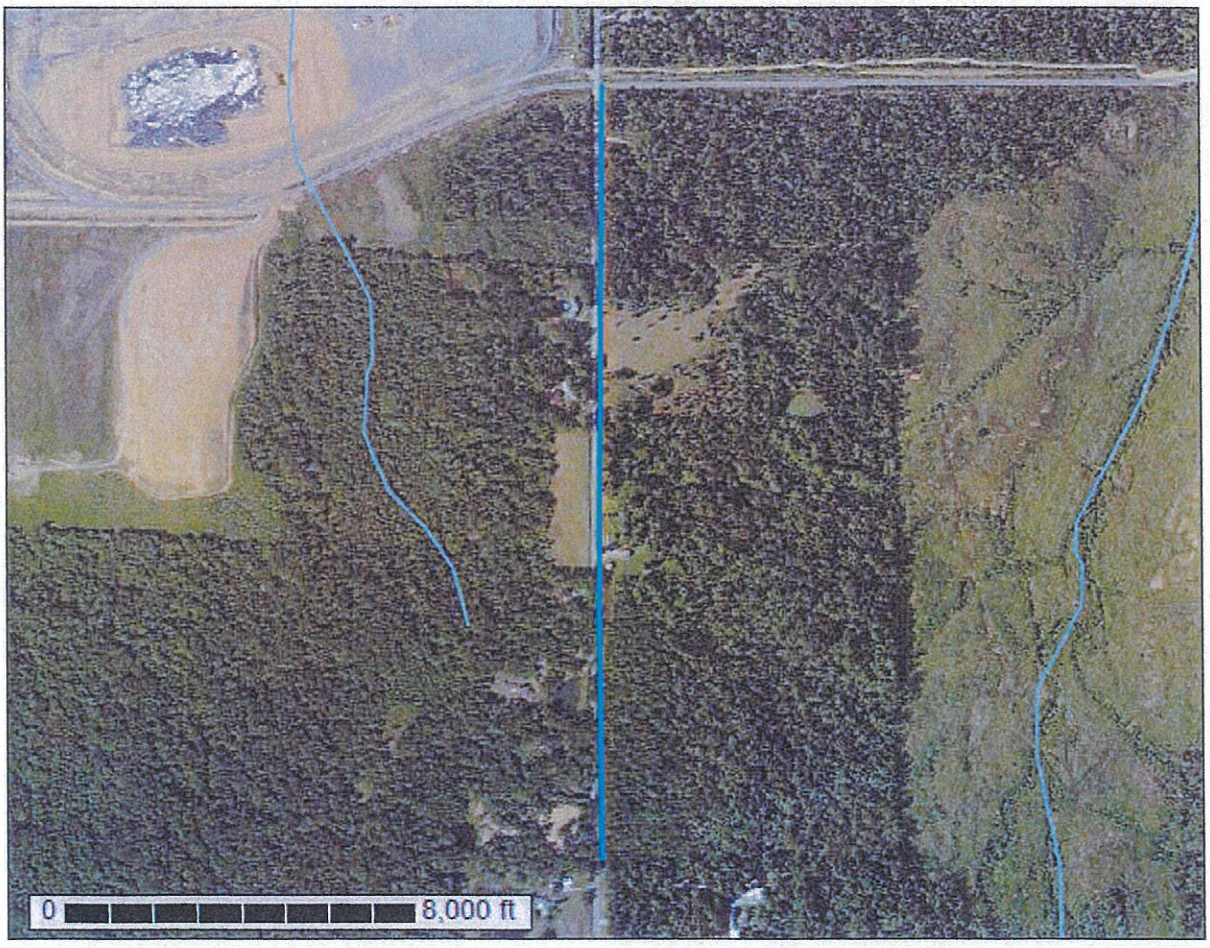
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Williamson County, Illinois

Soil Dwina Waterline 1



August 1, 2017

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

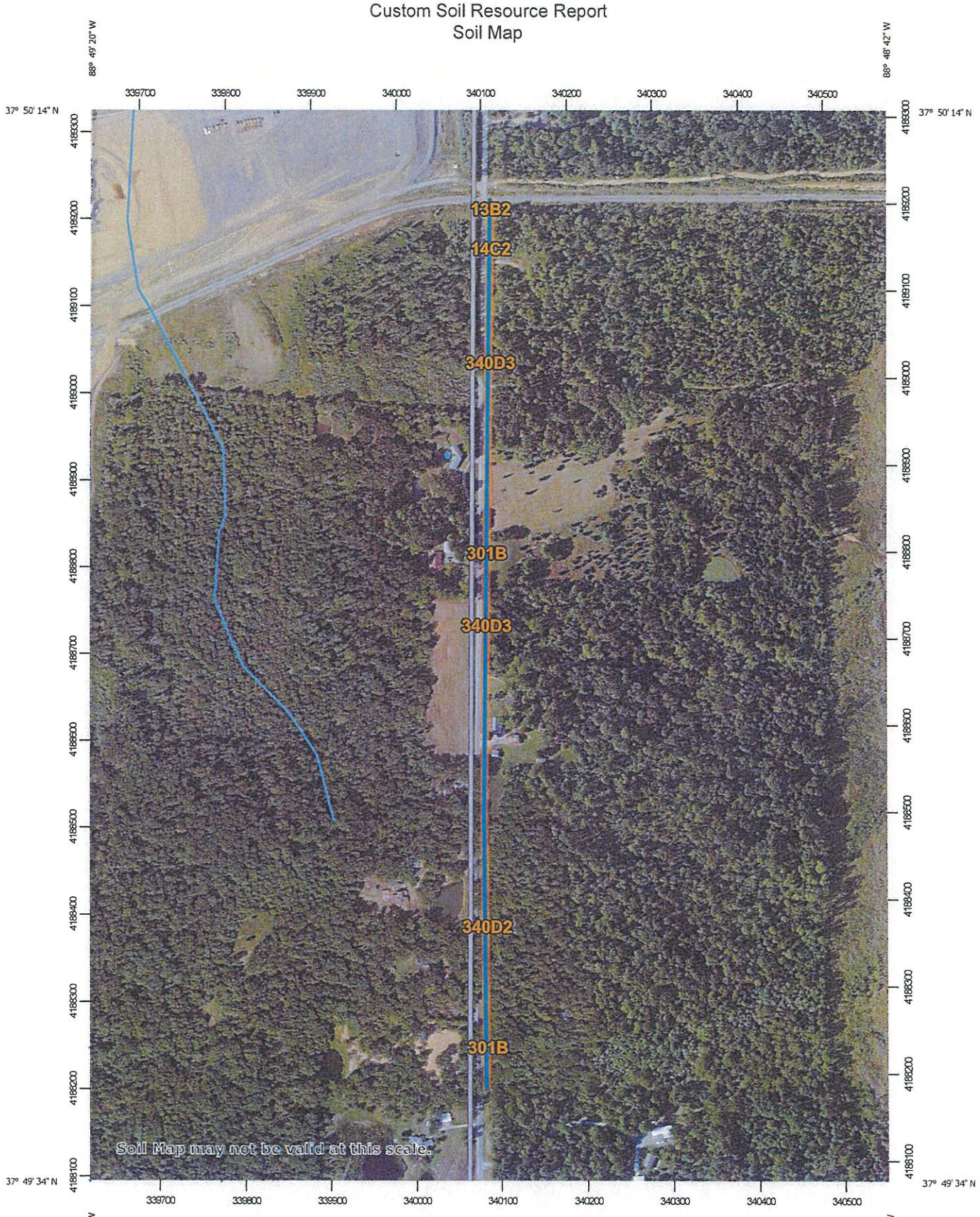
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:6,000 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 50 100 200 300

Feet: 0 250 500 1000 1500

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Williamson County, Illinois
Survey Area Data: Version 11, Sep 16, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 13, 2011—Oct 21, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

R06665

Map Unit Legend

Williamson County, Illinois (IL199)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
13B2	Bluford silt loam, 2 to 5 percent slopes, eroded	0.0	2.2%
14C2	Ava silt loam, 5 to 10 percent slopes, eroded	0.1	6.9%
301B	Grantsburg silt loam, 2 to 5 percent slopes	0.4	52.4%
340D2	Zanesville silt loam, 10 to 18 percent slopes, eroded	0.1	17.1%
340D3	Zanesville silty clay loam, 10 to 18 percent slopes, severely eroded	0.2	21.4%
Totals for Area of Interest		0.8	100.0%

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it

was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Williamson County, Illinois

13B2—Bluford silt loam, 2 to 5 percent slopes, eroded

Map Unit Setting

National map unit symbol: 2t95f
Elevation: 360 to 840 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 53 to 58 degrees F
Frost-free period: 175 to 195 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Bluford and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bluford

Setting

Landform: Ground moraines
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loess over mixed loess and drift

Typical profile

Ap - 0 to 6 inches: silt loam
E - 6.to 9 inches: silt loam
Btg - 9 to 32 inches: silty clay
2Btgx - 32 to 47 inches: silty clay loam
2Btg - 47 to 60 inches: silty clay loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: 5 to 20 inches to abrupt textural change; 19 to 45 inches to fragipan
Natural drainage class: Somewhat poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 6 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 13.0
Available water storage in profile: Very low (about 2.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C/D
Hydric soil rating: No

Minor Components

Ava

Percent of map unit: 5 percent
Landform: Ridges
Landform position (two-dimensional): Shoulder, summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Wynoose

Percent of map unit: 5 percent
Landform: Ground moraines
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

14C2—Ava silt loam, 5 to 10 percent slopes, eroded

Map Unit Setting

National map unit symbol: 2t95l
Elevation: 360 to 840 feet
Mean annual precipitation: 38 to 46 inches
Mean annual air temperature: 54 to 58 degrees F
Frost-free period: 180 to 195 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Ava, eroded, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ava, Eroded

Setting

Landform: Ridges, hillslopes
Landform position (two-dimensional): Shoulder, summit, backslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Convex
Across-slope shape: Convex, linear
Parent material: Loess over mixed loess and drift over till

Typical profile

Ap - 0 to 9 inches: silt loam
Bt and E - 9 to 28 inches: silty clay loam
Btx - 28 to 36 inches: silty clay loam
2Btx - 36 to 64 inches: silt loam

3Btb - 64 to 78 inches: silt loam

Properties and qualities

Slope: 5 to 10 percent
Depth to restrictive feature: 25 to 40 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.01 to 0.06 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 5.0
Available water storage in profile: Low (about 5.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Bluford, eroded

Percent of map unit: 10 percent
Landform: Ground moraines
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

301B—Grantsburg silt loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: 1lm2y
Elevation: 360 to 660 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 175 to 195 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Grantsburg and similar soils: 90 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Grantsburg

Setting

Landform: Loess hills
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Peoria and roxana loess over residuum

Typical profile

H1 - 0 to 11 inches: silt loam
H2 - 11 to 24 inches: silt loam
H3 - 24 to 38 inches: silty clay loam
H4 - 38 to 61 inches: silt loam
H5 - 61 to 80 inches: silt loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: 24 to 40 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.01 to 0.06 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Sodium adsorption ratio, maximum in profile: 4.0
Available water storage in profile: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Hydric soil rating: No

340D2—Zanesville silt loam, 10 to 18 percent slopes, eroded

Map Unit Setting

National map unit symbol: 1lm5w
Elevation: 360 to 660 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 175 to 195 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Zanesville, eroded, and similar soils: 90 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Zanesville, Eroded

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess over residuum

Typical profile

H1 - 0 to 4 inches: silt loam
H2 - 4 to 19 inches: silty clay loam
H3 - 19 to 39 inches: silt loam
H4 - 39 to 57 inches: channery silt loam
R - 57 to 67 inches: bedrock

Properties and qualities

Slope: 10 to 18 percent
Depth to restrictive feature: 19 to 32 inches to fragipan; 40 to 80 inches to lithic bedrock; 40 to 80 inches to paralithic bedrock
Natural drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.01 to 0.06 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Sodium adsorption ratio, maximum in profile: 4.0
Available water storage in profile: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Hydric soil rating: No

340D3—Zanesville silty clay loam, 10 to 18 percent slopes, severely eroded

Map Unit Setting

National map unit symbol: 1lm34
Elevation: 360 to 660 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 175 to 195 days
Farmland classification: Not prime farmland

Map Unit Composition

Zanesville, severely eroded, and similar soils: 90 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Zanesville, Eroded

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess over residuum

Typical profile

H1 - 0 to 4 inches: silt loam
H2 - 4 to 19 inches: silty clay loam
H3 - 19 to 39 inches: silt loam
H4 - 39 to 57 inches: channery silt loam
R - 57 to 67 inches: bedrock

Properties and qualities

Slope: 10 to 18 percent
Depth to restrictive feature: 19 to 32 inches to fragipan; 40 to 80 inches to lithic bedrock; 40 to 80 inches to paralithic bedrock
Natural drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.01 to 0.06 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Sodium adsorption ratio, maximum in profile: 4.0
Available water storage in profile: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Hydric soil rating: No

340D3—Zanesville silty clay loam, 10 to 18 percent slopes, severely eroded

Map Unit Setting

National map unit symbol: 1lm34
Elevation: 360 to 660 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 175 to 195 days
Farmland classification: Not prime farmland

Map Unit Composition

Zanesville, severely eroded, and similar soils: 90 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Zanesville, Severely Eroded

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, head slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess over residuum

Typical profile

H1 - 0 to 2 inches: silty clay loam
H2 - 2 to 19 inches: silty clay loam
H3 - 19 to 37 inches: silt loam
H4 - 37 to 55 inches: channery silt loam
R - 55 to 65 inches: bedrock

Properties and qualities

Slope: 10 to 18 percent
Depth to restrictive feature: 19 to 32 inches to fragipan; 40 to 80 inches to lithic bedrock; 40 to 80 inches to paralithic bedrock
Natural drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.20 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Sodium adsorption ratio, maximum in profile: 4.0
Available water storage in profile: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Hydric soil rating: No

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

Land Classifications

Land Classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Farmland Classification (Area 1)

Farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. It identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the "Federal Register," Vol. 43, No. 21, January 31, 1978.

Custom Soil Resource Report
Map—Farmland Classification (Area 1)



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of local importance
- Farmland of unique importance
- Not rated or not available

Soil Rating Lines

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of local importance
- Farmland of unique importance
- Not rated or not available

Soil Rating Points

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of local importance
- Farmland of unique importance
- Not rated or not available

Water Features

R06677

MAP INFORMATION

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

The soil surveys that comprise your AOI were mapped at 1:12,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Williamson County, Illinois
Survey Area Data: Version 11, Sep 16, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 13, 2011—Oct 21, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

R06678

Table—Farmland Classification (Area 1)

Farmland Classification— Summary by Map Unit — Williamson County, Illinois (IL199)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
13B2	Bluford silt loam, 2 to 5 percent slopes, eroded	All areas are prime farmland	0.0	2.2%
14C2	Ava silt loam, 5 to 10 percent slopes, eroded	Farmland of statewide importance	0.1	6.9%
301B	Grantsburg silt loam, 2 to 5 percent slopes	All areas are prime farmland	0.4	52.4%
340D2	Zanesville silt loam, 10 to 18 percent slopes, eroded	Farmland of statewide importance	0.1	17.1%
340D3	Zanesville silty clay loam, 10 to 18 percent slopes, severely eroded	Not prime farmland	0.2	21.4%
Totals for Area of Interest			0.8	100.0%

Rating Options—Farmland Classification (Area 1)

Aggregation Method: No Aggregation Necessary

Tie-break Rule: Lower

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Williamson County, Illinois

Soil Dwina Waterline 2



August 1, 2017

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

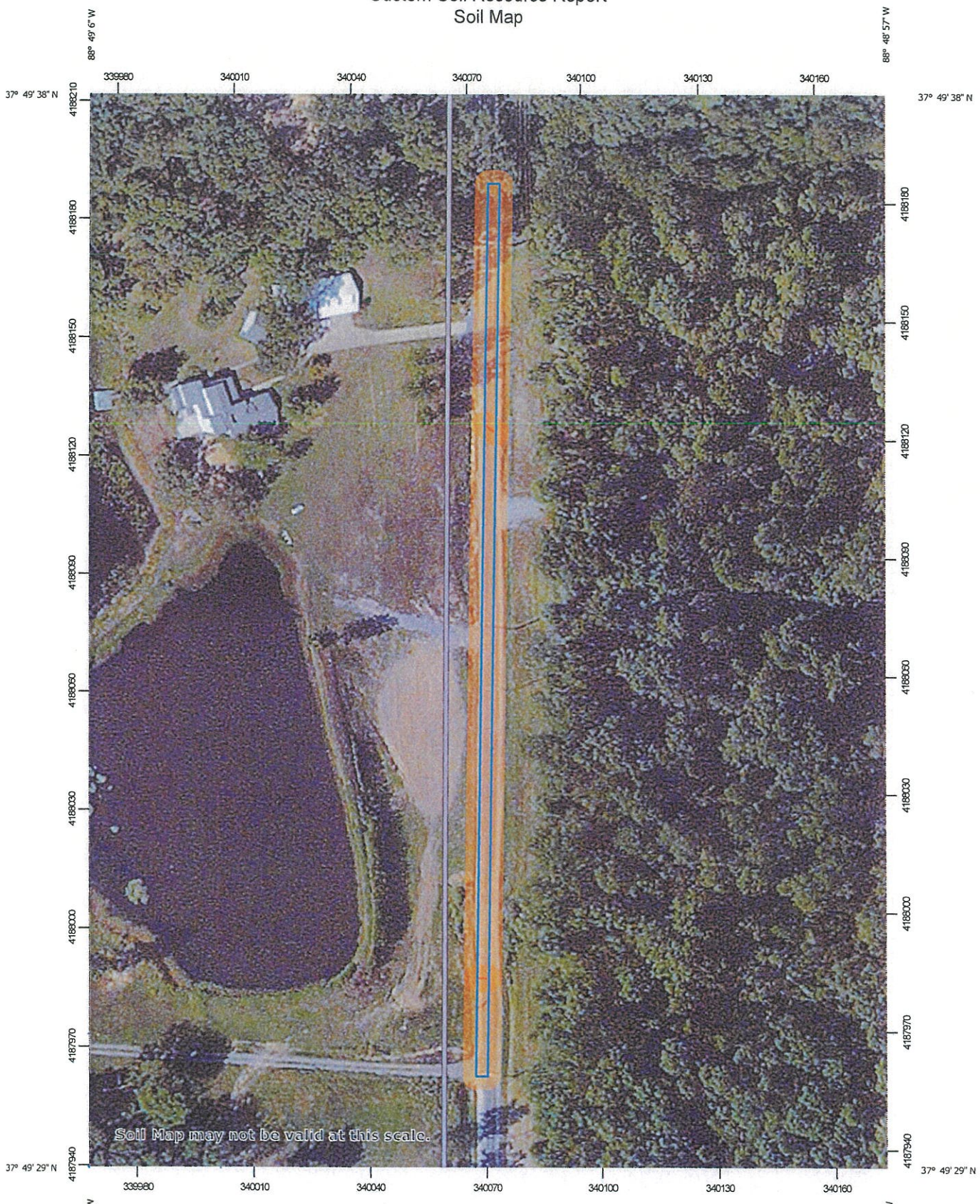
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:1,330 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 15 30 60 90

Feet
0 50 100 200 300

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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Soil Survey Area: Williamson County, Illinois
Survey Area Data: Version 11, Sep 16, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 13, 2011—Oct 21, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

R06689

Map Unit Legend

Williamson County, Illinois (IL199)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
10D	Plumfield silty clay loam, 10 to 18 percent slopes	0.1	61.6%
301B	Grantsburg silt loam, 2 to 5 percent slopes	0.1	38.4%
Totals for Area of Interest		0.2	100.0%

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the

development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Williamson County, Illinois

10D—Plumfield silty clay loam, 10 to 18 percent slopes

Map Unit Setting

National map unit symbol: 2wk1m
Elevation: 330 to 820 feet
Mean annual precipitation: 38 to 46 inches
Mean annual air temperature: 54 to 58 degrees F
Frost-free period: 180 to 195 days
Farmland classification: Not prime farmland

Map Unit Composition

Plumfield and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Plumfield

Setting

Landform: Ground moraines
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Head slope, side slope
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Loess over mixed loess and drift over till

Typical profile

Ap - 0 to 5 inches: silty clay loam
2Btx1 - 5 to 12 inches: silty clay loam
2Btx2 - 12 to 36 inches: silt loam
3Btgb - 36 to 70 inches: silty clay loam

Properties and qualities

Slope: 10 to 18 percent
Depth to restrictive feature: 5 to 20 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.02 to 0.06 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 5.0
Available water storage in profile: Very low (about 1.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Belknap, occasionally flooded

Percent of map unit: 5 percent
Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Bluford

Percent of map unit: 5 percent
Landform: Ground moraines
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

301B—Grantsburg silt loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: 1lm2y
Elevation: 360 to 660 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 175 to 195 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Grantsburg and similar soils: 90 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Grantsburg

Setting

Landform: Loess hills
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Peoria and roxana loess over residuum

Typical profile

H1 - 0 to 11 inches: silt loam
H2 - 11 to 24 inches: silt loam
H3 - 24 to 38 inches: silty clay loam
H4 - 38 to 61 inches: silt loam
H5 - 61 to 80 inches: silt loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: 24 to 40 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.01 to 0.06 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Sodium adsorption ratio, maximum in profile: 4.0
Available water storage in profile: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Hydric soil rating: No

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

Land Classifications

Land Classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Farmland Classification

Farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. It identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the "Federal Register," Vol. 43, No. 21, January 31, 1978.

Custom Soil Resource Report
Map—Farmland Classification



Map Scale: 1:1,330 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 15 30 60 90

Feet: 0 50 100 200 300

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of local importance
- Farmland of unique importance
- Not rated or not available

Soil Rating Lines

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of local importance
- Farmland of unique importance
- Not rated or not available

Soil Rating Points

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of local importance
- Farmland of unique importance
- Not rated or not available

Water Features

R06697

MAP INFORMATION

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

The soil surveys that comprise your AOI were mapped at 1:12,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Williamson County, Illinois
Survey Area Data: Version 11, Sep 16, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 13, 2011—Oct 21, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

R06698

Table—Farmland Classification

Farmland Classification— Summary by Map Unit — Williamson County, Illinois (IL199)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
10D	Plumfield silty clay loam, 10 to 18 percent slopes	Not prime farmland	0.1	61.6%
301B	Grantsburg silt loam, 2 to 5 percent slopes	All areas are prime farmland	0.1	38.4%
Totals for Area of Interest			0.2	100.0%

Rating Options—Farmland Classification

Aggregation Method: No Aggregation Necessary

Tie-break Rule: Lower

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

PART III OPERATIONS PLAN

1) Explain the proposed operation and why the IBR is needed. Locate on a mining operations map.

RESPONSE: **The proposed operation is to bury a four inch HPDE line along ~four thousand feet long and ~10 feet in wide along Dwina Road. The buried waterline will be used to bring underground water back the existing water holding cell/system. The water is currently being pumped underground through a series of pumps to the Dean Road Bleeder shaft. Then the water is pumped to the surface with a vertical turbine pump. A new vertical turbine pump will be installed on an existing 10 5/8" steel casing located on the adjacent IBR #41. A new concrete pad 10'x10' will be installed as a foundation for the pump on IBR #41. All water lines will be buried at least 36 inches deep after the water line leave the pumping site. The waterline will be installed across a small portion of IBR #37. The waterline will be bored under Dwina road.**

2) Surface Drainage Control

A) 1) Locate on the mining operations map or on a separate drainage map all proposed drainage control systems. Show drainage patterns of all affected mining areas.

RESPONSE: The surface drainage pattern is indicated on the attached Pre and Post-Mine Surface Topography Map.

2) Will all surface drainage from the affected mining area be collected and treated prior to leaving the IBR area?

Yes ____ No **X** ____.

If yes, delineate how and where surface drainage will be collected and treated, and list permit numbers and type of permit that the drainage control systems are operated under. If above answer is no, explain how regulatory compliance will be achieved without treatment, i.e., address the requirements of 1816.46(e)/1817.46(e).

RESPONSE: **A sediment pond exemption is requested for this permit area due to its size (1.0 acres). Silt fence and/or straw bales will be placed along the down-slope edge of the disturbed area to minimize sediment loss from the disturbed areas as needed. Due to the small diameter of the waterline being installed, the trench will be immediately reclaimed during construction. The reclaimed trench will be seeded and mulched to reduce runoff and promote cover establishment.**

B) Will all surface drainage from unaffected areas be intercepted and diverted around the affected mining area?

Yes ____ No X .

If no, please discuss.

RESPONSE: **Due to the small diameter waterline being installed. Reclamation concurrently with the installation of the waterline therefore no surface drainage problem are anticipated.**

C) Overland Flow Diversions and Sediment Ponds:

Are either overland flow diversions or sediment ponds to be constructed?

Yes ___ No X .

If yes, complete applicable parts of the SCM-1 or UCM-1 Part IV (surface drainage control).

D) Are surface mining activities, including road crossings, proposed within 100 ft of any stream (ephemeral, intermittent, or perennial)?

Yes X Yes No _____.

If **Yes**,

a) For any stream(s) located outside the proposed permit boundary where disturbance within 100ft is proposed go to Part D.2

b) For any stream(s) located **within** the proposed boundary where disturbance within 100 ft is proposed go to Part D.1.

If **No**, go to Part D.6.

D.1. Provide a Stream Delineation Report and/or Wetland Delineation Report. Information contained in the report(s) shall meet the requirements found at 1780.14/1784.23, 1780.29/1784.29, 1816.43/1817.43 and 1816.97/1817.97.

RESPONSE:

Indicate the number of each type of stream located within the proposed permit area.

☐ Ephemeral ☒ Intermittent ☐ Perennial

D.2 Is a stream buffer variance requested?

Yes X No____

If **YES**,

a) For stream(s) located **outside** the proposed permit boundary go to Part D.3.
b) For stream(s) located **inside** the proposed permit boundary go to Part D.4.

If **NO**, provide a justification that each disturbed stream is ephemeral based on both parts of the definition of ephemeral stream found at **Section 1701.5 Appendix A**. Briefly describe the disposition of the ephemeral stream(s) during operations and post-mining. Nomenclature of ephemeral streams must be consistent with maps and reports. No further information is required in this part of the application if all streams are ephemeral.

D.3 For each intermittent and/or perennial stream located **outside** the permit boundary where a stream buffer variance is requested, provide the name of the stream and describe how the requirements of Section 1816.57/1817.57 will be met. No further information is required for streams outside the proposed permit boundary.

Response: A stream buffer variance is being requested because the proposed boundary is within a stream buffer zone for an un-named tributary of Pond Creek. A proposed water line will run along the opposite side of the existing county roadway. There will be no impact on stream riparian zone or water quality/quantity.

D.4 For each intermittent and/or perennial stream located **inside** the permit boundary where a buffer variance is requested, describe the proposed activities. Where a bridge, road, culvert or other crossing is proposed for any streams that will not be diverted, provide the information required in Section 1780.37/1784.24. In addition, describe how compliance with Section 1816.57/1817.57 will be achieved.

D.5 For each stream diversion complete the applicable parts of the SCM-1 or UCM-1.

D.6 Discuss how the designated 100 ft stream buffer zone will be marked for any intermittent and/or perennial stream that will not be disturbed by surface mining activities. Cleary indicate the 100 ft. stream buffer zone on all maps. If NO streams are located within the proposed permit boundary or within 100 ft of the proposed permit boundary indicate N/A.

3) Roads and other activities:

A) Are roads to be constructed in the IBR area?

Yes ___ No _X_.

If yes, complete the applicable part of the SCM-1or UCM-1 (transportation facilities).

B) If the operations involve blasting, or any other activities not specifically addressed above, complete applicable parts of the SCM-1 or UCM-1.

4) Are any existing structures proposed for utilization in the IBR?

Yes ____ No _X__.

If yes, complete Part IV.4 of the SCM-1 or UCM-1.

PART IV RECLAMATION PLAN

1) Provide a reclamation plan map outlining proposed reclamation of the lands within the proposed IBR area and state how the IBR area will be reclaimed in conformity with the original plan.

RESPONSE:

- See the Pre and Post-Mine Land Use (Reclamation Map)
- The buried waterline will not be recovered. It will remain buried, and final site reclamation will be conducted "over" it.
- All disturbed acres will be returned to their previous land use. (Residential or Fish and Wildlife (Herbaceous)).
- The entire disturbed area will be graded for positive drainage.
- The topsoil will be amended, if necessary, and fertilized and prepared for appropriate planting.

2) Post Mining Land Use

A) Provide a detailed description of proposed post-mining land uses and capabilities employing land use and capability categories listed below. Provide acreage figures for each post-mining land use proposed for the existing permit, the IBR area and total permit after inclusion of the IBR acreage and designate the post-mining land uses on the Post Mining Land Use Map. Acreage figures for post-mining land use must differentiate between mined and surface disturbance areas based on the mining line used in the premining section of the application.

	Existing Permit (ac)			IBR (ac)			Total Permit (ac)		
Land Use	Prime	Hcap	NCrop	Prime	Hcap	NCrop	Prime	Hcap	NCrop
Cropland	13.0	8.7	2.5				13.0	8.7	2.5
Pasture Land	0.0	0.8	5.5				0.0	0.8	5.5
Grazing Land	0.0	0.0	0.0				0.0	0.0	0.0
Forestry	0.0	0.0	14.3				0.0	0.0	14.3
Residential	0.0	0.0	1.5				0.0	0.0	1.5
Industrial/Commercial	0.3	0.0	0.0				0.3	0.0	0.0
Recreation	0.0	0.0	0.0			0.1 *	0.0	0.0	0.1
Fish & Wildlife Habitat (Herbaceous)	5.5	22.8	46.0		0.3	0.6 *	5.5	23.1	46.6
Fish & Wildlife Habitat (Woody)	0.0	0.8	571.8				0.0	0.8	571.8
Fish & Wildlife Habitat (Wetland)	0.0	0.0	0.2				0.0	0.0	0.2
Fish & Wildlife Habitat (Water)	0.0	0.0	9.2				0.0	0.0	9.2
Developed Water Resources	0.0	0.0	19.3				0.0	0.0	19.3
Undeveloped Land	0.0	0.0	0.0				0.0	0.0	0.0
Total	19.1	25.9	677.2	0.0	0.3	0.7	18.8	33.4	671.0

Prime: Prime farmland

HCap: High Capability - meeting productivity requirements of 62 Ill. Adm. Code 1825.

NonCrop: Non-Cropland - All soils which do not qualify as prime farmland or high capability

* = "Negative Determination" Acres

3) Are trees located within the proposed boundary area?

Yes ___ No X .

Response: All construction activity will accrue within the existing managed road right of way.

If yes, then pursuant to Sections 1784.21 (a)(2)(A) and (C) and 1817.97 (b) the applicant shall:

A) Provide a Protection and Enhancement Plan (PEP) and an Incidental Take (IT) authorization request to the Department for the Indiana bat meeting the specifications of the "Range-wide Indiana Bat Protection and Enhancement Plan Guidelines" (revised 2013) developed by the U.S. Fish and Wildlife Service and the Office of Surface Mining, or justify why no PEP and IT are required under those guidelines.

B) Discuss whether or not the project is consistent with the Northern long-eared bat Final 4(d) Rule (January 2016), and if not then provide a PEP and IT authorization request to the Department consistent with the 2013 Indiana bat guidelines referenced above.

EcoCAT
Ecological Compliance Assessment Tool

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Applicant: Williamson Energy, LLC
Contact: James Plumley
Address: 16824 Liberty School Road
Marion, IL 62959

Project: Dwina Road Water Line
Address: Dwina Road, Marion

Description: Water Line in Road ROW

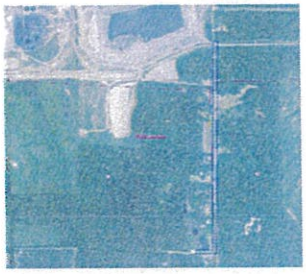
IDNR Project Number: 1803336
Date: 10/23/2017

Natural Resource Review Results

This project was submitted for information only. It is not a consultation under Part 1075.

The Illinois Natural Heritage Database shows the following protected resources may be in the vicinity of the project location:

Chuck-Will's-Widow *(Caprimulgus carolinensis)*



Location

The applicant is responsible for the accuracy of the location submitted for the project.

County: Williamson

Township, Range, Section:
8S, 3E, 13
8S, 4E, 7
8S, 4E, 18

IL Department of Natural Resources Contact
Impact Assessment Section
217-785-5500
Division of Ecosystems & Environment

Disclaimer

The Illinois Natural Heritage Database cannot provide a conclusive statement on the presence, absence, or condition of natural resources in Illinois. This review reflects the information existing in the Database at the time of this inquiry, and should not be regarded as a final statement on the site being considered, nor should it be a substitute for detailed site surveys or field surveys required for environmental assessments. If additional protected resources are encountered during the project's implementation, compliance with applicable statutes and regulations is required.

Terms of Use

By using this website, you acknowledge that you have read and agree to these terms. These terms may be revised by IDNR as necessary. If you continue to use the EcoCAT application after we post changes to these terms, it will mean that you accept such changes. If at any time you do not accept the Terms of Use, you may not continue to use the website.

IDNR Project Number: 1803336

1. The IDNR EcoCAT website was developed so that units of local government, state agencies and the public could request information or begin natural resource consultations on-line for the Illinois Endangered Species Protection Act, Illinois Natural Areas Preservation Act, and Illinois Interagency Wetland Policy Act. EcoCAT uses databases, Geographic Information System mapping, and a set of programmed decision rules to determine if proposed actions are in the vicinity of protected natural resources. By indicating your agreement to the Terms of Use for this application, you warrant that you will not use this web site for any other purpose.

2. Unauthorized attempts to upload, download, or change information on this website are strictly prohibited and may be punishable under the Computer Fraud and Abuse Act of 1986 and/or the National Information Infrastructure Protection Act.

3. IDNR reserves the right to enhance, modify, alter, or suspend the website at any time without notice, or to terminate or restrict access.

Security

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Privacy

EcoCAT generates a public record subject to disclosure under the Freedom of Information Act. Otherwise, IDNR uses the information submitted to EcoCAT solely for internal tracking purposes.

Herbaceous Vegetation Assessment

Dwina Road Waterline

Pond Creek Mine

Williamson County, IL

Prepared for:

Williamson Energy, LLC

Prepared by:

William O'Leary, M.S.

HMG Engineers, Inc.

1032 N. 6th Street

Murphysboro, Illinois 62966

October 2017

INTRODUCTION

HMG Engineers, Inc. (HMG) was contacted by Williamson Energy, LLC seeking assistance in identifying existing herbaceous vegetation located in an area planned for the laying of a water line. The corridor which is 10 feet wide begins along the east side of Dwina Road at its intersection with the mine rail loop, located southeast of the preparation plant. The water line is scheduled to be buried along the top outslope of the east road ditch. The line will extend south approximately 3,360 feet where it will cross under the road and then extend an additional 750 feet, approximately, along the west side of the road (Figure 1).

Williamson Energy, LLC informed HMG of a concern regarding Chuck-Wills-Widows (*Caprimulgus carolinensis)*, a listed (threatened) bird species in Illinois. Chuck-Wills-Widows reportedly nest on the ground among dead leaves, pine needles, or bare dirt in dense thickets near openings. State biologists were wanting more information about the composition of herbaceous vegetation along the proposed waterline corridor.

METHODS

Five representative locations were selected along the length of the corridor, 4 on the east side of the road and 1 on the west side (Figure 1). At each location dominant herbaceous species were identified and a visual estimate made of percent cover to the nearest 5 %. The east side corridor is under or adjacent to an overhead power line, vegetation is managed to prevent woody growth. The west side part of the corridor is managed by intensive mowing.

RESULTS

Species recorded are typical of species in Southern Illinois which dominate areas where succession is held back by regular mowing (Table 1). This management scheme favors perennial and biennial grasses and legumes like tall fescue, purpletop grass, broomsedge, and red clover. Where the frequency of mowing is somewhat less, aggressive annuals like foxtails and goldenrods will invade. Where mowing is less often yet, aggressive perennials and biennials like Japanese honeysuckle, Sericea lespedeza, Trumpet creeper vine, and blackberry will begin to invade. In summary, the corridor vegetation is typical for areas developing varying degrees of old field vegetation due to varying degrees of mowing frequency. This is consistent with normal management of road and power line rights of ways. Table 2 shows that over 80% of the vegetation is comprised of tall fescue, Japanese honeysuckle, green foxtail, and purpletop grass.

CONCLUSIONS

The typical nesting habitat of the Chuck-Will's-Widow, namely bare dirt, leaf, or pine needle cover in dense thickets near openings is not present on the proposed water line area. The proposed corridor is open, void of any canopy, with ground cover dominated by living annual, biennial, and perennial herbaceous vegetation.

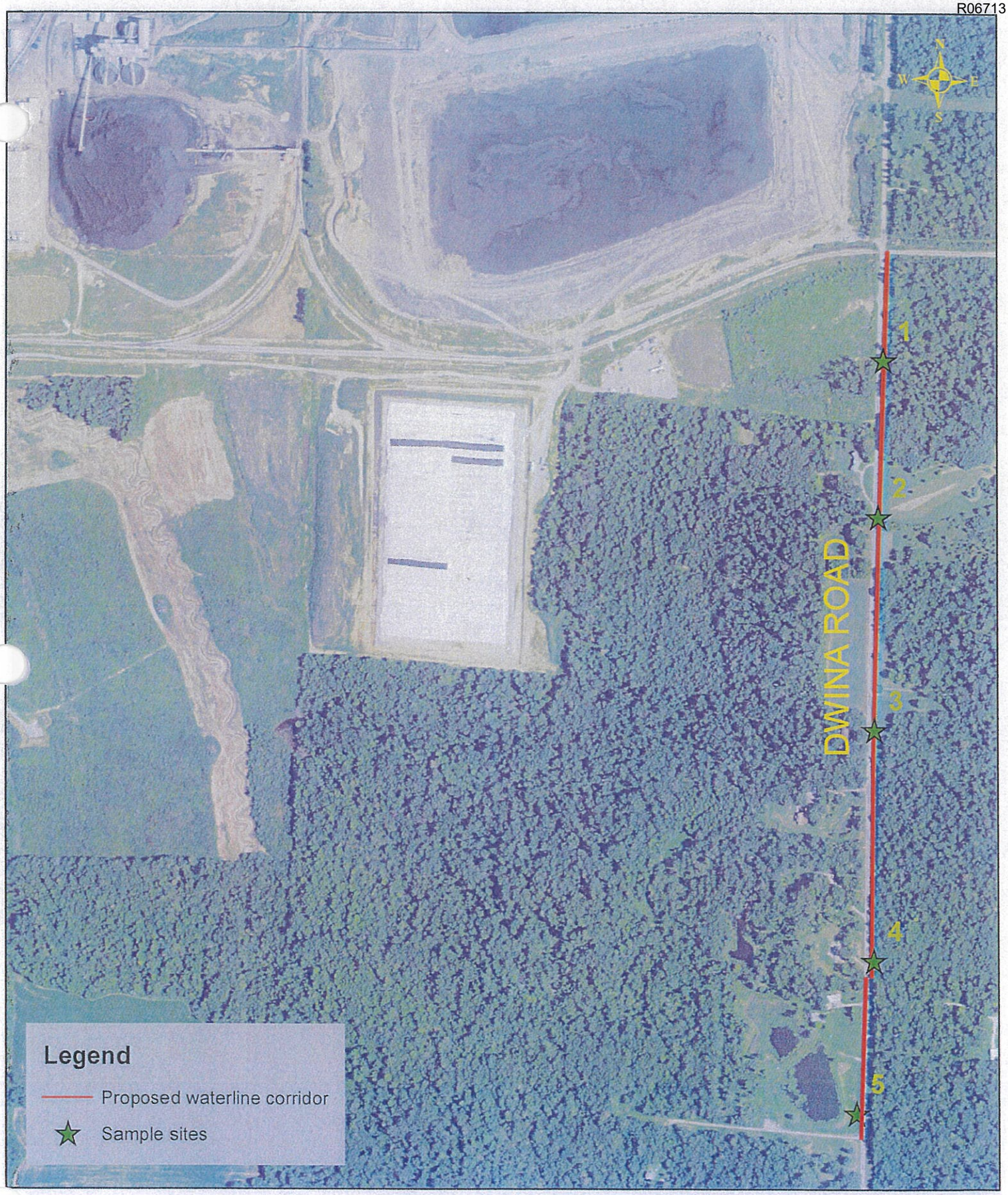


Figure 1. Location of waterline corridor southeast of preparation plant, and location of sample locations.

