BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	AS 2021-002
Petition of Midwest Generation	)	
for an Adjusted Standard from 845.740(a)	)	
and Finding of Inapplicability of Part 845	)	(Adjusted Standard)
(Powerton Station)	)	

To: See attached service list.

NOTICE OF ELECTRONIC FILING

PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Pollution Control Board a RECOMMENDATION OF THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY, a copy of which is herewith served upon you.

Respectfully submitted,

Dated: September 22, 2021

ILLINOIS ENVIRONMENTAL
PROTECTION AGENCY,

Respondent,

BY: /s/Christine Zeivel
Christine Zeivel

Christine Zeivel, #6298033
Division of Legal Counsel
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276
(217) 782-5544
Christine.Zeivel@Illinois.Gov

THIS FILING IS SUBMITTED ELECTRONICALLY

SERVICE LIST

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ILLINOIS POLLUTION CONTROL BOARD
Carol Webb, Hearing Officer
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100 W. Randolph, Suite 11-500
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BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	AS 2021-002
Petition of Midwest Generation	)	
for an Adjusted Standard from 845.740(a)	)	
and Finding of Inapplicability of Part 845	)	(Adjusted Standard)
(Powerton Station)	)	

To: See attached service list.

RECOMMENDATION OF THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

The Illinois Environmental Protection Agency ("Illinois EPA" or "Agency"), by one of its attorneys, hereby files its Recommendation Midwest Generation LLC's request for a finding of inapplicability of Part 845 to its Service Water Basin at its Powerton Station in Pekin, Tazewell County, Illinois, pursuant to Section 28.1 of the Illinois Environmental Protection Act ("Act"). 415 ILCS 5/28.1, 35 Ill. Adm. Code §104.416. For the reasons stated below, Illinois EPA stipulates that the Service Water Basin is not a CCR surface impoundment under Part 845 and therefore does not object to the Board granting Petitioner relief, subject to the condition that the Service Water Basin not be used to treat, store, or dispose of CCR in the future. In support of its Recommendation, Illinois EPA states as follows:

I. INTRODUCTION

1. On April 15, 2021, the Board adopted new regulations providing standards for disposal of CCR in surface impoundments at 35 Ill. Adm. Code 845 ("Part 845"). *See* Board Docket R2020-019. The Part 845 rules became effective on April 21, 2021. 45 Ill. Reg. 5884 (May 7, 2021).

2. On May 11, 2021, Midwest Generation, LLC ("MWG") filed a petition for an adjusted standard from 35 Ill. Adm. Code §845.740(a) and a finding of inapplicability of Part 845 for certain

impoundments located at its Powerton Station ("Petition"), in which it requests a hearing on its petition.

3. MWG's Petition concerns four surface impoundments, which Petitioner designates as: (1) the Ash Surge Basin; (2) the Metal Cleaning Basin, (3) the Bypass Basin, and (4) the Service Water Basin.[1] *See* Petition, p. 1.

4. Specifically, MWG is seeking the following adjusted standards from the requirements contained in Part 845:

a. Ash Surge, Metal Cleaning and Bypass Basins: MWG seeks an adjusted standard to allow the decontamination and retention of the existing liners rather than the liners' removal as required for closure by removal in Section 845.740(a).

b. Service Water Basin: MWG asserts the Service Water Basin does not satisfy the regulatory definition of a CCR surface impoundment and seeks an adjusted standard finding that Part 845 of the Board's regulations is inapplicable.

5. Illinois EPA must make a recommendation to the Board as to the disposition of the Petition within 45 days after the filing of the petition or at least 30 days before a hearing, unless otherwise ordered by the hearing officer or Board. 35 Ill. Adm. Code §104.416. On August 19, 2021, in response to a motion for extension of time filed by the Agency, the Board ordered the Agency to file its Recommendation by November 22, 2021.

6. This Recommendation addresses MWG's request for an adjusted standard finding that Part 845 is inapplicable to the Service Water Basin. Illinois EPA will address MWG's petition for

[1] The impoundment identified by MWG as the Service Water Basin is identified as the "Secondary Ash Basin" in Illinois EPA's Answer to Board Question Number 1(l) in the R20-019 rulemaking proceedings. *See* Pre-Filed Answers, Aug. 3, 2020, p. 182 (PCB No. R2020-019). To avoid confusion in this proceeding, this Recommendation will remain consistent with the Petition and refer to this impoundment as the Service Water Basin.

adjusted standard from Section 845.740(a) for the Ash Surge, Metal Cleaning and Bypass Basins in a separate recommendation.

II. NOTICE AND ACCEPTANCE

7. A petitioner must "submit to the Board proof that, within 14 days after filing of the petition, it has published notice of the filing of the petition by advertisement in a newspaper of general circulation in the area likely to be affected by the petitioner's activity that is the subject of the adjusted standard proceeding." 415 ILCS 5/28.1; 35 Ill. Adm. Code §104.408(a).

8. On May 19, 2021, MWG filed with the Board a certification of publication and a copy of the notice published on May 15, 2021, pursuant to 35 Ill. Adm. Code §§104.408(a), (b).

9. On June 3, 2021, the Board accepted MWG's petition for adjusted standard.

III. REQUEST FOR FINDING OF INAPPLICABILITY

10. MWG alleges that the Service Water Basin does not meet the definition of a CCR surface impoundment and is therefore "seeking an adjusted standard finding that the CCR rules are inapplicable to the Service Water Basin." *See* Petition, p. 2.

11. MWG cites several previous Board proceedings in support of the Board's authority to grant a petition for an adjusted standard and issue a finding that certain Board regulations are inapplicable. *See* Petition, pp. 14-15 (citing *In the Matter of: Petition of Apex Material Technologies, LLC for an Adjusted Standard from Portions of 35 Ill. Adm. Code 807.104 and 810.103, or, in the Alternative, a Finding of Inapplicability,* AS15-2, slip op. pp. 51-52 (June 18, 2015); *In the Matter of: Petition of Westwood Lands, Inc. for and Adjusted Standard from Portions of 35 Ill. Adm. Code 807.104 and 35 Ill. Adm. Code 810.103 or, in the Alternative, a Finding of Inapplicability,* AS09-3, slip- op at 16 (Oct. 7, 2010); *In the Matter of: Petition of Jo'Lyn Corporation and Falcon Waste and Recycling for an Adjusted Standard from 35 Ill. Adm. Code*

Part 807 or, in the Alternative, a Finding of Inapplicability, AS 04-2, slip op. at 13-14 (Apr. 7, 2005).

12. All the petitions subject of the cases cited by Petitioner request findings of inapplicability or, in the alternative, an adjusted standard from the subject regulations. Such an approach is logical since an adjusted standard from a regulation is not necessary where a regulation does not apply. In both *Westwoods* and *Jo'Lyn*, where the Board determined its solid waste regulations inapplicable, it denied the requested adjusted standards as moot. *Westwoods* slip op. at 16, *Jo'Lyn* slip. op. at 14. The Board focused its analysis on applying the facts to the definition of "waste" and not the factors required in an adjusted standard petition contained in 35 Ill. Adm. Code 104.406.

13. Accordingly, Illinois EPA will address Petitioner's request for a finding of inapplicability first, separately from the request for an adjusted standard exempting the Service Water Basin from Part 845.

14. In December 2019, Illinois EPA identified the Service Water Basin as a CCR surface impoundment based on historic records on file. The Agency sent a fee invoice to MWG dated December 16, 2019. *See* Ex. A. MWG did not agree that the Service Water Basin was a CCR surface impoundment and began discussions with the Agency in response. MWG did not pay the fees as invoiced by the due date of January 31, 2020. In its March 25, 2020 letter, Illinois EPA provided an allowance for MWG to demonstrate that the Service Water Basin does not contain CCR; however, the fees were still due at that time. *See* Ex. B. Illinois EPA issued MWG a Violation Notice on July 28, 2020 (VN W-2020-00042) for failure to pay the initial fee. *See* Ex. C. The VN process yielded several meetings and written responses from MWG on the matter of demonstrating that the Service Water Basin is not a CCR surface impoundment.

15. MWG submitted several documents in support of its demonstration that the Service Water Basin is not a CCR surface impoundment. Many of the submittals were sent in response to Agency questions and requests for additional information. In summary, the submittals contained a bathymetric survey, calculation of estimated sediment in the bottom of the Service Water Basin, laboratory analysis of samples from the Service Water Basin, and comparison of the samples to CCR from the Ash Surge Basin at the Powerton Station.

16. Figures from the bathymetric survey, dated February 26, 2021, were submitted per Agency request, and are contained in the Petition as Exhibit 20. Figure 3 of Exhibit 20 of the Petition compares the contours of the Service Water Basin based on the as-built drawings and the contours of the bathymetric survey. The as-built drawing contours are taken from the 2013 survey performed in conjunction with the relining of the Service Water Basin. This comparison indicates the current contours are similar to the construction drawing contours. *See* Pet. Ex. 20, p. 3 (PDF p. 1247). MWG has indicated that the Service Water Basin has not been emptied of sediment since 2013. *See* Ex. D, pp. 3-4. The bathymetric survey provides no indication of sediment accumulation or a delta-like alluvial structure in the basin. *See* Pet. Ex. 20, Fig. 3 (PDF p. 1251). If CCR had been sluiced in, even incidentally, since 2013, the Agency would expect to see some measurable accumulation of sediment and/or a delta-like alluvial structure in the Service Water Basin. *See* Ex. E (Shaw Affidavit).

17. In addition to the bathymetric survey, the Agency reviewed historic aerial photos of the Service Water Basin taken between 1995 and 2017. *See* Ex. E (Shaw Affidavit). The Service Water Basin does not change in appearance throughout the review period. There are no deltas present, nor visible changes in the unit, in over twenty years. In contrast, other known CCR surface

impoundments at the Powerton Station had various changes in appearance, including deltas and removals, throughout the same time period.

18. MWG provided an estimated calculation of sediment within the Service Water Basin, which yielded 52 cubic yards ("CY") of material in the bottom of the unit. *See* Pet. Ex. 19 and 20. The Agency asked for a comparison of this amount to that of an amount removed in a known CCR surface impoundment of similar size at the Powerton Station. *See* Ex. E (Shaw Affidavit). On August 18, 2021, MWG replied in a letter that 310 CY was removed from the Bypass Basin in the most recent removal. *See* Ex. F. Comparing the amount of material in the Service Water Basin, which has not been emptied since 2013, to a known CCR surface impoundment at the Powerton Station provides support that the Service Water Basin does not contain enough material in it to indicate any appreciable amounts of CCR. *See* Ex. E (Shaw Affidavit).

19. MWG took five sediment samples located at various points in the Service Water Basin, including near the inlet of the basin. The sediment samples were sent to a geotechnical laboratory to (1) determine grain size, (2) conduct a weight to volume relationship analysis, and (3) compare moisture, inorganic and organic content utilizing ASTM method 2974. CCR from MWG's Joliet 9 Station and, per Agency request, CCR from MWG's Powerton Station, were also subjected to these analyses for comparison. *See* Ex. E (Shaw Affidavit).

20. The laboratory analyses differed significantly between the sediment in the Service Water Basin and the CCR from both the Joliet 9 and Powerton Stations. Laboratory data is contained in the submittals dated November 25, 2020 (Ex. G)[2], February 26, 2021 (Ex. H)[3], and July 27, 2021

[2] Exhibit G contains a cover letter to Illinois EPA submitting a memo from Petitioner's consultant, KPRG, evaluating sediment in the Service Water Basin, along with other disputed units operated by Petitioner. The KPRG memo is also included in the Petition as Petitioner's Exhibit 19.

[3] Exhibit H is a memo from Petitioner's consultant, KPRG, further discussing the sampling locations in the Service Water Basin, along with other disputed units operated by Petitioner. Exhibit H is also included in the Petition as Petitioner's Exhibit 20.

(Ex. D). Discussion of sampling methodology is contained in the submittals dated November 25, 2020 (Ex. G), February 26, 2021 (Ex. H), May 12, 2021 (Ex. I)[4], and July 27, 2021 (Ex. D).

21. The sediment sampling required multiple attempts in each location to yield enough sediment for an adequate sample. Much of the volume of sample attempts was water and needed to be repeated to obtain enough sediment. *See* Ex. H and Ex. I.

22. Grain size analysis reports describe the sediment from the Service Water Basin to be brown silty sand with some black sandy silt. *See* Pet Ex. 19, p.6 and Ex. G, encl. p 6. The Powerton CCR sample was described as black sand with silt. *See* Ex. J. The differences between the sediment and the Powerton CCR are better illustrated in the actual laboratory results provided as Revised Table 3, which contains the sediment and CCR samples quantified by standardized particle sizes. *See* Ex. J. For the material collected from the Service Water Basin, silt sized particles made up the highest percentages (73 to 84%) in the North, Center, West and South Outlet samples. Medium (43 to 45%) and fine sand (23%), and silt (18 to 20%) made up the highest percentages of sediment in the South and East sediment samples. In contrast, CCR from the Powerton Ash Surge Basin was comprised of mostly medium sand (70%), with some course (13%) and fine sand (10%), and very little silt (3%) and clay (2%).[5] The grain size analysis indicates that the small amount of material in the Service Water Basin is not CCR. *See* Ex. E (Shaw Affidavit).

23. MWG used the weight to volume relationship of the material to determine the amount of solids versus water in the samples. As indicated above, MWG had difficulty obtaining enough solid material to comprise a sample and the weight to volume relationship quantifies the field observation. The data from the geotechnical laboratory shows that 48 to 73% of the samples were

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[4] Exhibit I is a memo from Petitioner's consultant, KPRG, proposing additional sample collection at the Service Water Basin, per Illinois EPA request.

[5] The geotechnical results for the Powerton CCR sample are in the July 26, 2021 Particle Size Distribution Report. *See* Ex. K.

water. In contrast, only 4% of the Powerton CCR is comprised of water. The percentages are given as volume as solids or volume of water per cubic foot. *See* Ex. D, p. 3 and Table 1.