Table 1. Dwina Road waterline herbaceous vegetation, October 24, 2017.

Sample site	Species	Scientific name	% Cover
1	Japanese honsysuckle	*Lonicera japonica*	70
	Sericea lespedeza	*Lespedeza cuneata*	10
	Canada goldenrod	*Solidago canadensis*	10
	Trumpet creeper vine	*Campsis radicans*	5
2	Green foxtail	*Setaria viridis*	30
	Tall fescue	*Festuca arundinacea*	25
	Purpletop grass	*Tridens flavus*	20
	Japanese honeysuckle	*Lonicera japonica*	15
3	Purpletop grass	*Tridens flavus*	20
	Green foxtail	*Setaria viridis*	20
	Japanese honeysuckle	*Lonicera japonica*	20
	Broomsedge	*Andropogon virginicus*	15
	Canada goldenrod	*Solidago canadensis*	10
	Common blackberry	*Rubus allegheniensis*	5
4	Tall fascue	*Festuca arundinacea*	90
	Green foxtail	*Setaria viridis*	10
5	Tall fascue	*Festuca arundinacea*	70
	Yellow foxtail	*Setaria pumila*	20
	Red clover	*Trifolium pratense*	10

Table 2. Relative dominance for the site.

	total %
Tall fescue	38.9
Japanese honsysuckle	22.1
Green foxtail	12.6
Purpletop grass	8.4
Canada goldenrod	4.2
Yellow foxtail	4.2
Broomsedge	3.2
Sericea lespedeza	2.1
Red clover	2.1
Trumpet creeper vine	1.1
Common blackberry	1.1
	100.0

R06716

RECEIVED
AUG 15 2017
00308157
PRESERVATION SERVICES

Department of Natural Resources
AUG 18 2017
Impact Assessment Section

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Illinois Department of Natural Resources

One Natural Resources Way Springfield, Illinois 62702-1271
www.dnr.illinois.gov

Bruce Rauner, Governor
Wayne A. Rosenthal, Director

IHPA REVIEW
H/A
AC
AR
File Wm / IDNR

August 10, 2017

Rachel Leibowitz, Ph.D.
Deputy State Historic Preservation Officer
IDNR Historic Preservation Division
1 Old State Capitol Plaza
Springfield, IL 62701

2 COPIES RCVD & CD

Dear Dr. Leibowitz:

Pursuant to the requirements of the Programmatic Agreement between the Illinois Historic Preservation Agency and IDNR concerning mining, please review the enclosed Archaeological Survey Short Report.

PROJECT: Williamson Energy, Permit 375: waterline
LOCATION: starting 0.4 miles north of the intersection of Dwina Road and Corinth Road North, ~~Cornith,~~ IL, running northward for 0.75 miles IL
COUNTY: Williamson CONTRACTOR: ARG (Titus)

The Phase One archaeological survey of **0.9 acres** has not recorded any archaeological sites; project clearance is recommended.

In accordance with the established procedures for coordination of Illinois Department of Natural Resources projects, IDNR-Office of Realty and Environmental Planning requests the concurrence of the State Historic Preservation Office in our determination that the proposed undertaking is a **no effect** regarding status of any Historic Property.

If no reply is received from IHPA within 45 days, IDNR will conclude that, as per the Programmatic Agreement, this application is approved and will proceed with the undertaking.

Sincerely,

Dawn E. Cobb

Dawn Cobb
Archaeologist
Office of Realty and Environmental Planning

dc:mbs

ENCLOSURE 2 hardcopies; 1 CD

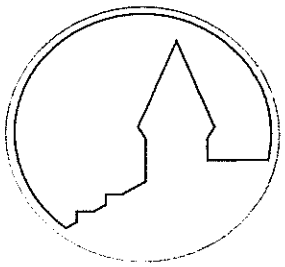
CONCUR
By: Rachel Leibowitz
Deputy State Historic Preservation Officer
Date: 8-18-17

Illinois Archaeological Survey Short Report

Phase I Cultural Resources Survey and Assessment of the Dwina Road Waterline for Williamson Energy, LLC, Williamson County, Illinois

Prepared for
Williamson Energy, LLC
Marion, Illinois

Prepared by
American Resources Group, Ltd.
Carbondale, Illinois



Principal Investigator
Steve Titus

Author
Cally Lence

Cultural Resources Management
Report No. 1990

August 2017

ARCHAEOLOGICAL SURVEY SHORT REPORT
Illinois Historic Preservation Agency
1 Old State Capitol Plaza, Springfield, Illinois 62701-1507
(217) 782-4836

Reviewer:
Date:
Accept: Reject:

IHPA Log Number:

LOCATIONAL INFORMATION AND SURVEY CONDITIONS:
County: Williamson **Quadrangle:** Pittsburg, Illinois 7.5'

Project Type/Title: Phase I Cultural Resources Survey and Assessment of the Dwina Road Waterline for Williamson Energy, LLC, Williamson County, Illinois (ARG CRM 1990).
Funding and/or Permitting Federal/State Agencies: IDNR

Legal Location:
Section: 7 (SWSW), 18 (W2NW) **Township:** 8S **Range:** 4E
Section: 13 (NESE) **Township:** 8S **Range:** 3E

UTM Coordinates:
North End: **UTM North:** 4189211 **UTM East:** 340110
South End: **UTM North:** 4187964 **UTM East:** 340069

Location: Survey area is located along the west (southern ¼ mile) and east (northern ½ mile) sides of Dwina Road; the southern end of the survey corridor begins approximately 0.63 km (0.4 mile) north of the intersection of Dwina Road and Corinth Road, and extends northward approximately 1.25 km (0.75 mile). The survey area is approximately 3.6 km (2.25 miles) west-northwest of Corinth, Illinois.

Project Description: Phase I archaeological survey of a proposed waterline for Williamson Energy, LLC IDNR Mine Permit No. 375.
Topography: Slopes and ridge crest
Elevation (' AMSL): 485'-560'
Soils: Ava-Bluford-Wynoose (University of Illinois 1966)
Drainage: Unnamed Intermittent, Pond Creek, Middle Fork Big Muddy River, Big Muddy River River, Mississippi River
Land Use/Ground Cover (include % visibility): Grass and weeds 0-20% visibility
Survey Limitations: None

ARCHAEOLOGICAL AND HISTORICAL INFORMATION:
Historic Plats/Atlases/Sources: ISM/DNR Inventory of Archaeological Sites; IHPA HARGIS database;
1837 GLO Plat Maps of Township 8 South, Ranges 3 and 4 East (General Land Office) (Attachment B, Figure B-1);
1876 Atlas of the State of Illinois (Warner and Beers) (Attachment B, Figure B-2);
1908 Standard Atlas of Williamson County, Illinois (George A. Ogle and Company) (Attachment B, Figure B-3);
1940s? township plat map (W.W. Hixson) (Attachment B, Figure B-4);
1941 USGS West Frankfort, Ill. 15-minute series topographic quadrangle (Attachment B, Figure B-5)

Previously Reported Sites: Within one-mile of project area, 52 sites: 11WM111–144, 11WM147–148, 11WM153, 11WM313, 11WM333–342, 11WM350, 11WM364–366

Previous Surveys: Within project area: 90364 (not in CRM report archive) (covers northern 230 m (0.14 mile) of current survey area). In 1-mile of project area: 669 (Vander Leest 1981), 14961 (Ensor et al. 2005), 18699 (Faberson 2009), 18933 (Anderson 2010), 20334 (Craig and Rein 2014), 20730 (Lence 2014), 90345 (not in report CRM archive), 90389 (not in CRM report archive)

Regional Archaeologist Contacted: None, consulted the Illinois Inventory of Archaeological Sites
Investigation Techniques: Systematic surface survey along a single transect in areas where surface visibility exceeded 25 percent; systematic, screened shovel testing at 15 m intervals along a single transect in areas where ground surface visibility fell below 25 percent.
Time Expended: 2 Hours
Sites/Find Spots Located: None
Cultural Material: n/a
Curated At: n/a
Collection Techniques: n/a

Area Surveyed (acres and square meters): 0.9 acre; 3,642 square meters

RESULTS OF INVESTIGATIONS AND RECOMMENDATIONS: (check one)

_x_ **Phase I archaeological reconnaissance has located no archaeological material; project clearance is recommended.**

_ **Phase I archaeological reconnaissance has located archaeological materials; site(s) does(do) not meet requirements for National Register eligibility; project clearance is recommended.**

_ **Phase I archaeological reconnaissance has located archaeological materials; site(s) may meet requirements for National Register eligibility; further testing is recommended.**

_ **Phase II archaeological investigation has indicated that site(s) does(do) not meet requirements for National Register eligibility; project clearance is recommended.**

_ **Phase II archaeological investigation has indicated that site(s) meet requirements for National Register eligibility; formal report is pending and a determination of eligibility is recommended.**

Comments: American Resources Group recently completed an intensive, Phase I cultural resources survey of a proposed waterline in northeastern Williamson County, Illinois. The project area is located approximately 3.6 km (2.25 miles) west-northwest of Corinth along Dwina Road (Attachment A, Figure A-1).

The site-file search and architectural records review conducted prior to beginning the field survey revealed that no archaeological sites or architectural properties had been recorded within the present project area. One previously recorded archaeological site/cemetery (Alsup Cemetery), is, however, located on a wooded ridge spur along the western side of Dwina Road in the extreme southeastern corner of Section 12. This cemetery was recorded in 1981 and revisited in 2003 (Ensor et al. 2003; Vander Leest 1981). Though no stones were observed during either the 1981 or the 2003 surveys, local informants indicated that at least two individuals were buried there. The presence of two cedar trees in an unplowed location supported the oral history. The cemetery will not be impacted by the current project area, as it is located on the opposite (west) side of the road from the proposed waterline, which will be constructed just east of the road ditch along the east side of Dwina Road, a distance of approximately 20 m.

The results of the pre-field records and literature review suggested that both prehistoric and historic site density was apt to be low in the project area, due to its relatively great distance form a perennial water source and primarily sloping topography. The pre-field review of historic maps indicated there no structures plotted on any of the maps within the project area (Attachment B, Figures B-1–B-5).

The project area is comprised of 3-m-wide (10-foot-wide) linear corridor comprising approximately 0.9 acre of land where a waterline is planned for construction. The project corridor is located along the west (along the southern ¼ mile) and east (along the northern ½ mile) sides of Dwina Road. The project area was primarily located in mowed and unmowed grass and weeds; the southern portion along the west side of Dwina Road had recently been scalped by mowing, allowing up to 50 percent ground surface visibility in this area, which was surface surveyed along a single transect (Attachment C, Figure C-1). The remaining areas were primarily in high grass and weeds (Attachment C, Figures C-2–C-4). Ground surface visibility was negligible in these areas. Though much of this area was situated on sloping ground adjacent to the road ditches (which was surface surveyed along a single transect), the ridge tops and areas with less than 20 percent slope were subject to systematic, screened shovel testing at 15 m intervals along a single transect.

No cultural resources were identified during the present investigation, indicating the proposed undertaking will not have an adverse effect on significant cultural resources. It is recommended that the proposed undertaking be allowed to proceed as planned without any additional cultural resources investigations.

ARCHAEOLOGICAL CONTRACTOR INFORMATION:

Archaeological Contractor: American Resources Group, Ltd.
Address/Phone: 127 North Washington Street
Carbondale, Illinois 62901-1507 / (618) 529-2741

Surveyor(s): Kevin Lomas, Steve Titus **Survey Date(s):** August 3, 2017
Report Completed by: Cally Lence **Date:** August 4, 2017
Submitted by (signature and title): Steve Titus, Principal Investigator

ATTACHMENT CHECK LIST: (#1 through #4 are mandatory)

_x_ **1) Relevant portion of USGS 7.5' topographic quadrangle map(s) showing project location and any recorded site;**
_x_ **2) Project map(s) depicting survey limits and, when applicable, approximate site limits and concentrations of cultural materials;**
__ **3) Site form(s): (two copies of each form);**
_x_ **4) All relevant project correspondence;**
_x_ **5) Additional information sheets as necessary.**

Address of Owner/Agent/Agency To Whom SHPO Comment Should Be Mailed To:

Williamson Energy, LLC
16824 Liberty School Road
Marion, Illinois 62959

Contact Person: Mr. James Plumley
Telephone Number: (618) 969-8259

American Resources Group, Ltd.
127 North Washington Street
Carbondale, Illinois 62901-1507

Contact Person: Mr. Steve Titus
Telephone Number: (618) 529-2741

REVIEWERS COMMENTS:

List of Attachments

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Attachment A

Project Topographic Maps

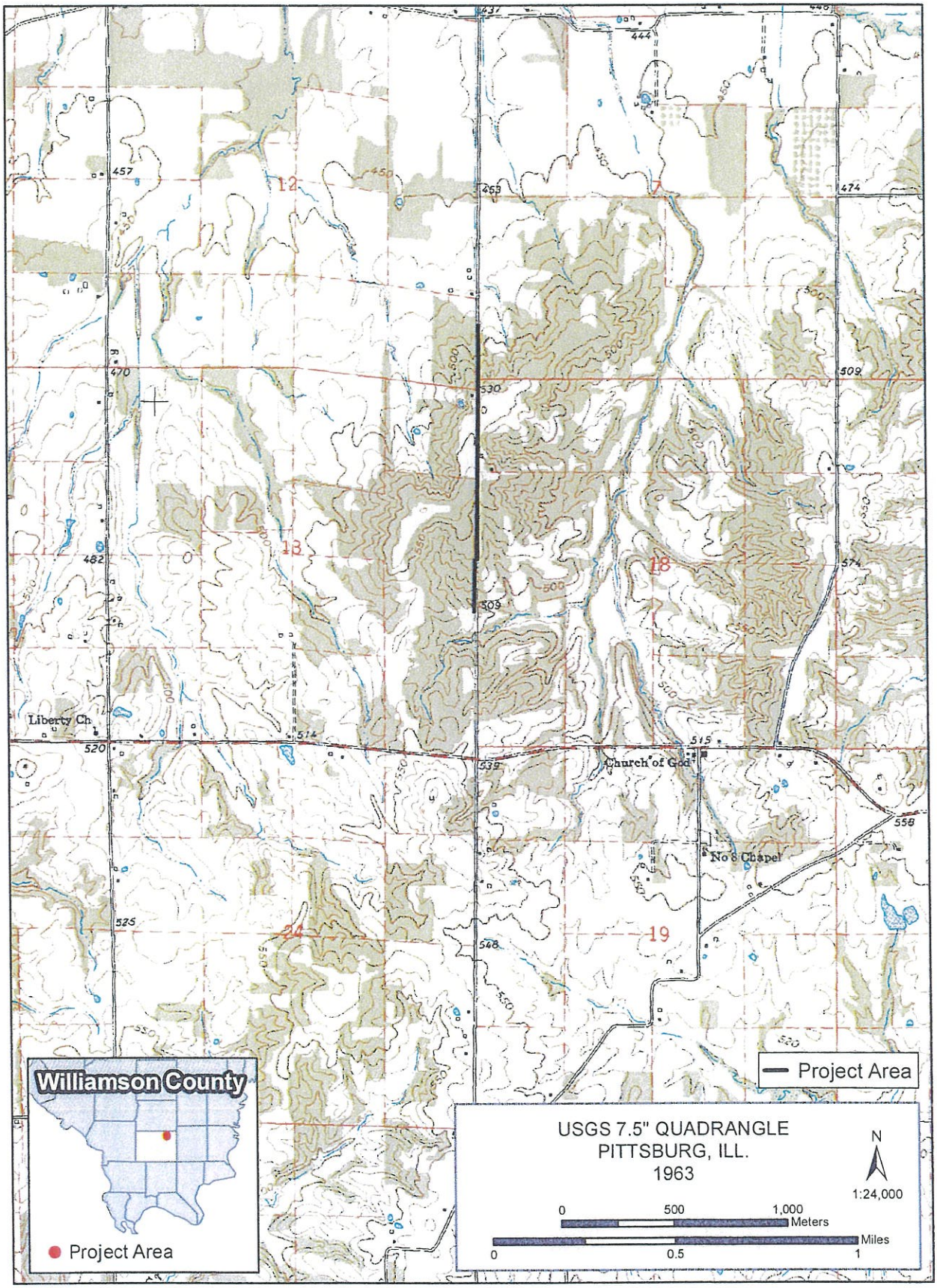


Figure A-1. Topographic location of the project area, Williamson County, Illinois (USGS 1963).

Attachment B

Historic Maps

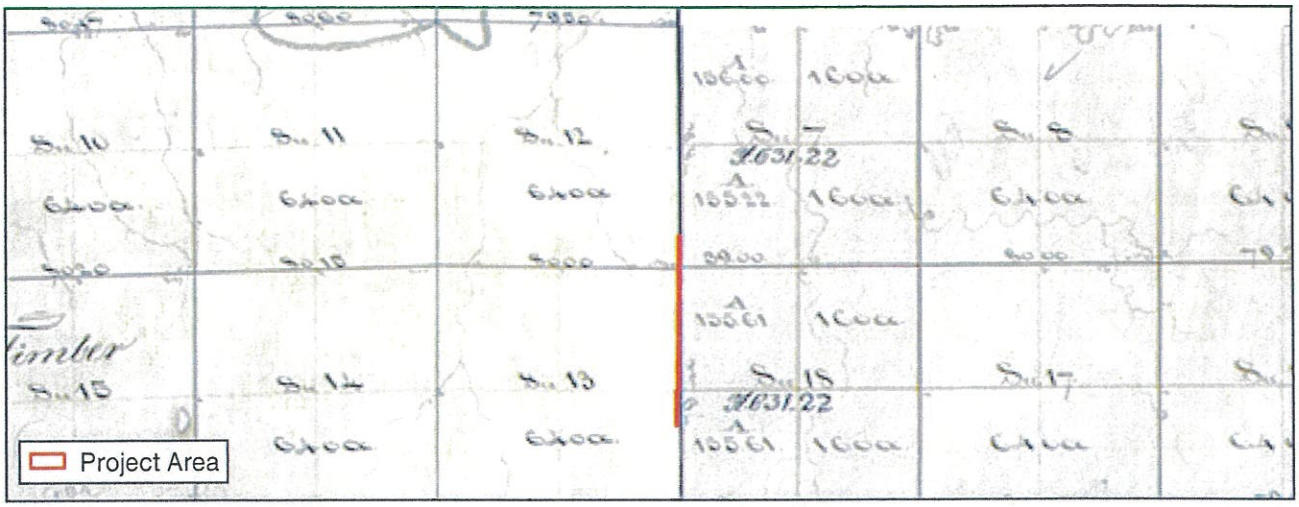


Figure B-1. Portion of the 1837 GLO Plat Maps of Township 8 South, Ranges 3 and 4 East (Illinois State Archives 2017).

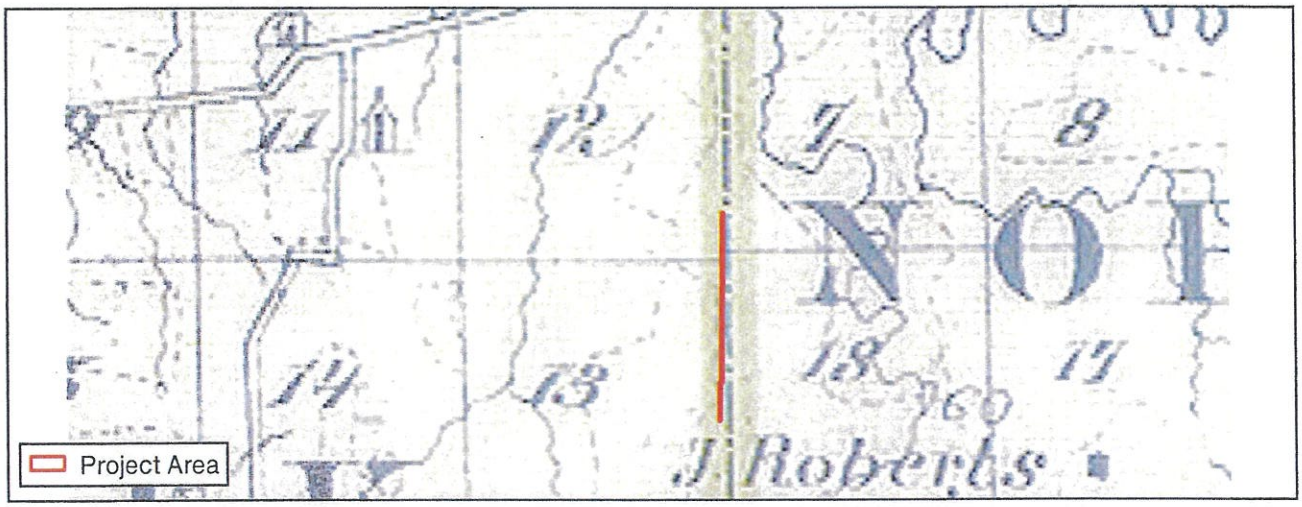


Figure B-2. Portion of the 1876 Atlas of the State of Illinois illustrating the project area (Warner and Beers 1876).

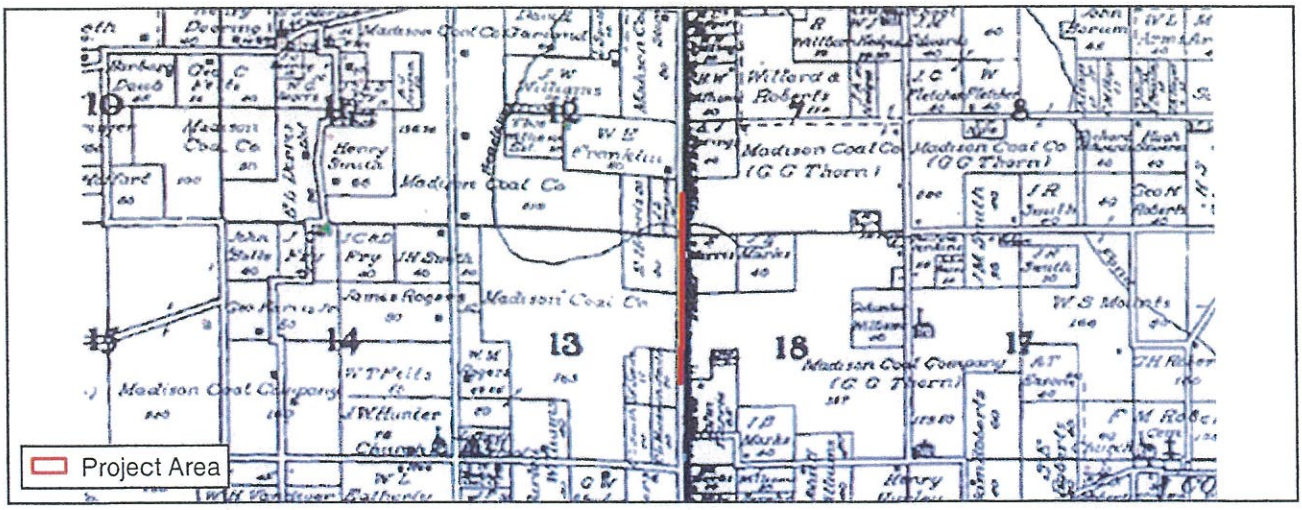


Figure B-3. Portion of the 1908 Atlas of Williamson County, Illinois, illustrating the project area (George A. Ogle and Company 1908).

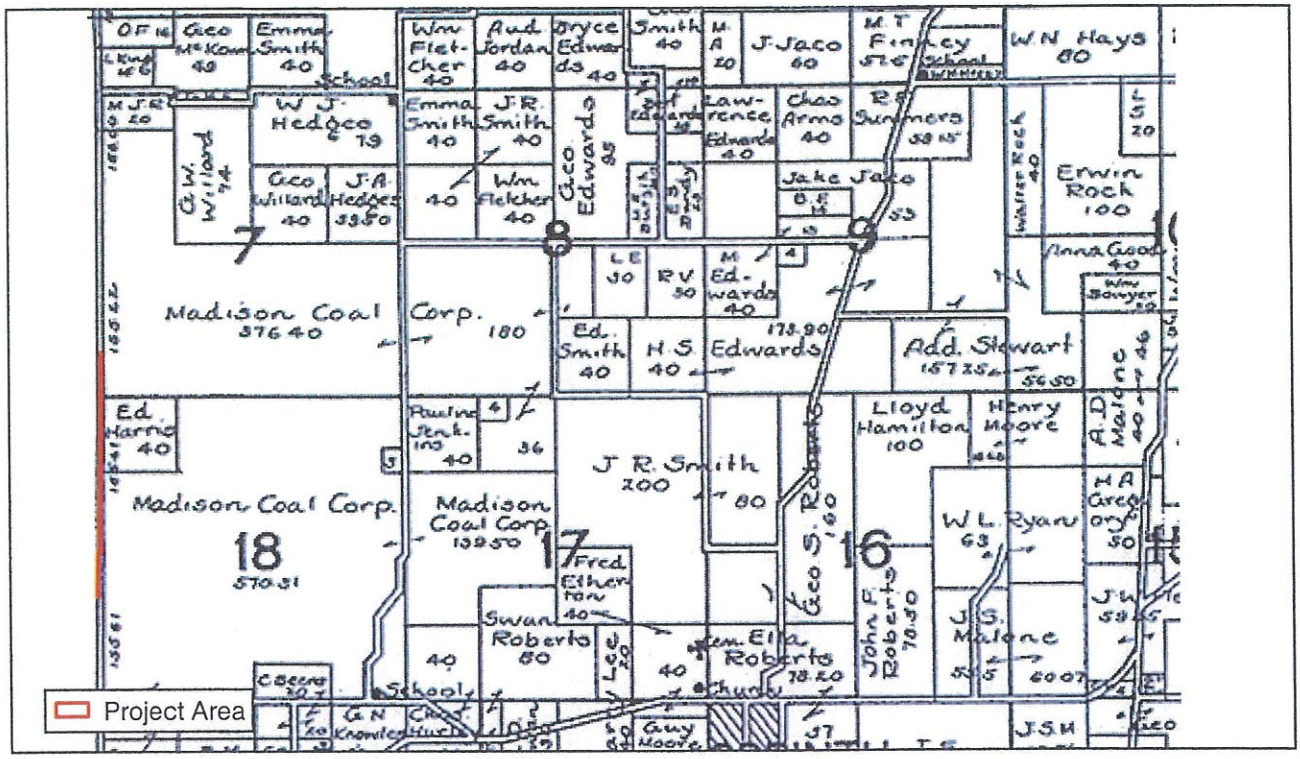


Figure B-4. Portion of the 1940s? Plat Book of Williamson County, illustrating the project area (W.W. Hixson 1940s?).

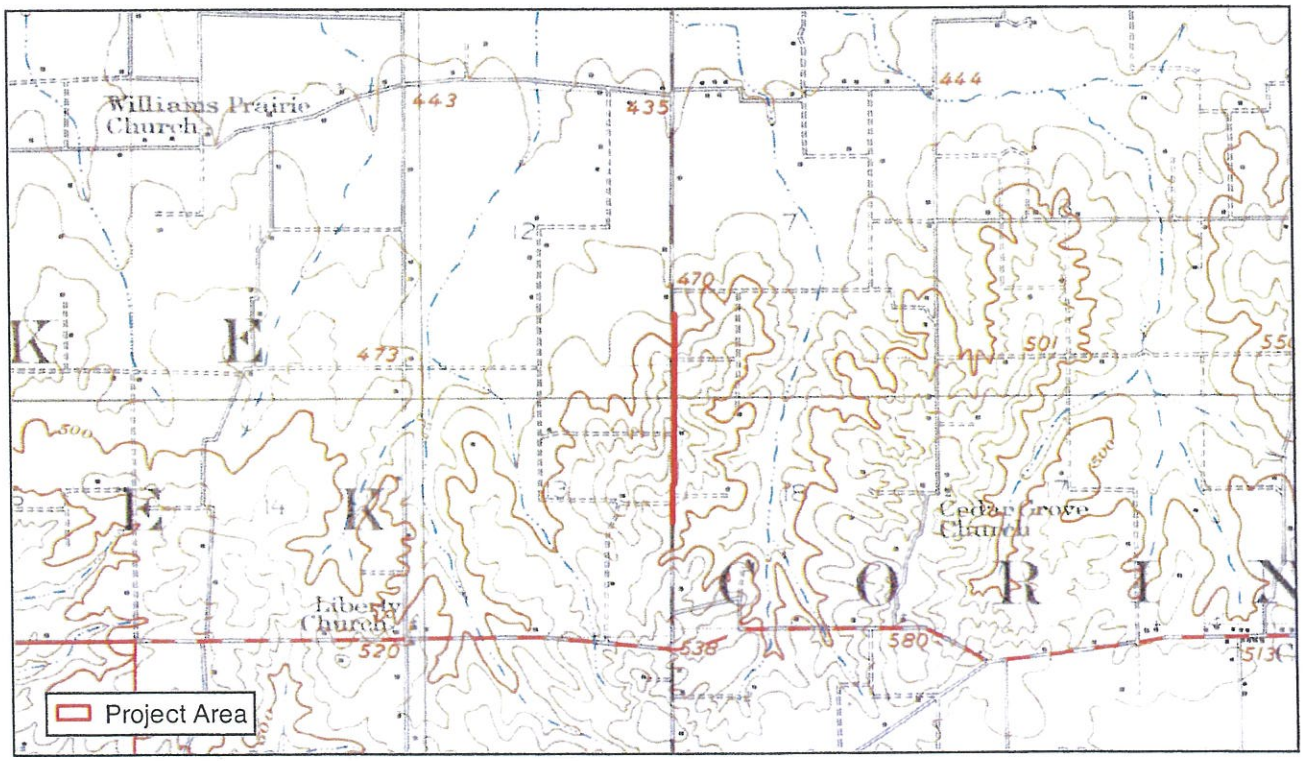


Figure B-5. Portion of the 1941 West Frankfort, Illinois, USGS 15' series topographic quadrangle illustrating the project area (USGS 1941).

Attachment C

Project Photographs



Figure C-1. Southern end of the project corridor looking north along west side of Dwina Road.



Figure C-2. Near southern end of the project corridor looking north along east side of Dwina Road.



Figure C-3. North end of project corridor looking south along east side of Dwina Road.



Figure C-4. North end of project corridor looking north along east side of Dwina Road (at mine entrance).

Attachment D

References Cited

Anderson, J.M.
2010 *A Cultural Resource Survey for the Williamson Energy Concrete Borehole and Access Road in Williamson County, Illinois*. Archaeological Survey Short Report, Cultural Resource Analysts, Inc., Lexington, KY.

Craig, J., and J. Rein
2014 *Phase I Cultural Resource Survey of 13-Acre Mach Mining IBR Project, Williamson County, Illinois*. Prairie Archaeology and Research, Springfield, Illinois.

Ensor, H.B., C. Lence, and S. Titus
2005 *Phase I Cultural Resources Survey of the Steelhead Development Corporation, LLC, Williamson County Project Area.* Cultural Resources Management Report No. 1324, American Resources Group, Carbondale, Illinois.

Faberson, T.
2009 *A Cultural Resource Survey for a Proposed 183-Acre Williamson Energy Pond Creek 1 Coal Mine Operation in Section 7, Township 8 South, Range 4 East in Williamson County, Illinois.* Contract Publication Series 08-164, Cultural Resource Analysts, Inc., Lexington, KY.

George A. Ogle and Company
1908 *Standard Atlas of Williamson County, Illinois*. George A. Ogle and Company, Chicago.

Illinois State Archives
2017 1837 GLO Township Plats, Townships 8 South, Ranges 3 and 4 East. In Illinois Secretary of State, Federal Township Plats of Illinois website http://landplats.ilsos.net

Lence, C.
2014 *Phase I Cultural Resources Survey and Assessment of a 10-Acre Proposed Permit Area for Williamson Energy's Pond Creek No. 1 Mine, Williamson County, Illinois*. Cultural Resources Management Report No. 1875, American Resources Group, Carbondale, Illinois.

United States Geological Survey (USGS)
1963 Pittsburg, Illinois, 7.5 minute topographic map.

1941 West Frankfort, Illinois, 15 minute topographic map.

University of Illinois
1966 *General Soil Map of Illinois.* Agricultural Experiment Station, University of Illinois, Urbana. In cooperation with U.S. Department of Agriculture, Soil Conservation Service.

Vander Leest, B.
1981 *A Cultural Resource Survey of The Proposed Zeigler #6 Mine in Williamson County, Illinois*. Espey, Huston and Associates, Austin, Texas. Document No. 81283, EH&A Job No. 1317.

Warner and Beers
1876 *Atlas of the State of Illinois*. Warner and Beers, Chicago.

W.W. Hixson and Company
1940s? *Plat Book of Williamson County, Illinois.* W.W. Hixson and Company. Rockford, Illinois.

DOCUMENT

30

STATE OF ILLINOIS

ENVIRONMENTAL PROTECTION AGENCY

Subject: Williamson Energy, LLC – Pond Creek Mine No. 1

Data: Log No. 9083-19

Reviewed by: I. Ward **Date:** 06/10/19

Log No. 9083-19 ⇒IBR No. 79 to OMM Permit No. 375.

Log No. 9083-19

- IBR to OMM Permit No. 375 requests the addition of 17.01 acres.
- IBR area is located in Sections 35 and 36, Township 7 South, Range 3 East, Franklin County.
- IBR is for installation of a supply shaft to transport supplies underground as required for the continued effective operation of approved mine plan, belt air shaft and fan to supply required ventilation along with six (6) steel cased boreholes with a diameter less ten 10 5/8 inches for power and other supplies, power substation, dry storage barn and equipment yard.
- Runoff from the area approved herein will be controlled by silt fence, mulching, seeding, vegetation, rock check dams, erosion control blankets, etc.

* Action: Reference Log Nos. 9083-19 in CA as additional permit acreage.

083-119
Due date: 3-29-18
R06736

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Illinois Department of
Natural Resources

One Natural Resources Way Springfield, Illinois 62702-1271
www.dnr.illinois.gov

Bruce Rauner, Governor
Wayne A. Rosenthal, Director

February 9, 2018

Mr. Carson Pollastro
Williamson Energy, LLC
P.O. Box 99
Johnston City, IL 62951

RECEIVED
FEB 15 2018
IL Environmental Protection Agency
MARION REGIONAL OFFICE

Re: Permit No. 375
Incidental Boundary Revision No. 79

Dear Mr. Pollastro:

The appropriate Department technical staff have reviewed the proposed incidental boundary revision dated December 18, 2017, and the supplemental information dated, January 18, 2018, submitted by the permittee for the Pond Creek No. 1 Mine. The request would add 19.9 acres to conduct surface coal mining activities. The additional acres would be used for the installation and operation of a materials shaft, an air shaft and fan, six steel-cased boreholes, a power substation, a storage building, and an equipment storage yard.

Section 1774.13: The Department finds the permittee has demonstrated in its request, and field inspections by the Department's field representative have confirmed, that these areas meet the requirements for an incidental boundary revision, as outlined in 62 Ill. Adm. Code 1774.13(d). Section 1774.13(d)(6) publication requirements have been met. Section 1774.13(c) findings are below.

DEPARTMENT FINDINGS

Section 1761.11(d): The proposed permit area is adjacent to the right-of-way of Davis Road. The only proposed coal mining activities in the permit area within 100 feet of the public road is the construction of a mine access road. Thus, the provisions of 1761.14(b) do not apply.

Section 1761.11(e): The proposed permit area is within three hundred (300) feet measured horizontally of an occupied dwelling. The applicant shall establish a three hundred (300) foot buffer around the dwelling, not disturb within the buffer zone and shall install and maintain buffer zone markers to prevent disturbance within the buffer zone. No mining operations are proposed within three hundred (300) feet measured horizontally of the dwelling.

Section 1773.15(c)(12): The effect of the proposed permitting action on properties listed on or eligible for listing on the National Register of Historic Places has been taken into account by the Department.

Section 1817.13: Upon completion of drilling activities, a borehole/well completion diagram shall be submitted to the Department for all boreholes (dewater, injection, observation, methane vent, rockdust, power supply, etc.) within thirty (30) days of completion of drilling activities. Pursuant to 62 Ill. Adm. Code 1817.13, each borehole shall be properly cased/lined. The construction diagram shall include the location and surveyed elevation of each borehole, a unique name for the borehole and details on the casing/construction materials used. A copy of the borehole/well completion diagram can be found on at:

https://www.dnr.illinois.gov/mines/LRD/Pages/FormsApplicationsMemoranda.aspx

under Miscellaneous Permittee/Operator Forms. Construction all boreholes/monitoring wells shall be in accordance with Operator Memorandum 2017-01.

Section 1817.15: Pursuant to 62 Ill. Adm. Code 1817.15, each borehole shall be properly abandoned and sealed when no longer needed for its intended purpose. Proof of plugging shall be submitted to the Department within sixty (60) days of the date of this approval letter. A copy of the plugging affidavit form can be found on the Department's Forms webpage at:

https://www.dnr.illinois.gov/mines/LRD/Pages/FormsApplicationsMemoranda.aspx,

under Miscellaneous Permittee/Operator Forms. Proof of plugging of all boreholes shall be in accordance with Operator Memorandum 2015-02.

All other conditions and provisions contained in the approved permit also apply to this revision. Approval from this agency does not relieve the permittee from obtaining approval from other agencies requiring such.

The Department is in receipt of the fee and bond. Please forward two copies of your request letter and map(s) to Illinois Environmental Protection Agency, Mine Pollution Control Program, 2309 West Main Street, Suite 116, Marion, Illinois 62959. Mining activities on these 19.9 acres may commence.

Should you have any questions, please contact Will Gillespie at our Benton Office.

Sincerely,

Nick San Diego, Supervisor
Land Reclamation Division

NSD:WG:gr

cc: W. Gillespie
Mine Pollution Control Program, IEPA
M. Parrish

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020

INCIDENTIAL BOUNDARY REVISION FOR PERMIT NO. 375

North Supply Shaft

FRANKLIN COUNTY, IL
Pond Creek #1 Mine

December 18, 2017

IBR # 79

R06739

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020 Fax: 618-983-3017

December 18, 2017

Mr. Dean Spindler
Illinois Department of Natural Resources
Land Reclamation Division
One Natural Resources Way.
Springfield, Il. 62702

RE: IBR to Permit No. 375, Williamson Energy, LLC: **19.9-acre IBR for a North Supply Shaft.**

Dear Mr. Spindler:

An application (2 Copies) for the above-referenced IBR is enclosed for Williamson Energy, LLC

A Cultural Resources Survey will be completed and submitted at the end of the written text.