24. MWG then compared moisture, inorganic and organic content utilizing the ASTM 2974 method to estimate how much of the solids were organic verses inorganic in nature. The ASTM 2974 method reports the inorganic material as "ash." This ASTM method does not determine that a material is coal ash or CCR; rather, it is a more general term used to describe something cooked in a furnace and completely burned. *See* Ex. H, p. 4. Illinois EPA confirmed this description of the method by obtaining the ASTM 2974 method. *See* Ex. L. MWG used this analysis to estimate the percentage of organic and inorganic material in the Service Water Basin, in an effort to compare the tonnage of inorganic sediment to atmospheric deposition using the Soil Loss Equation. *See* Ex. G, p. 5.

25. It should be noted that MWG uses a Soil Loss Equation based on erosion of farm fields and construction sites as an estimate for atmospheric deposition. *See* Petition, p.13 and Ex. 21 ("Predicting Rainfall Erosion Losses"); *see also* Ex. G (November 25, 2020), Ex. H (February 26, 2021), Ex. M (March 9, 2021), Ex. I (May 12, 2021), and Ex. D (July 27, 2021). Two tons/acre/year of soil loss is appropriately utilized in a soil loss evaluation, but Illinois EPA does not agree with its application to atmospheric deposition in unclosed surface impoundments. Accordingly, the Agency did not rely on the atmospheric deposition estimation during the review of the various submittals; rather, the Agency focused and relied upon the bathymetric survey, the volume of material estimated in the Service Water Basin and grain size distribution to evaluate whether: (1) appreciable amount of material is present in the Service Water Basin; and (2) if that material is CCR. *See* Ex. E (Shaw Affidavit).

26. For the reasons explained above, Illinois EPA agrees that Petitioner has provided sufficient information demonstrating that the Service Water Basin is not a CCR surface impoundment subject to Part 845's requirements. Therefore, Petitioner's request for adjusted standard is moot and not evaluated in this Recommendation.

IV. RECOMMENDATION

WHEREFORE, for the above and foregoing reasons, Illinois EPA stipulates that the Service Water Basin is not a CCR surface impoundment subject to Part 845 and therefore does not object to the Board granting Petitioner relief, subject to the condition that the Service Water Basin not be used to treat, store, or dispose of CCR in the future.

Respectfully submitted,

ILLINOIS ENVIRONMENTAL
PROTECTION AGENCY,

Respondent,

Dated: September 22, 2021

BY: /s/ Christine Zeivel
Christine Zeivel, #6298033
Division of Legal Counsel
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276
(217) 782-5544
Christine.Zeivel@Illinois.Gov

THIS FILING IS SUBMITTED ELECTRONICALLY

CERTIFICATE OF SERVICE

I, the undersigned, on affirmation certify the following:

That I have served the attached **RECOMMENDATION OF THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY** with supporting documents (except Exhibit L) by e-mail upon Kristen L. Gale at the e-mail address of kg@nijmanfranzetti.com, upon Susan Franzetti at the e-mail address of sf@nijmanfranzetti.com, upon Molly Snittjer at the e-mail address of ms@nijmanfranzetti.com, upon Carol Webb at the e-mail address of Carol.Webb@illinois.gov, and upon Don Brown at the e-mail address of Don.Brown@illinois.gov.

That I have served the attached **RECOMMENDATION OF THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY** with supporting documents (including Exhibit L) to those listed on the Service List by placing a true copy in an envelope duly address bearing proper first-class postage in the United States mail at Springfield, Illinois on September 23, 2021.

That my e-mail address is Christine.Zeivel@Illinois.gov.

That the number of pages in the e-mail transmission is two hundred thirty-six (236).

That the e-mail transmission took place before 4:30 p.m. on the date of September 22, 2021.

/s/ Christine Zeivel
September 22, 2021

Exhibit List

Exhibit A – Illinois EPA Initial Invoice, issued for the Powerton Station December 16, 2019.

Exhibit B – Illinois EPA Letter to MWG re: Invoice for CCR Surface Impoundments at the Powerton Station, dated March 25, 2020.

Exhibit C – Illinois EPA Violation Notice No. W-2020-00042, issued July 28, 2020.

Exhibit D – KPRG Memorandum re: Evaluation of Sediment in Powerton Generating Station's Service Water Basin, dated July 27, 2021.

Exhibit E – Affidavit of Melinda K. Shaw.

Exhibit F – MWG Letter to Illinois EPA, dated August 18, 2021.

Exhibit G – Nijman Franzetti MWG Letter to Illinois EPA, dated November 25, 2020, with KRPG Memorandum re: Evaluation of Sediment Quantities in Joliet Generating Station's Pond 1 and Pond 3 and Powerton Generating Station's Service Water Basin, dated November 19, 2020, enclosed.

Exhibit H – KPRG Memorandum re: Sampling Location Discussion as part of Evaluation of Sediment Quantities in Joliet Generating Station's Pond 1 and Pond 3 and Powerton Generating Station's Service Water Basin, dated February 26, 2021.

Exhibit I – KPRG Memorandum re: Additional Sampling Location Discussion for Powerton Generating Station's Service Water Basin , dated May 12, 2021.

Exhibit J – Revised Exhibit 1: Table 3: Comparison of Distribution of Particle Sizes for Powerton CCR and Powerton's Service Water Basin Material, submitted to Illinois EPA on August 6, 2021.

Exhibit K – Midland Standard Engineering, Inc. Geotechnical Laboratory Report, dated July 26, 2021.

Exhibit L – Standard Test Methods for Determining the Water (Moisture) Content, Ash Content and Organic Material of Peat and Other Organic Soils, ASTM International, Inc., accessed pursuant to License Agreement on March 9, 2021.[1]

Exhibit M – Nijman Franzetti MWG Letter to Illinois EPA, dated March 9, 2021, with exhibits.

Exhibit N – Affidavit of Gabriel Neibergall

[1] Illinois EPA's license agreement with ASTM prohibits electronic reproduction of methods obtained under the agreement. Exhibit L is served to the Board and Petitioner in hard copy with the Recommendation. Exhibit L is redacted for electronic filing.

Exhibit

A

Illinois Environmental Protection Agency
Division of Water Pollution Control
1021 North Grand Avenue East
Springfield, IL 62794-9276

Powerton Generating Station
Attn: Accounts Payable
13082 East Manito Rd,
Pekin, IL 61554-8587

Billing Date	Mon December 16, 2019
Due Date	Tue January 31, 2020
Account Number	W1798010008
Facility Name	Powerton

Initial Invoice

Pond ID	Pond Description	Amount
W1798010008-01	Ash Basin	75,000.00
W1798010008-02	Sec. Ash Basin	75,000.00
W1798010008-03	Metal Cleaning Basin	75,000.00
W1798010008-04	Bypass Basin	75,000.00
W1798010008-05	Former Ash Basin	75,000.00

Amount Due **$375,000.00**

Other Information/Messages

Questions. Please direct any technical/permit questions to the Permit Section at (217) 782-0610. Questions about the amount of your fee should be emailed to: EPA.AcctsReceivable@illinois.gov

- See Reverse Side for Additional Important Information –

Return bottom portion with a check made payable to Illinois EPA

Payment
Remittance Stub

Account Information

Acct. Number	W1798010008
Facility Name	Powerton
IEPA Program	COALIN
Billing Date	Mon December 16, 2019

Amount Due

Tue January 31, 2020	**$375,000.00**
Amount Enclosed	

Please remit payment to:
Illinois Environmental Protection Agency
Fiscal Services #2
P.O. Box 19276
Springfield, IL 62794-9276

Illinois Environmental Protection Agency
Division of Water Pollution Control
1021 North Grand Avenue East
Springfield, IL 62794-9276

Other Information

State Law Compliance. The owner or operator of a CCR surface impoundment shall pay all fees pursuant to 415 ILCS 5/22.59(j). The owner or operator of a CCR surface impoundment is ultimately responsible and liable for determining an accurate number of CCR impoundments under its control and the fees owed to the Agency under 415 ILCS 5/22.59(j). The amount specified by the Agency within this invoice does not waive or modify the statutory requirement, per 415 ILCS 5/22.59(j) as added by Public Act 101-171, that the owner or operator accurately pay the required initial fee and annual fee for each CCR surface impoundment.

Collection Notice. Failure to submit the amount due by the due date constitutes a violation of Section 22.59 of the Illinois Environmental Protection Act, 415 ILCS 5/22.59(j). The Agency may utilize any available collection procedures to recover unpaid fees and all accumulated interest. These may include, but are not limited to, enforcement actions pursuant to Section 31 of the Illinois Environmental Protection Act, 415 ILCS 5/31, submittal of the unpaid amounts for Comptroller's Offset pursuant to 30 ILCS 210, or submittal of the unpaid fee to the Illinois Department of Revenue's Debt Collection Bureau pursuant to 30 ILCS 210.

Exhibit

B

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 · (217) 782-3397
JB PRITZKER, GOVERNOR JOHN J. KIM, DIRECTOR

217-782-1020

March 25, 2020

Powerton Generating Station
Attn: Accounts Payable
13082 East Manito Road
Pekin, Illinois 61554-8587

Re: Invoice for CCR Surface Impoundments at the Powerton Station.

Dear Sir or Madame:

Pursuant to Section 22.59(j) of the Illinois Environmental Protection Act ("Act"), the Illinois Environmental Protection Agency ("Illinois EPA") invoiced coal combustion residuals ("CCR") surface impoundments at an electrical generating facility operated by Midwest Generation at the Powerton Generating Station (Powerton Station). These invoices provided a billing date of December 16, 2019, and a due date of January 31, 2020.

To date, Midwest Generation has failed to timely remit payment to Illinois EPA for invoiced CCR surface impoundments. In a meeting on January 7, 2020, and in a letter dated January 29, 2020, Midwest Generation has disputed whether one or more of the invoiced CCR surface impoundments should be considered a CCR surface impoundment as defined in Section 3.143 of the Act (415 ILCS 5/3.143).

Illinois EPA provides the following preliminary analysis regarding the disputed CCR surface impoundments and maintains that fees are owing to Illinois EPA:

<u>Powerton Station W1798010008-02 Secondary Ash Basin</u>

- Permit #2010EB0007 states that the Secondary Ash Basin will receive ash and slag sluice waters.
- Discussions with Midwest Generation staff on January 7, 2020, indicate that before relining in 2013 the basin had never required cleaning to function.

Midwest Generation may make a demonstration that the Secondary Ash Basin does not contain CCR and Illinois EPA will review such a demonstration. Midwest Generation may submit an environmental media sampling plan of the bottom contents of this Pond for Illinois EPA review.

Based on the above, the Illinois EPA does not consider the Secondary Ash Basin to have completed closure. The appropriate fee for a CCR surface impoundment that has not completed closure is $75,000.00.

Powerton Station W1798010008-03 Metal Cleaning Basin

- Permit #2009EB2748 states that the Metal Cleaning Basin will receive ash and slag sluice waters.
- Discussions with Midwest Generation staff on January 7, 2020 confirm that CCR is periodically placed in the Metal Cleaning Basin.

Based on the above, the Illinois EPA does not consider the Metal Cleaning Basin to have completed closure. The appropriate fee for a CCR surface impoundment that has not completed closure is $75,000.00.

Total Fees Due to the Agency

Powerton Station	
W1798010008-02 Secondary Ash Basin	$75,000.00*
W1798010008-03 Metal Cleaning Basin	$75,000.00
Total	**$150,000.00**

*The Illinois EPA is allowing Midwest Generation to make a further demonstration that this pond does not meet the definition of a CCR surface impoundment, which could reduce the total by $75,000.00.

Given the above analyses, Illinois EPA requests that within 30 days Midwest Generation either, submit the fees that are due, or arrange a meeting or conference call to discuss any surface impoundments still in dispute. Please note that the Illinois EPA may utilize any available collection procedures to recover unpaid fees.

Please submit all payments responsive to this notification to: Illinois EPA, Fiscal Services #2, P.O. Box 19276, Springfield, Illinois 62794-9276. If you have any questions concerning the information provided above, please call 217-782-1020.

Sincerely,

William E. Busch

William E. Buscher, P.G.
Manager, Hydrogeology and Compliance Unit
Division of Public Water Supplies
Bureau of Water

cc: Darin LeCrone
Rex Gradeless
Ai Kindlon
Records

Exhibit
C

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 • (217) 782-3397
JB PRITZKER, GOVERNOR JOHN J. KIM, DIRECTOR

217/785-0561

July 28, 2020

CERTIFIED MAIL # 7019 1120 0001 3038 4251
RETURN RECEIPT REQUESTED

Powerton Generating Station
c/o Joe Kotas
13082 East Manito Road
Pekin, IL 61554-8587

Re: Violation Notice: POWERTON GENERATING STATION - POWERTON STATION
Facility Id.: 6282
Violation Notice No.: W-2020-00042

Dear Mr. Kotas:

This constitutes a Violation Notice pursuant to Section 31(a)(1) of the Illinois Environmental Protection Act ("Act"), 415 ILCS 5/31(a)(1), and is based upon a review of available information and an investigation by representatives of the Illinois Environmental Protection Agency ("Illinois EPA").

The Illinois EPA hereby provides notice of alleged violations of environmental laws, regulations, or permits as set forth in Attachment A to this notice. Attachment A includes an explanation of the activities that the Illinois EPA believes may resolve the specified alleged violations, including an estimate of a reasonable time period to complete the necessary activities. Due to the nature and seriousness of the alleged violations, please be advised that resolution of the violations may also require the involvement of a prosecutorial authority for purposes that may include, among others, the imposition of statutory penalties.