One copy was hand delivered to Williams Gillespie at the IDNR office in Benton, IL.

Please let me know if you have any questions or need further information.

Sincerely,

James Plumley

James Plumley
Permit Coordinator—Foresight Energy, LLC

enclosure
Cc: Chris Skelton
Williams Gillespie

RECEIVED
FEB 14 2019
IL Environmental Protection Agency
MARION REGIONAL OFFICE

R06740

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951
Office: 618-983-3020 Fax: 618-983-3017

December 18, 2017

Mr. Williams Gillespie
Illinois Department of Natural Resources
Land Reclamation Division
503 E. Main St.
Benton, Il. 62812

RE: IBR to Permit No. 375, Williamson Energy, LLC: **19.9-acre IBR for a North Supply Shaft**

Dear Mr. Gillespie:

An application for the above-referenced IBR is enclosed for Williamson Energy, LLC.

A Cultural Resources Survey is included with this submittal and concurrence.

Please let me know if you have any questions or need further information.

Sincerely,

James Plumley

James Plumley
Permit Coordinator—Foresight Energy, LLC

enclosure
Cc: Chris Skelton

Cover Sheet: Application for Coal Mining and Reclamation Operations

Applicant: Williamson Energy, LLC
Name of Company, Corporation, Partnership or Individual. **[1777.11]**

AVS ID: 156747

Application Type: ☐ New
☒ Existing Permit No. 375

☐ Revision No. _____ ☐ Renewal No. _____ ☐ Transfer No. _____
☐ IPR _____ ☒ IBR _____ ☐ Mid-Term _____

Permit Type: ☐ Surface ☒ Underground ☐ Carbon Recovery

Name of Mine: Pond Creek No.1 Mine

MSHA ID No.: 11-03141(Mine);IL08-03141-02 (Refuse) **[1778.13(g)]**

List the Mine Safety and Health Administration (MSHA) number(s) for all mine associated structures that require MSHA approval.

	Impoundment Type/Name	MSHA No.
1.		
2.		
3.		
4.		
5.		
6.		

Is application to be used as an application for an NPDES and/or IEPA Subtitle D?

If this is an application for an NPDES permit, the Consolidated Permits Program, Application Form 2C (renewal), Form 2D (new), or Form 2E (sanitary) must be completed.

☐ YES ☒ NO

If YES,

☐ IEPA Subtitle D State Permit
☐ NPDES *(New)* ☐ NPDES *(Renewal)*
☐ NPDES *(Modification)*

☐ I Waive my right of the 90-day permit issuance deadline as required by Section 39(a)(4) of the Illinois Environmental Protection Act and 35 Ill. Adm. Code 309.225(c) of the Illinois Pollution Control Board Rules and Regulations.

I, James Plumley, Authorized Person, under penalties
(Signature, Title)

of perjury, declare that I have examined this application, including the accompanying statements and documents, and that, to the best of my knowledge, it is true and correct. I also certify that all printed copies of this application provided to the Department and County Clerk(s) are identical. **(Signer must be at least a Vice-President or duly authorized representative)**

Dated: 12/18/17

PART 1: Administrative Information

1.1 General Information

1.1.1 Applicant: Williamson Energy, LLC
AVS ID: 156747
Applicant is a: [X] Corporation [ ] Partnership [ ] Sole Proprietor
[ ] Association or other Business Entity **[1778.13(a)]**
Individual Contact: James Plumley, Authorized Person **[1778.13(b)]**
(Name and Title)
Address/PO Box: P.O. Box 99
City: Johnston City
State: IL
Zip Code: 62951
Email Address:
Phone Number: 618-983-3020
Fax Number: 618-983-3017
Tax ID/FEIN No. 20-0888529

1.1.2 Resident Agent who will accept service of process for the applicant: **[1778.13(b)]**
Company: Williamson Energy, LLC
Individual Contact: James Plumley
(Name and Title)
Address/PO Box: PO Box 99
City: Johnston City
State: IL
Zip Code: 62951
Email Address: James.plumley@foresight.com
Phone Number: 618-983-3020
Fax Number: 618-983-3017
Tax ID/FEIN No. 81-0669143

1.1.3 Who will be the operator at the permit site? **[1778.13(b)]**
[ ] Applicant [X] Other/Contract operator
If the operator is not the applicant, then complete Table 1.4.1 for the company/entity.

1.1.4 Who will pay Abandoned Mine Land Reclamation fees? **[1778.13(b)]**
[X] Applicant [ ] Other/Contract operator

1.2 Acreage and Timetable

1.2.1

Mine: Pond Creek 1 Mine
Address/PO Box: PO Box 99
City: Johnston City
State: IL
Zip Code: 62951

Pit or Portal No./Name	County	Sec(s)	Twp	Range	Total Acres
North Portal	Franklin	35	7S	3E	.2
North Portal	Franklin	36	7S	3E	19.7
				TOTAL:	19.9

Shadow Area	County	Sec(s)	Twp	Range	Total Acres
				TOTAL:	

1.2.2 Indicate type of disturbance from mining and acreage associated with each type. **[1780.11/1784.11]**

Type of Disturbance:	**Acres**
Area Strippings	
Mine Waste Areas	
Processing Areas & Support Facilities	8.9
Soil Storage Areas	
Diversions	
Auger Mining *(to be surface affected)*	
Contour Stripping	
Steep Slopes *(equal to or greater than 37%)*	
Coal Recovery *(Gob & Slurry)*	
Other	
Undisturbed Areas	11.0
TOTAL ***(must equal total acres being permitted)***	19.9
Shadow Area	

1.2.3 For each phase (permit) of the proposed surface coal mining and reclamation operation over the life of the mine, provide the anticipated or actual starting and termination date and the anticipated number of acres to be affected. **[1779.12]** Designate the boundaries of each phase on the Pre-mining Land Use. **[1779.24(c)]**

Phase/Permit	Start Date	End Date	Acres to be Affected

1.2.4 Indicate on the Pre-mining Land Use Map where future permits for coal refuse piles, coal waste impoundments, or other surface facilities would be located. Provide a general statement that future facilities will be located X number of miles from the current permit.

1.3 Property Ownership

1.3.1 Complete Table 1.3.1 for (1) each legal or equitable owner of record, (2) each holder of leasehold interest, and (3) any purchaser of record under a real estate contract for the surface and mineral property within the proposed permit boundary. **[1778.13(e), 1778.15(a)]**

Complete Table 1.3.1 Property Interest Holders Within Permit Area

1
.3.1A If the proposed permit is for a surface mine where the private mineral estate has been severed from the private surface estate, also provide with Department with:

- A copy of the written consent of the surface owner to the extraction of coal by surface mining methods; or
- A copy of the conveyance that expressly grants or reserves the right to extract the coal by surface mining methods; or
- If the conveyance does not expressly grant the right to extract the coal by surface mining methods, provide the Department with documentation that, under the applicable State law, the applicant has the legal authority to extract the coal by surface mining methods. **[1778.15(b)]**

Provide as an Attachment to Part 1.3.1A.

1.3.2 Complete Table 1.3.2 for any owner of record for property (surface and subsurface) contiguous to any part of the proposed permit boundary. **[1778.13(f)]**

Complete Table 1.3.2 Property Interest Holders Contiguous to the Permit Area

1
.3.2A Does the applicant have an interest in any lands, options or pending bids on interest for lands which are contiguous to the proposed permit area?

☐ Yes ☒ No

If YES, the applicant shall also provide a statement of all lands, interest in lands, options, or pending bids on interests held or made by the applicant for lands contiguous to the area described in the permit application. **[1778.13(h)]**

Upon request by the applicant, this information may be held in confidence by the Department, if not on public file. Does the applicant wish any of the above information to be held confidential?

☐ Yes ☐ No

If YES, the applicant shall identify which information is to be held confidential in its statement. **[1778.13(h)]**

1.3.3 Provide a map ID (name) which shows all boundaries of lands and names of present owners of record of those lands, both surface and subsurface, included in or contiguous to the permit area. The map shall also show which lands within the permit area are **controlled properties** (i.e. applicant is claiming legal right to enter and begin surface coal mining and reclamation operations) versus **uncontrolled properties** (i.e. applicant does not yet have the legal right of entry). **[1779.24(a) and (b)]**

Provide Map of Controlled vs. Uncontrolled Properties as an Attachment to Part 1.3.3.

1.3.4 Complete Table 1.3.4 for any owner of record for property (surface and subsurface) identified in table 1.3.1 and shown on the appropriate map identified in 1.3.3, not owned by the applicant, identifying the documents and legal rights claimed to enter and mine.

All properties identified in Table 1.3.4 that the applicant does not have a legal right to enter and begin mining operations shall require submission of a Property Ownership Waiver form for each property identified for the application to be considered administratively complete [see Operator Memorandum No. 2011-01] as an Attachment to Part 1.3.4.

Complete Table 1.3.4 Uncontrolled Interest Within Proposed Boundary.

1.4 Ownership and Control Information

1.4.1 Complete Table 1.4.1 to identify all owners/controllers of the applicant. Ownership or control is evidenced by:

- Being a permittee of a surface coal mining operation; or
- Based on instruments of ownership or voting securities, owning of record in excess of fifty (50) percent of an entity; or
- Having any other relationship which gives one person authority directly or indirectly to determine the manner in which an applicant, an operator, or other entity conducts surface coal mining operations

The following relationships are presumed to constitute ownership or control unless a person can demonstrate that the person subject to the presumption does not in fact have the authority directly or indirectly to determine the manner in which the relevant surface coal mining operation is conducted.

- Being an officer or director of an entity; or

- Being the operator of a surface coal mining operation; or
- Having the ability to commit the financial or real property assets or working resources of an entity;
- Being a general partner in a partnership; or
- Based on the instruments of ownership or the voting securities of a corporate entity, owning of record ten (10) through fifty (50) percent of the entity; or
- Owning or controlling coal to be mined by another person under a lease, sublease or other contract and having the right to receive such coal after mining or having authority to determine the manner in which that person or another person conducts a surface coal mining operation.

[1773.5, 1778.13(c)(1) to (c)(3)]

See Permit 375

1.4.2 If an owner/controller identified in Table 1.4.1 is or has been associated with a permitted surface coal mining and reclamation operation in the United States within the five (5) years preceding the date of the application, the applicant shall complete Table 1.4.2. **[1778.13(c)(4)]**

See Permit 375

1.4.3 For any other pending surface coal mining operation in any State in the United States filed by an owner/controller identified in Table 1.4.2, the applicant shall complete Table 1.4.3. **[1778.13(c)(5)]**

See Permit 375

1.4.4 For any surface coal mining operation (permitted or applied for) owned or controlled by the applicant, the applicant shall complete Table 1.4.4. **[1778.13(d)(1)]**

See Permit 375

1.5 Violation History

1.5.1 Has the applicant, any subsidiary, affiliate, or persons controlled by or under common control with the applicant, had Federal, State, or Tribal coal mining permit suspended or revoked in the last five (5) years preceding the date of submission of the application? **[1778.14(a)(1)]**

☐ Yes ☒ No

1.5.2 Has the applicant, any subsidiary, affiliate, or persons controlled by or under common control with the applicant, had forfeited a performance bond or similar security deposited in lieu of bond? **[1778.14(a)(2)]**

☐ Yes ☒ No

If YES to either Questions 1.5.1 or 1.5.2, the applicant shall complete Table 1.5 for any permit/company associated with permit suspension, revocation or bond forfeiture. **[1778.14(a) and (b)]**

1.5.3 The applicant shall complete Table 1.5.3 for all violations received by the applicant during the three (3) year period preceding the application date. **[1778.14(c)]**

See Permit 375

1.5.3A For any outstanding violation or violation under appeal listed in Table 1.5.3, the applicant shall provide supporting documentation showing good faith efforts from the issuing agency or appeals proceedings. **[1773.15(b), 1778.14(c)]**

Provide as an Attachment to Part 1.5.3A.

1.5.4 The applicant shall complete Table 1.5.4 for all violations received by surface coal mining operations owned/controlled by the applicant. **[1778.14(c)]**

See Permit 375

1.6 Affidavits, Certifications, Insurance Certificates, Newspaper Notice. The applicant shall attach the appropriate affidavits required for the type of operations proposed, a draft public notice, and a valid certificate of insurance.

1.6.1 Check and attach the completed documents for the proposed operations, if applicable:

	Underground Mining Affidavit
	Planned Subsidence Mitigation Right of Entry Affidavit
	Underground Slurry Disposal Affidavit
	Public Land Survey Monuments Certification
X	Engineering Certification
	Occupied Dwelling Buffer Zone Waiver

1.6.2 Attach a draft public notice and indicate below the name of the newspaper to publish the notice. **[1778.21].**

Marion Daily Republican

Provide draft public notice as an Attachment to Part 1.6.2.

1.6.3 The applicant shall provide proof of general liability insurance from an authorized provider (licensed to write from the Illinois Department of Insurance). If the certificate is intended to also cover liability in the event of subsidence-related damages, this should be clearly indicated on the certificate. **[1778.18, 1817.121(c)(3)]**

Provide certificate of insurance as an Attachment to Part 1.6.3. **See Permit 375**

ENGINEERING CERTIFICATION

I hereby certify the engineering design used in preparation of this application, attachments, and supplements were done by me or under my direct supervision.

I certify that I am familiar with all of the plans, specifications, reports, and maps submitted as part of this application and that said information is accurate.

I certify to the best of my knowledge all such design is in accordance with all applicable local, state and federal laws, rules and regulations.

I further certify that all applicable maps and/or drawings have been individually sealed in accordance with the Professional Engineering Act, 225 ILCS 325/15.

INDIVIDUAL P.E. CERTIFICATION

James Plumley
Name

IL 067610
Illinois Registration Number (Seal)

Williamson Energy, LLC
Firm

PO Box 99

Johnston City, IL 62951

Address



Signature

618-983-3020
Phone Number

1-18-18
Date

PROFESSIONAL DESIGN FIRM CERTIFICATION

Complete if applicable. If not, respond N/A.

_____ As an employee of a Professional Design Firm as defined by the Illinois Department of Financial and Professional Regulation, I certify that the professional design firm is registered and in good standing with the Illinois Department of Financial and Professional Regulation.

Professional Design Firm Name

Professional Design Firm Number

Attachment 1.6.2

PUBLIC NOTICE

Pursuant to the Surface Coal Mining Land Conservation and Reclamation Act (PA-81-1015, as amended) and the Rules and Regulations of the Act, Williamson Energy, LLC, P. O. Box 99, Johnston City, IL 62951, hereby gives notice that a request for a 19.9 acre Incidental Boundary Revision (IBR) was submitted to the Illinois Department of Natural Resources, Office of Mines and Minerals, Land Reclamation Division under the provisions of Section 1774.13 (d) (2 to complete a supply shaft to transport supplies underground as required for the continued effective operation of the approved mine plan, belt air shaft and fan to supply required ventilation along with six (6) steel cased boreholes with a diameter < 10 $^{5}/_{8}$ inches for power and other supplies, power substation, dry storage barn and equipment grave yard(6.8 acres).

The proposed permit area is described: 19.90 acres of the NW/4, SW/4 of Section 36 and Part of NE/4, SE/4 of Section 35 , Township 7S, R3E of the 3rd Principal Meridian, Franklin County, IL.

The physical location is on Davis Road and approximately 25 feet north of the Gunn Road intersection in Franklin County, Illinois.

The applicant will also be accessing the site from Davis Road at approximately 90 degree angle from Davis Road.

Copies of the application are on file for inspection at the following office, and written comments may be addressed to: Illinois Department of Natural Resources, Office of Mines & Minerals, Land Reclamation Div., One Natural Resources Way, Springfield, IL 62702-1271.

The closing date of the comment period for this IBR is seven (7) days from the date of this Public Notice.

Public Notice will be ran in the Marion Daily Republican.

TABLE 1.3.1
Property Interest Holders Within Permit Area

Name	Address	Type of Holder: Legal/Equitable/Leaseholder/Purchaser	Surface or Mineral Property	Parcel ID	Map ID Reference
Natural Resourve Partners LP	601 Jefferson Street, Houston, TX 77002	Legal	Mineral	All	All
Donald E. and Leilani S Grant	17712 Dean Road, Johnston City, IL 62591	Legal	Surface	12-36-300-002	12-36-300-002

R06750

TABLE 1.3.2
Property Interest Holders Contiguous to the Permit Area

Name	Address	Surface or Mineral Property	Parcel ID	Map ID Reference
Keith G and Diann R Browning Family Trust	11163 Roger Rd. West Frankfort, IL 62896	Surface	12-36-300-003	
Browning Brothers Trust No. 2004	16654 Neilson Road, West Frankfort, IL 62896	Surface	12-35-400-002	
Roger Mull	17368 Nielson Road, West Frankfort, IL 62896	Surface	12-36-300-013	
Melissa D Easley	2765 Melvin Rd, West Frankfort, IL 62896	Surface	12-36-300-014	
Donald L Fort	2009 E Cleveland, West Frankfort, IL 62896	Surface	12-36-300-015	
Ronald H Harkins	488 Davis Rd, Thompsonville, IL 62890	Surface	12-36-300-009	
Demerious J Harkins	488 Davis Rd, Thompsonville, IL 62890	Surface	12-36-300-010	
Todd Culp	424 Davis Rd, Thompsonville, IL 62890	Surface	12-36-300-011	
James L Gunn Jr	628 Davis Rd, Thompsonville, IL 62890	Surface	12-36-300-007	

Table 1.3.4
Uncontrolled Interests Within Proposed Boundary

Property Owner (Name)	Parcel ID	Map ID Reference	Type of Document	Date of Execution	Identification of the Specific Lands to which the Document Pertains	Explanation of the Legal Rights Claimed (including whether any rights are the subject of pending litigation)	Pending Litigation? Y/N	Check if no legal rights claimed.
N/A								

R06752

TABLE 1.4.1
Owners and Controllers of the Applicant

Name	Address	SSN (voluntary)/EIN	Ownership or Control Relationship to the Applicant/ Position- Title	Ownership Percentage	Location in Organizational Structure	Date Position Assumed	Termination Date
See Permit 375							

R06753

TABLE 1.4.2
Ownership and Control Information for Other Permitted U.S. Surface Coal Mining and Reclamation Operations

Owner/Entity from Table 1.4.1	Permittee/Company Name of Operation in U.S. Individual has been Associated with for the Previous 5 Years.	Position Title to Company	Company EIN	Federal or State Permit Number	State	Name of Regulatory Authority	MSHA Number with Date of Issuance
See Permit 375							

TABLE 1.4.3
Pending Permit Applications Associated with a Table 1.4.2 Operations of Owners and Controllers

Name of Owner/Controller from Table 1.4.2	Name of Applicant Company	Position Title	State	Name of Regulatory Authority	Permit Application Number or other Identifier	Date of Permit Application
See Permit 375						

TABLE 1.4.4
Surface Coal Mining Operations Owned or Controlled by the Applicant

Name of Surface Coal Mining Operation (Company)	Address	EIN	Applicant's Relationship to Company (Including Percentage of Ownership and Location in Organizational Structure)	State	Name of Regulatory Authority	Federal or Sate Permit Number	MSHA Number and Date of Issuance
See Permit 375							

R06756

TABLE 1.5
Revocation/Suspension and Forfeiture History

Enforcement				Permit Information					Appeal Information			
Entity/Permittee	Suspension, Revocation, or Bond Forfeiture	Date of Enforcement	Reason of Enforcement	Permit No.	State and Regulatory Authority	Permit Issue Date	Bond Amount (Forfeiture)	Current Status of Permit, Bond, or Similar Security Involved	Type of Appeal (Administrative, Judicial)	Date	Location of Proceeding	Status
See Permit 375												

R06757

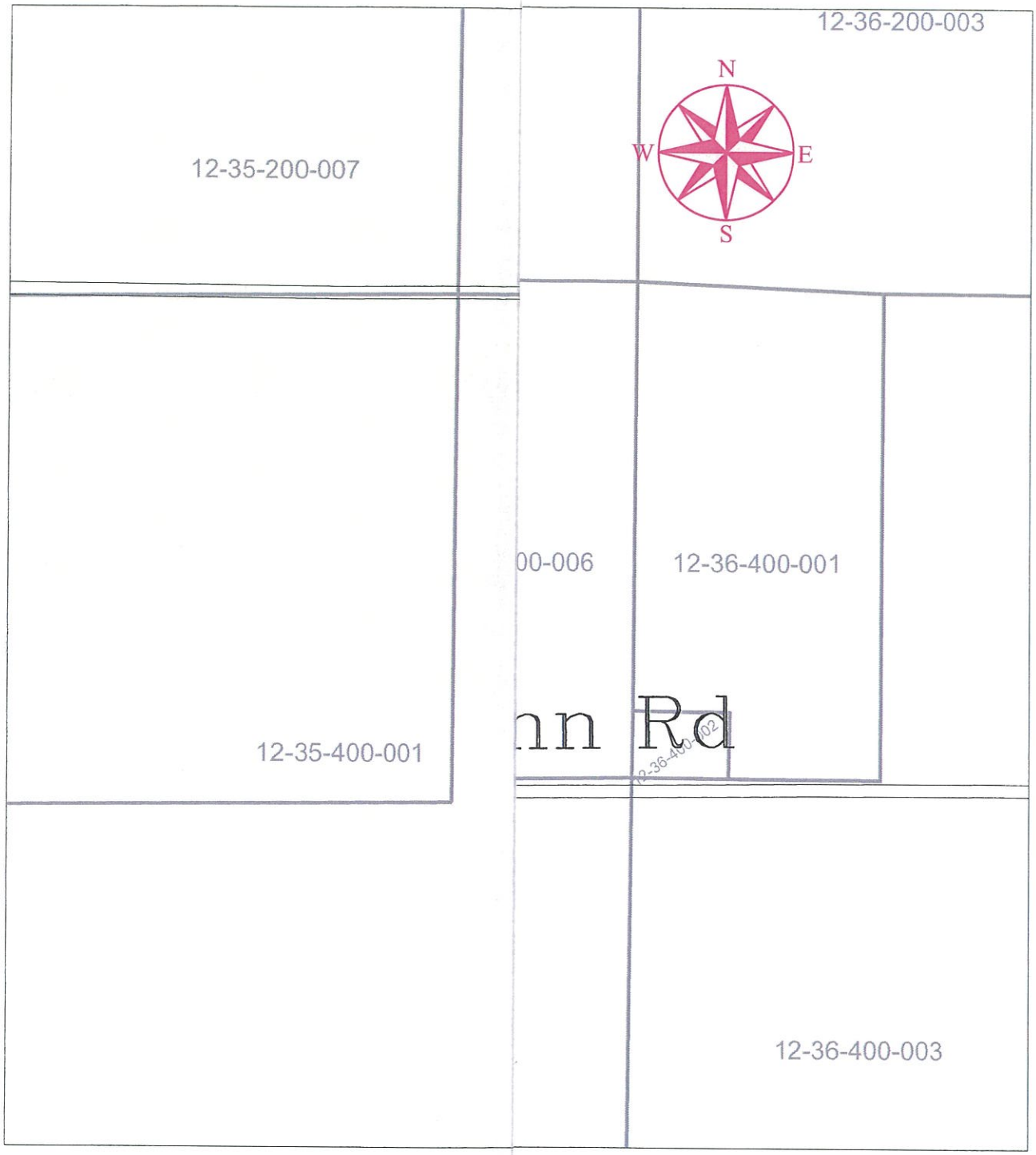
TABLE 1.5.3
List of Violations by Applicant the Past 3 Years

Issuing Agency	State and Permit No. or MSHA Number	State Violation No. or MSHA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
See Permit 375								

R06758

TABLE 1.5.4
Violation History for Surface Coal Mining Operations Owned/Controlled by Applicant

Issuing Agency	State and Permit No. or AISIA Number	State Violation No. or AISIA Violation No.	Issue Date	Name of Company or Person to Whom Violation Issued	Description of the Violation	Date, Location and Type of Administrative or Judicial Proceeding	Violation Status	Abatement Actions
See Permit 375								



Surface Ownership Map

North Supply Shaft IBR

Williamson Energy, LLC

Proposed Surface Permit Area	
Proposed Area to Be Disturbed	
Existing Surface Permit Area	
Public Road	
300.014, 12-36-300-002	Tract Information Including PIN #

Drawn By JLP	Date 7/24/17	ILLINOIS DEPARTMENT OF NATURAL RESOURCES PERMIT NO. 375
Approved By JLP	Date 12/17/17	Surface Ownership Map
Revised:		POND CREEK MINE NO. 1
		Prepared By WILLIAMSON ENERGY, LLC. P.O. BOX 99, JOHNSTON CITY, ILLINOIS 62951
Scale AS NOTED	Project No.	Rev. / Map # Map 2

MEMORANDUM OF REAL ESTATE LEASE

This Memorandum dated this 20th day of June, 2017, by and between Donald E. Grant and Leilani S. Grant, husband and wife, with a mailing address at 17712 Dean Road, Johnston City, Illinois 62951, hereinafter called "Lessor", and Williamson Energy, LLC, a Delaware Limited Liability Company, with a mailing address at P.O. Box 99, Johnston City, Illinois 62951 hereinafter called "Lessee".

KNOW ALL MEN BY THESE PRESENTS that Lessor and Lessee have entered into a Real Estate Lease of even date herewith concerning various interests in the surface only of the following described premises located in Franklin County, Illinois:

> The Center One-third of the North Three-Fourths of the West half of the Southwest Quarter of Section Thirty-six (36), Township Seven (7) South, Range Three (3) East of the Third P.M., and containing twenty (20) acres, more or less.
>
> PIN: 12-36-300-002

Lessor is the owner of the rights granted in said Lease.

Said Lease has an initial Fifteen (15) year term with the right to renew on a year to year basis.

All persons having reason to be concerned with the title as to the foregoing premises are hereby given notice of the existence of said Real Estate Lease and of the duty to inquire about its

terms and conditions with regard to the title to the foregoing premises. Inquiries may be made to Lessee at the address set forth above.

Dated the date set forth above.

Donald E. Grant

Donald E. Grant

Leilani S. Grant

Leilani S. Grant

WILLIAMSON ENERGY, LLC

By: _____

Lee M. Landon, Regional Land Manager

STATE OF ILLINOIS)

) SS

COUNTY OF)

I, the undersigned, a Notary Public, in and for said County, in the State aforesaid, do hereby certify that Donald E. Grant, personally known to me to be the same person whose name is subscribed to the foregoing instrument, appeared before me this day in person, and acknowledged that he signed, sealed, and delivered the said instrument as his free and voluntary act and deed, for the uses and purposes herein set forth, including the release and waiver of the right of homestead.

Given under my hand and seal this 20 day of June, 2017.

OFFICIAL SEAL
STACI R LOWRY
Notary Public - State of Illinois
My Commission Expires Jan 14, 2019

Notary Public

STATE OF ILLINOIS)

) SS

COUNTY OF)

I, the undersigned, a Notary Public, in and for said County, in the State aforesaid, do hereby certify that Leilani S. Grant, personally known to me to be the same person whose name is subscribed to the foregoing instrument, appeared before me this day in person, and acknowledged that she signed, sealed, and delivered the said instrument as her free and voluntary act and deed, for the uses and purposes herein set forth, including the release and waiver of the right of homestead.

Given under my hand and seal this 20 day of June, 2017.

OFFICIAL SEAL
STACI R LOWRY
Notary Public - State of Illinois
My Commission Expires Jan 14, 2019

Notary Public

STATE OF ILLINOIS)

) SS

COUNTY OF WILLIAMSON)

I, the undersigned Notary Public, in and for said County in the State aforesaid, do hereby certify that Lee M. Landon, Regional Land Manager personally known to me to be a duly authorized person of WILLIAMSON ENERGY, LLC, a Delaware Limited Liability Company, and personally known to me to be the same person whose name is subscribed to the foregoing instrument, appeared before me this day in person, and acknowledged that he signed, sealed and delivered the said instrument as such authorized person pursuant to authority given by the Members of said limited liability company, as his free and voluntary act, and as the free and voluntary act and deed of said Company, for the uses and purposes therein set forth.

Given under my hand and seal this 20 day of June, 2017.

Notary Public

Notary Public

PART 2: Pre-mining Information

2.1 Pre-mining Land Use Information

2.1.1 Pre-mining land use and capability acreages. Complete Table 2.1.1: Land Use Capability (Pre-mine) Summary giving the acreage and capability of each land use within the proposed permit area, employing only land use categories of 62 Ill. Adm. Code 1701.5, the "fish and wildlife" land use category must be subdivided per Operator Memorandum 2015-01, and as provided in Table 2.1.1. Use only these land uses for completing the land use maps. The information shall be broken down with a separate table for each landowner. **[1780.23/1784.15]**

Note: other agencies, such as USACE, may define land uses differently.

See Table 2.1.1

2.1.2 Provide slope measurements to represent existing land surface configuration of proposed permit area. A soils map of medium intensity prepared to NRCS specifications or a contoured aerial photo may be submitted to meet this requirement. **[1779.24/1783.24(l)]**

☒ Check here if using one of the above maps or photos.

Does the Soils Map submitted with the application meet the requirements to provide slope measurements?

☐ YES ☒ NO

If NO, provide a contoured aerial photo for the proposed boundary.

N/A

2.1.3 Has previous mining activity occurred within the permit and/or adjacent area? **[1816.133/1817.133]**

☒ YES ☐ NO

If YES, provide the following: **[1777.14(b); 1779.25(a)(8)/1783.25(a)(8)]**

a) Type of mining and the approximate date of extraction.

☐	Surface Mining	Approx. Dates:
X	Underground Mining	Approx. Dates: Ongoing

b) What coal seam or other minerals(s) were extracted?

Illinois 6 Seam

c) Delineate on the Pre-mining Land Use Map the areas disturbed by previous mining activities, including active, inactive or abandoned underground mine work along with any mine opening to the surface.

N/A

d) Identify, on the Pre-mining Land Use Map, areas where surface coal mining operations were conducted prior to August 3, 1977; after August 3, 1977 and prior to May 3, 1978; after May 3,

1978 and prior to February 1, 1983; and any permanent regulatory program permit issued after February 1, 1983. **[1777.14(b)]**

N/A

e) Identify the land uses preceding any type of mining, if known.

N/A

2.1.4 Is any of the permit area subject to local or county zoning?

☐ YES ☒ NO

If YES, provide a description of the existing land uses and land classifications under local law, if any, for the proposed permit and adjacent areas.

2.1.5 Provide the location of surface and subsurface man-made features within, passing through, or passing over the proposed permit area on the Pre-mining Land Use Map. Such features should include, but are not limited to, major electric transmission lines, pipelines, agricultural drainage tile fields, gas and oil wells, and water wells. For gas, oil, and water wells provide the depth, if available, of the well. **[1779.24(e)/1783.24(e)]**

See Operation Map

2.1.4 If any of the land uses changed within the last five (5) years, indicate the acreage and changes of land uses. **[1780.23(a)(1)/1784.15(a)(1)]**

N/A

2.2 Pre-mining Soils Information The applicant is strongly recommended to use the USDA Web Soil Survey. The web soil survey has the ability to create a Custom Soil Survey report for the application area which will generate many of the information requirements for pre-mining soils and prime farmland restoration plans which may reference this report. Please note there are extra soil data tables, including Land Classification, Non-irrigated Capability Class, and Vegetation Productivity, and the data from the Soil Property and Qualities tab which must specifically be extracted when creating a custom report.

NOTE: The acreage of the Area of Interest must agree with the permit acreage. This report may be referenced in responding to portions of the required soil information.

2.2.1 The narrative of land capability and productivity shall employ the USDA National Resources Conservation Service's Land-Capability Classification (Agriculture Handbook No. 210) in conjunction with the soil information provided under the published soil survey completing the Soil Information Chart in Part 2.2.9. Optimum levels management productivity information may be found in Bulletin 811. **[1779.21/1783.21].**

NOTE: This Bulletin has periodic updates in a supplemental table.

See Attached Soil Report 2.2.1

2.2.2 A Soils Map shall be provided as required by Part 2.2. Soil map scale must be the same scale as the Pre-mining Land Use Map and Post Mining Land Use/Capability Reclamation Map, unless otherwise approved by the Department. Does the submitted Soils Map represent a map developed by the National Resources Conservation Service (NRCS)? **[1779.21/1783.21]**

☒ YES ☐ NO

If YES, complete the following:

a) Has the NRCS soil map been modified in any way except by a change in scale?

☐ YES ☒ NO

If YES, explain the nature of the changes.

2.2.3 For surface mines, delineate on the Soils Map, the area which will incur actual mining (removal of overburden and/or deposition of overburden for the extraction of coal). You may identify any areas proposed to remain undisturbed. **[1780.14]**

For underground mines, you may identify any areas proposed to remain undisturbed. **[1784.23]**

N/A

2.2.4 Are any of the identified map units correlated as prime farmland by NRCS criteria?

☒ YES ☐ NO

If YES, explain and provide documentation to meet the requirements of **1785.17 or 1823.11**, if a request for grandfathering, negative determination or underground mine exemption is sought. If prime farmlands exist which will not meet the exemption criteria described above, a prime farmlands restoration plan must be provided in Parts 8.2 through 8.4. **[1785.17(b)/1823.11]**

N/A

2.2.5 Indicate the average topsoil thickness of each of the Soil Map units to be affected. Locate on Soils Map the test holes for soil horizon thickness sampling. Provide the average and methodology for determining the average pre-mining topsoil thickness in inches for: **[1779.21/1783.21]**

- Non-cropland capability _____ inches
- High capability _____ inches
- Prime Farmland ~8 inches

2.2.6 List the soil types and acreages of areas that will require the B and/or portions of the C horizon to be removed and replaced in order to establish the root medium necessary to achieve soil productivity consistent with the proposed post-mining land use. Alternatively, a narrative description explaining why specific soil type acres information for reclamation plan achievement is not necessary may be provided. **[1780.18(b)(4)/1784.13(b)(4)]**

N/A

2.2.7 Are selected overburden materials proposed to be used in lieu of or as a supplement to the A-horizon?

☐ YES ☒ NO

If YES, provide the appropriate information required by Part 2.2.9. **[1779.21(b)/1783.21(b)].**

N/A

Also, **identify** the source of the substitute materials and the topsoil to be substituted away from (not removed) on a separate soils map, labeled Topsoil Substitution Map and/or describe the area in narrative form. **[1780.14/1784.23]**

N/A

2.2.8 Explain why the proposed plan will provide the best available material of equal or better quality than present topsoil or surface existing material. **[1816.22(b)/1817.22(b)].** This section must be addressed when affecting previously disturbed areas if the surface soil is not to be salvaged. If topsoil substitutes or supplements are proposed, a demonstration of their suitability shall be required based on analysis of thickness of soil horizons, total depth, texture, percent coarse fragments, pH, and aerial extent of the different kinds of soils. The Department shall require other chemical and physical analyses, field-site trials, or greenhouse tests if determined to be necessary or desirable to demonstrate the stability of the topsoil substitutes or supplements. **[1780.18(b)(4)/1784.13(b)(4)]; [1779.21/1783.21]**

N/A

2.2.9 Complete Table 2.2.9: Soils Information Chart acreage for each of the map units (soil type and slope classification) of prime farmland, high capability (include grandfathered and negatively determined prime farmland) and non-cropland capability land with respect to areas within the permit area. All soils previously disturbed by home sites, farmsteads, roads, etc., shall be tabulated as non-cropland capability and need not undergo a negative determination. The Soil Information Chart must be broken out by land owner, if there is more than one. **[1779.21(a)/1783.21(a)]; [1785.17]**

See Table 2.2.9

Optional-addition: If applicable, quantify map units acreage values on Table 2.2.9: Soils Information Chart for areas which will not be disturbed. **[1779.21(a)/1783.21(a)]**

2.3 Areas Where Mining is Limited or Prohibited

2.3.1 Does the proposed permit area include areas designated unsuitable for surface coal mining and reclamation operations, or under study for designation in an administrative proceedings as unsuitable for surface coal mining and reclamation operations? **[1773.15(c)(3)]**

☐ YES ☒ NO

If YES, identify these areas on the Pre-mining Land Use and Operations Map.

2.3.2 Does the proposed permit area include lands within boundaries of the National Park System, National Wildlife Refuge System, the National System of Trails, the National Wilderness Preservation System, the Wild and Scenic Rivers System, and National Recreation Areas, etc.? **[1761.11(a)]**

☐ YES ☒ NO

If YES, identify these areas on the Pre-mining Land Use and Operations Map.

2.3.3 Does the proposed permit area include lands within the boundaries of any national forest? **[1761.11(b)]**

☐ YES ☒ NO

If YES, identify these areas on the Pre-mining Land Use and Operations Map.

2.3.4 Are there any publicly owned parks or any places included in the National Register of Historic Places on or within 1,000 feet of the proposed permit area? **[1761.11(c)]**

☐ YES ☒ NO

If YES, identify these areas on the Pre-mining Land Use and Operations Map.

2.3.5 Does the operations plan propose any surface coal mining operations within 100 feet measured horizontally of the outside right-of-way line of any public road? **[1761.11(d)]**

☐ YES ☒ NO

If YES, complete the following:

a) Describe the measures to be used to insure that the interest of the affected public and landowners will be protected. **[1761.11(d)(2)(B)]**

b) In the public notice of the application required in Section 1.6.2, identify the public road(s), describe the activities to be conducted within 100 feet of the road(s), and indicate the opportunity for a public hearing on this matter. **[1761.11(d)(2)(A)]**

2.3.6 Does the proposed permit area include any public roads which are to be removed, relocated or closed? **[1761.14]**

☐ YES ☒ NO

If YES, complete the following:

a) Submit the necessary approvals of the authority with jurisdiction over the public road. **[1761.14(b)(2)]**

b) If a public road is to be replaced or re-located within the permit area, provide evidence that a bond has or will be posted with the authority with jurisdiction over the public road. If such bond has not been nor will be posted, address road replacement costs in Table 11.5.1.14.

c) Describe the measures to be used to insure that the interest of the affected public and landowners will be protected. **[1761.14(b)(5)]**

d) In the public notice of the application required in Part 1.6.2, identify the public road(s) to be removed, relocated or closed, and indicate the opportunity for a public hearing on this matter. **[1761.14(b)(3) and (4)]**

2.3.7 Does the operations plan propose any surface coal mining operations within 300 feet measured horizontally from any occupied dwelling other than a haul road or access road which connects with an existing public road on the side of the public road opposite the dwelling? **[1761.11(e)]**

☐ YES ☒ NO

If YES, include a waiver from the owner of the dwelling meeting the following requirements: **[1761.15]**

- The waiver shall be by lease, deed, or other conveyance from the owner of the dwelling. The waiver must clarify that the owner and signator had the legal right to deny mining and knowingly waived that right.
- Provide proof that the waiver has been properly filed in public property records pursuant to State laws.