A written response, which may include a request for a meeting with representatives of the Illinois EPA, must be submitted via certified mail to the Illinois EPA within 45 days of receipt of this letter. If a meeting is requested, it shall be held within 60 days of receipt of this notice. The response must include information in rebuttal, explanation, or justification of each alleged violation and a statement indicating whether or not the facility wishes to enter into a Compliance Commitment Agreement ("CCA") pursuant to Section 31(a) of the Act. If the facility wishes to enter into a CCA, the written response must also include proposed terms for the CCA that includes dates for achieving each commitment and may include a statement that compliance has been achieved for some or all of the alleged violations. The proposed terms of the CCA should contain sufficient detail and must include steps to be taken to achieve compliance and the necessary dates by which compliance will be achieved.

The Illinois EPA will review the proposed terms for a CCA provided by the facility and, within 30 days of receipt, will respond with either a proposed CCA or a notice that no CCA will be issued by the Illinois EPA. If the Illinois EPA sends a proposed CCA, the facility must respond in writing by either agreeing to and signing the proposed CCA or by notifying the Illinois EPA that the facility rejects the terms of the proposed CCA.

If a timely written response to this Violation Notice is not provided, it shall be considered a waiver of the opportunity to respond and meet, and the Illinois EPA may proceed with referral to a prosecutorial authority.

Written communications should be directed to:

Illinois EPA – Division of Public Water Supplies
Attn: Andrea Rhodes, CAS #19
P.O. BOX 19276
Springfield, IL 62794-9276

All communications must include reference to this Violation Notice number, W-2020-00042.

Questions regarding this Violation Notice should be directed to Andrea Rhodes at 217/785-0561.

Sincerely,

Mary F. Reed

Mary F. Reed
Manager, Compliance Assurance Section
Division of Public Water Supplies
Bureau of Water

Attachments

BOW ID: W1798010008

ATTACHMENT A

POWERTON GENERATING STATION - POWERTON STATION, ID NO 6282
VIOLATION NOTICE NO. W-2020-00042:

Questions regarding the violations identified in this attachment should be referred to Andrea Rhodes at (217) 785-0561.

A review of information available to the Illinois EPA indicates the following violations of statutes, regulations, or permits. Included with each type of violation is an explanation of the activities that the Illinois EPA believes may resolve the violation including an estimated time period for resolution.

Coal Combustion Residuals Surface Impoundment Fees

The Illinois Environmental Protection Act ("Act") Section 22.59 (j) establishes a fee system for Coal Combustion Residuals ("CCR") surface impoundments. CCR surface impoundments must pay an initial fee of seventy-five thousand dollars for CCR surface impoundments that have not completed closure and fifty thousand dollars for CCR surface impoundments that have completed closure and are in post-closure care.

(j) The owner or operator of a CCR surface impoundment shall pay the following fees:

(1) An initial fee to the Agency within 6 months after the effective date of this amendatory Act of the 101st General Assembly of:

$50,000 for each closed CCR surface impoundment; and

$75,000 for each CCR surface impoundment that have not completed closure.

(2) Annual fees to the Agency, beginning on July 1, 2020, of:

$25,000 for each CCR surface impoundment that has not completed closure; and

$15,000 for each CCR surface impoundment that has completed closure, but has not completed post-closure care.

To achieve compliance payment in full is expected immediately.

ATTACHMENT A

POWERTON GENERATING STATION - POWERTON STATION, ID NO 6282
VIOLATION NOTICE NO. W-2020-00042:

Violation Date	Violation Description
02/01/2020	Failure to submit a $75,000 initial fee for Powerton Station, Secondary Ash Basin (IEPA ID # W1798010008-02) that was due January 31, 2020. The Agency has determined that Secondary Ash Basin is a CCR surface impoundment that has not completed closure, and therefore, is subject to an initial fee.
Rule/Reg	Section 22.59(j)(1) of the Act 415 ILCS 22.59(j)(1).

Exhibit

D

KPRG

ENVIRONMENTAL CONSULTATION & REMEDIATION

KPRG and Associates, Inc.

MEMORANDUM

FROM: Joshua D. Davenport, P.E., KPRG and Associates, Inc.

DATE: July 27, 2021

SUBJECT: Evaluation of Sediment in Powerton Generating Station's Service Water Basin

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Additional sampling was performed at the Service Water Basin at the Powerton Generating Station and the content of those samples were evaluated.

SECTION 1-INTRODUCTION

The Powerton Generating Station burns coal to generate steam to produce electricity. The Service Water Basin (SW Basin) is the end of the wastewater treatment system. The Service Water Basin receives water from the ash surge basin, the ash bypass basin, and rainwater from the property. The coal combustion residual ("CCR") material produced by the Powerton coal burning process was sampled and submitted to the same geotechnical laboratory as the SW Basin samples. The samples were analyzed for grain size analysis, weight-to-volume relationship, and ASTM 2974. The results of these analyses were used as the comparison material against the Service Water Basin material.

A previous evaluation of material from the SW Basin. Initially only one sample was evaluated from the SW Basin; however, in discussions with IEPA, only one sample was considered insufficient for them to make a determination that the SW Basin is not a CCR surface impoundment. It was proposed that up to three additional samples would be collected and evaluated in the same manner as the original SW Basin sample.

SECTION 2-EVALUATION PROCESS

The evaluation of the additional SW Basin samples was performed based on the following steps.

Previously, the estimated quantity in the SW Basin was determined to be approximately 52 cubic yards (CY). The quantity was based on comparing the bottom elevation from the as-built drawings and the bottom elevations from the bathymetric survey. A further discussion of this comparison was previously submitted to IEPA.

KPRG in cooperation with Ruettiger, Tonelli & Associates, Inc (RT&A) collected the additional SW Basin samples on June 14, 2021. The samples were collected by RT&A

navigating a boat around the surface impoundment and KPRG collecting the samples in the identified locations using a clamshell sampler. The sample locations are shown on Figure 1. The sampling procedure was the same as what was described in the previous document discussing the proposed sampling locations. It was originally proposed to collect up to three samples, but it was decided to collect samples from the west side of the basin and adjacent to the southwest outlet of the basin for comparison purposes. The five (5) individual samples were collected and submitted to the same geotechnical laboratory that performed the analyses on the original SW Basin sample. The submitted samples of the sediment were analyzed for grain size, weight-to-volume relationship of the sediment, and ASTM 2974. The analyses results were used to evaluate the material identified in the surface impoundment.

SECTION 3- SURFACE IMPOUNDMENT EVALUATIONS

On the day of the sampling, the water level within the basin was lower than its typical operating water level and it was estimated that approximately four (4) to five (5) feet of water was in the basin. KPRG asked that the water level be lowered because it was thought the sampling process would be easier with less water for the clamshell sampler to pass through both before and after collecting the sample. As stated above, the five (5) additional samples were collected from the SW Basin at the locations shown on Figure 1 along with the location for the original SW Basin sample.

The samples were collected from the east, north, center, west, and near the southwest outlet locations in the basin. The collected samples were classified by the sampling results as the following soil types:

- SW Basin East = Black Silty SAND;
- SW Basin North = Black SILT with Sand;
- SW Basin Center = Black SILT
- SW Basin West = Black SILT
- SW Basin South Outlet = Black SILT

The following observations were noted during the sampling:

- The material associated with each sample was black, very soft/mucky and smelled like rotting material. No sand texture was noted in the samples.
- The sample material was so soft that it would slip through your fingers.
- The material seemed organic in nature.