NOTE: If a valid waiver was obtained before August 3, 1977 from the owner of an occupied dwelling to conduct operations within 300 feet of the dwelling, a new waiver need not be obtained. [1761.15(c)]

2.3.8 Does the operations plan propose any surface coal mining operations within 300 feet measured horizontally of any public building, school, church, community or institutional building or public park? **[62 Ill. Adm. Code 1761.11(f)]**

☐ YES ☒ NO

2.3.9 Are there any public or private cemeteries or Indian burial grounds or other areas where human bodies are interred located in or within one hundred (100) feet of the proposed permit area? **[62 Ill. Adm. Code 1761.11(g)]**

☐ YES ☒ NO

If YES, locate on the Pre-mining Land Use Map, Operations Map and Post Mining Land Use/Capability Reclamation Plan Map the boundaries of the above-referenced areas and indicate a 100 foot buffer zone around the cemetery or burial ground. **[1779.24(j)/1783.24(j)]**

2.3.10 Are valid existing rights claimed for any part of the permit area? **[1761.5; 1761.16]**

☐ YES ☒ NO

If YES, complete Part 2.6, 2.7, or 2.8 to substantiate the claim.

2.4 Public Parks, Historic Properties

2.4.1 Provide a description of the historic properties (archeological sites and/or historic standing structures) listed or potentially eligible for listing on the National Register of Historic Places and any known archeological features within the proposed permit and adjacent areas. The description of the historic properties occurring within the permit area and adjacent areas shall be based upon available data. If studies have been completed and submitted for review prior to this application, attach a copy of the results of that review. For significant revisions other than shadow area revisions, attach a copy of the IHPA review. **[1779.12/1783.12]**

N/A

2.4.2 If investigations are underway or under review, reference the current status. **[1779.12(b)/1783.12(b)]**

NOTE: Studies which are submitted to the Department shall be submitted as a separate document (3 hard copies, plus one on disk in pdf format or other format as directed by the Department)

N/A

2.4.3 If historic properties are to be avoided, provide a map showing their location in lieu of either a Phase I evaluation or a Phase II evaluation. A qualified archaeologist shall create the map and identifying field markings to be employed to ensure the site(s) will not be disturbed by surface coal mining and reclamation operations. The map is to be submitted in duplicate in separate cover from the rest of the application and labeled Historic Properties Protection Map. The Department will hold the map as a confidential document. If a revision proposes a disturbance not previously identified, identify its location to any avoidance area. **[1773.13(d)(3)].**

N/A

2.4.4 Is this an underground mine with planned subsidence?

☐ YES ☒ NO

If YES, provide photos and a Shadow Area Structure Photo Reference Map with information on structures within the angle of draw of planned subsidence operations. **[1784.20(b)(8)]**

2.4.5 Provide a plan for publicly owned park(s), or place(s) listed on the National Register of Historic Places, that may be adversely affected by the proposed operation describing the measures to be employed: **[1780.31/1784.17]**

- To prevent adverse impacts caused by surface mining related activities including, but not limited to, loss or destruction of historic properties; or
- If valid existing rights exist or joint agency approval is to be obtained under 62 Ill. Adm. Code 1761.17(d), to minimize adverse impacts. If valid existing rights are to be claimed, complete Sections 2.5 or 2.6 of this application, whichever is applicable.

N/A

2.5 Valid Existing Rights (VER) Good Faith/All Permits Standard. [1761.16(b)(2)]

The applicant must provide a property rights demonstration under 62 Ill. Adm. Code 1761.5(a) if the applicant's request for VER is based upon the good faith/all permits standard in Section 1761.5(b)(1). This demonstration must include the following items: **[1761.16(b)]**

2.5.1 A legal description of the land to which the request pertains.

N/A

2.5.2 Complete documentation of the character and extent of the current interests in the surface and mineral estates of the land to which the request pertains.

N/A

2.5.3 A complete chain of title for the surface and mineral estates of the land to which the request pertains.

N/A

2.5.4 A description of the nature and effect of each title instrument that forms the basis for the request, including any provision pertaining to the type of method of mining or mining-related surface disturbances and facilities.

N/A

2.5.5 A description of the type and extent of surface coal mining operations that the applicant or permittee claims the right to conduct, including the method of mining and mining-related surface activities and facilities, and an explanation of how those operations would be consistent with State property law.

N/A

2.5.6 Complete documentation of the nature and ownership, as of the date that the land came under the protection of 62 Ill. Adm. Code 1761.11, of all property rights for the surface and mineral estates of the land to which the request pertains.

N/A

2.5.7 Names and addresses of the current owners of the surface and mineral estates of the land to which the request pertains.

N/A

2.5.8 If the coal interests have been severed from other property interests, documentation that the owners of other property interests in the land to which the request pertains have been notified and provided a minimum of 14 days to comment on the validity of the applicant or permittee's property rights claims.

N/A

2.5.9 Provide any comments received in response to the notification provided under Part 2.5.8. above.

N/A

2.5.10 Approval and issuance dates and identification numbers for any permits, licenses, and authorizations that the applicant, permittee or a predecessor in interest obtained before the land came under the protection of 62 Ill. Adm. Code 1761.11.

N/A

2.5.11 Application dates and identification numbers for any permits, licenses, and authorizations for which the applicant, permittee or a predecessor in interest submitted an application before the land came under the protection of 62 Ill. Adm. Code 1761.11.

N/A

2.5.12 An explanation of any other good faith effort that the applicant, permittee or a predecessor in interest made to obtain the necessary permits, licenses, and authorizations as of the date that the land came under the protection of 62 Ill. Adm. Code 1761.11.

N/A

2.6 Valid Existing Rights (VER) Needed for and Adjacent Standard. [1761.16(b)(3)]

The applicant must provide a property rights demonstration under 62 Ill. Adm. Code 1761.5(a) if the applicant's request for VER is based upon the good faith/all permits standard in Section 1761.5(b)(1). This demonstration must include the following items: **[1761.16(b)]**

2.6.1 A legal description of the land to which the request pertains.

N/A

2.6.2 Complete documentation of the character and extent of the current interests in the surface and mineral estates of the land to which the request pertains.

N/A

2.6.3 A complete chain of title for the surface and mineral estates of the land to which the request pertains.

N/A

2.6.4 A description of the nature and effect of each title instrument that forms the basis for the request, including any provision pertaining to the type of method of mining or mining-related surface disturbances and facilities.

N/A

2.6.5 A description of the type and extent of surface coal mining operations that the applicant or permittee claims the right to conduct, including the method of mining and mining-related surface activities and facilities, and an explanation of how those operations would be consistent with State property law.

N/A

2.6.6 Complete documentation of the nature and ownership, as of the date that the land came under the protection of 62 Ill. Adm. Code 1761.11, of all property rights for the surface and mineral estates of the land to which the request pertains.

N/A

2.6.7 Names and addresses of the current owners of the surface and mineral estates of the land to which the request pertains.

N/A

2.6.8 If the coal interests have been severed from other property interests, documentation that the owners of other property interests in the land to which the request pertains have been notified and provided a minimum of 14 days to comment on the validity of the applicant or permittee's property rights claims.

N/A

2.6.9 Provide any comments received in response to the notification provided under Part 2.6.8 above.

N/A

2.6.10 Explain how and why the land is needed for and immediately adjacent to the operation upon which the request is based. This explanation shall include a demonstration that prohibiting expansion of the operation onto that land would unfairly impact the viability of the operation as originally planned before the land came under the protection of 62 Ill. Adm. Code 1761.11.

N/A

2.7 Valid Existing Rights (VER) Standards for Mine Roads. [1761.16(b)(4)]

If the request relies upon one of the standards for roads in 62 Ill. Adm. Code 1761.5(c)(1) through (c)(4), satisfactory documentation of one or more of the following must be submitted showing that: **[1761.5(c)]**

2.7.1 The road existed when the land upon which it is located came under the protection of 62 Ill. Adm. Code 1761.11, and the applicant has a legal right to use the road for surface coal mining operations.

N/A

2.7.2 A properly recorded right of way or easement for a road in that location existed when the land came under the protection of 62 Ill. Adm. Code 1761.11, and, under the document creating the right-of-way or easement, and under any subsequent conveyances, the applicant has a legal right to use or construct a road across that right of way or easement to conduct surface coal mining operations.

N/A

2.7.3 A valid permit for use or construction of a road in that location for surface coal mining operations existed when the land came under the protection of 62 Ill. Adm. Code 1761.11.

N/A

2.7.4 Valid existing rights exist under 62 Ill. Adm. Code 1761.5(a) and (b).

N/A

Table 2.1.1
Land Use Capability (Pre-Mining) Summary

SURFACE OWNER	DISTURB CATEGORY	LAND CAPABILITY	PRE-MINE LAND USE ACREAGE															Subtotal
			Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation	Public Roads	Cemetery	Other	
Donald E. and Leilani S Grant	Mining Area	Prime	5.7															5.7
		Neg. Det.				0.1												0.1
		High Cap.	3.2															3.2
		Limited Capability																0.0
		Subtotal	8.8	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9
	Unaffected (Optional)	Prime	3.1															3.1
		Neg. Det.				0.0												0.0
		High Cap.	7.5			0.4												7.8
		Limited Capability																0.0
		Subtotal	10.6	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0
	Total Area	Prime	8.8															8.8
		Neg. Det.				0.1												0.1
		High Cap.	10.6			0.4												11.0
		Limited Capability																0.0
		Subtotal	19.4	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.9

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Table 2.2.9
Soils Information Chart

SURFACE OWNER	SOIL IDENTIFICATION					MINING OR DISTURBANCE AREA				UNAFFECTED (OPTIONAL)				
						Prime Soils		NonPrime Soils		Prime Soils		NonPrime Soils		
	Soil Map Symbol	Soil Name	Slope [%]	Capability Class	Productivity Index (optimum)*	Prime Farmland [acres]	Neg Det PFL [acres]	High Capability [acres]	Limited Capability [acres]	Prime Farmland [acres]	Neg Det PFL [acres]	High Capability [acres]	Limited Capability [acres]	TOTALS [acres]
	376A	Cisne Silt Loam	0 to 2%	3w	109	2.5				1.6				4.1
Donald E. and Leilani S Grant	639A	Wynoose silt loam	0 to 2%	3w	95			3.2				7.8		11.0
	3108A	Bonnie silt loam	0 to 2%	3w	111		0.1				0.0			0.1
	3382A	Belknap silt loam	0 to 2%	3w	117	3.2				1.6				4.7
														0.0
														0.0
														0.0
														0.0
														0.0
														0.0
														0.0
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														0.0
														0.0
														0.0
														0.0
														0.0
														0.0
														0.0
					TOTALS:	5.7	0.1	3.2	0.0	3.1	0.0	7.8	0.0	19.9

*** Bulletin 811 (adjusted for slope and erosion)**

Information required under 1785.17, 1823,1779.21 and/or 1783.21

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Soil Types within Proposed Permit Bounda			
Type	Disturbed	Undisturbed	Prim
3382A	3.18	1.57	
376A	2.39	1.56	
639A	3.27	7.84	
3108A	0.06	0.03	
Total	8.90	11.00	

Legend

Proposed IBR Boundary

Area Disturbed

Soil Type



Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951

Soils Map

Revisions

No	Date	By	No	Date	By
1			6		
2			7		
3			8		
4			9		
5			10		

File Location:

Drawn By: JLP
Checked By: JLP
Approved By: JLP
Date: 12/17/17
Scale: 1"=200'
Drawing #: North Supply Shaft Soil Map

Soils Map

N
W
E
S

Scale 1"=200'

0
400'
800'

Attachment 2.2.1

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Franklin County, Illinois

North Portal 7-27-17



July 27, 2017

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.



Map Scale: 1:2,220 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 30 60 120 180

Feet: 0 100 200 400 600

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

R06786

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Franklin County, Illinois
Survey Area Data: Version 10, Sep 16, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 13, 2011—Oct 21, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

R06787

Map Unit Legend (North Supply Shaft)

Franklin County, Illinois (IL055)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
376A	Cisne silt loam, bench, 0 to 2 percent slopes	4.1	20.7%
639A	Wynoose silt loam, bench, 0 to 2 percent slopes	11.0	55.4%
3108A	Bonnie silt loam, 0 to 2 percent slopes, frequently flooded	0.1	0.4%
3382A	Belknap silt loam, 0 to 2 percent slopes, frequently flooded	4.7	23.5%
Totals for Area of Interest		19.9	100.0%

Map Unit Descriptions (North Supply Shaft)

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Franklin County, Illinois

376A—Cisne silt loam, bench, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2snm6
Elevation: 360 to 840 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 175 to 195 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Cisne, bench, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cisne, Bench

Setting

Landform: Structural benches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Peoria silty loess over roxana silty loess

Typical profile

Ap - 0 to 8 inches: silt loam
E - 8 to 17 inches: silt loam
Bt1 - 17 to 37 inches: silty clay loam
2Bt2 - 37 to 60 inches: silty clay loam
2C - 60 to 79 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: 15 to 23 inches to abrupt textural change
Natural drainage class: Poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.02 to 0.20 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 13.0
Available water storage in profile: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Hydric soil rating: Yes

Minor Components

Hoyleton, bench

Percent of map unit: 10 percent
Landform: Structural benches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

639A—Wynoose silt loam, bench, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2t95n
Elevation: 360 to 840 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 53 to 58 degrees F
Frost-free period: 175 to 195 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Wynoose, bench, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Wynoose, Bench

Setting

Landform: Structural benches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess over mixed loess and drift over ablation till

Typical profile

Ap - 0 to 7 inches: silt loam
Eg - 7 to 19 inches: silt loam
Btg - 19 to 36 inches: silty clay
2Btg - 36 to 66 inches: silty clay loam
3Btgb - 66 to 79 inches: silty clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: 13 to 24 inches to abrupt textural change
Natural drainage class: Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.02 to 0.20 in/hr)

Depth to water table: About 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 12.0
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Hydric soil rating: Yes

Minor Components

Bluford, bench

Percent of map unit: 10 percent
Landform: Structural benches
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

3108A—Bonnie silt loam, 0 to 2 percent slopes, frequently flooded

Map Unit Setting

National map unit symbol: 2tbrr
Elevation: 330 to 490 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 175 to 195 days
Farmland classification: Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season

Map Unit Composition

Bonnie, frequently flooded, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bonnie, Frequently Flooded

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

Ap - 0 to 10 inches: silt loam
Cg1 - 10 to 27 inches: silt loam
Cg2 - 27 to 79 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Frequent
Frequency of ponding: Frequent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very high (about 12.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Hydric soil rating: Yes

Minor Components

Belknap

Percent of map unit: 10 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

3382A—Belknap silt loam, 0 to 2 percent slopes, frequently flooded

Map Unit Setting

National map unit symbol: 2tbrv
Elevation: 330 to 490 feet
Mean annual precipitation: 35 to 46 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 175 to 200 days
Farmland classification: Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season

Map Unit Composition

Belknap, frequently flooded, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Belknap, Frequently Flooded

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Silty alluvium

Typical profile

Ap - 0 to 7 inches: silt loam
Bw - 7 to 59 inches: silt loam
Bg - 59 to 79 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: About 6 to 24 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very high (about 12.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: B/D
Hydric soil rating: No

Minor Components

Bonnie, frequently flooded

Percent of map unit: 5 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Piopolis, frequently flooded

Percent of map unit: 5 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Land Classifications

This folder contains a collection of tabular reports that present a variety of soil groupings. The reports (tables) include all selected map units and components for each map unit. Land classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Prime and other Important Farmlands (North Supply Shaft)

This table lists the map units in the survey area that are considered important farmlands. Important farmlands consist of prime farmland, unique farmland, and farmland of statewide or local importance. This list does not constitute a recommendation for a particular land use.

In an effort to identify the extent and location of important farmlands, the Natural Resources Conservation Service, in cooperation with other interested Federal, State, and local government organizations, has inventoried land that can be used for the production of the Nation's food supply.

Prime farmland is of major importance in meeting the Nation's short- and long-range needs for food and fiber. Because the supply of high-quality farmland is limited, the U.S. Department of Agriculture recognizes that responsible levels of government, as well as individuals, should encourage and facilitate the wise use of our Nation's prime farmland.

Prime farmland, as defined by the U.S. Department of Agriculture, is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. It could be cultivated land, pastureland, forestland, or other land, but it is not urban or built-up land or water areas. The soil quality, growing season, and moisture supply are those needed for the soil to economically produce sustained high yields of crops when proper management, including water management, and acceptable farming methods are applied. In general, prime farmland has an adequate and dependable supply of moisture from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, an acceptable salt and sodium content, and few or no rocks. The water supply is dependable and of adequate quality. Prime farmland is permeable to water and air. It is not excessively erodible or saturated with water for long periods, and it either is not frequently flooded during the growing season or is protected from flooding. Slope ranges mainly from 0 to 6 percent. More detailed information about the criteria for prime farmland is available at the local office of the Natural Resources Conservation Service.

For some of the soils identified in the table as prime farmland, measures that overcome a hazard or limitation, such as flooding, wetness, and droughtiness, are needed. Onsite evaluation is needed to determine whether or not the hazard or limitation has been overcome by corrective measures.

A recent trend in land use in some areas has been the loss of some prime farmland to industrial and urban uses. The loss of prime farmland to other uses puts pressure on marginal lands, which generally are more erodible, droughty, and less productive and cannot be easily cultivated.

Unique farmland is land other than prime farmland that is used for the production of specific high-value food and fiber crops, such as citrus, tree nuts, olives, cranberries, and other fruits and vegetables. It has the special combination of soil quality, growing season, moisture supply, temperature, humidity, air drainage, elevation, and aspect needed for the soil to economically produce sustainable high yields of these crops when properly managed. The water supply is dependable and of adequate quality. Nearness to markets is an additional consideration. Unique farmland is not based on national criteria. It commonly is in areas where there is a special microclimate, such as the wine country in California.

In some areas, land that does not meet the criteria for prime or unique farmland is considered to be *farmland of statewide importance* for the production of food, feed, fiber, forage, and oilseed crops. The criteria for defining and delineating farmland of statewide importance are determined by the appropriate State agencies. Generally, this land includes areas of soils that nearly meet the requirements for prime farmland and that economically produce high yields of crops when treated and managed according to acceptable farming methods. Some areas may produce as high a yield as prime farmland if conditions are favorable. Farmland of statewide importance may include tracts of land that have been designated for agriculture by State law.

In some areas that are not identified as having national or statewide importance, land is considered to be *farmland of local importance* for the production of food, feed, fiber, forage, and oilseed crops. This farmland is identified by the appropriate local agencies. Farmland of local importance may include tracts of land that have been designated for agriculture by local ordinance.

Report—Prime and other Important Farmlands (North Supply Shaft)

Prime and other Important Farmlands–Franklin County, Illinois		
Map Symbol	**Map Unit Name**	**Farmland Classification**
376A	Cisne silt loam, bench, 0 to 2 percent slopes	Prime farmland if drained
639A	Wynoose silt loam, bench, 0 to 2 percent slopes	Farmland of statewide importance
3108A	Bonnie silt loam, 0 to 2 percent slopes, frequently flooded	Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
3382A	Belknap silt loam, 0 to 2 percent slopes, frequently flooded	Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

PART 3: Mining Operations Plan

3.1 Mining Operations Plan

3.1.1 Describe the type and method of mining procedures and proposed engineering techniques to be employed in the operation of the proposed mine. Describe the major equipment to be employed and how such equipment will be used in the different aspects of the mining operation. Provide an estimation of the anticipated annual coal production and anticipated total coal production by tonnage once the mine is at full operational capacity. **[1780.11(a)/1784.11(a)]**

Excavator and trucks, dozer, scraper, and rotary drill

3.1.2 Describe the proposed mining operations plan for the permit area in terms of the mining sequence, the employment of facilities, establishment and maintenance of erosion control facilities, air pollution control facilities, coal storage, cleaning and loading areas, location and placement of topsoil, spoil, coal waste, or other storage facilities. This description shall include the following: **[1780.11(b)/1784.11(b)]**

The proposed operation is construction of a graved access road containing two CMP (12" and 18") to allow off site drainage to pass under access road. Construction of various concrete pad ((1) 20'x5'x4", (2) 40'x50'x1.5', (1) 40'x20'x1.5') will be completed to support a belt air fan, material shaft collar, emergency man hoist, mine power substation. Various holes and shafts will be drilled including 16.5' concrete lined material shaft (raise bored), 8' finished concrete belt air shaft (raise bored), (six) 10 5/8 steel lined full grouted holes for power supply, compressed air and material supply/utility holes to the mine. All shaft and holes will be ~490 feet deep and will be vertical raise bores. There will be ~three drill pits required for drilling these boreholes. The pits will be approximately 10'x10'x10'. Each pit will be reclaimed after the completion of the drill the respective holes. A three sided dry barn storage building (pole barn structure 50'x100') will be constructed with a gravel floor. The remaining 6.8 acre graveled area will serve as a supply yard for mine supplies. If buried utility lines (powerline, control line, air lines, and/or public water line) necessary, they will be buried at least four feet.

a) How each type of overburden (soil horizons, glacial drift and consolidated material) will be handled with regards to different types of mining equipment. If toxic materials have been identified as occurring in the overburden, describe how these materials will be handled to insure proper disposal. **[1780.11(b)/1784.11(b)]; [1780.18(b)(7)/1784.13(b)(7)]**

Topsoil and subsoil will be store separately

b) Measures to be employed to prevent or minimize exposure of soil stockpiles to excessive water and wind erosion, unnecessary compaction and contamination by undesirable materials. **[1780.11(b)(2)/1784.11(b)(2)]**

Silt fence will be used around entire IBR, soil stockpile will be seed during the first planting season with approve seed mix from permit 375

c) Describe methods and treatment measures to be used on exposed areas where topsoil has been removed to prevent excess air and water pollution. **[1816.95/1817.95]**

Area will be gravel with durable rock or have lime stabilization completed to prevent excess air and water pollution.

3.1.3 Locate all soil horizon storage areas and/or root medium stockpiles on the Operations Map. Identify each storage area as to its content. **[1780.14(b)(5)/1784.23(b)(5)]**

See Operation Map

3.1.4 Provide a plan for topsoil, subsoil and/or substitute materials removal, storage and redistribution. **[1780.18(b)(4)/1784.13(b)(4)]**

See Operation Map

3.1.5 The Operations Map and plans shall show the lands proposed to be affected within the proposed permit by the operation, according to the sequence of mining and reclamation and any change in a facility or feature to be caused by the proposed operations if the facility or feature was shown in response to the General Mapping Requirements for the Operations Map. **[1780.14(b)(2)/1784.23(b)(2)]**

See Operation Map

3.1.6 For surface mines, locate all areas where lateral support removal will approach the minimum distance allowed. State the minimum width of lateral support to be left in appropriate areas, including adjacent landowners, road right-of-ways, pipelines and power line easements. Be sure to account for highwall sloping when such slopes are to be incorporated into the proposed reclamation plan. **[1816.99]**

N/A

3.1.7 Disposal of Non-coal Mine Wastes. Concerning non-coal waste, describe measures to be employed to ensure that all debris, acid-forming and toxic-forming materials, and materials constituting a fire hazard are disposed of in accordance with 62 Ill. Adm. Code 1816.89/1817.89 and 1816.102(f)/1817.102(f). Provide a description of contingency plans which have been developed to preclude sustained combustion of such materials.

See Permit 375

3.1.8 If surface mining activities are to be conducted within 500 feet of an underground mine describe the measures to be employed to comply with the requirements of 62 Ill. Adm. Code 1816.79 of the regulations. **[1780.27]**

N/A

3.2 Transportation Facilities

3.2.1 Which, if any of the following facilities, are to be constructed, used, or maintained within the proposed permit area?

- ☒ Road *(identify in space below)*
- ☐ Conveyor *(identify in space below)*
- ☐ Rail System *(identify in space below)*

For transportation facilities identified above, provide a detailed description of each; include the following:

a) Specifications for each road width, road gradient, road surface, road cut, fill embankment, culvert, bridge, drainage ditch, and drainage structure; **[1780.37(a)(1)/1784.24(a)(1)]**

See Road Profile Drawing. Access road only have two culvert pipes (12" and 18") installed.

b) A report of appropriate geotechnical analysis, where the Department's approval is required for alternative specifications, or for steep cut slopes under 62 Ill. Adm. Code 1816.150/1817.150; **[1780.37(a)(2)/1784.24(a)(2)]**

N/A

c) A description of measures to be taken to obtain the Department's approval for alteration or relocation of a natural drainageway under 62 Ill. Adm. Code 1816.150/1817.150; **[1780.37(a)(3)/1784.24(a)(3)]**

N/A

d) A description of measures, other than use of a rock headwall, to be taken to protect the inlet end of a ditch relief culvert, for approval by the Department under 62 Ill. Adm. Code 1816/1817.150; **[1780.37(a)(4)/1784.24(a)(4)]**

N/A

e) The drawings and specifications for each proposed ford of a perennial or intermittent stream that is used as a temporary route, as necessary for approval of the ford by the Department in accordance with 62 Ill. Adm. Code 1816.151(c)(2)/1817.151(c)(2); **[1780.37(a)(5)/1784.24(a)(5)]**

N/A

f) A general description of each road, conveyor, or rail system to be constructed, used, or maintained within the proposed permit area: **[1780.37(a)(6)/1784.24(a)(6)]**

Road will be covered with a durable rock surface.

g) A description of the plans to remove and reclaim each road that will not be retained under an approved post-mining land use, and the schedule for this removal and reclamation. **[1780.37(a)(7)/1784.24(a)(7)]**

All durable rock will be recovered and used at other location or for filling adjacent shafts. All road culverts will be removed and properly disposed of offsite. Topsoil will be spread evenly over the entire road surface to comply with the post-mine land used of cropland.

h) A discussion of the removal/construction/or relocation of powerlines related to transportation facilities and structures associated with roads **[1780.11(b)(3)]**

All powerlines will be reclaimed from property by removing the power poles. All power poles will be properly disposed of offsite.

3.2.2 For roads identified in Part 3.2.1, please indicate the classification in accordance with 62 Ill. Adm. Code 1816.150/1817.150 below: [*Primary or Ancillary*]

Road Identification	Road Classification
Entrance Road	Ancillary
	Choose Type

	Choose Type
	Choose Type
	Choose Type
	Choose Type
	Choose Type
	Choose Type

3.2.3 Transportation facilities shall be located on the Operations Map. Provide specification and plan-profiles of existing grade line, proposed road centerline, ditch flow lines, road cut, fill embankment, culvert, bridge and drainage structures, and typical cross sections. **[1780.37/1784.24]**

See road profile drawing

3.2.4 If any roads identified in Part 3.2.2 are classified as primary, the following requirements shall be met:

a) Each primary road shall be designed and constructed in accordance with **1816.151/1817.151**. Provide a summary of the design criteria used for each primary road proposed in the area below this item. Additional design calculations and/or drawings shall be included.

b) **Primary Road Certification.** The plans and drawings for each primary road shall be prepared by, or under the direction of, and certified by a qualified registered professional engineer as meeting the requirements of 62 Ill. Adm. Code 1816.150/1817.150 and 1816.151/1817.151 in accordance with prudent engineering practices. The professional engineer shall be experienced in the design and construction of roads, as evidenced by the placement of a registered engineer's seal on the certification. **[1780.37(b)/1784.24(b)]**

3.2.5 Are any roads constructed to facilitate surface coal mining operations proposed to be permanent?

☐ YES ☒ NO

If YES, locate on the Post Mining Land Use/Capability Reclamation Map and include appropriate discussion how modifications will be accomplished including the removal and disposition of any excess road material.

3.3 Air Pollution Control Plan

3.3.1 Provide a plan detailing fugitive dust control practices to be employed during proposed surface coal mining and reclamation operations. **[1780.15/1784.26]; [1816.150(b)(1)/1817.150(b)(1)]**

See Permit 375

3.3.2 Provide a description of the steps to be taken to comply with the requirements of the Clean Air Act (42 U.S.C. 7401 et seq.), and other applicable air and water quality laws and regulations and health and safety standards. **[1780.18(b)(9)/1784.13(b)(9)]**

See Permit 375

3.3.3 Fire Control Plan

a) Concerning non-coal mine waste, provide a description of contingency plans which have been developed to preclude sustained combustion of such materials. **[1780.18(b)(7)/1784.13(b)(7)].**

N/A

b) Provide a plan detailing how coal mine waste fires shall be extinguished. **[1816.87/1817.87]**

N/A

c) Provide a plan detailing how coal stockpile fires shall be extinguished. [225 ILCS 720/4.08]

N/A

3.4 Mine Waste Material

3.4.1 Non-Coal Mine Waste. Identify the nature of all non-coal waste material to be disposed of within the permit area, including but not limited to, grease, lubricants, paints, flammable liquids, garbage, tires, abandoned mining machinery, lumber and other hazardous and/or combustible materials generated during coal mining operations. Describe how and where each waste will be generated, stored, and disposed in accordance with 62 Ill Adm. Code 1816.89/1817.89 and indicate locations of all areas in which such materials are to be disposed of on the mining operations map. **[1816.89/1817.89]**

Note: All wastes are to be managed according to the Title 35 of the Illinois Administrative Code, Subtitle G and any non-coal mine waste defined as "hazardous" under Section 3001 of the Resource Conservation and Recovery Act (RCRA) (P. L. 94-580, as amended) and 40 CFR 261 shall be handled in accordance with the requirements of Subtitle C of RCRA and in accordance with the Illinois Environmental Protection Act as implemented by Title 35, Subtitle G, Part 721.

N/A

3.4.2 Coal Processing and Underground Development Waste. Will coal refuse waste and/or underground development from activities inside and/or outside the proposed permit area be disposed of within the proposed permit area?

☐ YES ☒ NO

If YES, list in Table 3.4.2 the nature of ALL coal waste material to be disposed of within the permit area and give the potential acidities and net neutralization potentials for each coal waste.

Table 3.4.2. List of coal waste materials to be disposed within the permit area.

Type of material shall be limited to the following designations: *Coarse Coal Refuse, Filter Cake, Fine Coal Refuse, Fly Ash, Bottom Ash, or Wastewater Treatment slurry.*

Type of Material	Source Mine Permit and Preparation Plant or Ash Generator	Potential Acidities	Net Neutralization Potential
Choose a Type			
Choose a Type			
Choose a Type			

Choose a Type			

3.4.3 Physical Properties of Underground Development Material and Coal Waste. Provide a physical and engineering analysis of the underground development material, coal waste or in case there is no coal waste production at the time of this application, the coal seam and the strata immediately above and below it, from which the underground development material and/or the coal waste will be generated. The analysis shall include: thickness of coal seam and strata that may contain acid-forming or alkalinity materials moisture content, the, maximum dry density, optimum moisture content, grain size distribution, coefficient of friction, and cohesion. **[1780.22(b)(2) and (b)(3)/1784.22(b)(2) and (b)(3)].**

3.5 Operation of Coal Refuse Disposal Areas Provide the information required in the following table for each Coal Refuse Disposal Area to be constructed or modified through this application.

Table 3.5. List of Coal Refuse Disposal Areas to be constructed or modified.

Type of facility shall be limited to the following designations: *Coal Refuse Pile, Coal Waste Impoundment, Incised Slurry Pond, Slurry Sump (No Discharge), or Underground Slurry Injection.*

Name of Facility			
Type of Facility	Choose an item.	Choose an item.	Choose an item.
Latitude (DD)			
Longitude (DD)			
Anticipated Construction Date			
Surface/ Shadow Area of Disposal (acres)			
Total coarse Coal Refuse Storage Volume (cubic yards)			
Total Fine Coal Refuse Storage Volume (cubic yards)			

3.5.1 Design and Construction Details of Coal Refuse Disposal Areas. Provide location and detailed construction plan (including engineering calculations, cross sections, maps and drawings) for each proposed structure in accordance with 62 Ill Adm. Code 1780.14(b)(8)/1784.23(b)(7). Take into account that:

a) Coal mine waste shall be disposed in compliance with requirements of 62 Ill. Adm. Code 1816.81/1817.81 through 1816.84/1817.84.

b) For coal processing waste dams and embankments meeting the MSHA size criteria, each plan shall comply with the requirements of MSHA 30 CFR 77.216-1 and 77.216-2, each plan shall contain typical cross-sections of all proposed levees, dams and excavations and the results of a geo-technical investigation as prescribed under 62 Ill. Adm. Code 1816.49/1817.49.

3.5.2 Operation and Maintenance of Coal Refuse Disposal Areas

a) **Surface and Groundwater Protection.** For all coal waste disposal areas, explain measures to be taken to avoid pollution of surface or groundwater due to leaching through levees or dams and through underlying soil as required in 62 Ill Adm. Code 1816.81(a)(1)/1817.81(a)(1). Locate and provide details of:

- All streams, creeks, and surface water impoundments within coal waste disposal areas or which receive runoff from coal waste disposal areas.
- Diversions as necessary to divert surface water around coal waste disposal areas.
- Diversions or other devices designed to collect surface runoff from waste disposal sites and transport same to appropriate treatment facility, including but not limited to: down drains, terraces, benches, under drains, spring collectors and leachate collectors.
- Location and discharge flow rate calculations of under drain, internal/ leachate drain and associated NPDES discharge points.
- Description of extent, properties, construction and operation of liners or caps to be used on the coal refuse disposal area and/or structure.

b) **Monitoring.** For all coal waste disposal areas explain measures to be taken to safely operate the coal refuse disposal area and ensure that final disposal facility is suitable for reclamation in accordance with 62 Ill Adm. Code 1816.81/1817.81. Measures to ensure safety can include a description of:

- Scope and frequency of inspections
- Maintenance of embankments and liners
- Controls to ensure compaction standards.
- Maintenance of runoff conveyance and discharge structures

3.5.3 Coal Waste Dams and Embankments. If there are dams or embankments constructed of, or designed to contain coal processing waste that are proposed to be built or modify in this permit application, provide the information required in the following Table 3.5.3.

Identify in the table: each coal waste dam's class according to USDA Technical Release 60 criteria; each coal waste dam's hazard classification according to MSHA 30CFR 77.216 criteria; the dam's height, slopes, top width, top and bottom elevation, pool elevation for every phase of construction, all proposed dam's discharge structures, and any associated NPDES discharge point to which runoff from the structure will be directed.

Table 3.5.3: List of Coal Waste Dams and Embankments

Class criteria shall be limited to the following designations: *Class A, Class B, or Class C.*

MSHA structure classification shall be limited to the following designations: *Low Hazard, Medium Hazard, High Hazard, or Not an MSHA Structure.*

Measurements of varying slopes, heights, and discharge structures according to construction phases shall be included.

Name of Facility			
Class Criteria as in TR-60	Class A	Class B	
MSHA Structure Classification	Choose a Hazard Classification	Choose a Hazard Classification	
Structure Height at top of dam measured from Downstream Toe (Feet)			
Top of Dam Width			
Upstream Slope			
Downstream Slope			
Top Elevation of embankment			
Bottom Elevation of Embankment			
Pool Elevation (feet)			
Discharge Structures			
Associated NPDES Permit			

3.5.4

Disposal of Coal Waste in Underground Workings.

a) The return of coal processing waste to underground workings must be approved by both the Department and MSHA as required by **Section 1784.25(a).** Has the applicant received approval from MSHA to conduct the prosed operations?

☐ YES ☐ NO

If YES, provide documentation. If NO, indicate the status of the necessary MSHA approval **[1784.25(a)]**.

b) Provide the source and type of waste to be stowed and the transport medium. **[1784.25(c)]**

c) Is the applicant proposing to use pneumatic transport to return the coal processing waste to the underground workings? **[1784.25(e)]**

☐ YES ☐ NO

If YES, is the applicant requesting to be exempted from requirements of hydrologic monitoring?

☐ YES ☐ NO

If YES, provide a detailed justification for the monitoring exemption.

d) **Surface Disturbance Operations:** In addition to providing all relevant parts of this application for permitting surface disturbances, provide the following:

i) On the Operations Map and Underground Mine Plan Map, provide the location of all coal waste slurry transport lines from the point of origin to the disposal boreholes. Locate specific features such as pump stations, cleanout points, etc. **[1784.25(a)]**

ii) Provide a written plan describing the design, operation, and maintenance of the proposed coal processing waste disposal facility, including flow diagrams and any other drawings and maps submitted to MSHA for their approval. Include information on periodic inspection of the delivery system to recognize deterioration and avoid failure. **[1784.25(a)]**

iii) Define the type, size and thickness of the lines to be used. **[1784.25(a)]**

iv) Provide detail on a monitoring system to assure any leak or break in the line can be detected and the system shut down to minimize any potential negative impacts. **[1784.25(a)]**

v) Should a release of slurry on the surface occur from either borehole overflow or breaks in the delivery system, provide an emergency contingency plan to minimize environmental harm. **[1784.25(c)]**

e) **Underground Workings Disposal Area**

i) Provide the anticipated volume of slurry to be disposed of in the proposed area and the anticipated life of the operation. **[1784.25(a)]**

ii) On the Underground Mine Plan Map, provide the location of all areas targeted to receive the underground waste material. Include pillar geometry, incorporate floor contours, barriers and any constructed mine seals that serve to control the area of backfill. Also, locate all boreholes for disposal, return water, vent wells and monitoring wells. **[1784.25(b)]**

iii) Is the applicant proposing to circulate decant water back out of the mine? **[1784.25(c)]**

☐ YES ☐ NO

If YES, provide a plan to monitor input and outtake volumes over the life of the operation.

iv) If mine seals are present and are intended to confine the area where backfill material and transport medium will be limited to, provide the locations on the Underground Mine Plan Map and indicate the design of such seals to achieve this purpose. **[1784.25(b)]**

v) Within the defined area of containment, provide the anticipated percentage of area to be filled. **[1784.25(b)]**

vi) Discuss any influence the backfilling operation will have on active underground mine operations. **[1784.25(b)]**

vii) Provide information and engineering analysis of the potential impacts to existing mine stability. Provide a discussion and analysis of the stratum underlying the mined coal and any potential influence the backfilling operation will have on mine stability and subsidence. **[1784.25(b)]**

f) **Hydrologic Balance Protection:** In addition to completing all applicable questions of Part 4 "Hydrologic and Geologic Information", provide the following.

i) Provide quality information on the coal waste material to be disposed. **[1784.25(b)]**

ii) Provide the proposed construction details for all boreholes for this underground waste disposal operation to demonstrate protection of the hydrologic balance. **[1784.25(c)]**

iii) Is the backfill material proposed to be dewatered (i.e. decant water returned to the surface facility)? **[1784.25(c)]**

☐ YES ☐ NO

If YES, provide the controlling elevation of the return pump intake relative to the mine void and mine workings gradient to define the anticipate pool elevation.

iv) If applicable, describe the handling of return water. Indicate if the water will be directed to the preparation plant or stored in an impoundment on permit if not. If the water will be released to surface streams, indicate if treatment is necessary and provide proposed treatment methods. **[1784.25(c)]**

v) Is transport water to be permanently retained in the underground workings?

☐ YES ☐ NO

If YES, provide information on the elevational level the retained water will rise to both during the operations and long-term after cessation of the disposal operations. **[1784.25(c)]**

vi) Provide information with supporting documentation on the stratigraphic location of any potable water resources in relation to the area to be backfilled. **[1784.25(c)]**

vii) Provide information with supporting documentation on the stratigraphic location of aquitards, if any, in relation to the potable water resources and the area to be backfilled. **[1784.25(c)]**

viii) Based on the geologic and hydrogeologic information presented, provide an evaluation on the potential effects the proposed underground disposal operations may have on the hydrologic regime. **[1784.25(c)]**

ix) Are permanent monitoring wells to be installed to monitor water levels and/or quality changes? **[1784.25(d)]**

☐ YES ☐ NO

If YES, provide the locations of monitoring wells on the Underground Mine Plan Map and the Hydrogeologic Map Information. Detail the purpose of each, quality parameters to be monitored, the frequency of monitoring and how the data will be used to determine if unanticipated or negative impacts to the hydrologic regime are occurring from this proposed operation.

If NO, provide justification for the omission of long-term monitoring wells in the plan.

3.6 Coal Preparation

3.6.1 Are coal processing operations proposed in this permit application?

☐ YES ☒ NO

If YES, complete the following:

a) Will processing of coal take place within the proposed permit area?

☐ YES ☐ NO

If YES, locate processing facilities on the Operations Map and give a general description of the coal processing operation at this facility as required by 62 Ill Adm. Code 1780.11(b)(3)/1784.11(b)(3); 1780.14(b)(4) and 1784.23(b)(4). In the case in-situ processing activities are proposed, description of these operations shall comply with 62 Ill Adm. Code 1785.22.

If NO, and coal preparation plants are not located within the permit area, the applicant shall obtain a permit in accordance with 62 Ill Adm. Code 1785.21, and operate complying with the requirements of 62 Ill Adm. Code 1827.

3.6.2 Describe the fresh water (makeup) and slurry circuits for this operation and depict location of makeup water and slurry circuits on the Surface Drainage Control Plan Map. Indicate if a discharge occurs and if so, it should be included on Schedule A. If a discharge does not occur, a detailed description of how this will be accomplished must be submitted. **[1780.11(b)/1784.11(b)]**

3.6.3 What safeguards are provided to prevent the discharge of slurry fines and untreated slurry water during emergency situations (e.g. power outages, mechanical equipment breakdown, plant shutdowns, etc.) and/or high rainfall events?

a) Also indicate where the slurry would go by gravity flow in the event of an emergency discharge, and the environmental impact this would have. **[1777.11(a)(3)]; [1780.11(a)/1784.11(a)]**

3.7 Blasting (Refer to Technical Guidance Document 3 when completing this section)

3.7.a Is blasting to be conducted as part of a surface mine?

☐ YES ☒ NO

If YES, skip to 3.7.1.
If NO, proceed to 3.7.b

3.7.b Is blasting to be conducted as part of a underground mine?

☐ YES ☒ NO

If YES, proceed to 3.7.c.
If NO, no further blasting information is required.

3.7.c Are surface blasting activities incident to underground mining, including, but not limited to, initial rounds of slopes and shafts that are within 50 vertical feet of the original ground surface proposed?

☐ YES ☐ NO

If YES, skip to 3.7.2.
If NO, no further blasting information is required.

3.7.1 Surface Mine Blasting

a) Provide a copy of the proposed blasting schedule(s). **[1816.64]**

b) Provide a list of persons to whom the schedule will be distributed for each blasting area described including local governments within one mile of the blasting area; Township and County road commissioners within one mile of the blasting area; utilities within one mile of the blasting area; and the County Clerk of the county where blasting will occur. **[1816.64]**

Name	Address

c) Provide a copy of the format used to notify persons within one-half (½) mile of the permit area as to how to obtain a pre-blast or condition survey. **[1816.62(a)]**

d) Provide a brief description of procedures to be used to perform pre-blast or condition surveys and for distributing copies of the survey reports to owners/residents and the Department. **[1816.62(e)]**

e) Provide a copy of the blasting report form. **[1816.68]**

f) Provide the distance to, and the names and addresses of the owners of, all dwellings or other structures within one half (½) mile of the proposed permit area or within one mile of the blasting area, whichever distance is greater. **[1816.62(b)]**

Name	Address	Distance

g) Will blasting be conducted within one thousand (1,000) feet of any building used as a dwelling, public building, school, church, community building or institutional building outside the permit area or within five hundred (500) feet of an active or abandoned underground mine? **[1816.61(c)(1)]**

☐ YES ☐ NO

If YES, proceed to next question.
If NO, proceed to 3.7.1.h

h) If a blast design is required, it may be presented as part of this application or at a time, before the blast, for approval by the Department. If the blast design is not included with this application, please state when you plan to submit the design. **[1816.61(c)(2)]**

- The blast design shall contain sketches of the drill patterns, delay periods, and decking and shall indicate the type and amount of explosives to be used, critical dimensions, and the location and general description of structures to be protected, as well as a discussion of design factors to be used, which protect the public and meet the applicable air blast, flyrock, and ground vibration standards in 62 Ill. Adm. Code 1816.67. **[1816.61(c)(3)]**

- The blast design shall be prepared and signed by a certified blaster. **[1816.61(c)(4)]**

i) Include information setting forth the limitations the operator will meet with regard to ground vibration and airblast, the basis for those limitations, and the methods to be applied in controlling the adverse effects of blasting operations. **[1780.13(a)/1816.67]**

j) Include a description of any system to be used to monitor compliance with the standards of 62 Ill. Adm. Code 1816.67, including the type, capability, and sensitivity of any blast monitoring equipment and proposed procedures and locations of monitoring. **[1780.13(b)/1816.67]**

k) Blasting operations within five hundred (500) feet of active underground mines require approval of the Department and Federal Mine Safety and Health Administration (MSHA). If blasting operations are expected to occur within five hundred (500) feet of an active underground mine, please include the written approvals of the Department and MSHA, or state when the written approvals will be submitted prior to conducting blasting operations. **[1780.13(c)]**

3.7.2 Underground Mine Blasting

a) Provide a copy of the proposed blasting notice. **[1817.64]**

b) Provide a list of persons to whom the notice will be distributed for each blasting area described including local governments within one mile of the blasting area; Township and County road commissioners within one mile of the blasting area; utilities within one mile of the blasting area; and the County Clerk of the county where blasting will occur. **[1817.64]**

Name	Address

c) Provide a copy of the format used to notify persons within one-half (½) mile of the permit area as to how to obtain a pre-blast or condition survey. **[1817.62(a)]**

d) Provide a brief description of procedures to be used to perform pre-blast or condition surveys and for distributing copies of the survey reports to owners/residents and the Department. **[1817.62(e)]**

e) Provide a copy of the blasting report form. **[1817.68]**

f) Provide the distance to, and the names and addresses of the owners of, all dwellings or other structures within one half (½) mile of the proposed permit area or within one mile of the blasting area, whichever distance is greater. **[1817.62(b)]**

Name	Address	Distance

g) Will blasting be conducted within one thousand (1,000) feet of any building used as a dwelling, public building, school, church, community building or institutional building outside the permit area or within five hundred (500) feet of an active or abandoned underground mine? **[1817.61(d)(1)]**

☐ YES ☐ NO

If YES, proceed to next question.
If NO, proceed to 3.7.2.h

h) If a blast design is required, it may be presented as part of this application or at a time, before the blast, for approval by the Department. If the blast design is not included with this application, please state when you plan to submit the design. **[1817.61(d)(2)]**

- The blast design shall contain sketches of the drill patterns, delay periods, and decking and shall indicate the type and amount of explosives to be used, critical dimensions, and the location and general description of structures to be protected, as well as a discussion of design factors to be used, which protect the public and meet the applicable air blast, flyrock, and ground vibration standards in 62 Ill. Adm. Code 1817.67. **[1817.61(d)(3)]**

- The blast design shall be prepared and signed by a certified blaster. **[1817.61(c)(4)]**

i) Include information setting forth the limitations the operator will meet with regard to ground vibration and airblast, the basis for those limitations, and the methods to be applied in controlling the adverse effects of blasting operations. **[1817.67]**

j) Include a description of any system to be used to monitor compliance with the standards of 62 Ill. Adm. Code 1817.67, including the type, capability, and sensitivity of any blast monitoring equipment and proposed procedures and locations of monitoring. **[1817.67]**

3.8 Existing Structures

3.8.1 Are existing structures proposed to be used in connection with or to facilitate the surface coal mining and reclamation operations?

☐ YES ☒ NO

If YES, complete the following:

a) Provide a list of all of the existing structures to be used including: roads, bridges, culverts, fills, berms, benches, waste banks, discharge structures, diversions, rail loops, rail sidings, rail spurs, refuse areas, shafts, spoil piles, utility lines, terraces, drains, wells, exploration holes, boreholes, barricades, fences, storage areas, mine buildings, tipples, storage facilities, repair facilities, surge ponds, treatment plants, pipelines, conveyors, and other man-made structures or areas disturbed by mining activities.

b) Provide the following information as required by 62 Ill. Adm. Code 1780.12(a)/1784.12(a):

- The location of structures on the Operations Map.
- Plans of the structure detailing its current, pre-mining condition.
- Approximate dates, beginning and completion for construction of the structure.
- A showing that the structure meets the performance standards of 62 Ill. Adm. Code 1810 through 1828. The showing shall include monitoring data or other substantiating evidence.

3.8.2 Are any structures proposed to be modified or reconstructed for use in connection with or to facilitate the surface coal mining and reclamation operations?

☐ YES ☒ NO

If YES, complete the following:

a) In accordance with as required by 62 Ill. Adm. Code 1780.12(b)/1784.12(b), a compliance plan for each existing structure to be modified or reconstructed for use in connection, or to facilitate coal mining and reclamation operations, shall be submitted with the following information:

- Design specifications for reconstruction or modification of the structure to meet the design and performance standards of 62 Ill. Adm. Code 1810 through 1828,
- A schedule for reconstruction or modification of the structure showing dates for beginning and completing interim steps as well as final reconstruction,
- Provisions for monitoring the structure during and after modification to ensure that the performance standards of 62 Ill. Adm. Code 1810 through 1828 are met, and
- A showing that the risk of harm to the environment or to public health or safety is not significant during the period of modification or reconstruction.

3.9 Shaft, Slope, and Miscellaneous Borehole Construction.

3.9.1 For the shafts and/or slopes being proposed, describe the measures to be implemented to minimize disturbance to the prevailing hydrologic balance and to ensure the safety of people, livestock, fish and wildlife, and machinery in the permit area and adjacent area. [1816.13/1817.13]

All shafts when idle will be covered with a perforated metal cap to prevent access to the mine workings by people, livestock, fish and wildlife, and machinery, and to keep acid or other toxic drainage from entering ground water or surface water. The boreholes will

be permanently sealed within 60 days of when the borehole becomes inactive.

3.9.2 For each shaft and/or slope, provide a drawing showing those features which are relevant to protecting the hydraulic balance. The drawing shall include:

- The physical dimensions of excavations and entry lining material;
- The type of entry lining material;
- The measures which will be used to seal the annulus between the entry lining and adjacent rock;
- Water rings and conductor pipes;
- Elevation of land surface, coal seam, and any other mine workings penetrated by the structure; and
- Provide the latitude and longitude (in decimal degrees) for each shaft and/or slope.

Belt Air shaft – 8' diameter fully lined finished concrete. One water ring will be installed at the bottom of the shaft. All water collected will be pumped underground back into the mine water system for re-use. Hole # NSBELTAIR Lat 37.8676, Long 88.8347 490 feet Deep

Material Shaft – 16.5' diameter fully lined finished concrete. One water ring will be installed at the bottom of the shaft. All water collected will be pumped underground back into the mine water system for re-use. Hole # NSMATERIAL Lat 37.8670, Long 88.8346 490 feet Deep

3.9.3 Will the Applicant be conducting any surface blasting activities incidental to underground mining, including, but not limited to, initial rounds of slopes and/or shafts that are within fifty (50') vertical feet of the original ground surface? **[1817.61(a)]**

☐ YES ☒ NO

If YES, complete the appropriate items in Part 3.7: Blasting.

3.9.4 For each borehole or group of boreholes being proposed, describe the measures to be implemented to minimize disturbance to the prevailing hydrologic balance and ensure the safety of people, livestock, fish and wildlife, and machinery in the permit area and adjacent area. **[1816.13/1817.13]**

All boreholes when idle will be covered with a perforated metal cap to prevent access to the mine workings by people, livestock, fish and wildlife, and machinery, and to keep acid or other toxic drainage from entering ground water or surface water. The boreholes will be permanently sealed within 60 days of when the borehole becomes inactive.

3.9.5 For each borehole or group of boreholes which will be constructed in a similar manner, provide a sketch indicating:

- The depth (or depth range) and diameter of each drill hole;
- The depth (or depth range) and diameter of each casing string, type and thickness of casing material in each string, and spacing of collars and any centralizers;
- Intervals to be cemented, grouted, or otherwise sealed and the method of placement;
- Any geophysical logging which is proposed;
- The names and numbers of boreholes to which the sketch applies; and
- Provide the latitude and longitude (in decimal degrees) for each borehole.

Six utility boreholes will be installed. All holes will be 10 5/8" diameter steel line fully grouted hole wall thickness of .218" approximately ~490 feet deep, No geophysical logging

proposed. (NSUTILITY#1 Lat 37.8675, Long 88.8347), (NSUTILITY#2 Lat 37.8675, Long 88.8347), (NSUTILITY#3 Lat 37.8675, Long 88.8347), (NSUTILITY#4 Lat 37.8670, Long 88.8336), (NSUTILITY#5 Lat 37.8670, Long 88.8336), (NSUTILITY#6 Lat 37.8670, Long 88.8336)

PART 5: Drainage Control

5.1 Pre-mining Drainage Patterns

5.1.1 Show the pre-mining drainage patterns of all areas to be affected by the mining and reclamation activities within the permit boundary and properties adjacent to the permit boundary. The map shall include, at minimum, adequate contour mapping, a delineation of the watershed boundaries, and shall depict the size of each watershed. If the applicant has provided an Existing Streams Location Map, it can be referenced if it addresses the requested information of this part. **[1780.14/1784.23]**

See Topo Map

5.1.2 Do any ephemeral, intermittent, or perennial streams as defined by Section 1701.5 occur within the proposed permit area? **[1816.43(b)/1817.43(b)]**

☒ YES ☒ NO

IF YES, complete the appropriate items of Part 6.0: Stream Diversions.

See Attachment 5.1.2, Small Ephemeral stream within the IBR boundary and along the southern border will not be disturbed during construction or maintenance of this IPR. The intermittent stream on the western edge of the IBR will have a 100 feet stream buffer zone marked by T-post with red painted tops.

5.2 Drainage Control

5.2.1 Will all surface drainage from the affected mining area be collected and treated prior to leaving the permit area? **[1816.46(b)(2)/1817.46(b)(2)]**

☐ YES ☒ NO

If NO, explain how regulatory compliance will be achieved without treatment, i.e., address the requirements of **62 Ill. Adm. Code 1816.46(e)/1817.46(e)**.

Williamson Energy is request small area drainage exemption. Silt fence and straw bales will be used to temporary sediment control during construction. After construction is complete a durable rock surface will be installed and all area will be seeded during the first planting season after completion of construction.

5.2.2 Will all surface drainage from unaffected areas be intercepted and diverted around the affected mining area. **[1816/1817.43(a)]**

☐ YES ☒ NO

If NO, explain why this is not necessary.

Alternative drainage control (Silt Fence and Straw bales) will be used to manage the minimal runoff expected from the IBR. All disturbed area will be graveled, lime stabilized, or seed during the first planting season after construction work is completed.

If YES, based on the definitions of "perennial" and "intermittent" streams as outlined in 62 Ill. Adm. Code 1701.Appendix A, does the Applicant propose to divert a perennial or intermittent stream?

☐ YES ☐ NO

If YES, complete the appropriate items of Part 6.0: Stream Diversions.

5.2.3 Describe the timing in which all construction of the sediment ponds and surface drainage control structures will be completed. Include a discussion of the vegetation stabilization of these structures. **[1816(b)(3)/1817.46(b)(3)]; [1816.49(a)(7)/1817.49(a)(7)]**

Silt fence will be installed prior to any disturbance.

5.3 Conveyance Ditch Design

5.3.1 Does the Applicant propose to construct conveyance ditch(es) to collect surface water drainage from affected mining areas and direct it to treatment facilities?

☐ YES ☒ NO

Does the Applicant propose to construct conveyance ditch(es) to intercept surface drainage from unaffected areas and direct it around the affected mining area?

☐ YES ☒ NO

If either answer above is YES, complete Table 5.3.1 and complete the remaining questions within Part 5.3: Conveyance Ditch Design. **(Refer to Technical Guidance Document 2)**

a) Provide detailed design and construction calculations for the ditches listed in Table 5.3.1. **[1816.43/1817.43]**

b) For all ditches listed in Table 5.3.1, indicate the location of each on the Operations Map in relation to the proposed mining operations. Include the drainage area reporting to each channel on the Surface Drainage Control Plan Map and/or indicate the drawing(s) that provide the information required and provide a specific reference in the area below this item. **[1780.14(b)(6)/1784.23(b)(6)]**

c) Provide typical cross-sections for each ditch listed in Table 5.3.1 depicting the bottom width, side slopes, depth based on the appropriate precipitation event, and freeboard depth. (Indicate the drawing(s) that provide the information required and provide a specific reference in the area below this item.) **[1780.14(b)(6)/1784.23(b)(6)]**

d) Provide profiles for each ditch listed in Table 5.3.1 depicting the flow line slope and the depth based on the appropriate precipitation event. (Indicate the drawing(s) that provide the information required and provide a specific reference in the area below this item.) **[1780.14(b)(6)/1784.23(b)(6)]**

e) Based on calculated flows, define areas that require supplemental erosion control such as rip rap or dry dams on the Surface Drainage Control Plan Map. Provide details and calculations on the design of additional erosion control features **[1780.14(b)(6)/1784.23(b)(6)]**

5.3.2 Are culvert(s) being proposed within any of the ditches listed in Table 5.3.1?

☐ YES ☒ NO

If YES, complete the following items:

a) Identify the culverts by an identification name, the ditch which the culvert is associated with, and the station at which the culvert is located.

Two road culvert will be installed

b) Provide design calculations for each culvert identified in Part 5.3.3.1. **[1816.150(b)/1817.150(b)]**

See Attachment 5.3.3.1

c) Provide a profile for each culvert, depicting the following information:

i. Culvert length, size, and type;
ii. Slope;
iii. Invert inlet and outlet elevations; and
iv. Available headwater depth.

Culvert 1 – CMP 12" diameter (50-100) feet long Invert 429.6' and outlet 429.1'
Culvert 2 – CMP 18" diameter (60-120) feet long Invert 425.5' and outlet 425.0'

5.3.3 Provide details of the proposed erosion and sediment control measures to be employed during the construction of the proposed conveyance ditches. **[1816.43(a)(2)/1817.43(a)(2)]**

5.3.4 Describe the measures to ensure that all temporary ditches are removed and reclaimed and that all permanent ditches meet the requirements of 62 Ill. Adm. Codes 1700-1850 for permanent structures, have been maintained properly, and meet the requirements of the approved reclamation plan. **[1816.56/1817.56]**

5.4 Sediment/Fresh Water/Holding Pond Design. (Note: This includes all constructed ponds other than Coal Refuse Disposal Areas covered under Part 3.5 "Operation of Coal Refuse Disposal Areas". These structures are considered "impoundments" as defined in 62 Ill. Adm. Code 1701.Appendix A.) **(Refer to Technical Guidance Document 2)**

5.4.1 Sediment pond design. Complete Table 5.4.1 for all proposed sediment ponds. **[1816.46(c)/1817.46(c)]**

5.4.2 Discuss the design basis for the sediment pond(s) calculations. Submit calculations used in spillway designs and determination of inflow volume and pond volume. **[1816.45/1817.45, 1816.46/1817.46, & 1816.49/1817.49]**

5.4.3 Submit a typical section of the embankment(s), details of the principal and emergency spillways and a plan view of each pond at a scale of 1 inch = 200 ft. or larger showing pond bottom contours and points of inflow. **[1816.45/1817.45, 1816.46/1817.46, & 1816.49/1817.49]**

5.4.4 For all sedimentation ponds provide design information showing compliance with the requirements of 62 Ill. Adm. Code 1816.46/1817.46. Each plan shall, at minimum, comply with the requirements of MSHA, 30 CFR 77.216-1 and 77.216-2. **[1816.45/1817.45, 1816.46/1817.46, & 1816.49/1817.49]**

5.4.5 Explain what criteria will be used to monitor and determine periodic and/or timely removal of sediments from sediment ponds, ditches and any other conveyance and treatment structure before the facilities lose their storage or conveyance volume capacity. If sediment removal becomes necessary, explain how the sediment will be removed, where it will be disposed of, and what disposal methods will be used. **[1816(c)(1)(C)(vi)/1817.46(c)(1)(C)(vi)]**

5.4.6 Will pH adjustment be necessary on any of the discharges in order to meet the applicable State and Federal Standards? **[1780.21(h); 1784.14(g)]**

☐ YES ☐ NO

If YES, discuss in detail, along with detailed basis of design. The basis should include a detailed description of the proposed treatment facilities, process flow diagrams, and design calculations. **[1780.21(h)/1784.14(g)]**

5.4.7 Will the mining operation involve the construction of any fresh water and/or holding ponds? **[1816.49/1817.49]** (*All temporary and permanent impoundments must meet these requirements.*)

☐ YES ☐ NO

If YES, complete the following items:

a) Locate on the Operations Map all fresh water ponds, holding ponds and dam locations. Depict on the Surface Drainage Control Plan Map all watershed limits and indicate which impoundments are proposed to remain permanent. For permanent impoundments, complete Section 5.5.2. **[1780.25(a)/1784.16(a)]; [1816.46(c)(1)(C)/1817.46(c)(1)(C)]**

b) Provide construction and maintenance details of dams, spillways, seepage control measures, and erosion control measures for inlets and outlets. Employ maps and cross sections where necessary. Where design plans for proposed structures are not provided, submit a certification statement providing a schedule for submission of detailed design plans for each structure. **[1780.25(b)/1784.16(b)]; [1816.46(c)(2)/1817.46(c)(2)]**

5.4.8 For each structure that meets or exceeds the size or other criteria of MSHA, 30 CFR 77.216(a), the detailed design plan shall:

a) Be prepared by or under the direction of and sealed by a qualified registered professional engineer licensed under the Illinois Professional Engineering Act; **[1780.25(a)(2)(A)/1784.16(a)(2)(A)]**

b) Include any design and construction requirements for the structure, including any required geo-technical information; **[1780.25(a)(2)(B)/1784.16(a)(2)(B)]**

d) Describe the operation and maintenance requirements for each structure; and **[1780.25(a)(2)(C)/1784.16(a)(2)(C)]**

e) Describe the timetable and plans for removal of each structure, if appropriate. **[1780.25(a)(2)(D)/1784.16(a)(2)(D)]**

5.4.9 For each structure that does not meet the size or other criteria of MSHA, 30 CFR 77.216(a), the detailed plan shall:

a) Be prepared by or under the direction of and sealed by a qualified registered professional engineer licensed under the Illinois Professional Engineering Act; **[1780.25(a)(3)(A)/1784.16(a)(3)(A)]**

b) Include any design and construction requirements for the structure, including any required geo-technical information; **[1780.25(a)(3)(B)/1784.16(a)(3)(B)]**

c) Describe the operation and maintenance requirements for each structure; and **[1780.25(a)(3)(C)/1784.16(a)(3)(C)]**

d) Describe the timetable and plans for removal of each structure if appropriate. **[1780.25(a)(3)(D)/1784.16(a)(3)(D)]**

5.5 Sediment/Fresh Water Pond Reclamation.

5.5.1 Describe proposed reclamation plans for each structure, including a time table and plans for removal and disposal of material. Each plan shall: **[1780.25(a)(2)(D)/1784.16(a)(2)(D)]**

a) Be prepared by or under the direction of, and sealed by a qualified registered professional engineer licensed under the Illinois Professional Engineering Act; **[1780.25 a)(3)(A)/1784.16(a)(3)(A)]**

b) Contain a description, plan view, and cross-section of the structure and its location; **[1780.25(a)(1)(B)/1784.16(a)(1)(B)]**

c) Contain preliminary hydrologic and geologic information required to assess the hydrologic impact of the structure. **[1780.25(a)(1)(C)/1784.16(a)(1)(C)]**

d) If underground mining has occurred beneath or adjacent to the proposed impoundment, the plan shall incorporate a technical discussion and evaluation of the potential effect subsidence of the surface and subsurface strata would have on the structure. **[1780.25(a)(1)(D)/1784.16(a)(1)(D)]**

e) For structures where the detailed design plans are not submitted to the Department with the general plan, the plan shall contain a certification statement which includes a schedule setting forth the dates that detailed design plans are to be submitted. For these structures, the detailed design plans must be submitted to the Department and approved in writing prior to the beginning of construction. **[1780.25(a)(1)(E)/1784.16(a)(1)(E)]**

5.5.2 For permanent impoundments, including sedimentation ponds, provide the following information:

a) Provide sufficient design data and calculations to substantiate that the design is in accordance with NRCS engineering standard 378 "Ponds" or NRCS technical release #60 "Earth Dams and Reservoirs". **[1816.49(a)(4)(B)/1817.49(a)(4)(B)]**

b) Based on the location of the pond relative to existing or proposed surface mining disturbances, and the projected post mining reclamation and post mining land uses, provide an evaluation of the anticipated water quality to assure it will be suitable for the intended use. **[1816.49(b)(2)/1817.49(b)(2)]**

c) The relationship of the impoundment to the post-mining land use. **[1816.49(b)(6)/1817.49(b)(6)]**

d) Describe methods of dropping surface runoff over excavated impoundment side slopes. Discuss design criteria to be employed for downdrain structures and perimeter diversions. **[1816.49(b)(7)/1817.49(b)(7)]**

e) Plans of access roads and other use related facilities. **[1816.49(b)(4)/1817.49(b)(4)]**

5.5.3 Are any structures 20 feet or higher?

☐ YES ☐ NO

Do any structures impound more than 20 acre-feet?

☐ YES ☐ NO

If the answer to either above is YES, for each structure meeting the criteria, provide stability analysis and include strength parameters, pore pressures, and long-term seepage conditions. Include description of each engineering design assumption and calculation with discussion of each alternative considered in selection design parameters and construction methods. **[1780.25(a)(2)/1784.16(a)(2)]**

Submission of MSHA certification documents for a detailed design plan shall satisfy the requirements, in so far as the MSHA informational and design standard requirements are duplicative of the requirements. If the applicant wishes to submit such certification. Justification that all design standards are duplicative must be provided for the Department to accept the certification without adequate supporting design. **[1780.25(a)(2)/1784.16(a)(2)]**

5.5.4 Describe in detail a rehabilitation design plan for each siltation structure and/or fresh water pond to be implemented and completed prior to abandonment. Any departures from detailed design plan requirements must be designated as such and be accompanied by supporting documentation. **[1816.56/1817.56; 225 ILCS 720/9.05]**

Attachment 5.1.2

Wetland & Stream Delineation

North Portal Site

Franklin County, Illinois

Prepared for

Williamson Energy, LLC

Prepared by

HMG Engineers, Inc.

1032 North 6th Street
Murphysboro, Illinois 62966

July 2017

PROJECT DESCRIPTION

HMG Engineers, Inc. (HMG) was contacted by Williamson Energy, LLC who requested a wetland and stream delineation on a tract located in the S1/2 NW ¼ SW ¼ Section 36, T7S, R3E located in southeastern Franklin County, Illinois (Figures 1 and 2). The delineation area is approximately 19 acres located west of Davis Road and south of Nielson Road. WGS84 latitude/longitude is 37.86777/-88.83315.

METHODS

HMG conducted a wetland and stream delineation for the project area. Results of that investigation are reported herein. Background information was reviewed including aerial photography, topography, watershed, floodplain maps, and National Wetland Inventory. A field investigation was conducted on July 25, 2017 by HMG Environmental Scientist, William O'Leary. Stream identification utilized COE "bed and bank" criteria. Wetland delineation followed criteria of the 1987 U.S. Army Corps of Engineers Wetlands Delineation Manual, including Regional Supplement, Midwest Version 2.0 (U. S. Army Corps of Engineers [COE] 2010). Global positioning equipment was used to locate features in the field.

BACKGROUND

USGS Topographical Map (see Figure 4), aerial photography (see Figure 3), soils (Figure 5), National Wetlands Inventory (NWI, Figure 6), and floodplain maps (Figure 6) were reviewed. Past and current aerial photographs identified that the site is, and has been for many years, tilled on a regular basis in the production of row crops. The western quarter of the site has a soil type 3382A, Belknap which is not a hydric soil. The remainder of the area has hydric soils including Cisne, Bonnie, and Wynoose. There are no NWI sites in the project area, which is not in the flood plain of Pond Creek (Figure 6).

FIELD DELINEATION

No stream channels are identified on the USGS topographical map. The only drainage feature evident from aerial photography are lighter colored linear features located in the western portion. Past and present aerial photo review reveal that these lighter colored areas have been historically and continuously farmed through, making bed and bank features unlikely. Field investigation confirmed this to be the case, with standing corn rows present within these lighter areas and no bed and bank present. Representative photographs were taken facing upgrade and downgrade. (see Appendix A).

The east-west oriented tree row along the southern boundary was inspected. One channel exhibiting bed and bank characteristics was noted. Bed and bank character begins at point A in Figure 3 and ends at point B. Because this channel is separated from downstream streams by a reach with no discernable bed and bank, it is an isolated feature which would not fall within Clean Water Act, Section 404 jurisdiction. The channel was classified as ephemeral for the following reasons:

- Drainage area is less than 20 acres.
- The channel is not depicted on a USGS topographic map.
- Upland plants were observed rooted in the channel bottom, particularly trumpet creeper (*Campsis radicans)*, a facultative upland plant, indicating groundwater level

below depth needed to support wetland plants.
- No obligate or facultative wetland plants were observed.
- No meanders, riffles, or pools were observed.
- No head cuts were observed.
- No base flow was observed.

There is a ditch present on the west perimeter which the company does not plan to disturb, according to company personnel. There is also a road ditch along the east perimeter, along Davis Road, which will be crossed for access. Both ditches flow from north to south. According to the company, the row of trees along the southern boundary will not be disturbed.

RESULTS

As a result of the review and field investigation, no Clean Water Act, Section 404 jurisdictional streams or wetlands were identified that will be affected by planned disturbances. The Davis Road ditch and isolated ephemeral channel along the southern border, are not 404 jurisdictional. The ditch along the western boundary and the southern isolated ephemeral channel are not planned for disturbance. There are no bed and bank channels associated with flow routes in the cropfield. There are no wetlands in the project area.

SUMMARY

Based on the above analysis, no 404 jurisdictional waters were identified that are planned for disturbance in the project area.

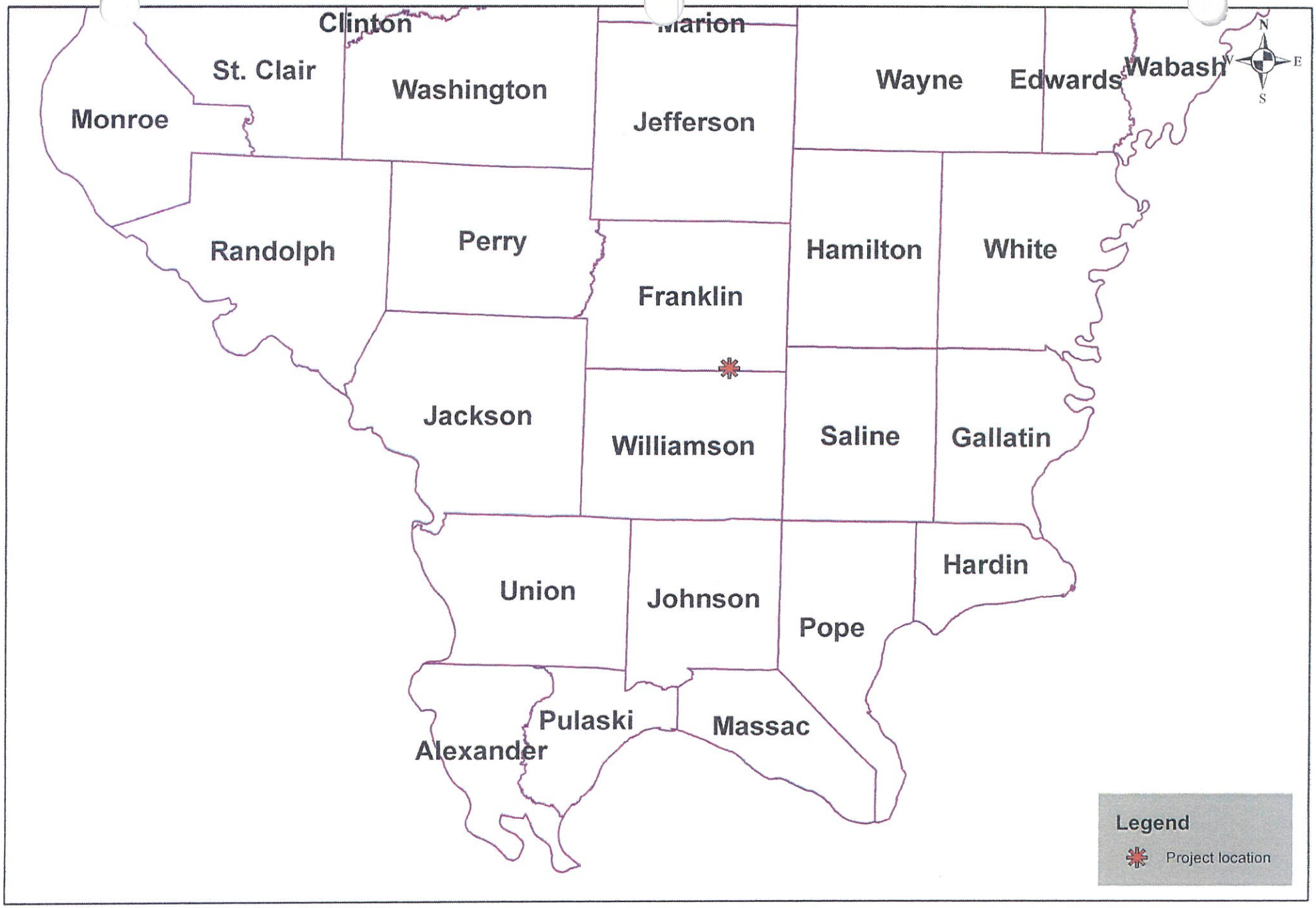


Figure 1. Site location in Southern Illinois.

R06830

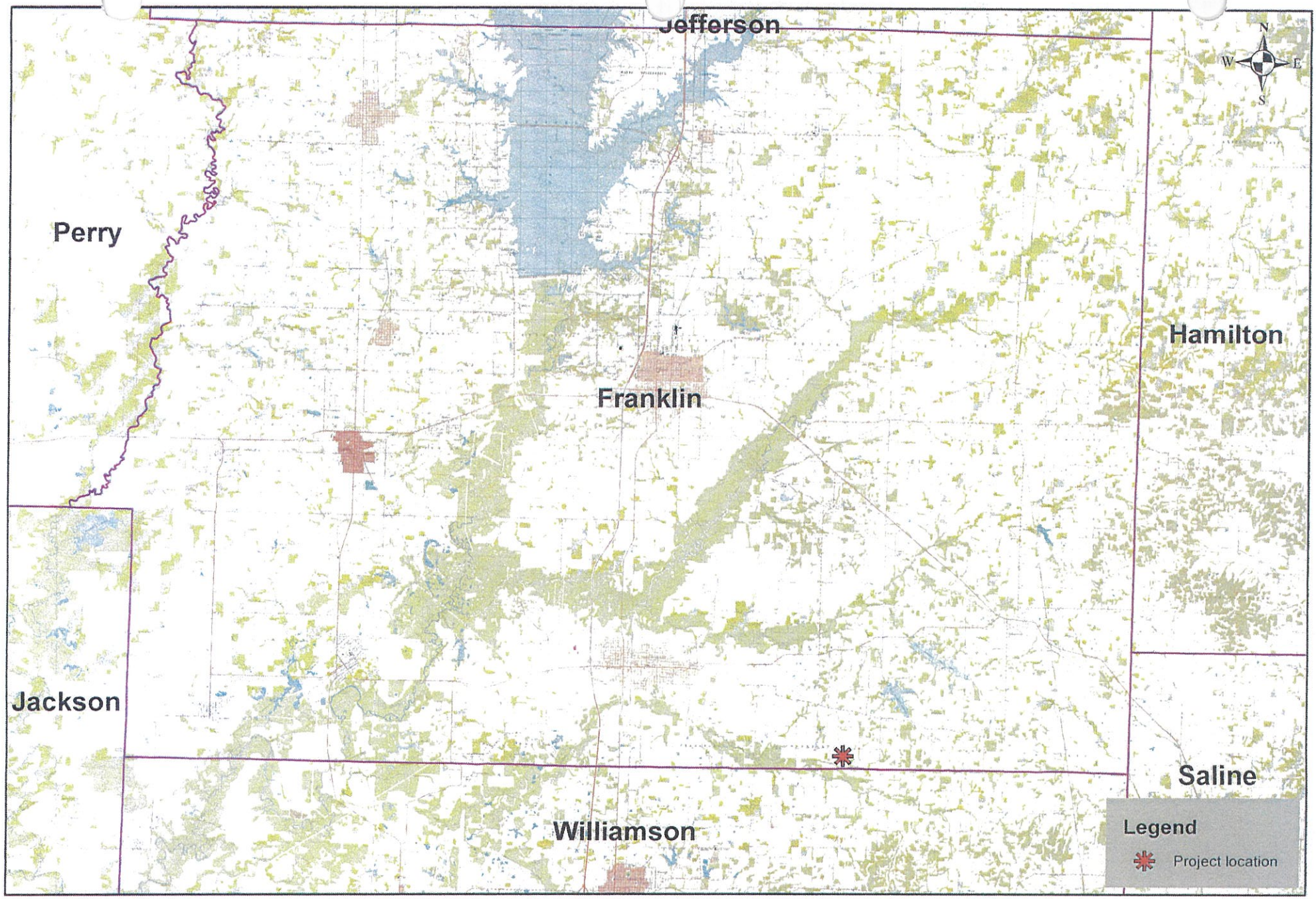


Figure 2. Site location in Franklin County.

R06831



Figure 3. Aerial photograph (2015) of the site.