With the lower water level, material was visible along the edge of the liner above the waters' edge. This material was collected by hand and included as part of the east, north, and west samples submitted to the geotechnical laboratory. This material was a brown silty sand with some black sandy silt. The black sandy silt did not appear to be CCR but appeared to be colored sand based on total dissolved solids that are black in color. This material was the only sandy material observed in the basin and was not visible in the center of the basin because water was still present. Sandy material was not noted in the center sample.

A gravel road is present along the perimeter of the SW Basin situated adjacent to the crest of the basin's embankment; the gravel road location is noted on Figure 1. The appearance of the sand used to construct the gravel road has the same color and particle size as the sand noted along the perimeter of the SW Basin. The elevations surrounding the SW Basin are such that runoff from the adjacent gravel road would run into the basin.

CCR material from Powerton was collected and submitted for analysis for grain size, weight-to-volume relationship, and ASTM 2974. The Powerton CCR was identified as black sand with silt.

<u>Calculation of the Volume of Material in the Service Water Basin</u>
The bathymetric survey of the SW Basin showed that a measurable quantity of material was marginally present or not present. Reviewing the as-built drawings of the basin from when it was re-lined in 2013, the bottom elevation is ±441 ft amsl. The bottom elevations from the bathymetric survey average ±440.80 ft amsl. Based on comparing the bottom elevation from the as-built drawings and the bottom elevations from the bathymetric survey, minimal material is present or not present to a point, which causes minimal change in the bottom elevation determined during the survey. AutoCAD Civil 3D 2020 was also used to compare the as-built drawings with the survey performed by RT&A. The AutoCAD Civil 3D 2020 comparison was performed with the bottom elevations of the survey and the bottom elevations of the as-built drawings considered equal. This comparison determined a volume of about 52 CY.

The five additional samples were used to provide additional analysis of the material to the original SW Basin sample. Attached are Tables of the results, which include the original SW Basin sample collected along the south side of the basin and is labeled as "SW Basin South". The weight-to-volume relationship analyses from the samples showed that the material in the SW Basin ranged from 31% to 44% solids as shown in Table 1. (Ex. 1) Based on the ASTM 2974 test results (included as Ex. 2), the organic content in the soils ranged from 16% to 40% and the non-organic matter ranged from 59% to 83% as shown in Table 2. (Ex. 1) Accordingly, of the volume of the 52 CY of material, the additional samples collected show that the solids quantity throughout the basin ranges from 15 CY to 22 CY of which 3.8 CY to 6.7 CY are organic matter and 9.5 CY to 19.1 CY is non-organic matter. The weight-to-volume relationship analysis showed that the density of the materials in the basin (not including the water) ranged from 85.3 lbs/cubic feet (lbs/ft^3) to 104.4 lbs/ft^3. (Ex. 3). Based upon that, the tonnage of solid non-organic material in the SW Basin ranges from approximately 11.3 tons to 22.1 tons.

With open topped basins/ponds, about two tons per acre per year (2 tons/acre/year) of matter will accumulate in the bottom of a basin/pond from air dispersion.[1] The SW Basin

[1] The 2 t/ac/yr is actually the calculation used to offset potential soil erosion calculated for maintenance of landfill covers. The lost soil is replaced by natural processes at a rate that is the same or greater than the tolerance level (2/t/ac/yr).

was last cleaned out during the spring of 2013 and the bathymetric survey that determined the volume of material in the basin was performed on July 14, 2020. The amount of time that has passed between these two dates is 2,257.25 days or 6.2 years. The surface area of the basin is approximately 87,791 square feet (2.02 acres) based on the surface area at the top of the basin embankment. Based on the above amount of time and above surface area the matter that has accumulated in the SW Basin from air dispersion is about 24.9 tons. (Ex. 1, Table 3).

<u>Grain Size Comparison of the Material in SW Basin</u>

Enough material could be collected from the SW Basin center area to submit a sample for analysis. The center area sample was submitted and analyzed for the grain size, weight–to-volume relationship of the material, and ASTM 2974 along with the other samples. The material in the SW Basin was identified as black silt in the west, center, and south outlet samples, black silty sand in the east sample, and black silt with sand in the north sample. These results were compared to the Powerton CCR sample that was classified as black sand. This comparison shows that the material in the SW Basin samples is not CCR material. The grain size analyses of the five additional samples (included as Ex. 4) shows that the material in the SW Basin consists of 1.6% to 45.1% fine sand and 25.8% to 95.0% fines. (Ex. 1, Table 3). The highest percentage of fines in the additional samples was noted in the center sample, which consisted of 84.2% silt and 10.8% clay. By comparison, the grain size of the Powerton CCR consists of approximately 10.8% fine sand and 5.9% fines and the remainder consists of coarse to medium sand (approximately 83.3%).

Reviewing the grain size analyses of the additional samples shows that the majority of the material in the basin is silt, with the total percentage of the material classified as greater than 73% silt for four of the five samples. This is in contrast to the Powerton CCR that is predominantly sand with the total percentage of the CCR classified as 94.1% combined coarse, medium, and fine sand. The only sample with a silt percentage less than 73% is the east sample. The east sample has about the same percentage of silt at 20.2% compared to the previously collected south sample at 18.7%. This is notable because the adjacent contours surrounding the SW Basin, specifically on the east and south side consists of a gravel road with sand. It was observed that the color and size of the sand along the east and south side slopes of the SW Basin are similar to the sand observed as part of the gravel road that surrounds the basin. Based upon the contours of the surrounding land at the southeast corner of the SW Basin slope towards the basin, it is more likely than not that the sand on the east and south side is due to stormwater runoff and subsequent erosion flowing into the basin.

W:\projects\midwest gen\attorney client privilege\pond drawings\bathymetric surveys\sw basin comparison.dwg