R06832

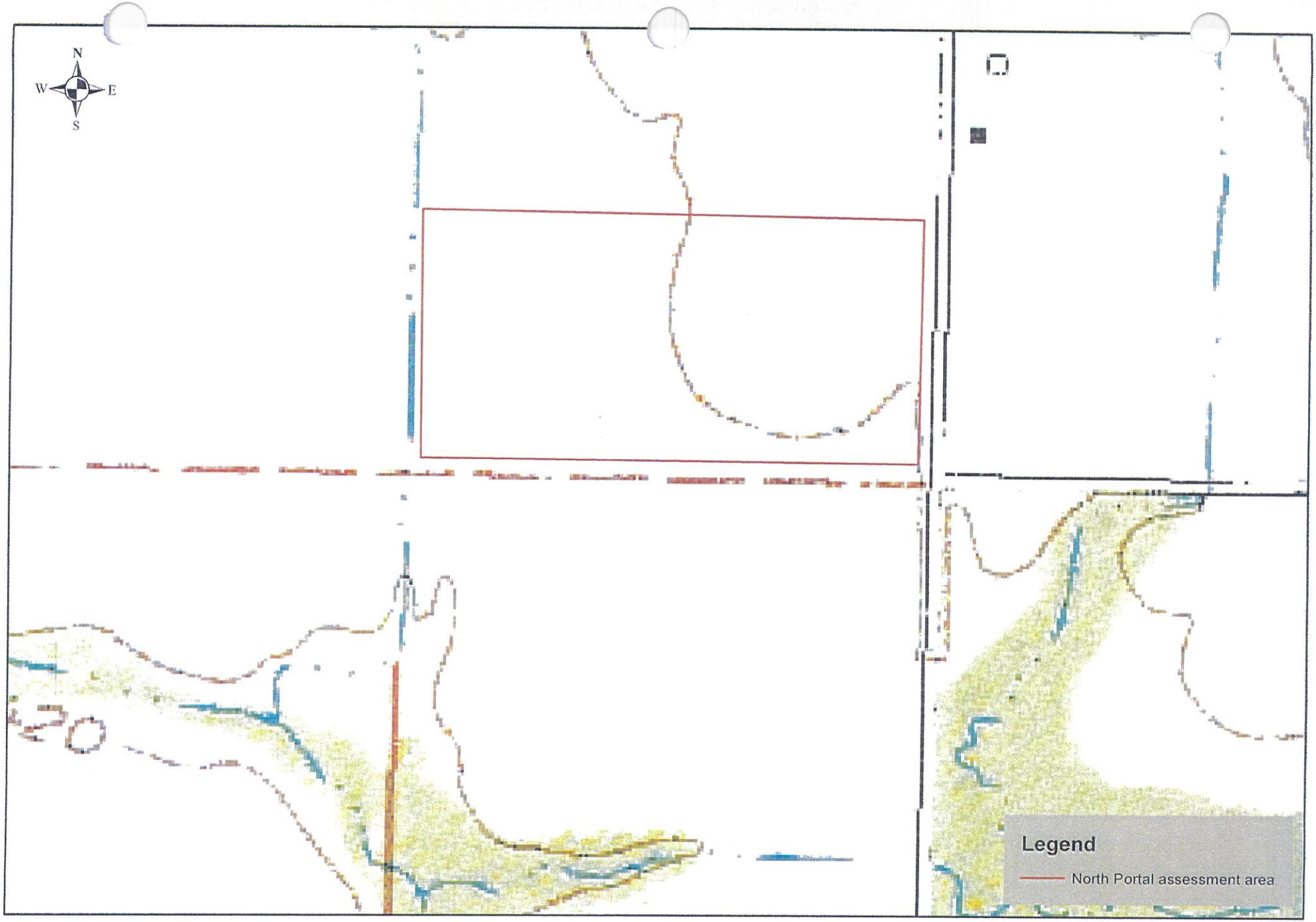


Figure 4. USGS topographic map of the site.

R06833

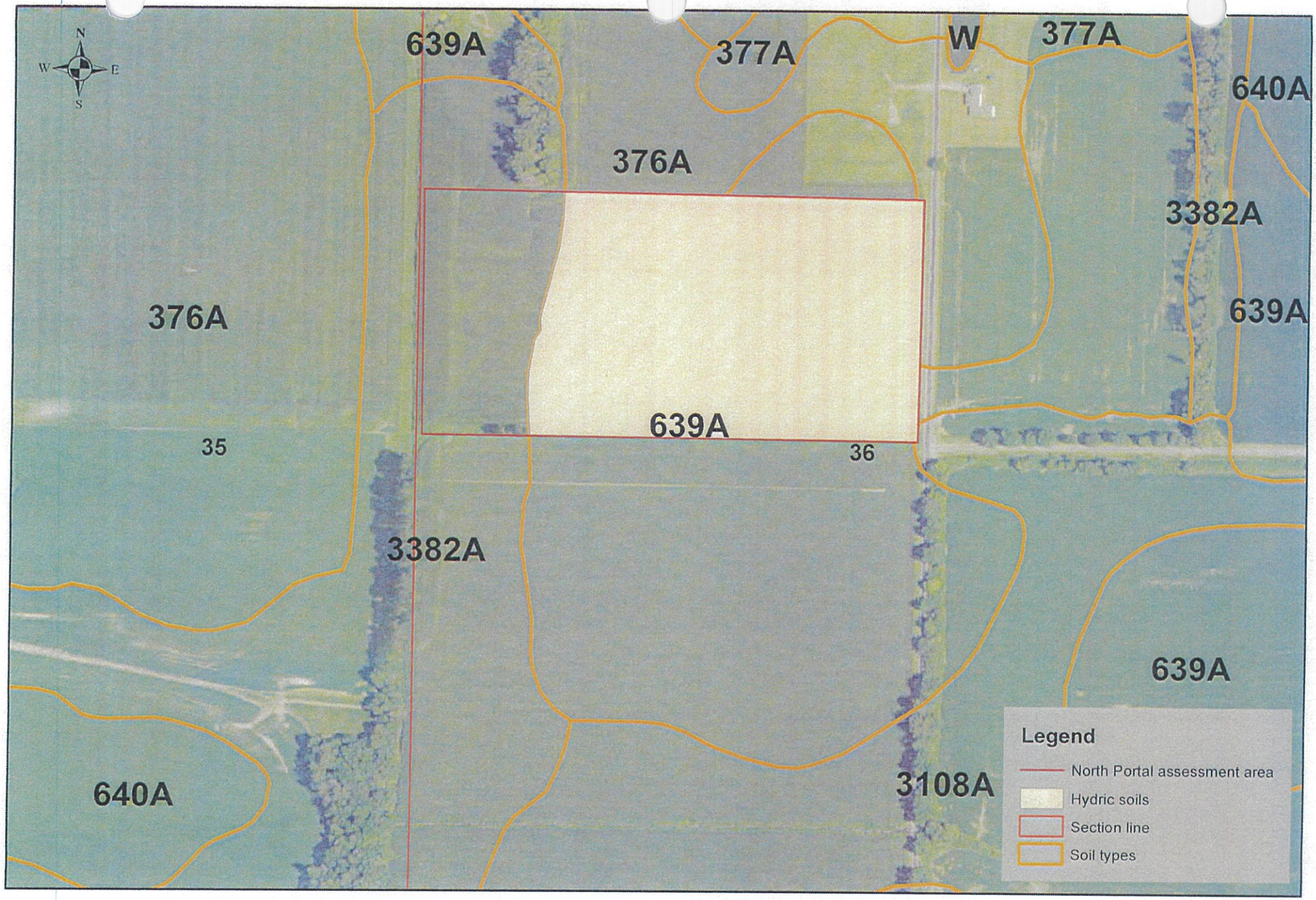


Figure 5. Soils map.

R06834



Figure 6. Floodplain and NWI sites.

R06835

9083-19
Part 2 of 2
R06836

APPENDIX A

PHOTOGRAPHIC DOCUMENTATION



Drainage feature in crop field facing down grade.



Drainage feature in crop field facing upgrade.

See Figure 3 for photo location.



Bed and bank channel, lower end, point B Figure 3.

Attachment 5.3.3.1

Culvert Selection: Access Road For North Supply Shaft

Summary: Area 1 requires one (1) 12 inch diameter corrugated steel culverts (or equivalent) for the access road to the surface site. Area 2 requires one (1) 18 inch diameter corrugated steel culverts (or equivalent) for the access road to the surface site to allow offsite drainage to pass under the access road.

1----Specifically required per 62 Ill. ADM. Code, Ch. 1, Section 1817.43 c) 3), drainage flow must safely pass the peak runoff of a 2-year / 6-hour precipitation event. For this particular site, the event is approximately 2.6 inches of rainfall.

2----Use Talbot's Formula for round, steel corrugated culvert sizing (standard method for most Illinois County Highway Departments) to safely pass a 2.6-inch rainfall event.

The watershed runoff for the culvert selection was coefficient 0.3 "Flat Land".

Please see attached calculations sheets for further details.

Using Talbot's Formula to Determine the Correct Culver Size To Carry Surface Drainage

The program that calculates the Talbot Formula (a=C*A3/4) allows the user to plug in the data fields and a square footage water flow area is computed. The computed value must then be correlated to the Pipe Area list of standard sized culverts. Where the flow area value is between the listed pipe sizes, standard practice is to select the next up or use multiple smaller diameter pipes.

The attached 2-yr. 6 hr. hydrograph was taken from the NRCS Compilation of Bullentin 71-Rainfall Frequency Atlas of the Midwest (Illinois State Water Survey) by Floyd Huff and James Angel. This hydrograph shows 2.6 inches of rain for the area near Williamson Energy's Mach Mine facilities for the 6-hour duration of a 2-year event. This equates to an average of 0.433 inches of rain per hour for this 2-hr.--6 year event. For comparison, the 100-yr/24-hr. event is 0.33-inches/hr.

Note: "Talbot's Formula" by Professor Arthur N. Talbot, Water Resources Engineering---University of Illinois at Champaign.

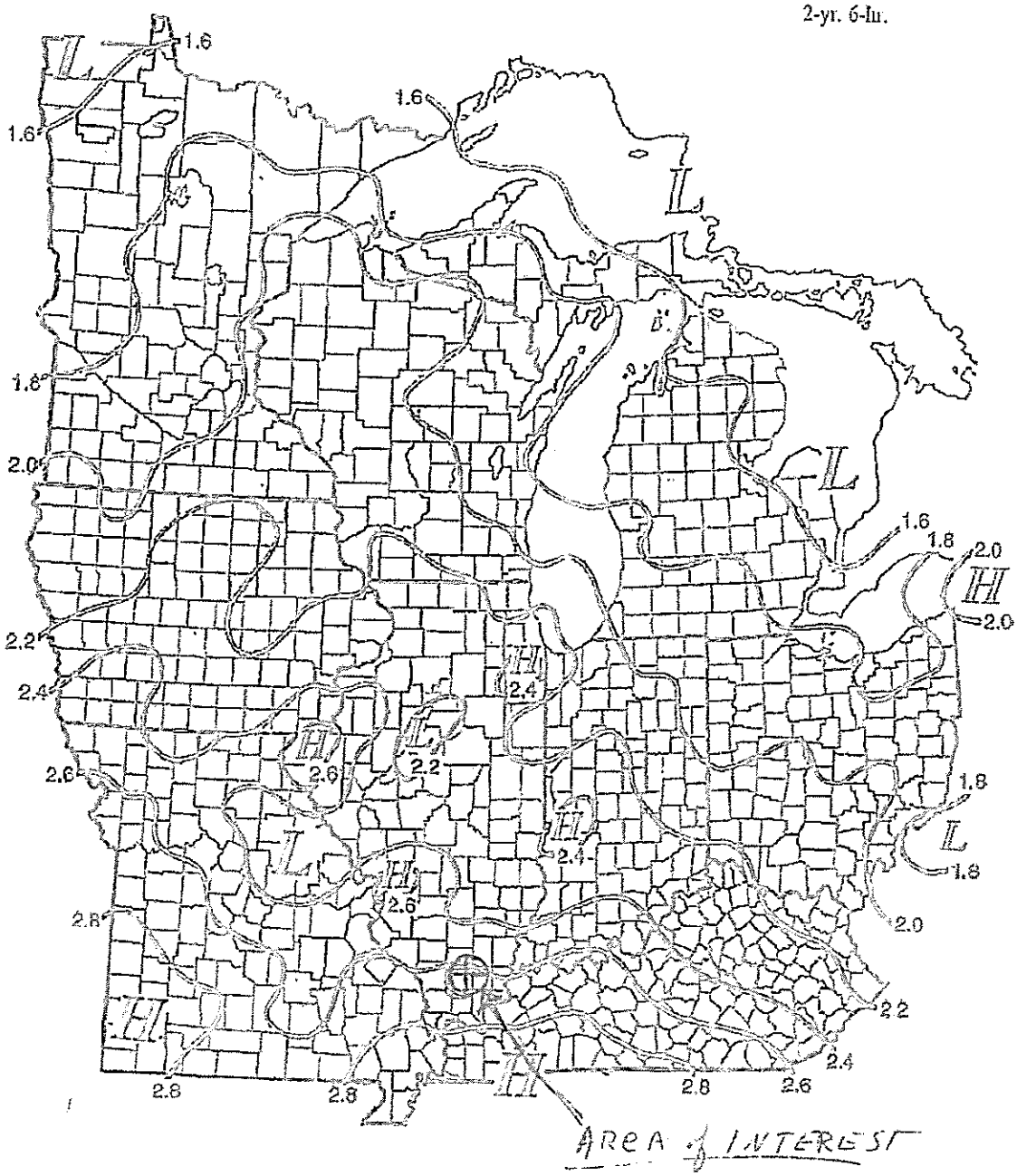


Figure 4. Spatial distribution of 6-hour rainfall (inches)

Attachment 5.3.3.1 Continuted

Talbot's Forumla

Area 1 Road Culvert

$a=C*A^{3/4}$

a= Required Section of Waterway in Square feet
A= Drainage area in acres
C = Talbot's Coefficient

Talbolts Coefficient

	Mountainous	Hilly Land		Rolling Land		Flat Land	
C =	1	0.8	0.6	0.5	0.4	0.3	0.2

Label	Area (acres)	Talbot Coefficient	Waterway Area (ft^2)	Pipe Size (In.)	CMP Number
Area 1	1.1	0.2	0.21	12	1

Pipe Area

	Pipe Area (ft^2)				
Pipe Size	1 Culvert	2 Culverts	3 Culverts	4 Culverts	5 Culverts
12 Inch	0.79	1.57	2.36	3.14	3.93
18 Inch	1.77	3.53	5.30	7.07	8.84
24 Inch	3.14	6.28	9.42	12.57	15.71
30 Inch	4.91	9.82	14.73	19.63	24.54
36 Inch	7.07	14.14	21.21	28.27	35.34
42 Inch	9.62	19.24	28.86	38.48	48.11
48 Inch	12.57	25.13	37.70	50.27	62.83
54 Inch	15.90	31.81	47.71	63.62	79.52
60 Inch	19.63	39.27	58.90	78.54	98.17
66 Inch	23.76	47.52	71.27	95.03	118.79
72 Inch	28.27	56.55	84.82	113.10	141.37
84 Inch	38.48	76.97	115.45	153.94	192.42
96 Inch	50.27	100.53	150.80	201.06	251.33
108 Inch	63.62	127.23	190.85	254.47	318.09
120 Inch	78.54	157.08	235.62	314.16	392.70

Attachment 5.3.3.1 Continuted

Talbot's Forumla

Area 2

$a=C*A^{3/4}$

a= Required Section of Waterway in Square feet
A= Drainage area in acres
C = Talbot's Coefficient

Talbolts Coefficient

	Mountainous	Hilly Land		Rolling Land		Flat Land	
C =	1	0.8	0.6	0.5	0.4	0.3	0.2

Label	Area (acres)	Talbot Coefficient	Waterway Area (ft^2)	Pipe Size (In.)	CMP Number
Area 1	15.58	0.2	1.57	18	1

Pipe Area

	Pipe Area (ft^2)				
Pipe Size	1 Culvert	2 Culverts	3 Culverts	4 Culverts	5 Culverts
12 Inch	~~0.79~~	1.57	2.36	3.14	3.93
18 Inch	1.77	3.53	5.30	7.07	8.84
24 Inch	3.14	6.28	9.42	12.57	15.71
30 Inch	4.91	9.82	14.73	19.63	24.54
36 Inch	7.07	14.14	21.21	28.27	35.34
42 Inch	9.62	19.24	28.86	38.48	48.11
48 Inch	12.57	25.13	37.70	50.27	62.83
54 Inch	15.90	31.81	47.71	63.62	79.52
60 Inch	19.63	39.27	58.90	78.54	98.17
66 Inch	23.76	47.52	71.27	95.03	118.79
72 Inch	28.27	56.55	84.82	113.10	141.37
84 Inch	38.48	76.97	115.45	153.94	192.42
96 Inch	50.27	100.53	150.80	201.06	251.33
108 Inch	63.62	127.23	190.85	254.47	318.09
120 Inch	78.54	157.08	235.62	314.16	392.70

PART 6: Stream Diversions

The design and construction of all stream channel diversions of perennial and intermittent streams shall be sealed by a qualified registered professional engineer as meeting the performance standards of this Section.

6.1 Disturbance Information. Are surface mining activities (including road crossings) or permit boundaries proposed within 100 ft of **any** stream (ephemeral, intermittent, or perennial)?

☒ YES ☐ NO

If YES,

a) For any stream(s) located **outside** the proposed permit boundary where disturbance within 100 ft is proposed go to Part 6.3; and
b) For any stream(s) located **outside** the proposed permit boundary where NO disturbance within 100 ft will occur go to Part 6.10; and
c) For any stream(s) located **within** the proposed permit boundary where disturbance within 100 ft is proposed go to Part 6.2.

If NO, go to Part 6.10.

6.2 Stream Information. Provide a Stream Delineation Report and/or Wetland Delineation Report. Information contained in the report(s) shall meet the requirements found at **1780.14/1784.23, 1780.29/1784.29, 1816.43/1817.43 and 1816.97/1817.97.**

6.2.1 Stream Classification. Indicate the number of each type of stream located within the proposed permit area.

[1] Ephemeral [1] Intermittent [ ] Perennial

6.3 Stream Buffer Variance. Is a stream buffer variance requested? **[1816.57/1817.57]**

☐ YES ☒ NO

If YES,

a) For stream(s) located **outside** the proposed permit boundary go to Part 6.4
b) For stream(s) located **inside** the proposed permit boundary go to Part 6.5.

If NO, provide a justification that each disturbed stream is ephemeral based on both parts of the definition of ephemeral stream found at **Section 1701.5 Appendix A.** Refer to Operator Memorandum No. 2017-06 for guidance regarding ephemeral stream justification. Briefly describe the disposition of the ephemeral stream(s) during operations and post-mining. Nomenclature of ephemeral streams must be consistent with maps and reports. No further information is required in Part 6 of the application **if** all streams are ephemeral.

See Wetland and Stream delineation Report Attachment 5.1.2. A small ephemeral stream is located along the south edge of the proposed permitted area. No impact is proposed for this area. The stream is determined to be ephemeral because the drainage area is less than 1 square mile and the stream does not receive contribution from

groundwater flow. The stream was examined to have upland plants rooted in the stream bed and an absence of obligate or facultative wetland plants. The stream does not show any meanders, riffles, pools and no active erosional features.

A small intermittent stream is located on the western edge of the IBR. This stream will be protected with a 100 feet buffer zone and no disturbance is proposed inside the buffer zone.

6.4 Streams Outside Permit Boundary. For each intermittent and/or perennial stream located outside the permit boundary where a stream buffer variance is requested, provide the name of the stream and describe how the requirements of **1816.57/1817.57** will be met. No further information is required in Part 6 of the application for streams outside the proposed permit boundary.

N/A

6.5 Existing Streams Locations. Provide the **Existing Streams Location and Watershed Map** meeting the specifications found in Part 2.1.3.c. **[1780.14/1784.23]; [1780.29/1784.29]; [1816.43/1817.43]; [1816.97/1817.97]**

6.6 Habitat Characterization. Pre-Mining Stream Habitat Characterization of each stream channel to be either temporarily or permanently diverted shall be discussed in Part 7.1.3.a. **[1780.16(a)(2)(B)/1784.21(a)(2)(B)]; [1816.97(f)/1817.97(f)]; [1816.43(a)(3)/1817.43(a)(3)]**

6.7 Temporary Stream Diversions. Temporary diversions shall be removed promptly when no longer needed to achieve the purpose for which they were authorized. **[1816.43/1817.43]**

6.7.1 Temporary Stream Diversion Construction Narrative. For each temporary diversion proposed, discuss the proposed construction practices including the following information: **[1780.29/1784.29]; [1816.43/1817.43];** [Memorandum No. 2005-04]

a) Estimated diversion construction beginning and ending dates.

b) Erosion control practices during construction to reduce addition of suspended solids to streamflow outside the permit area.

c) Estimated date when erosion control and vegetation will be sufficiently established to allow diversion of water through the temporary channel.

d) Indicate the timing and method of contacting the Department for approval upon stabilization of the stream channel. Department approval is required before water may be diverted through the temporary stream channel.

e) Indicate below if a Sediment Pond Exemption is requested (1816.46(e)/1817.46(e)) for diversion channel spoil.

If NO – explain why an exemption is not required.
If YES – describe methods to prevent diversion channel spoil from impacting surrounding area, including disposition of channel spoil.

f) Outline a reporting schedule to be submitted to the department during construction and submit a report to the Department within 30 days after completion of the temporary diversion that has been sealed by a qualified registered professional engineer.

g) Discuss how the activity will comply with the Rivers, Lakes, and Streams Act (Ill. Rev. Stat. 1991, ch. 19, pars. 52-79) [615 ILCS 5], Section 404 of the Federal Water Pollution Control Act of 1972, as amended (30 U.S.C. 1344), and all local ordinances.

6.7.2 Temporary Stream Diversion Locations. Provide a **Stream Diversion Map** meeting the requirements in Part 2.1.3.j. **[1780.14/1784.23]; [1780.29/1784.29]; [1816.43/1817.43]**

6.7.3 Temporary Stream Diversion Plan-Profile and Cross-Section. For each temporary stream diversion proposed, provide drawings depicting the following information: **[1780.14/1784.23]; [1780.29/1784.29]; [1816.43/1817.43]**

a) Cross-sections showing the limits and configuration of the proposed activities, dimensions, channel linings, normal water surfaces, side slopes and inflection points (cut and fill, curves, and straight sections).

b) A profile of the temporary stream diversion depicting the flow line slope and the water level for the 10-year 6 hour storm event.

c) Detailed channel sizing calculations demonstrating the temporary diversion channel is adequate to convey the 10-year 6 hour storm event. The calculations shall include run-off volumes from the drainage area.

6.7.4 Post-Diversion Reclamation. Describe the reclamation of temporary stream diversions after flow has been diverted to the restored or relocated stream channel, provide the following information: **[1780.18(b)(5)/1784.13(b)(5)]; [1816.43/1817.43]; [1816.116/1817.116]; [1816.97/1817.97] IF all responses to this part are the same as Forest or Wildlife Woody** Post Mining-Land Use information provided in Part 12, indicate such in the space below.

a) Describe proposed soil preparation and a soil testing plan related to reclamation and revegetation procedures. **[1780.18(b)(5)(G)/1784.13(b)(5)(G)]**

b) Describe the methods for the use of **temporary** seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c)]; [1816.114/0817.114]**

c) Describe the timing and methods proposed to transition from the temporary vegetation to the permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

d) Provide a permanent species list that will achieve the designated Post-Mining Land Use that meets the requirements of 1816.111 (a) and (b)/1817.111 (a) and (b) and 1816.97(g)/1817.97(g). If non-native species are proposed to achieve the Post-Mining Land Use, provide adequate justification meeting the requirements of 1816.111(a)(2)/1817.111(a)(2). Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates. **[1780.18(b)(5)/1784.13(b)(5)]**

e) If a bat Protection and Enhancement Plan (PEP) is part of the application, the applicant shall ensure consistency between this part and the bat PEP. Describe measures taken to ensure consistency.

f) Describe a **periodic measurement plan** of the vegetation as outlined in 1816/1817.116(b)(1) that will be used to identify if remedial actions are necessary to achieve the approved species and / or Post-Mining Land Use vegetation success standards during the applicable period of liability. Refer to Operator Memorandum No. 2017-02 for additional information regarding tree and shrub planting maintenance. Information provided shall also **describe a remedial action plan** to achieve the approved vegetative species, invasive species management, or Post-Mining Land Use success. Remedial actions required to meet Sections 1817.111 (a) and (b) may include but are not limited to mowing, burning, undesirable invasive species control, irrigation and pest and disease control. **[1816.116(b)(1)/1817.116(b)(1)];[1816.111(a) and (b)/1817.111(a) and (b)]**

6.8 Permanent Stream Diversion. The following requirements for a permanent stream diversion must be met: **[1816.43/1817.43]**

6.8.1 Classification. The following information in Part 6.8 contains construction and restoration plan information for (indicate the number of each type):

☐ Permanent Restored Stream(s) ☐ Permanent Relocated Stream(s)

6.8.2 Permanent Stream Diversion Construction Narrative. For each permanent diversion proposed, discuss the proposed construction practices including the following information: **[1780.29/1784.29] [1816.43/1817.43];** [Operator Memorandum No. 2005-04]

a) Estimated permanent channel construction beginning and end dates.

b) Erosion control practices during construction to reduce addition of suspended solids to streamflow outside the permit area.

c) Estimated date when erosion control and vegetation will be sufficiently established to allow diversion of water through the temporary channel.

d) Indicate the timing and method of contacting the Department for approval upon stabilization of the stream channel. Department approval is required before water may be diverted through the temporary stream channel.

e) Indicate below if a Sediment Pond Exemption is requested (1816.46(e)/1817.46(e)) for diversion channel spoil.

If NO – explain why an exemption is not required.
If YES – describe methods to prevent diversion channel spoil from impacting surrounding area, including disposition of channel spoil.

f) Discuss how the activity will comply with the Rivers, Lakes, and Streams Act (Ill. Rev. Stat. 1991, ch. 19, pars. 52-79) [615 ILCS 5], Section 404 of the Federal Water Pollution Control Act of 1972, as amended (30 U.S.C. 1344), and all local ordinances.

g) Outline a reporting schedule to be submitted to the department during construction and submit a report to the Department within 30 days after completion of the permanent stream channel that has been sealed by a qualified registered professional engineer.

6.8.3 Permanent Stream Diversion Locations. Ensure that the **Stream Diversions Map** submitted in Part 6.8.2 meets the requirements in Part 2.1.3.j. **[1780.14/1784.23]; [1780.29/1784.29]; [1816.43/1817.43]**

6.8.4 Permanent Stream Channel Plan-Profile and Cross-Section. Permanent stream channels shall approximate the original pre-mining stream characteristics. For each permanent stream channel proposed, provide drawings depicting the following information: **[1780.14/1784.23]; [1780.29/1784.29]; [1816.43/1817.43]**

a) A profile depicting bed slopes, pool-riffle ratios, and normal water surfaces.

b) Plans and drawings for boulder deflectors, check dams, and other instream habitat structures.

c) Cross-sections showing the limits and configuration of the proposed activities, dimensions, channel linings, normal water surfaces, side slopes and inflection points (cut and fill, curves, and straight sections).

d) Include a calculated flow rate (cfs) and velocity (ft/sec) at representative locations for low flow and normal flow and the 100-year flood condition that will allow a freeboard of no less than 0.3 feet.

e) Channel sizing calculations to demonstrate that the proposed stream channel and surrounding flood plain are adequate to convey the 100-year 6 hour storm event. The calculations shall include run-off volumes from the drainage area.

6.8.5 Permanent Stream Channel Reclamation. Describe the reclamation of permanent stream channels, provide the following: **[1780.18(b)(5)/1784.13(b)(5)]; [1816.14/1817.43]; [1816.116/1817.116]; [1816.97/1817.97] IF all responses to this part are the same as Forest or Wildlife Woody** Post Mining-Land Use information provided in Part 12, indicate such in the space below.

a) Describe proposed soil preparation and a soil testing plan related to reclamation and revegetation procedures. **[1780.18(b)(5)(G)/1784.13(b)(5)(G)]**

b) Describe the methods for the use of **temporary** seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c)]; [1816.114/0817.114]**

c) Describe the timing and methods proposed to transition from the temporary vegetation to the permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

d) Provide a permanent species list that will achieve the designated Post-Mining Land Use that meets the requirements of 1816.111 (a) and (b)/1817.111 (a) and (b) and 1816.97(g)/1817.97(g). If non-native species are proposed to achieve the Post-Mining Land Use, provide adequate justification meeting the requirements of 1816.111(a)(2)/1817.111(a)(2). Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates. **[1780.18(b)(5)/1784.13(b)(5)]**

e) If a bat Protection and Enhancement Plan (PEP) is part of the application, the applicant shall ensure consistency between this part and the bat PEP. Describe measures taken to ensure consistency.

f) Describe a **periodic measurement plan** of the vegetation as outlined in 1816/1817.116(b)(1) that will be used to identify if remedial actions are necessary to achieve the approved species and / or Post-Mining Land Use vegetation success standards during the applicable period of liability. Refer to Operator Memorandum No. 2017-02 for additional information regarding tree and shrub planting maintenance. Information provided shall also **describe a remedial action plan** to achieve the approved vegetative species, invasive species management, or Post-Mining Land Use success. Remedial actions required to meet Sections 1817.111 (a) and (b) may include but are not limited to mowing, burning, undesirable invasive species control, irrigation and pest and disease control. **[1816.116(b)(1)/1817.116(b)(1)]; [1816.111(a) and (b)/1817.111(a) and (b)]**

6.9 Culverts and Crossing of Non-Diverted, Temporary, and/or Permanent Stream Channels. Where a bridge, road, culvert or other crossing is proposed for any streams, provide the following information: **[1780.37/1784.24]**

a) Name of stream(s) with nomenclature consistent with names used in maps and reports.

b) Description of construction methods and sequence including water handling during construction and erosion/sediment control measures for each crossing.

c) Calculations of the hydraulic capacity of each structure.

d) Is the proposed structure(s) temporary or permanent? If temporary, include plans for removal.

e) A profile of the each stream bed at minimum 100 feet above and below the proposed location of the structure(s) unless the Department requires a greater distance to demonstrate appropriate engineering design to contain and control flow. The profile(s) shall depict normal and flood water surface elevations and the backwater effects of the structure.

f) Cross-section of the structure(s) showing the inlet and outlet invert elevations, length of the culvert, slope of the culvert, and the elevation of the road surface.

g) Describe how the original stream channel(s) and associated riparian vegetation will be restored.

6.10 Stream Buffer Zone. Discuss how the designated 100 ft stream buffer zone will be marked for any intermittent and/or perennial stream that will not be disturbed by surface mining activities. Cleary indicate the 100 ft. stream buffer zone on all required maps in Part 2.1.3. If NO streams are located within the proposed permit boundary or within 100 ft of the proposed permit boundary indicate N/A. **[1816.57(b)/1817.57(b) and 1816.11/1817.11]**

The stream buffer zone will be marked with steel post with painted red tops to signify a protected area. Post spacing will be at 100 feet apart.

PART 7: Fish and Wildlife

7.1 Pre-mining Fish and Wildlife Resources: Each application shall include fish and wildlife resource information for the permit and adjacent area. Prior to initiating fish and wildlife resource information studies, the applicant shall contact the Department to determine what fish and wildlife resources information will be required. If the applicant has not contacted the Department as described above, an explanation shall be supplied in the space below. **[1780.16(a)/1784.21(a)]; [1780.16(a)(1)(A)/ 1784.21(a)(1)(A)]**

See Attachment 7.1

7.1.1 Vegetation Map. Provide a Vegetation Map meeting the specifications outlined in Part 2.1.3.b **[1779.19/1783.19]; [1779.24(l)/1783.24(l)]; [1780.16(a)(2)(B) & (C)/1784.21(a)(2)(B)&(C)]**

See Pre-Mine Land Used Map

7.1.2 Habitat Descriptions. Provide a description of the habitat types for each listed Pre-Mining Land Use category, excluding cropland, within the proposed permit area. Include information for areas categorized as Residential, Industrial/Commercial, Recreational, and Undeveloped that contain trees or other potential habitats of high value for fish and wildlife. Include specific information on pre-mining woody and herbaceous vegetation species. In addition, provide a general description of the habitat found in the adjacent half mile area, specifically addressing any potential habitats of high value. **[1784.15(a)(1)/1780.23(a)(1)]; [1779.19(a)/1783.19(a)];** [Operator Memorandum 2015-01]

See Pre-Mine Land Used Map

a) For Wildlife Wetland Pre-Mining Land Use located within the proposed permit area, discuss how these areas will be avoided or replaced, and enhanced where applicable and provide general information on the steps taken to comply with the Section 404 of the Clean Water Act. If no Wildlife Wetland exits within the proposed permit area pre-mining, indicate N/A. **[1780.18(b)(9)/1784.13(b)(9)];[1816.97(f)/1817.97(f)]**

7.1.3 Other Site Specific Habitats of High Value: Address any habitats of unusually high value for fish and wildlife located within the proposed permit and adjacent half mile area. The following information is required: **[1780.16(a)(2)(B)/1784.21(a)(2)(B)]; [1816.97(f)/1817.97(f)]**

a) **Stream Habitat Characterization**: For **each** intermittent and perennial stream discussed in Part 6, provide a description of the riparian vegetation and a narrative discussing any critical habitat for threatened and endangered aquatic species. Provide a **general** discussion on how stream habitat will be avoided or replaced, and enhanced where practicable. If no intermittent or perennial streams were identified in Part 6 indicate N/A. **[1780.16(a)(2)(B)/1784.21(A)(2)(B)]; [1816.97(f)/1817.97(f)]**

i) Provide general information on the steps taken to comply with Section 404 of the Clean Water Act regarding streams and associated riparian areas. **[(1780.18(b)(9)/1784.13(b)(9)]**

b) **Shelter, Protection, and Reproductive Areas**: Discuss areas within the proposed permit and adjacent half mile area such as cliffs supporting raptors, caves, migration routes and wintering areas and measures to protect these areas and enhance where practicable. If none of these areas exist indicate N/A. **[1780.16(a)(2)(B)/1784.21(a)(2)(B)]; [1816.97(f)/1817.97(f)]**

c) **Agency Consultation:** Discuss any additional habitats of high value identified through other agency consultations as requiring protection by applicable state and federal laws, this may include a larger adjacent area as defined by consultation. If no other habitats of high value were identified through consultation indicate N/A. **[1780.16(a)(2)(C)/1784.21(a)(2)(C)]; [1780.16(a)(1)(B)(iii)/1784.21(a)(1)(B)(iii)]**

7.2 Threatened and Endangered Species: Information required in this section will ensure that the proposed operations adhere to the Endangered Species Act of 1973, as amended, the Migratory Bird Treaty Act, as amended, the Bald and Golden Eagle Protection Act, as amended and other applicable state and federal laws. **[1773.12]; [1780.16/1784.21]; [1816.97/1817.97]**

7.2.1 T&E Species List. Provide a complete threatened and endangered species list for both state and federally listed species that are known to occur within the county(ies) of the proposed permit area and each adjacent counties. This information may be provided in Attachment 7.2.1. **[1780.16(a)(1)(B)/1784.21(a)(1)(B)]; [1780.16(a)(2)(A)/1784.21(a)(2)(A)]; [1816.97(b)/1817.97(b)]**

See Attachment 7.1 / See Permit 375

a) **Likely to Occur Determination.** For each threatened and endangered species listed in part 7.2.1 provide a determination based on species habitat requirements regarding the likelihood that the species may occur within the proposed permit and, if applicable, the adjacent half mile area. In addition, provide the rationale justifying the determination. If an attachment is provided, it should be titled Attachment 7.2.1.a. If multiple attachments are necessary they should be titled Attachment 7.2.1.a 1 of 2 etc. **[1780.16(a)(1)(B)/1784.21(a)(1)(B)], [1780.16(a)(2)(A)/1784.21(a)(2)(A)]; [1816.97(b)/1817.97(b)]**

b) **Reporting of Technical Data.** Provide the names and qualifications of person(s) or organization(s) that collected and analyzed threatened and endangered species data and made the determinations of likely occurrences of those species. **[1777.13]**

c) **Format and Contents**: The information presented shall be current, clear and concise, filed in the format required by the Department, and contain explicit citations. Where required by the Department, relevant portions of the referenced materials shall be presented by photocopying or abstracting. If references to previously approved permits are made, the relevant portions of the permits must be supplied in accordance with Operator Memorandum No. 90-08 or an explanation

shall be provided below why this information is not provided. This information may be supplied in Attachment 7.2.1.c if necessary. **[1777.11(a) and (b)]**

d) **Agency Consultation**: Discuss any additional species identified through other agency consultations as requiring protection by applicable state and federal laws. If no other species information is required indicate N/A. **[1780.16(a)(2)(C)/1784.21(a)(2)(C)]; [1780.16(a)(1)(b)(iii)/1784.21(a)(1)(b)(iii)]**

7.2.2 T&E Species Protection and Enhancement Plans. Do any trees exist within the proposed permit area? **[1780.16(b)/1784.21(b)]**

☒ YES ☐ NO

IF YES, the applicant shall:

a) Provide a Protection and Enhancement Plan and an Incidental Take Authorization request as Attachment 7.2.2 for the Indiana bat meeting the specifications of the "Range-wide Indiana Bat Protection and Enhancement Plan Guidelines" (revised 2013) developed by the U.S. Fish and Wildlife Service and the Office of Surface Mining, or justify why a Protection and Enhancement Plan and Incidental Take authorization request are not required under those guidelines.

b) Discuss whether or not the project is consistent with the northern long-eared bat Final 4(d) Rule for Federal Actions (January 2016), and if not then provide a Protection and Enhancement Plan and Incidental Take Authorization request consistent with the 2013 Indiana bat guidelines referenced above. This information may be provided in Attachment 7.2.2.

No trees are within the area of the proposed disturbance on the IBR. No trees along the ephemeral stream will be disturbed during any construction activities.

c) Provide Protection and Enhancement Plans for any additional state or federally listed species that are likely to occur within the proposed permit and adjacent half mile area in Attachment 7.2.2.c. For any additional federally listed threatened or endangered species that are likely to occur in the permit area, provide an Incidental Take Authorization request with the Protection and Enhancement Plan.

d) If an applicant is in possession of any current Incidental Take Authorizations for state listed threatened or endangered species obtained through the Illinois Department of Natural Resources Office of Resource Conservation, list those species in the space below, otherwise indicate N/A.

7.2.3 Eagles. The applicant shall ensure that mining activity will be conducted in a manner that will not result in the taking of a Bald or Golden Eagle, or any other raptor protected under the Bald Eagle Protection Act, and their nests or eggs. "Take" includes the disturbance of protected eagles to the degree that it substantially interferes with breeding, feeding, or sheltering behavior or results in injury. **[1816.97(c) and (d)/1817.97(c) and (d)]**

a) Provide current and accurate information on distances to known Bald Eagle nests within the proposed permit boundary and within a one mile radius. If none exist, then this should be specifically stated. If nests exist within a one mile radius, a Protection and Enhancement Plan must be supplied. Information should also include any species protected under the Bald Eagle Protection Act as amended and may be provided in Attachment 7.2.3.