Electronic Filing: Received, Clerk's Office 09/22/2021

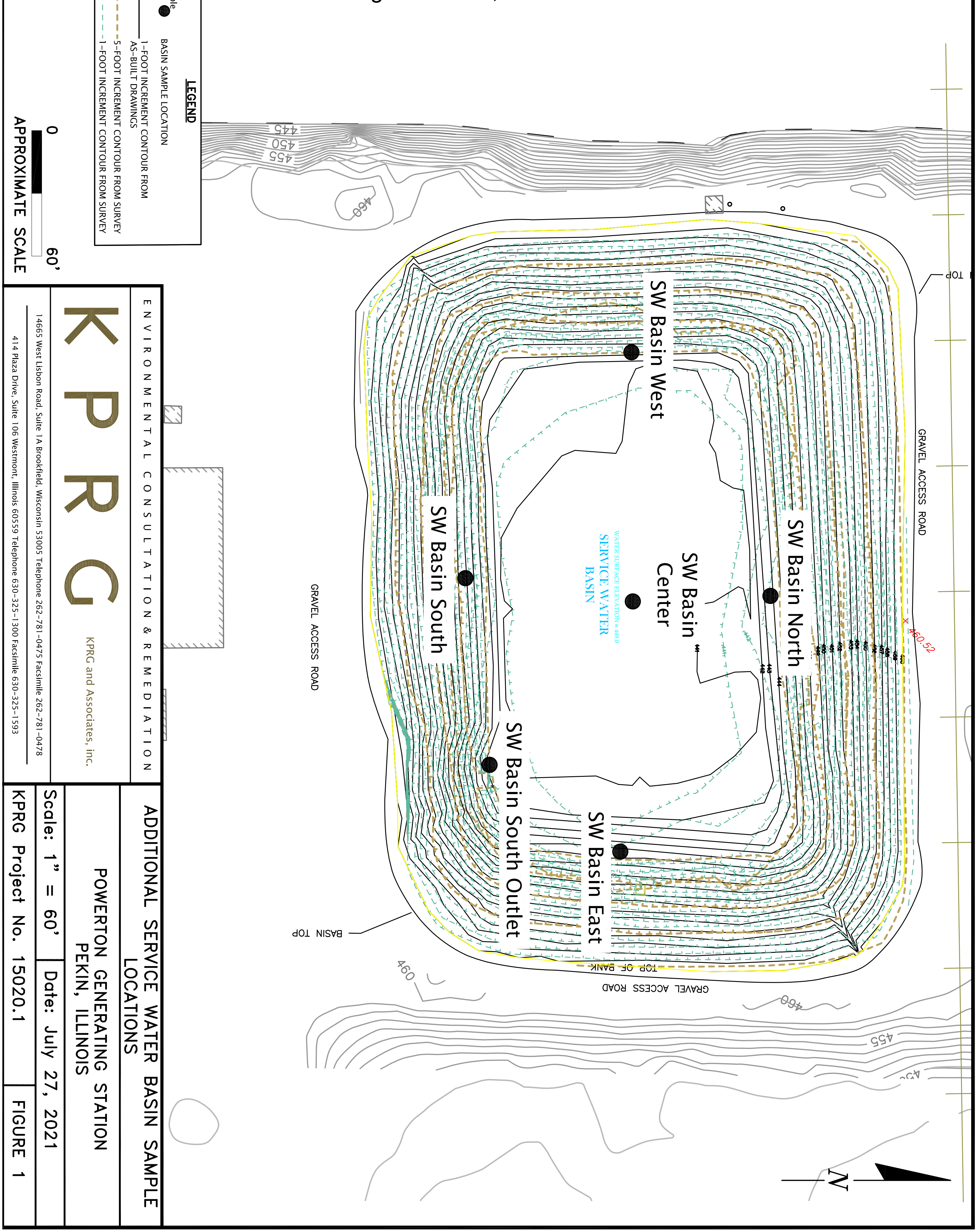

EXHIBIT 1: Table 1: Weight Volume Relationships of Soil

	Powerton CCR		SW Basin South		SW Basin East		SW Basin North		SW Basin Center		SW Basin West		SW Basin S. Outlet	
	Weight (lbs)	Volume (ft^3)	Weight (lbs)	Volume (ft^3)	Weight (lbs)	Volume (ft^3)	Weight (lbs)	Volume (ft^3)	Weight (lbs)	Volume (ft^3)	Weight (lbs)	Volume (ft^3)	Weight (lbs)	Volume (ft^3)
Density	62	--	115.7	--	104.4	--	85.5	--	85.4	--	84.4	--	85.3	--
Air	0	0.58	0	0	0	-0.01	0	-0.02	0	0.11	0	-0.02	0	-0.02
Water	2.2	0.04	29.9	0.48	35.4	0.57	44.2	0.71	35.9	0.58	45.3	0.73	44.8	0.72
Solids	59.8	0.38	85.8	0.52	69.1	0.44	41.2	0.31	49.4	0.32	39.0	0.29	40.5	0.30

Note: Volume quantity based on a total of 1 cubic foot

EXHIBIT 1: Table 2: Weight Volume Relationships of Soil

	Powerton CCR	SW Basin South	SW Basin East	SW Basin North	SW Basin Center	SW Basin West	SW Basin S. Outlet
Ash content %	81.10	91.76	83.57	60.87	59.69	62.00	62.71
organic matter %	18.90	8.24	16.43	39.13	40.31	38.00	37.29

EXHIBIT 4: Table 3: Comparison of Distribution of Particle Sizes for Joliet 9 CCR and Powerton's Service Water Basin Material

Sample	% +3"	% Gravel		% Sand			% Fines		Soil Classification
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay	
Powerton CCR	0.0	0.0	0.0	13.2	70.1	10.8	3.3	2.6	Black SAND w/ silt
SW Basin South	0.0	0.0	2.0	8.0	43.5	23.8	18.7	4.0	Black/gray silty SAND
SW Basin East	0.0	0.0	0.7	5.1	45.1	23.3	20.2	5.6	Black Silty SAND
SW Basin North	0.0	0.0	1.5	1.7	6.9	7.7	73.4	8.8	Black SILT with sand
SW Basin Center	0.0	0.0	0.0	0.3	1.6	3.1	84.2	10.8	Black SILT
SW Basin West	0.0	0.0	0.0	0.7	3.2	4.3	81.0	10.8	Black SILT
SW Basin S. Outlet	0.0	0.0	0.5	0.4	3.7	6.2	78.8	10.4	Black SILT

SW Basin surface at top of slope = 87,791.1 Sq.ft = 2.0154 acres

Material Quantities Based on 2 tons/ac/yr

SW Basin surface at top of slope = 87791.14 Sq.ft

Last clean out occurred between March and June 2013

Time between Clean out and survey is from 6/15/2013 and 7/14/2020 for a total of 2,257.25 days

SW Basin top slope surface

2.0154 acres	2 tons	2257.25 days	=	24.9 tons
	ac/yr	365 days/yr		

6.2 years

MIDLAND STANDARD ENGINEERING TESTING, INC.

410 NOLEN DRIVE, SOUTH ELGIN, IL 60177 P(847) 844-1895 F(847) 844-3875

Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
ASTM 2974

Project # 21448

Project Name: Powerton Station 15020.1

Sample Description: Black Silty SAND to SILT

Date Received: 6/14/21

Date Tested: 6/22/21

Tested by: JDS

Southwest Basin

METHOD D, 750°C

METHOD C, 440°C

	SAMPLE ID	East	North	West
	SPECIMEN #	1	2	3
	TEST DATE:	6/22/21	6/22/21	6/22/21
	TEST TEMP:	440°C	440°C	440°C
1. wt of crucible, no cover	1	26.07	28.78	26.05
2. wt. of crucible & unburnt sample, r	2	44.02	38.44	35.73
3. wt. of crucible & burned sample, n	3	41.07	34.66	32.12
4. wt. of dry sample at start	B	17.95	9.66	9.68
5. net wt. of ash	C	15.00	5.88	6.07
6. ash content, %	D	83.57	60.87	62.71
7. organic matter, %	OM,%	**16.43**	**39.13**	**37.29**

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Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
ASTM 2974