The following resource is suggested:

National Bald Eagle Management Guidelines USFWS

N/A

7.2.4 Reporting of Threatened and Endangered and Other Protected Species: Describe the steps and timeframe for reporting any state or federally listed species, or other protected species to the Department, should the operator become aware of the species existence within the proposed permit area. **[1816.97(b)/1817.97(b)]**

See Attachment 7.1

7.3 General Fish and Wildlife Protection and Enhancement Measures: The applicant shall, to the extent possible and with the best technology currently available, minimize disturbances and adverse impacts on fish and wildlife and related environmental values and achieve enhancement of these resources where practicable. **[1780.16(b)/1784.21(b)]; [1816.97(a)/1817.97(a)]**

7.3.1 Protection Measures. Provide information on measures using the best technology currently available how the applicant will protect fish and wildlife and related environmental values. The following information is required: **[1780.16(b)(3)/1784.21(b)(3)]; [1816.97(e)/1817.97(e)]**

a) **Electric Powerlines**. If powerlines are proposed to be relocated or constructed at any point during operations, then discuss the measures to ensure electric powerlines are designed and constructed to minimize any hazards to raptors and migratory birds to ensure that the Bald Eagle Protection Act and the Migratory Bird Treaty Act have been considered and addressed where applicable. This information may be provided in Attachment 7.3.1.a if necessary **(1780.16(b)(3)(A)/1784.21(b)(3)(A)/1816.97(e)(1)/1817.97(e)(1)).**

The following are suggested resources:
"Suggested Practices for Avian Protection from Powerlines: The State of the Art in 2006"

"Reducing Avian Collisions with Power Lines: The State of the Art in 2012"

Powerline will be constructed in accordance with Suggested Practices for Avian Protection of powerlines.

b) **Haul and Access Roads.** Describe how access and haul roads will be located and operated to avoid or minimize impacts on species protected under the Endangered Species Act, Migratory

Bird Treaty Act, and the Bald Eagle Protection Act, or discuss why these protection measures are not applicable. **[1780.16(b)(3)(A)/1784.21(b)(3)(A)]; [1816.97(e)(2)/1817.97(e)(2)]**

See Permit 375

c) **Fences and Overland Conveyers.** Describe how fences and overland conveyers and other potential barriers will be designed and constructed to allow passage of large mammals, or discuss why these protection measures are not applicable. **[1780.16(b)(3)(A)/1784.21(b)(3)(A)]; [1816.97(e)(3)/1817.97(e)(3)]**

See Permit 375

d) **Exclusion from Ponds.** Provide information on whether or not ponds on site will contain hazardous concentrations of toxic-forming materials and if so, then describe how control measures, management techniques, and monitoring methods will be used to ensure how wildlife protected under the Endangered Species Act, Migratory Bird Treaty Act, and the Bald Eagle Protection Act are excluded from these areas. **[1780.16(b)(3)(A)/1784.21(b)(3)(A)]; [1816.97(e)(4)/1817.97(e)(4)]**

N/A

7.3.2 Enhancement Measures. Provide a **detailed** description of enhancement measures that will be used during the reclamation and post-mining phases of operations to develop aquatic and terrestrial habitats. Measures may include but are not limited to: restoration of streams and wetlands, retention of ponds, establishment of wildlife food and cover, addition of perches or nest boxes, habitat diversification of croplands, and any other management strategies designed to enhance wildlife habitat. **[1780.16(b)(3)(b)/1784.21(b)(3)(b)]**

See Permit 375

Attachment 7.1

EcoCAT
Ecological Compliance Assessment Tool

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Applicant: Williamson Energy, LLC
Contact: Chris Skelton
Address: PO Box 99
Johnston City, IL 62951

IDNR Project Number: 1801405
Date: 08/25/2017

Project: North Portal Coal Prospect Drilling
Address: 16824 Liberty School Road, Marion

Description: Coal prospect drilling

Natural Resource Review Results

This project was submitted for information only. It is not a consultation under Part 1075.

The Illinois Natural Heritage Database contains no record of State-listed threatened or endangered species, Illinois Natural Area Inventory sites, dedicated Illinois Nature Preserves, or registered Land and Water Reserves in the vicinity of the project location.

Location

The applicant is responsible for the accuracy of the location submitted for the project.

County: Franklin

Township, Range, Section:
7S, 3E, 35
7S, 3E, 36



IL Department of Natural Resources Contact
Impact Assessment Section
217-785-5500
Division of Ecosystems & Environment

Disclaimer

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IDNR Project Number: 1801405

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PART 8: Cropland Capability Soils

8.1 High Capability Post-mining Land Use

8.1.1 Discuss planned final graded slopes of the replaced high capability areas. Include a discussion of slope lengths and slope steepness. **[1825.14(c)]**

8.1.2 Discuss planned replacement of soil horizons with respect to horizon thickness and total root zone (mention thickness of each horizon).

a) The topsoil replacement thickness will be ___ inches. **[1823.14]**

b) The root medium replacement thickness will be ___ inches **[1825.14**

8.1.3 Discuss how excessive compaction will be avoided. If excessive compaction cannot be avoided, provided a compaction alleviation plan. **[1825.14(e)]**

8.1.4 Discuss how wind and water erosion will be minimized. Include discussions of construction, timing, seeding, seeding equipment to be used and erosion control structures to be used. **[1825.14(f)]**

8.1.5 Discuss the management of these areas including crop rotations, green manuring, and levels of fertility. **[1780.18(b)/1784.13(b)]**

8.1.6 Discuss planned timing of the construction and removal, if applicable, of the erosion control structures. If erosion control design and construction is to be coordinated with the Natural Resources Conservation Service, please discuss. **[1825.14(f)]**

8.1.7 Discuss the management of positive surface drainage with respect to differential settling. **[1825.14]**

8.1.8 Discuss the methods of mulching to be used with respect to seasonal variation. **[1780.18(b)/1784.13(b)]**

8.1.9 If the post mining acreage of high capability land is proposed to be reduced for any individual landowner in the permit area other than the applicant, provide a letter of consultation and response, if received, from those landowners.**[1780.23 (b) and (c)/1784.15(b) and (c)]**

8.2 Pre-mining Prime Farmland Soils. The following information must be given, in order for the regulatory authority to evaluate whether the applicant has the technological capability to restore mined prime farmland to equivalent or greater productivity within a reasonable time. The applicant shall use the Soils Map and Soil Information Chart provided in Part 2.3.9 of the application. The applicant may also choose to include references to the Custom Soil Survey referenced in Part 2.3.

8.2.1 Pre-mining Soil Profile. The applicant must include a description of the original undisturbed soil profile. The description must discuss the following parameters for each soil horizon that collectively constitutes the root zone unless specific depths or horizons are requested. **[1785.17(c)]**

See Soil Report Attachment 2.2.1

a) Depth and thickness of each horizon (range and average).

See Soil Report Attachment 2.2.1

b) Moist bulk density of each major horizon (use USDA approved method or reference).

See Soil Report Attachment 2.2.1

c) Present pH and state of fertility (P&K) (A horizon only).

See Soil Report Attachment 2.2.1

d) Texture analysis of each horizon (use USDA texture classification).

See Soil Report Attachment 2.2.1

e) If B&C horizons are proposed to be mixed, submit evidence to support proposal.

See Soil Report Attachment 2.2.1

8.2.2 Pre-mining Soil Samples. Soil samples must be taken on the permit site to obtain the material necessary for the above-required information. Sample site locations must be indicated on the soils map. NRCS established values on bulk density may be used in lieu of field investigation. Use of soil information from related permits may be considered if they are representative of the proposed application area. Underground mine surface disturbances which are not exempt from prime farmland restoration requirements and which propose to leave the subsoil in place, may submit the information provided in a Custom Soil Survey except that onsite samples must be taken to provide the information required for A horizon thickness

See Soil Report Attachment 2.2.1

a) The applicant shall discuss the history of previous productivity and cropping practices on the prime farmland, if known, or may reference the productivity information from Bulletin 811, provided in response to Part 2.3.1. **[1785.17(c)(4)]**

See Soil Report Attachment 2.2.1

b) The applicant shall provide references or copies of available agricultural school studies, company data or other scientific data for comparable areas to demonstrate that the applicant, using

their proposed method of reclamation will achieve, within a reasonable time, equivalent or higher levels of yield after mining as existed before mining. **[1785.17(c)(3)]**

See Soil Report Attachment 2.2.1

8.3 Prime Farmland Soil Handling

8.3.1 Describe the equipment to be used in the removal and replacement of each soil horizon. **[1785.17(c)(2)]**

Topsoil will be removed with dozer, scraper, or truck and excavator.

8.3.2 Discuss how excessive compaction will be avoided. **[1823.14(c)]** If excessive compaction cannot be avoided, provide a compaction alleviation plan. **[1823.14(d)]**

Topsoil will be handled as little as possible to ensure minimal compaction. Topsoil will stockpile separately from any other soil type.

8.3.3 Discuss the timing of the removal and replacement of the horizons with regards to seasons, weather, and regulatory authority testing approval. **[1823.12, 1823.14(b) and (e)]**

Topsoil will be evenly redistributed over the site and planted during the next planting cycle. A cover crop will be used to prevent erosion prior to next planting cycle.

8.3.4 Discuss how mining operation will impact prime farmlands where the B and/or C horizons are to be left in place and how these soils layers will be protected or restored to their original capability **[1823.12]**

The subsoils will be ripped/plowed prior to having topsoil place over them to minimized compacting from surface operations.

8.3.5 Discuss how the prime farmland will be identified in the field in order to avoid contamination with non-prime farmland soils. **[1823.12]**

All topsoil is prime farmland soil

8.3.6 Are prime farmland topsoil or subsoils to be mixed with non-prime soils?

☐ YES ☒ NO

If YES, provide evidence showing how combining will not affect the permittee's ability to restore the pre-mining prime farmland productivity. **[1823.14(e)]**

8.3.7 Discuss whether stockpiles will be used or direct placement will be used. If stockpiling will be used, discuss. Locate on Operations Map. **[1823.13]**

Stockpiles will be shown on Operation Map

8.3.8 Discuss length of time stockpiles are to be in place. **[1823.13]**

Stockpiles will be let in place until operation of the supply shaft are completed.

8.3.9 Discuss how prime land stockpiles are to be identified in the field in terms of different horizons and prime versus non-prime farmland piles. **[1823.13]**

All topsoil on this project are prime topsoils

8.3.10 Discuss any intermittent stockpile relocations as to how, when and why. **[1823.13]**

N/A

8.3.11 Discuss temporary and/or permanent seeding and revegetation to prevent wind and water erosion. **[1823.13]**

Topsoil stockpiles will be seed using approved Permit 375 mix during the next appropriate growing cycle.

8.3.12 Discuss how contamination by other soil horizons or by fly rock will be prevented. **[1823.13]**

N/A

8.4 Prime Farmland Reclamation Plan and Map

8.4.1 Locate on the Post-mining Land Use/Capability Reclamation Map the location of the replaced prime farmland. Give acreage totals in Table 11.1. If the post mining acreage of prime farmland is proposed to be reduced for any individual landowner in the permit area other than the applicant, provide a letter of consent from those landowners. **[1785.17 (e)(5)]**

All disturbed are will be return to previous land used

8.4.2 Discuss how wind and water erosion will be minimized. Include discussions of construction, timing, seeding, seeding equipment to be involved and erosion control structures to be used. **[1823.14(e)]**

Silt fence and straw bales will be used to prevent erosion; Topsoil stockpiles will be seed using approved Permit 375 mix during the next appropriate growing cycle.

8.4.3 Discuss the management of these areas including crop rotations, green manuring levels of fertility and personnel responsible for management. Discuss the fertility management. Also, discuss the management in relation to any land leveling needed. **[1823.14(f)]**

Applicable soil nutrient and soil amendments will be used are required to me 1823.14(F)

8.4.4 Discuss the timing of the construction of the erosion control structures and the criteria used to determine the need for and construction design of erosion control systems. If erosion control design and construction is to be coordinated with the Natural Resources Conservation Service, please discuss. **[1823.14(g)]**

Silt fence will be install prior to any disturbance

8.4.5 Discuss the final graded slopes of the replaced prime farmland areas. Include a discussion of slope lengths. **[1816.102(a)/1817.102(a)]; [1823.14]**

Grade will be same as pre-mining grades.

8.4.6 Discuss the management of positive surface drainage with respect to differential settling. **[1823.14]**

N/A

8.4.7 Discuss the replacement of soil horizons with respect to horizon thickness and the total root zone.

N/A

a) The topsoil replacement thickness will be ___ inches. **[1823.14(e)]**

b) The root medium replacement thickness will be ___ inches **[1823.14(a)(1)]**

8.4.8 Include any other relevant information in support of a possible finding by the regulatory authority that the operator has the technological capability to restore prime farmland areas, within a reasonable time, to equivalent or higher levels of yield, as determined by the regulatory authority. **[1785.17(e)]**

N/A

PART 11: Reclamation Plan

11.1 Post-Mining Land Use

11.1.1 Provide a **Post Mining Land Use/Capability Reclamation Map** as required by the General Mapping Requirements.

Provide a detailed description of proposed post-mining land uses and capabilities employing land use and capability categories listed in Table 11.1: Land Use Capability (Post-Mining) Summary. Complete acreage figures for each post-mining land use proposed and designate its capability classification. This information shall be broken down by landowner in addition to the composite land uses and capabilities.

For surface mines, acreage figures for post-mining land use must differentiate between mined and surface disturbance areas based on the mining line used in Part 2.3.3 of the application. **[1777.11(a)(3)]**

See Pre-mine land use map.

11.1.2 Where a post-mining land use different from a pre-mining land use is proposed, provide:

a) A discussion explaining the consideration which has been given to making all the proposed surface mining activities consistent with surface owner plans and applicable state and local land use plans and programs. **[1780.23/1784.15]**

No

b) A copy of the comments from the owner of the surface concerning the proposed land use of the proposed permit area and from the state or local government agencies which would have to initiate, implement, approve or authorize the proposed uses of the land following reclamation. In the event the surface land owner does not provide comments; the applicant shall provide proof of mailing to the surface owner soliciting comments to show that a good faith effort was made to provide the surface owner with the opportunity to comment. **[1780.23/1784.15]**

11.1.3 Provide a detailed timetable for completion for each major step in the proposed reclamation plan. The time table shall include for: **[1780.18(b)(1)/1784.13(b)(1)]**

11.1.3.1 Surface mine mining areas:

a) The timing of the rough grading, root medium, and topsoil during active mining to meet the standards of Section 1816.101. **Note: If the plan proposes to reduce the time frames of distance to less than that allowed, it must be stated her and in the reclamation cost estimate section.**

b) The timing of the planting of initial and permanent vegetation after final grading as it relates to the proposed land use.

11.1.3.2 Surface and underground mines, support areas, including refuse disposal areas:

a) The timing of the rough grading, root medium, and topsoil during active mining to meet the standards of Section 1816.101/1817.101

Reclamation will be complete after used of supply shaft. Seeding will be completed during the first planting season after reclamation.

b) The timing of the planting of initial and permanent vegetation after final grading as it relates to the proposed land use.

Seeding will be completed during the first planting season after reclamation.

c) Any other reclamation proposed activities during the mining to minimize reclamation liability and its associated costs.

N/A

11.2 Backfilling and Grading

11.2.1 Describe the methods to be used for backfilling and grading the proposed permit area, including soil stabilization and compaction practices in accordance with 62 Ill. Adm. Codes 1816.102/1817.102 through 1816.107/1817.107.

Topsoil will be redistributed evenly of the entire site.

a) Provide a Post-mining Contour Map and appropriate cross-sections to illustrate and define the proposed post-mining configuration of the permit area. **[1780.18(b)(3)/1784.13(b)(3)]**

See topo map

11.2.2 To achieve the proposed post-mining configuration including cover requirements for refuse disposal areas, the Applicant shall provide soil balancing calculations to ensure an adequate quantity of material is available. These calculations shall include soil shrinkage and swell factors consistent with sound engineering practices as approved by the Department. **[1780.23(b)(1)/1784.15(b)(1)]**

N/A

a) Are borrow areas being proposed to provide a sufficient amount of material to achieve the post-mining configuration?

☐ YES ☒ NO

b) If YES, the Applicant shall include the locations of the borrow areas on the Post Mining Land Use/Capability Map and complete the appropriate items included in Part 5.0: Drainage Control.

11.2.3 For surface mines, does the proposed surface coal mining and reclamation operation require disposal of excess spoil?

☐ YES ☐ NO ☒ N/A

If YES, provide the following:

a) Each application shall contain descriptions, including appropriate maps and cross-section drawings, of the proposed disposal site and design of the spoil disposal structures according to 62 Ill. Adm. Code 1816.71 through 1816.74. These plans shall describe the geotechnical investigation, design, construction, operation, maintenance, and removal, if appropriate, of the site and structures. **[1780.35(a)]**

b) Each application shall contain the results of a geotechnical investigation of the proposed disposal site that include the information outlined in **62 Ill. Adm. Code 1780.35(b)**.

c) If, under 62 Ill. Adm. Code 1816.71(l), rocktoe buttresses or key-way cuts are required, the application shall include information as outlined in **62 Ill. Adm. 1780.35(c).**

If NO, will the spoil and other waste materials available from the entire permit area be insufficient to restore the disturbed area to its approximate original contour as addressed in 62 Ill. Adm. Code 1816.104.

11.2.4 Describe the timing in which all grading and the construction and removal or renovation of water and erosion control structures will be complete and the sequence for accomplishing the work in relation to seasonal weather conditions. **[1780.25(a)/1784.16(a)]**

11.3 Shaft, Slope and Borehole Sealing. Each shaft, drift, adit, tunnel, exploratory hole, entryway, or other opening to the surface from underground shall be capped, sealed, backfilled, or otherwise properly managed, as required by the Department, in accordance with Section 1816.13/1817.13, Operator Memorandum No. 00-01, Operator Memorandum No. 2015-02, consistent with 30 CFR 75.1711, and provide the following: **[1816.15/1817.15]**

11.3.1 Temporary Seals. In the event the mine is temporarily closed or abandoned, provide information on temporary seals to be constructed for prevention of entry to all mine openings. Include an appropriate timetable for construction of these seals. **[1816.14/1817.14]**

Steel vent caps will be used if necessary.

11.3.2 Permanent Sealing Plans

a) Provide a description, including appropriate cross-sections and plan views, of the measures to be used to seal or manage mine openings, and to plug, case, or manage exploration holes, other boreholes, wells, and other openings within the proposed permit area, in accordance with 62 Ill. Adm. Code 1816.13/1817.13 through 1816.15/1817.15 and shall reflect the following concerns:

- Completion using a combination of backfilling and sealing.
- The type and grade of materials to be used for backfilling and the intervals in which they will be used.
- Sections of casing, entry linings, or collar to be demolished.

- Design of hydraulic seals, including construction material, reinforcing, method of placement, design thickness, and method of anchoring.
- Design of gas ventilation piping that will be incorporated in seal design.
- Finished grading at land surface.
- A description of a permanent monument marker identifying the seal as a mine opening.
- A description of the location of all sealed shafts, slopes, or other entrance tunnels to be recorded with the appropriate recorder of deeds. This is in Operator Memorandum 00-01 as a RECOMMENDATION.

b) For any deviation from the established guidelines for sealing, backfilling, and capping, provide an engineering and hydrologic justification. **[1780.18(b)(8)/1784.13(b)(8); Operator Memorandum 00-01]**

The shaft and any boreholes will be plugged from top to bottom according to all MSHA and IDNR regulatory standards after they are no longer needed. Any steel casings will be cut off three feet below natural soil level and the void filled with subsoil, and then covered with topsoil, mulched and seeded. Shaft and belt air holes will be filled with stockpile shaft material/rip rap and have at least one foot concrete reinforced cap. All utility boreholes will be plugged and filled with neat cement. The shaft will be survey and fill in the Franklin County Courthouse as required by Operator Memorandum 00-01.

11.4 Abandonment and Closure of Refuse Disposal Areas

11.4.1 Describe proposed reclamation for all coal refuse disposal areas in accordance with 62 Ill Adm. Code 1780.18(b)/1784.13(b). The proposed reclamation plan shall include the following information:

- Timing of final coverage
- Cross sections of final cover and configuration.
- Type and amount of material proposed to be used for cover, including any coarse refuse used to provide a base over slurry prior to soil cover.
- Construction details of cover and caps.
- Relationship of the refuse disposal area to the post-mining land use.
- Any plans of access roads and other use related facilities.

N/A

11.4.2 If any structure is 20 feet or higher or impounds more than 20 acre-feet, provide a stability analysis of each structure which shall include strength parameters, pore pressures, and long-term seepage conditions. Also, to be included is a description of each engineering design assumption and calculation with a discussion of each alternative considered in selection design parameters and construction methods. (For impounding structures refer to Part 3.5.1.) **[1780.25(a)(2)/1784.16(a)(2)]**

11.4.3 Submission of MSHA certification documents for a detailed design plan shall satisfy the requirements, in so far as the MSHA informational and design standard requirements are duplicative of the requirements. **[1780.25(a)(2)/1784.16(a)(2)]**

N/A

11.5 Bond Estimation

11.5.1 Provide a detailed estimate of the cost of reclamation for the proposed operation required to be covered by a performance bond. Provide calculations and/or drawings, cross sections, etc., to support the reclamation cost estimate. Provide extra calculations for multiple pits or refuse areas. Complete the appropriate Table 11.5 sections. At a minimum, delineate all buildings, reinforced concrete structures and pavement/gravel areas to be reclaimed on the Bond Calculation Map. **[1780.18(b)(2)/1784.13(b)(2)]; [1800.14]**

NOTE: If incremental bonding is requested, provide a Bond Increment Map and provide the following information by increment.

The estimate of the cost of reclamation shall be based on:

- Bond Calculation Acreage *(Table 11.5.1.1)*
- Surface Mining Soil Reclamation *(Table 11.5.1.2)*
- Interior Grading *((Table 11.5.1.3)*
- Boxcut Outslope Grading *(Table 11.5.1.4)*
- Incline/Highwall Reclamation *(Table 11.5.1.5)*
- Gob Pile/Gob Impounding Structure/Slurry Reclamation *(Table 11.5.1.6)*
- Slurry Pond/Incised Refuse Reclamation *(Table 11.5.1.7)*
- Support Area Reclamation *(Table 11.5.1.8)*
- Building Reclamation *(Table 11.5.1.9)*
- Reinforced Concrete Structure Reclamation *(Table 11.5.1.10)*
- Pavement/Gravel Area Reclamation *(Table 11.5.1.11)*
- Borehole Backfilling *(Table 11.5.1.12)*
- Shaft/Slope Backfilling *(Table 11.5.1.13)*
- Public Road Reclamation *(Table 11.5.1.14)*

11.5.2 Indicate location and size of buried volatile material storage facilities.

N/A

Table 11.1
Land Use Capability (Post-Mining) Summary

SURFACE OWNER	DISTURB CATEGORY	LAND CAPABILITY	POST-MINE LAND USE ACREAGE															Subtotal
			Cropland	Pasture	Forest	Wildlife -Herb	Wildlife - Woody	Wildlife - Wetland	Wildlife - Water	Residential	Industrial/ Commercial	Undeveloped	Developed Water Resources	Recreation				
															Public Roads	Cemetery	Other	
Donald E. and Leilani S Grant	Mining Area	Prime	5.7															5.7
		Neg. Det.				0.1												0.1
		High Cap.	3.2															3.2
		Limited Capability																0.0
		Subtotal	8.8	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9
	Unaffected (Optional)	Prime	3.1															3.1
		Neg. Det.				0.0												0.0
		High Cap.	7.5			0.4												7.8
		Limited Capability																0.0
		Subtotal	10.6	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0
	Total Area	Prime	8.8															8.8
		Neg. Det.				0.1												0.1
		High Cap.	10.6			0.4												11.0
		Limited Capability																0.0
		Subtotal	19.4	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.9

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Table 11.5.1.1
Bond Calculation Acreages

Land Use/Operation	Acres	Cost
Prime Farmland (surface mined)		$0.00
High Capability (surface mined)		$0.00
Non-Cropland Capability (surface mined)		$0.00
Incline/Highwall Slopes (surface mined)		$0.00
Boxcut Spoil Area (surface mined)		$0.00
Water		$0.00
Support Facilities	19.9	$0.00
Refuse Disposal Area* (above grade)		$0.00
Refuse Disposal Area (below grade)		$0.00
Placeland/Unaffected		$0.00
Roads (to remain)		$0.00
Total (should equal Permitted acres)	19.9	$0.00

*Includes slurry inside refuse area

Table 11.5.1.8
Support Area Reclamation

			COST
Average thickness of grading entire support area:	0.75	feet	$0.00
Lime application for non-refuse area:		tons/acre	$0.00
Haul Road Removal			
Width of road:	50	feet	
Average thickness of road:	8	feet	
Length of road:	733	feet	
Haul distance to dispose of road material:	500	feet	$0.00
Railroad Removal			
Total length of railroad:		feet	
Haul distance to dispose of fill material:		feet	$0.00
Conveyor Removal			
Total length of conveyor:		feet	$0.00

Sediment Pond Backfill / Dam Removal

Pond ID	Backfill / Dam Removal	Yardage	Cost
			$0.00
			$0.00
			$0.00
			$0.00
			$0.00
			$0.00
			$0.00
			$0.00

Table 11.5.1.9
Building Reclamation

Note: All buildings must be located on the Bond Calculation Map

Building *(name/ID)* : Dry Barn

Building Type	Height (ft)	Length (ft)	Width (ft)	Concrete floor thickness (in.)	Cost
Preparation Plant					**$0.00**
Steel					**$0.00**
Wood/Metal					**$0.00**
Masonary					**$0.00**
Pole Barn	30	100	50	0	**$0.00**
Other					**$0.00**

Building *(name/ID)* : _____

Building Type	Height (ft)	Length (ft)	Width (ft)	Concrete floor thickness (in.)	Cost
Preparation Plant					**$0.00**
Steel					**$0.00**
Wood/Metal					**$0.00**
Masonary					**$0.00**
Pole Barn					**$0.00**
Other					**$0.00**

Building *(name/ID)* : _____

Building Type	Height (ft)	Length (ft)	Width (ft)	Concrete floor thickness (in.)	Cost
Preparation Plant					**$0.00**
Steel					**$0.00**
Wood/Metal					**$0.00**
Masonary					**$0.00**
Pole Barn					**$0.00**
Other					**$0.00**

Table 11.5.1.10
Reinforced Concrete Structure Reclamation

Note: All reinforced concrete structures must be located on the Bond Calculation Map

Structure *(name/ID)* : Material Shaft Pad

Structure Type	Height (ft)	Length (ft)	Width (ft)	Concrete floor thickness (in.)	Cost
Pads		50	40	18	$0.00
Footings					$0.00
Concrete Structures					$0.00

Structure *(name/ID)* : Material Shaft Pad

Structure Type	Height (ft)	Length (ft)	Width (ft)	Concrete floor thickness (in.)	Cost
Pads		50	40	18	$0.00
Footings					$0.00
Concrete Structures					$0.00

Structure *(name/ID)* : Belt Fan Pad

Structure Type	Height (ft)	Length (ft)	Width (ft)	Concrete floor thickness (in.)	Cost
Pads		40	20	18	$0.00
Footings					$0.00
Concrete Structures					$0.00

Structure *(name/ID)* : Substation Concrete Pad

Structure Type	Height (ft)	Length (ft)	Width (ft)	Concrete floor thickness (in.)	Cost
Pads		20	5	48	$0.00
Footings					$0.00
Concrete Structures					$0.00

Silos / Thickeners					
Type	Height (ft)	Length (ft)	Width (ft)	Concrete floor thickness (in.)	Cost
					$0.00
					$0.00
					$0.00
					$0.00

Table 11.5.1.12
Borehole Backfilling

Number of boreholes	Name / ID	Radius (inches)	Depth (feet)
1	NSUTILITY#1	5.3125	490
1	NSUTILITY#2	5.3125	490
1	NSUTILITY#3	5.3125	490
1	NSUTILITY#4	5.3125	490
1	NSUTILITY#5	5.3125	490
1	NSUTILITY#6	5.3125	490

TOTAL COST: **$0.00**

Table 11.5.1.13
Shaft / Slope Backfilling

Shaft Name/ID: Belt Air Shaft (NSBELTAIR)

Is MSHA acceptable fill available on site? Yes [ ] No [X]

Depth of removal of concrete below grade:		4 feet		
Depth of shaft/slope:		490 feet		
If round:	Radius:	4 feet		
If rectangular, provide	Length:	_____ feet	Width:	_____ feet
			COST:	**$0.00**

Shaft Name/ID: Material Shaft (NSMATERIAL)

Is MSHA acceptable fill available on site? Yes [ ] No [X]

Depth of removal of concrete below grade:		4 feet		
Depth of shaft/slope:		490 feet		
If round:	Radius:	8.25 feet		
If rectangular, provide	Length:	_____ feet	Width:	_____ feet
			COST:	**$0.00**

Shaft Name/ID: _____

Is MSHA acceptable fill available on site? Yes [ ] No [ ]

Depth of removal of concrete below grade:		_____ feet		
Depth of shaft/slope:		_____ feet		
If round:	Radius:	_____ feet		
If rectangular, provide	Length:	_____ feet	Width:	_____ feet
			COST:	**$0.00**

Shaft Name/ID: _____

Is MSHA acceptable fill available on site? Yes [ ] No [ ]

Depth of removal of concrete below grade:		_____ feet		
Depth of shaft/slope:		_____ feet		
If round:	Radius:	_____ feet		
If rectangular, provide	Length:	_____ feet	Width:	_____ feet
			COST:	**$0.00**

PART 12: Revegetation and Reclamation *(Excluding Cropland and Streams)*

12.1 Revegetation During Operations. Provide information specific to temporary, semi-permanent, and/or permanent revegetation of disturbed areas during construction and operations. **For responses that are identical,** "see response to question number X" is acceptable.

12.1.1 Revegetation of drainage control ditches. Describe plans for revegetation of ditches associated with construction of roads, conveyer systems, rail systems, and associated with controlling overland flow drainage. The following information is required: **[1816.43/1817.43]; [1816.45/1817.45]; [1816.111/1817.111]; [1816.114/1817.114]**

a) Describe the methods for the use of **temporary** seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c)]; [1816.114/0817.114]**

b) Describe the timing and methods proposed to transition from the temporary vegetation to the semi-permanent or permanent vegetative cover.

c) Provide a **semi-permanent or permanent** grass and forbs species list that meets the requirements of 1816.111 (a) and (b)/1817.111 (a) and (b). If non-native species are proposed, provide adequate justification meeting the requirements of 1816.111(c)/1817.111(c).

d) Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates for the semi-permanent or permanent grass and forbs list.

12.1.2 Revegetation of faces of embankments. Describe plans for revegetation of faces of embankments of sediment ponds. The following information is required: **[1816.46(b)(1) and (4)/1817.46(b)(1) and (4)]; [1816.49(a)(8)/1817.49(a)(8)]; [1816.111/1817.111]**

a) Describe the methods for the use of **temporary** seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c)]; [1816.114/0817.114]**

b) Describe the timing and methods proposed to transition from the temporary vegetation to the semi-permanent or permanent vegetative cover.

c) Provide a **semi-permanent or permanent** grass and forbs species list that meets the requirements of 1816.111 (a) and (b)/1817.111 (a) and (b). If non-native species are proposed, provide adequate justification meeting the requirements of 1816.111(c)/1817.111(c).

d) Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates for the semi-permanent or permanent grass and forbs list.

12.1.3 Revegetation of soil stockpiles. Describe plans for revegetation of subsoil and topsoil stockpiles and any sediment pond exemptions required for stockpiles. The following information is required **[1816.22(c)(2)(C)/1817.22(c)(2)(C)]; [1816.111/1817.111]**

a) Describe the methods for the use of **temporary** seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c)]; [1816.114/0817.114)]**

See Permit 375

b) Describe the timing and methods proposed to transition from the temporary vegetation to the semi-permanent vegetative cover.

See Permit 375

c) Provide a **semi-permanent** grass and forbs species list that meets the requirements of 1816.111 (a) and (b)/1817.111 (a) and (b). If non-native species are proposed, provide adequate justification meeting the requirements of 1816.111(c)/1817.111(c).

See Permit 375

d) Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates for the semi-permanent or permanent grass and forbs list.

See Permit 375

d) Is a Sediment Pond Exemption requested for any proposed soil stockpiles? **[1816.46(e)/1817.46(e)]**

☒ YES ☐ NO

If YES, justify the request and describe how the requirements of 1816.46(e)/1817.46(e) will be met.

Silt fence and straw bales will used to control drainage for entire site. Soil and Topsoil stockpiles will be seeded at the first possible planting season and covered with straw as necessary.

12.2 Post-Mining Reclamation Plans. Provide the following information on each proposed Post-Mining Land Use within the permit area, **excluding cropland and streams** (1780.18(b)(5)/1784.13(b)(5)). Plans for revegetation and reclamation must conform to the standards of success outlined in 1816.116/1817.116 and 1816.117/1817.117 and adhere to the Illinois Noxious Weed Law (1816.111(b)(5)). **For responses that are identical,** "see response to question number X" is acceptable. **For those Post-Mining Land Uses that are not proposed** indicate N/A.

See Land Used Map. Pre and Post Land use will be same.

12.2.1 Pasture Post-Mining Land Use Reclamation Plan. Describe plans for reclamation and revegetation of Pasture. The following information is required: **[1816.111/1817.111]; [1816.116/1817.116]**

a) Describe proposed soil preparation and a soil testing plan related to reclamation and re-vegetation procedures. **[1780.18(b)(5)(G)/1784.13(b)(5)(G)]**

b) Describe the methods for the use of **temporary** seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c)]; [1816.114/0817.114]**

c) Describe the timing and methods proposed to transition from the temporary vegetation to the permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

d) Provide a **permanent** pasture grass species list, describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates. **[1780.13(b)(5)/1784.18(b)(5)]**

e) Describe a **periodic measurement plan** of the vegetation as outlined in 1816/1817.116(b)(1) that will be used to identify if remedial actions are necessary to achieve the approved species and / or Post-Mining Land Use vegetation success standards during the applicable period of liability. Information provided shall also **describe a remedial action plan** to achieve the approved vegetative species, invasive species management, or Post-Mining Land Use success. Remedial actions required to meet Sections 1817.111 (a) and (b) may include but are not limited to mowing, burning, undesirable invasive species control, irrigation and pest and disease control. **[1816.116(b)(1)/1817.116(b)(1)];[1816.111(a) and (b)/1817.111(a) and (b)]**

12.2.2 Wildlife Herbaceous Post-Mining Land Use Reclamation Plan. Describe plans for reclamation and revegetation of Wildlife Herbaceous areas. The following information is required: **[1816.111/1817.111]; [1816.97/1817.97]; [1816.116/1817.116]; [1816.117/1817.117]**

a) Describe proposed soil preparation and a soil testing plan related to reclamation and revegetation procedures. **[1780.18(b)(5)(G)/1784.13(b)(5)(G)]**

See Permit 375

b) Describe the methods for the use of **temporary** seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c)]; [1816.114/0817.114]**

See Permit 375

c) Describe the timing and methods proposed to transition from the temporary vegetation to the permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

See Permit 375

d) Provide a **permanent** grass and forbs species list that meets the requirements of 1816.111 (a) and (b)/1817.111 (a) and (b) and 1816.97(g)/1817.97(g). If herbaceous species list is different for slopes of reclaimed refuse disposal facilities than for other herbaceous areas, please specify. If non-native species are proposed to achieve the Post-Mining Land Use, provide adequate justification meeting the requirements of 1816.111(a)(2)/1817.111(a)(2). Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates. **[1780.18(b)(5)/1784.13(b)(5)]**

See Permit 375

e) Describe a **periodic measurement plan** of the vegetation as outlined in 1816/1817.116(b)(1) that will be used to identify if remedial actions are necessary to achieve the approved species and / or Post-Mining Land Use vegetation success standards during the applicable period of liability. Information provided shall also **describe a remedial action plan** to achieve the approved vegetative species, invasive species management, or Post-Mining Land Use success. Remedial actions required to meet Sections 1817.111 (a) and (b) may include but are not limited to mowing, burning, undesirable invasive species control, irrigation and pest and disease control. **[1816.116(b)(1)/1817.116(b)(1)];[1816.111(a) and (b)/1817.111(a) and (b)]**

See Permit 375

12.2.3 Wildlife Woody Post-Mining Land Use Reclamation Plan. Describe plans for reclamation and revegetation of Wildlife Woody areas. The following information is required: **[1816.111/1817.111]; [1816.97/1817.97]; [1816.116/1817.116]; [1816.117/1817.117];**[OSM Directives TSR-16 Directive 931]

a) Describe proposed soil preparation and a soil testing plan related to reclamation and revegetation procedures. **[1780.18(b)(5)(G)/1784.13(b)(5)(G)]**

b) Describe the methods for the use of **temporary** seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c)]; [1816.114/0817.114]**

c) Describe the timing and methods proposed to transition from the temporary vegetation to the permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

d) Provide a permanent herbaceous ground cover species list and a woody species list that meet the requirements of 1816.111 (a) and (b)/1817.111 (a) and (b) and 1816.97(g)/1817.97(g). If non-native species are proposed to achieve the Post-Mining Land Use, provide adequate justification meeting the requirements of 1816.111(a)(2)/1817.111(a)(2). Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates. **[1780.18(b)(5)/1784.13(b)(5)]**

e) If a bat Protection and Enhancement Plan (PEP) is part of the application, the applicant shall ensure consistency between this part and the bat PEP. Describe measures taken to ensure consistency.

f) Describe a **periodic measurement plan** of the vegetation as outlined in 1816/1817.116(b)(1) that will be used to identify if remedial actions are necessary to achieve the approved species and / or Post-Mining Land Use vegetation success standards during the applicable period of liability. Refer to Operator Memorandum No. 2017-02 for additional information regarding tree and shrub planting maintenance. Information provided shall also **describe a remedial action plan** to achieve the approved vegetative species, invasive species management, or Post-Mining Land Use success. Remedial actions required to meet Sections 1817.111 (a) and (b) may include but are not limited to mowing, burning, undesirable invasive species control, irrigation and pest and disease control. **[1816.116(b)(1)/1817.116(b)(1)];[1816.111(a) and (b)/1817.111(a) and (b)]**

12.2.4 Wildlife Wetland Post-Mining Land Use Reclamation Plan. Describe plans for reclamation and revegetation of Wildlife Wetland areas. The following information is required: **[1701.5]; [1816.111/1817.111]; [1816.97/1817.97]; [1816.116/1817.116]; [1816.117/1817.117]; [1816.102(h)/1817.102(h)];** [OSM Directives System TSR-14 Directive 828]

12.2.4.1 Is the wetland a managed, engineered area that functions as part of a drainage control plan, a sediment control plan, or is not a fully incised wetland?

☐ YES ☐ NO

If NO, complete Part 12.2.4.2, If YES, the following information is required:

a) Describe how the soil type(s) in the proposed wetland area will support hydrophytic vegetation. If hydric soils are not present, describe how the area will function as a wetland without this wetland parameter.

b) Discuss the potential for the area to be inundated or saturated by surface or groundwater at a frequency to support hydrophytic vegetation on at least 30% of the surface acres of the wetland.

c) Provide a permanent wetland vegetation species list that is compatible with the Corp of Engineers Wetland Delineation Manual as described at 1816.116(a)(5)(A)/1817.116(a)(5)(A), however the most current version of this document shall be used (1701.5 Appendix A definition of best technology currently available includes vegetative selection). The species list must also meet the requirements of 1816.111 (a) and (b)/1817.111 (a) and (b) and 1816.97(g)/1817.97(g). If non-native species are proposed to achieve the Post-Mining Land Use, provide adequate justification meeting the requirements of 1816.111(a)(2)/1817.111(a)(2).

d) Provide a description of how the requirements found at 1816.49(b)/1817.49(b) will be met.

12.2.4.2 Is the wetland a depression created by removal of soil for the purposes of a borrow area or enhancement of wildlife habitat and not an engineered portion of a drainage control plan or sediment control plan?

☐ YES ☐ NO

If YES, the following information is required:

a) Describe how the soil type(s) in the proposed will support hydrophytic vegetation. If hydric soils are not present, describe how the area will function as a wetland without this wetland parameter.

b) Discuss the potential for the area to be inundated or saturated by surface or groundwater at a frequency to support hydrophytic vegetation on at least 30% of the surface acres of the wetland.

c) Provide a permanent wetland vegetation species list that is compatible with the Corp of Engineers Wetland Delineation Manual as described at 1816.116(a)(5)(A)/1817.116(a)(5)(A), however the most current version of this document shall be used (1701.5 Appendix A definition of best technology currently available includes vegetative selection). The species list must also meet the requirements of 1816.111 (a) and (b)/1817.111 (a) and (b) and 1816.97(g)/1817.97(g). If non-native species are proposed to achieve the Post-Mining Land Use, provide adequate justification meeting the requirements of 1816.111(a)(2)/1817.111(a)(2).

12.2.5 Wildlife Water and/or Developed Water Resources Post-Mining Land Use Reclamation Plan. Describe plans for reclamation and revegetation of Wildlife Water and/or Developed Water Resources areas. The following information is required: **[1816.49/1817.49]; [1816.56/1817.56]; [1816.97/1817.97]**

a) Provide a general description of how the requirements found at 1816.49(b) will be met.

b) Discuss how the post-mining water area will support and enhance fish and wildlife habitat. **[1816.97(g)(3)]**

12.2.6 Forest Post-Mining Land Use Reclamation Plan. Describe plans for reclamation and revegetation of Forest areas including the following information: **[1816.111/1817.111]; [1816.97/1817.97]; [1816.116/1817.116]; [1816.117/1817.117];** [OSM Directives TSR-16 Directive 931]

a) Describe proposed soil preparation and a soil testing plan related to reclamation and revegetation procedures. **[1780.18(b)(5)(G)/1784.13(b)(5)(G)]**

b) Describe the methods for the use of **temporary** seeding/mulching to control erosion, discuss the species, seeding rate by species per acre, and mulching methods and type of mulch. **[1816.111(c)/1817.111(c)]; [1816.114/0817.114]**

c) Describe the timing and methods proposed to transition from the temporary herbaceous cover vegetation to the permanent vegetative cover. **[1816.111(c)/1817.111(c)]**

d) Provide a permanent herbaceous ground cover species list and a woody species list that meet the requirements of 1816.111 (a) and (b)/1817.111 (a) and (b) and 1816.97(g)/1817.97(g). If non-native species are proposed to achieve the Post-Mining Land Use, provide adequate justification meeting the requirements of 1816.111(a)(2)/1817.111(a)(2). Describe seeding rate by species per acre, methods of planting and seeding, mulching and fertilizer plan and rates. **[1780.18(b)(5)/1784.13(b)(5)]**

e) If a bat Protection and Enhancement Plan (PEP) is part of the application, the applicant shall ensure consistency between this part and the bat PEP. Describe measures taken to ensure consistency.

f) Describe a **periodic measurement plan** of the vegetation as outlined in 1816/1817.116(b)(1) that will be used to identify if remedial actions are necessary to achieve the approved species and / or Post-Mining Land Use vegetation success standards during the applicable period of liability. Refer to Operator Memorandum No. 2017-02 for additional information regarding tree and shrub planting maintenance. Information provided shall also **describe a remedial action plan** to achieve the approved vegetative species, invasive species management, or Post-Mining Land Use success. Remedial actions required to meet Sections 1817.111 (a) and (b) may include but are not limited to mowing, burning, undesirable invasive species control, irrigation and pest and disease control. **[1816.116(b)(1)/1817.116(b)(1)];[1816.111(a) and (b)/1817.111(a) and (b)]**

12.2.7 Industrial/Commercial Post-Mining Land Use. Describe plans for reclamation and revegetation of Industrial/Commercial areas. The following information is required: **[1816.111/1817.111]; [1816.97/1817.97]; [1816.116/1817.116]; [1816.117/1817.117]**

a) Describe plans for utilization of the area for Industrial or Commercial purposes at the time of bond release.

b) Provide a ground cover species list and a woody species list, if applicable that meet the requirements of 1816.111 (a) and (b)/1817.111 (a) and (b) and 1816.97(i)/1817.97(i). If non-

native species are proposed to achieve the Post-Mining Land Use, provide adequate justification meeting the requirements of 1816.111(a)(2)/1817.111(a)(2).

12.2.8 Recreation Post-Mining Land Use. Describe plans for reclamation and revegetation of Recreation areas. The following information is required: **[1816.111/1817.111]; [1816.97/1817.97]; [1816.116/1817.116]; [1816.117/1817.117]**

a) Describe plans for utilization of the area for recreational purposes at the time of bond release.

b) Provide a ground cover species list and a woody species list, if applicable, that meet the requirements of 1816.111 (a) and (b)/1817.111 (a) and (b) and 1816.97(i)/1817.97(i). If non-native species are proposed to achieve the Post-Mining Land Use, provide adequate justification meeting the requirements of 1816.111(a)(2)/1817.111(a)(2).

12.3 Habitat Diversification in Cropland Post-Mining Land Use Areas. Describe plans to intersperse crop fields with trees, hedges, conservation drainage ways, or fence rows that will break up crop monocultures and diversify habitat, where appropriate and compatible with crop management and wildlife management practices. **[1816.97(h)/1817.97(h)]; [1816.111/1817.111]**

Small field in a larger group of farmland.

R06883

Department of Natural Resources

AUG 18 2017

Impact Assessment Section

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PRESERVATION SERVICES

Illinois Department of Natural Resources

One Natural Resources Way Springfield, Illinois 62702-1271
www.dnr.illinois.gov

Bruce Rauner, Governor
Wayne A. Rosenthal, Director

IHPA REVIEW
H/A
AC Concur 8/24/17
AR
File FK/IDNR

August 1, 2017

Rachel Leibowitz, Ph.D.
Deputy State Historic Preservation Officer
IDNR Preservation Services
1 Old State Capitol Plaza
Springfield, IL 62701

2 COPIES RCVD & CD

Dear Dr. Leibowitz:

Pursuant to the requirements of the Programmatic Agreement between IHPA and IDNR concerning mining, please review the enclosed Archaeological Survey Short Report.

PROJECT: Williamson Energy, LLC, Pond Creek Mine Permit 375, 20a. IBR for North Supply Shaft
LOCATION: northwest corner at the intersection of Davis and Gunn roads (0.25 miles north of intersection of Davius and Liberty School roads), West Frankfort, IL
COUNTY: Franklin
CONTRACTOR: ARG (Titus)

The Phase One archaeological survey of **20. acres** has not recorded any archaeological sites; project clearance is recommended.

In accordance with the established procedures for coordination of Illinois Department of Natural Resources projects, IDNR requests the concurrence of the State Historic Preservation Office in our determination that the proposed undertaking is a **no effect** regarding status of any Historic Property.

If no reply is received from IHPA within 45 days, IDNR will conclude that, as per the Programmatic Agreement, this application is approved and will proceed with the undertaking.

Sincerely,

Dawn E. Cobb

Dawn Cobb
Archaeologist
Office of Realty and Environmental Planning

dc:mbs

ENCLOSURE 2 hardcopies; 1 CD

CONCUR
By: Rachel Leibowitz
Deputy State Historic Preservation Officer
Date: 8/18/17

Illinois Archaeological Survey Short Report

Phase I Cultural Resources Survey and Assessment of the Proposed, 20-Acre North Supply Shaft IBR for Williamson Energy, LLC, Franklin County, Illinois

Prepared for
Williamson Energy, LLC
Marion, Illinois

Prepared by
American Resources Group, Ltd.
Carbondale, Illinois

Principal Investigator
Steve Titus

Author
Cally Lence

Cultural Resources Management
Report No. 1989

July 2017

ARCHAEOLOGICAL SURVEY SHORT REPORT
Illinois Historic Preservation Agency
1 Old State Capitol Plaza, Springfield, Illinois 62701-1507
(217) 782-4836

Reviewer:
Date:
Accept: **Reject:**

IHPA Log Number:

LOCATIONAL INFORMATION AND SURVEY CONDITIONS:
County: Franklin **Quadrangle:** Pittsburg, Illinois 7.5'

Project Type/Title: Phase I Cultural Resources Survey and Assessment of the Proposed, 20-Acre North Supply Shaft IBR for Williamson Energy, LLC, Franklin County, Illinois (ARG CRM 1989).
Funding and/or Permitting Federal/State Agencies: IDNR

Legal Location: S2NWSW
Section: 36 **Township:** 7S **Range:** 3E
UTM Coordinates: **Center Point UTM North:** 4192710 **UTM East:** 338743

Location: The project area is located at the intersection of Davis and Gunn roads, approximately 0.4 km (0.25 mile) north of the intersection of Davis and Liberty School roads, and 9.1 km (5.65 miles) southeast of West Frankfort, Illinois.
Project Description: Phase I archaeological survey of 20 acres for a mine supply shaft IBR (Permit 375) for Williamson Energy, LLC.
Topography: Low ridge and floodplain of Pond Creek/tributaries
Elevation (' AMSL): 427'–436'
Soils: Ava-Bluford-Wynoose (University of Illinois 1966)
Drainage: Pond Creek, Big Muddy River, Mississippi River
Land Use/Ground Cover (include % visibility): Cultivated field (corn, 85% visibility)
Survey Limitations: None

ARCHAEOLOGICAL AND HISTORICAL INFORMATION:
Historic Plats/Atlases/Sources: Illinois Inventory of Archaeological Sites; IHPA HARGIS database;
1807 GLO Plat Map of Township 7 South, Range 3 East (Illinois State Archives) (Attachment B, Figure B-1);
1876 Atlas of the State of Illinois (Warner and Beers) (Attachment B, Figure B-2);
1900 Map of Franklin County, Illinois (Guy Beauman) (Attachment B, Figure B-3);
1918 Standard Atlas of Franklin County, Illinois (Sims and Sons, Publishers) (Attachment B, Figure B-4),
1937? Plat Book of Franklin County, Illinois (W.W. Hixson) (Attachment B, Figure B-5);
1941 West Frankfort, Illinois, 15 minute topographic map (Attachment B, Figure B-6);
1951? Franklin County Plat Book, Illinois (Dudley Darrell) (Attachment B, Figure B-7)

Previously Reported Sites: Within project area: None. In 1-mile of project area: 11FK211

Previous Surveys: Within project area: None. In 1-mile of project area: 11688 (Wagner 2001)

Regional Archaeologist Contacted: None, consulted the Illinois Inventory of Archaeological Sites
Investigation Techniques: Systematic surface survey along transects spaced 5 m apart in cultivated fields.

Time Expended: 6 Hours
Sites/Find Spots Located: None
Cultural Material: n/a

Curated At: n/a
Collection Techniques: n/a
Area Surveyed (acres and square meters): 20 acres; 80,937 square meters

RESULTS OF INVESTIGATIONS AND RECOMMENDATIONS: **(check one)**

_X_ **Phase I archaeological reconnaissance has located no archaeological material; project clearance is recommended.**

_ **Phase I archaeological reconnaissance has located archaeological materials; site(s) does(do) not meet requirements for National Register eligibility; project clearance is recommended.**

_ **Phase I archaeological reconnaissance has located archaeological materials; site(s) may meet requirements for National Register eligibility; further testing is recommended.**

_ **Phase II archaeological investigation has indicated that site(s) does(do) not meet requirements for National Register eligibility; project clearance is recommended.**

_ **Phase II archaeological investigation has indicated that site(s) meet requirements for National Register eligibility; formal report is pending and a determination of eligibility is recommended.**

Comments: American Resources Group recently completed an intensive, Phase I cultural resources survey of a 20-acre parcel of land for Williamson Energy's proposed North Supply Shaft IBR for Mine Permit 375. The project area encompasses a portion of a level upland surface that overlooks the broad floodplain bordering the north (right) bank of Pond Creek to the south. A channelized, intermittent tributary of Pond Creek bounds the western end of the project area, and Pond Creek itself lies approximately .65 km (.4 mile) to the south. The project area is located about 9.1 km (5.65 miles) southeast of West Frankfort, in southern Franklin County, Illinois (Attachment A, Figure A-1). The survey was conducted by a two-person crew on June 25, 2017.

The site-file search and architectural records review conducted prior to beginning the field survey revealed that no archaeological sites or architectural properties had been recorded within the present project area. The results of the pre-field records and literature review suggested that prehistoric site density was apt to be moderately low in the project corridor due to its largely being located in a relatively level floodplain of Pond Creek and its tributaries. The pre-field review of historic maps also suggested there was little potential for the project corridor to contain historic sites (Attachment B, Figures B-1–B-7).

The project area is located on a broad, level upland surface north of Pond Creek, approximately 19 km (12 miles) upstream of the point where this perennial stream empties into the Big Muddy River and 1 km (.63 mile) downstream of its headwaters. The total area surveyed in the course of the present investigation is 20 acres.

At the time of survey, the project area was planted in 8-feet-high corn. Below the corn canopy, ground surface visibility was estimated to be approximately 85 percent (Attachment C, Figures C-1–C-4). The project area was surveyed through surface survey conducted along transects spaced 5 m apart.

No cultural resources were identified during the present investigation, indicating the proposed undertaking will not have an adverse effect on significant cultural resources. It is recommended that the proposed undertaking be allowed to proceed as planned without any additional cultural resources investigations.

ARCHAEOLOGICAL CONTRACTOR INFORMATION:

Archaeological Contractor: American Resources Group, Ltd.
Address/Phone: 127 North Washington Street
Carbondale, Illinois 62901-1507 / (618) 529-2741

Surveyor(s): Steve Titus, Kevin Lomas **Survey Date(s):** July 25, 2017
Report Completed by: Cally Lence **Date:** July 25, 2017
Submitted by (signature and title): Steve Titus, Principal Investigator

ATTACHMENT CHECK LIST: (#1 through #4 are mandatory)

_x_ 1) **Relevant portion of USGS 7.5' topographic quadrangle map(s) showing project location and any recorded site;**
_x_ 2) **Project map(s) depicting survey limits and, when applicable, approximate site limits and concentrations of cultural materials;**
___ 3) **Site form(s): (two copies of each form);**
_x_ 4) **All relevant project correspondence;**
_x_ 5) **Additional information sheets as necessary.**

Address of Owner/Agent/Agency To Whom SHPO Comment Should Be Mailed To:

Williamson Energy, LLC
16824 Liberty School Road
Marion, IL 62959

American Resources Group, Ltd.
127 North Washington Street
Carbondale, Illinois 62901-1507

Contact Person: Mr. James Plumley
Telephone Number: (618) 969-8259

Contact Person: Mr. Steve Titus
Telephone Number: (618) 529-2741

REVIEWERS COMMENTS:

List of Attachments

TOC

ATTACHMENT A: PROJECT TOPOGRAPHIC MAPS 11
Figure A-1. Topographic location of the project area, Franklin County, Illinois (USGS 1963). 12

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Attachment A

Project Topographic Maps

R06892

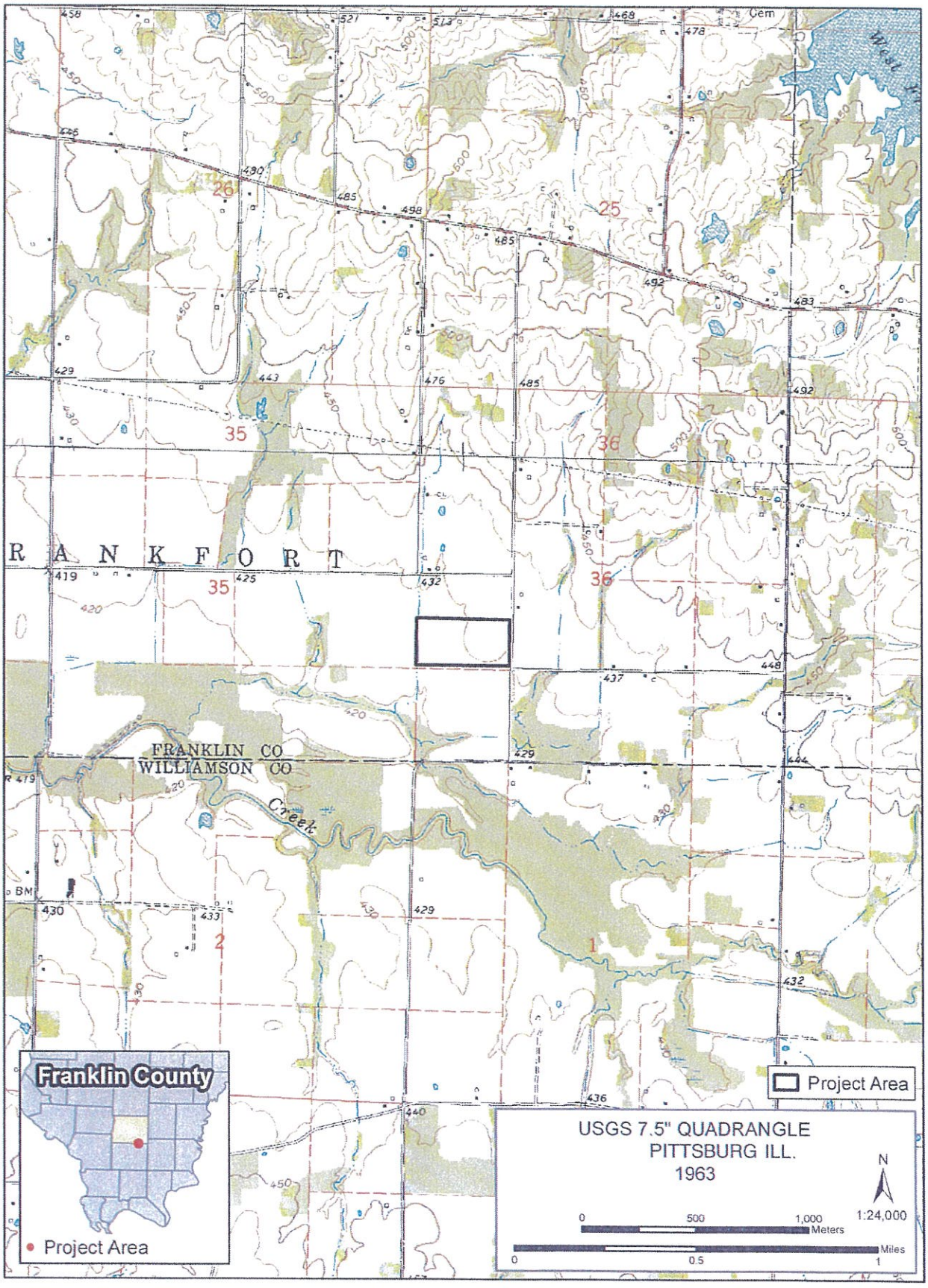


Figure A-1. Topographic location of the project area, Franklin County, Illinois (USGS 1963).

Attachment B

Historic Maps

R06894

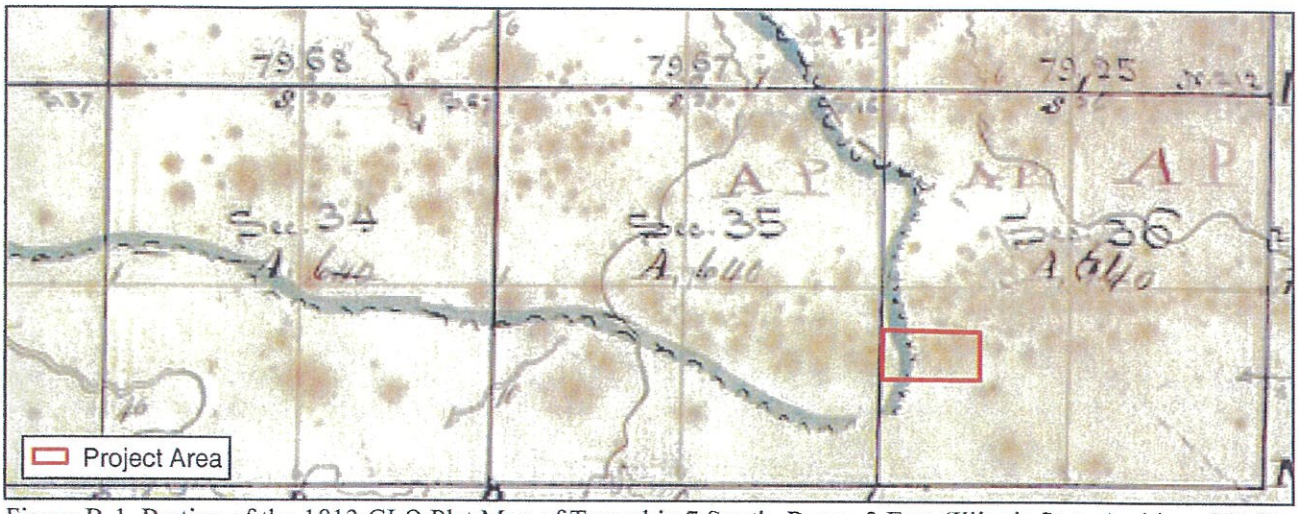


Figure B-1. Portion of the 1813 GLO Plat Map of Township 7 South, Range 3 East (Illinois State Archives 2017).

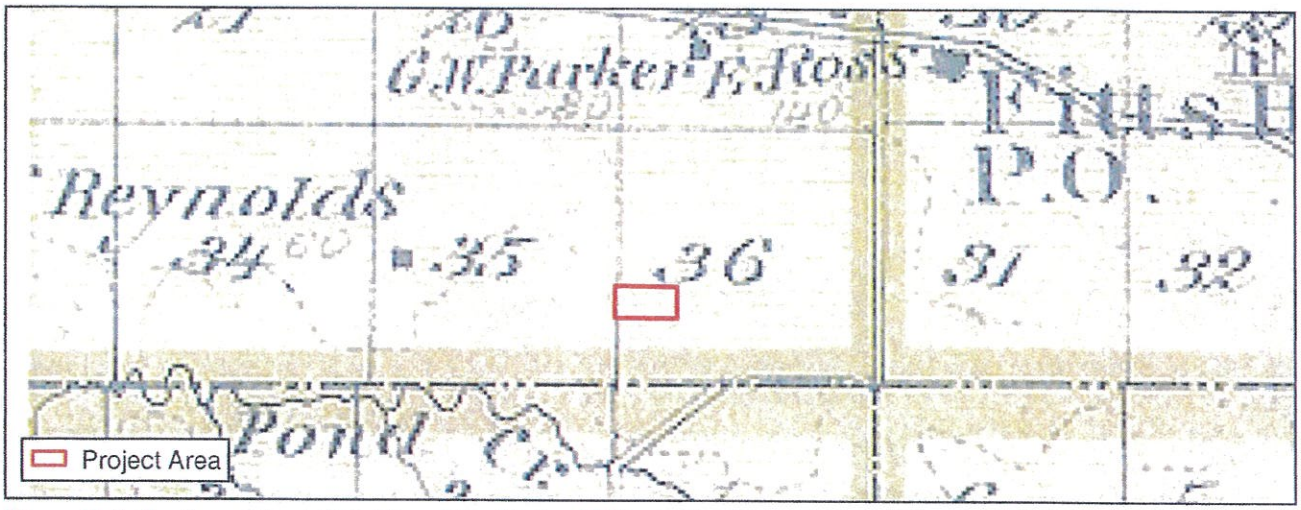


Figure B-2. Portion of the 1876 Atlas of the State of Illinois illustrating the project area (Warner and Beers 1876).

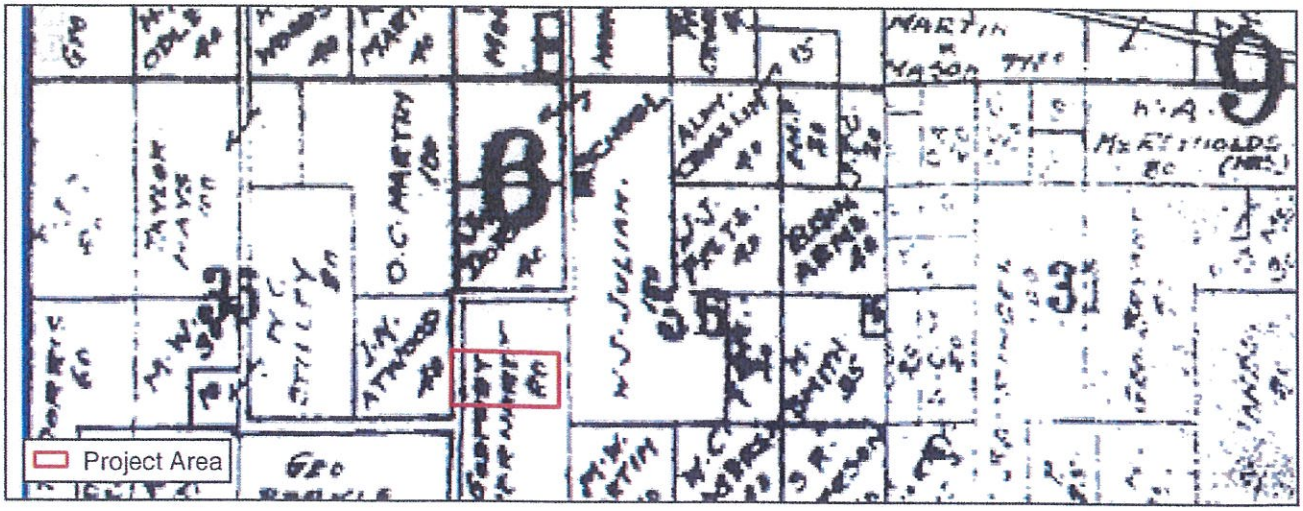


Figure B-3. Portion of the 1900 Map of Franklin County, Illinois, illustrating the project area (Beauman 1900).

R06895

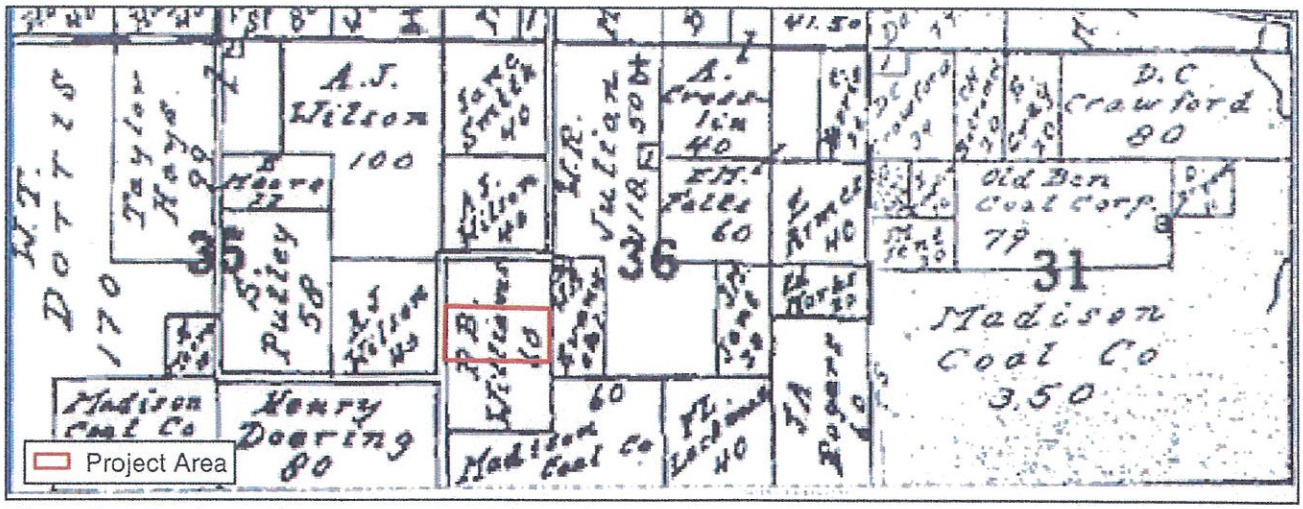


Figure B-4. Portion of the 1918 Standard Atlas of Franklin County, Illinois, illustrating the project area (Sims and Sons, Publishers 1918).

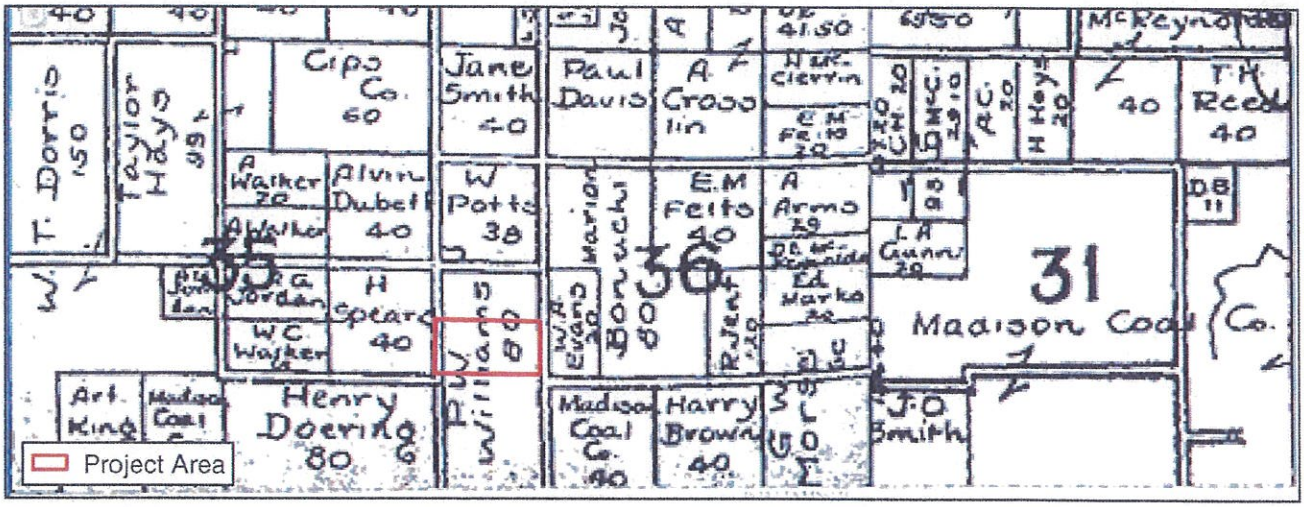


Figure B-5. Portion of the 1937? Plat Book of Franklin County, illustrating the project area (W.W. Hixson 1937?).

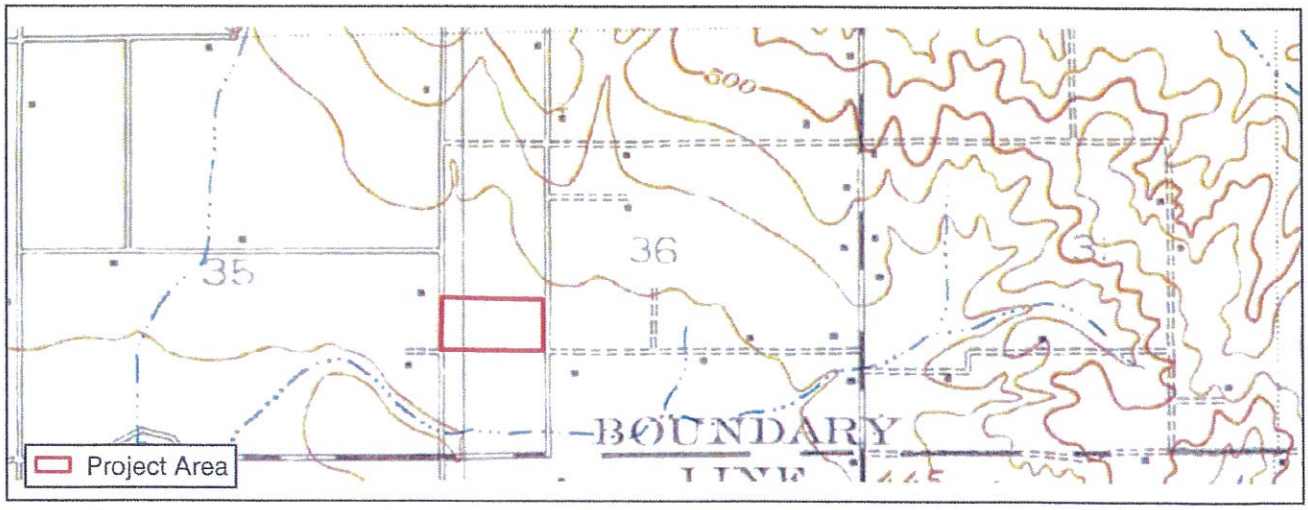


Figure B-6. Portion of the 1941 West Frankfort, Illinois, USGS 15' series topographic quadrangle illustrating the project area (USGS 1941).

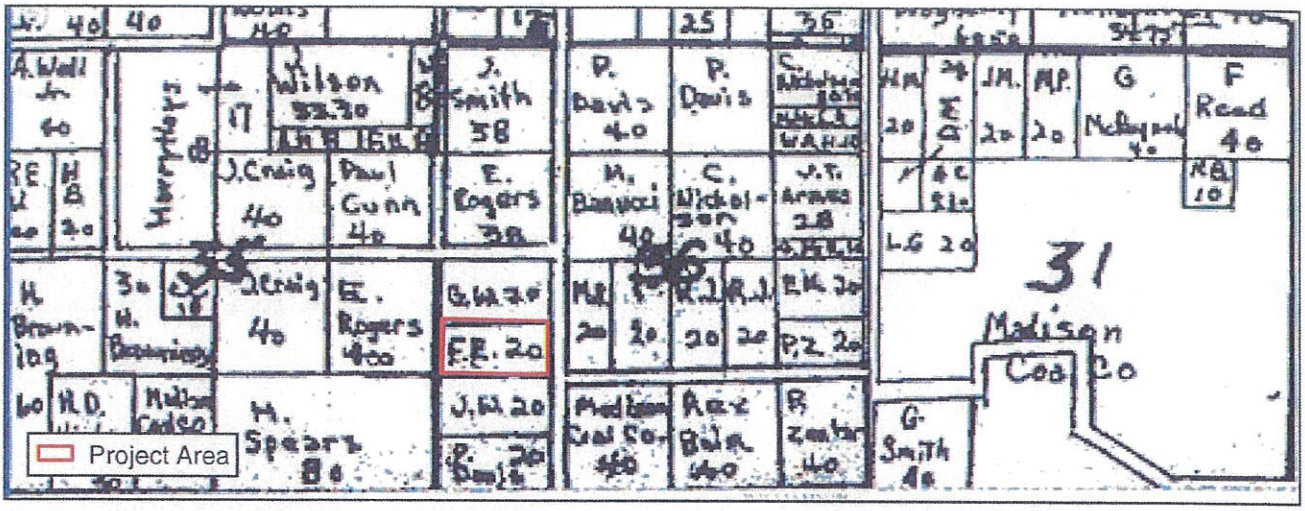


Figure B-7. Portion of the 1951? Plat Book of Franklin County, Illinois, illustrating the project area (Darrell 1951?).

Attachment C

Project Photographs

R06898



Figure C-1. Northeast corner of the project area, view south along Davis Road.



Figure C-2. Northwest corner of the project area, view east.

R06899

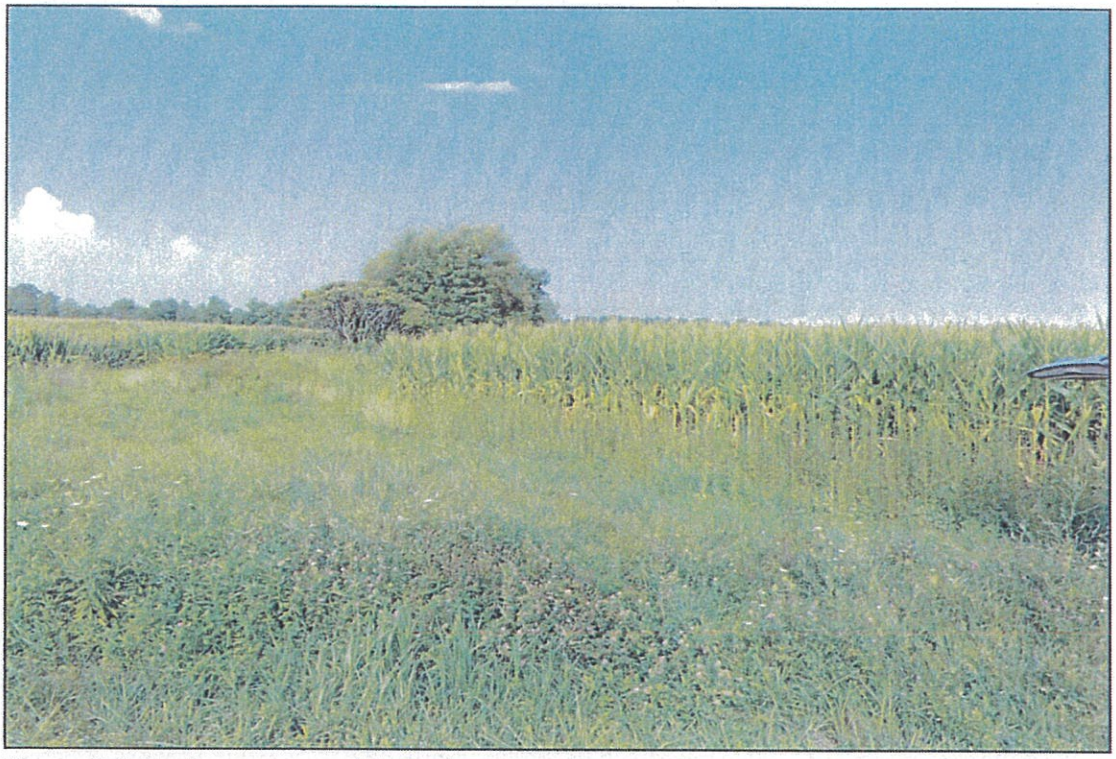


Figure C-3. Southeast corner of the project area, view west.



Figure C-4. View of ground surface below corn canopy.

Attachment D

References Cited

Beauman, Guy

1900 *Map of Franklin County, Illinois 1900.* Guy Beauman. Vienna, Illinois.

Darrell, D.

1951? *Franklin County Plat Book.* Drawn by Dudley Darrell.

Illinois State Archives

2017 1807 GLO Township Plat, Township 7 South, Range 3 East. In Illinois Secretary of State, Federal Township Plats of Illinois website http://landplats.ilsos.net/

Sims and Sons, Publishers

1918 *Atlas of Franklin County, Illinois, containing Map of County, Plats of all Townships with Owners' names, Illinois State Map, Map of the United States, population tables, and charts on treatment of domestic animals.* Christopher, Illinois.

United States Geological Survey (USGS)

1963 Pittsburg, Illinois, 7.5 minute topographic map.

1941 West Frankfort, Illinois, 15 minute topographic map.

University of Illinois

1966 *General Soil Map of Illinois.* Agricultural Experiment Station, University of Illinois, Urbana. In cooperation with U.S. Department of Agriculture, Soil Conservation Service.

Wagner, M.

2001 *Archaeological Survey Short Report, Power Plant Construction.* Center for Archaeological Investigations, Southern Illinois University, Carbondale, Illinois.

Warner and Beers

1876 *Atlas of the State of Illinois.* Warner and Beers, Chicago.

W.W. Hixson and Company

1937? *Plat Book of Franklin County, Illinois.* W.W. Hixson and Company. Rockford, Illinois.

R06902

Soil Types within Proposed Permit Boundary

Type	Disturbed	Undisturbed	Prime Farmland
3382A	3.18	1.57	Yes
376A	2.39	1.56	Yes
639A	3.27	7.84	Yes
3108A	0.06	0.03	Yes
Total	8.90	11.00	



Legend

- Proposed IBR Boundary
- Area Disturbed
- 10C Soil Type

Williamson Energy, LLC
PO Box 99
Johnston City, IL 62951

Soils Map

Revisions										
No	Date	By	No	Date	By					
1			6							
2			7							
3			8							
4			9							
5			10							

File Location:

Drawn By: JLP
Checked By: JLP
Approved By: JLP
Date: 12/17/17
Scale: 1"=200'
Drawing #: North Supply Shaft Soil Map

Soils Map
Scale 1"=200'

N
W E
S

800'
400'
0