Project # 21448
Project Name: Powerton Station 15020.1
Sample Description: Black Silty SAND to SILT

Date Received: 6/14/21
Date Tested: 6/22/21
Tested by: JDS

Southwest Basin

METHOD D, 750°C
METHOD C, 440°C

	SAMPLE ID	S. Outlet	Center	
	SPECIMEN #	4	5	
	TEST DATE:	6/22/21	6/22/21	
	TEST TEMP	440°C	440°C	
1. wt of crucible, no cover	1	25.78	29.11	
2. wt. of crucible & unburnt sample,	2	35.7	40.15	
3. wt. of crucible & burned sample,	3	31.93	35.7	
4. wt. of dry sample at start	B	9.92	11.04	
5. net wt. of ash	C	6.15	6.59	
6. ash content, %	D	62.00	59.69	
7. organic matter, %	OM,%	**38.00**	**40.31**	

SPF013

EXHIBIT 3

WEIGHT VOLUME RELATIONSHIPS OF SOIL

PROJECT NAME:	Powerton Station	**PROJECT NO:**	21448
SAMPLE LOCATION:	SW Basin - East	**DATE:**	6/14/21
SOIL CLASSIFICATION:	Black Silty SAND, SM	**CLIENT:**	KPRG Wisconsin

V=1.0 cf	Vv=0.56 cf	-Va=0.01 cf	*AIR*	Wa=0 lb	Wt=104.4 lb
		Vw=0.57 cf	*WATER*	Ww=35.4 lb	
		Vs=0.44 cf	*SOLIDS*	Ws=69.1 lb	

ENTER LABORATORY MOISTURE CONTENT, %- -	Mc=	51.2
ENTER SAMPLE WEIGHT, grams- - - - - - - -	W=	133.35
ENTER SAMPLE DIAMETER, inches- - - - - - -	Ds=	
ENTER SAMPLE LENGTH, inches- - - - - - - -	Ls=	
ENTER ESTIMATED/KNOWN SPECIFIC GRAVITY,Gs	Gs=	2.494
SAMPLE VOLUME, cubic inches- - - - - - - - -	V=	4.86 ((Ds/
WET DENSITY, #/cu ft- - - - - - - - - - - -	Wt=	104.4
WEIGHT OF SOLIDS, pounds- - - - - - - - - - -	Ws=	69.1
WEIGHT OF WATER, pounds- - - - - - - - - - -	Ww=	35.4
VOLUME OF SOLIDS, cubic feet- - - - - - - - -	Vs=	0.44
VOLUME OF WATER, cubic feet- - - - - - - - -	Vw=	0.57
VOLUME OF AIR, cubic feet- - - - - - - - - - -	Va=	-0.01
VOLUME OF VOIDS, cubic feet- - - - - - - - -	Vv=	0.56
POROSITY, n- - - - - - - - - - - - - -	**n=**	**0.56**
VOID RATIO, e- - - - - - - - - - - - -	**e=**	**1.25**
DEGREE OF SATURATION, Sr- - - - - - -	**Sr=**	**102%**
LOSS ON IGNITION - - - - - - - - -	FOC=	16.4%

EXHIBIT 3

WEIGHT VOLUME RELATIONSHIPS OF SOIL

PROJECT NAME:	Powerton Station	**PROJECT NO:**	21448
SAMPLE LOCATION:	SW Basin - South Outlet	**DATE:**	6/14/21
SOIL CLASSIFICATION:	Black SILT, ML	**CLIENT:**	KPRG Wisconsin

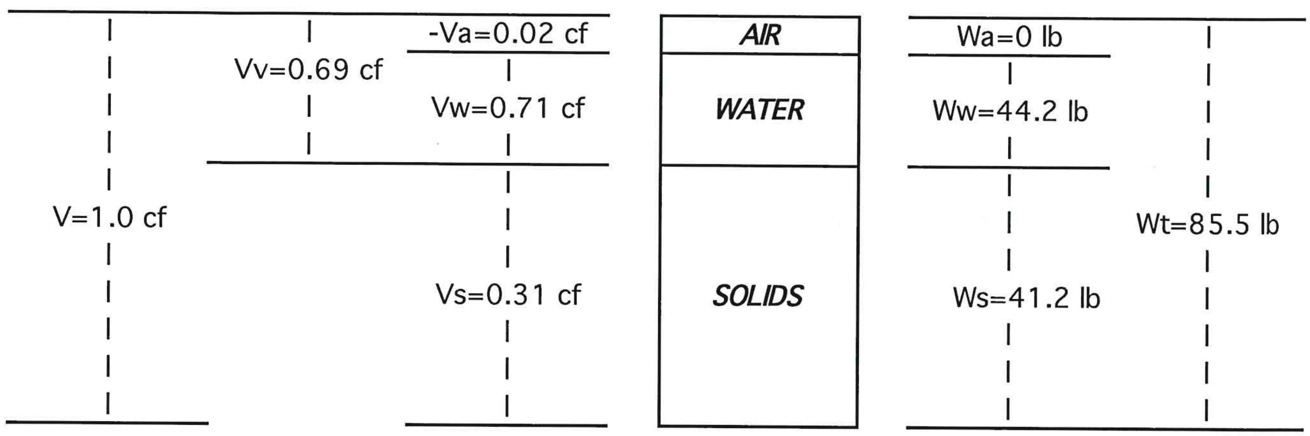
Total Volume	Voids	Volume	Phase	Weight	Total Weight
V=1.0 cf	Vv=0.70 cf	-Va=0.02 cf	*AIR*	Wa=0 lb	Wt=85.3 lb
		Vw=0.72 cf	*WATER*	Ww=44.8 lb	
		Vs=0.30 cf	*SOLIDS*	Ws=40.5 lb	

ENTER LABORATORY MOISTURE CONTENT, %- -	Mc= 110.7	
ENTER SAMPLE WEIGHT, grams- - - - - - - -	W= 108.90	
ENTER SAMPLE DIAMETER, inches- - - - - - -	Ds=	
ENTER SAMPLE LENGTH, inches- - - - - - - -	Ls=	
ENTER ESTIMATED/KNOWN SPECIFIC GRAVITY,Gs	Gs= 2.136	
SAMPLE VOLUME, cubic inches- - - - - - - - -	V= 4.86	((Ds/
WET DENSITY, #/cu ft- - - - - - - - - - - -	Wt= 85.3	
WEIGHT OF SOLIDS, pounds- - - - - - - - - - -	Ws= 40.5	
WEIGHT OF WATER, pounds- - - - - - - - - - -	Ww= 44.8	
VOLUME OF SOLIDS, cubic feet- - - - - - - - -	Vs= 0.30	
VOLUME OF WATER, cubic feet- - - - - - - - -	Vw= 0.72	
VOLUME OF AIR, cubic feet- - - - - - - - - - -	Va= -0.02	
VOLUME OF VOIDS, cubic feet- - - - - - - - -	Vv= 0.70	
POROSITY, n- - - - - - - - - - - - - -	**n= 0.70**	
VOID RATIO, e- - - - - - - - - - - - - -	**e= 2.29**	
DEGREE OF SATURATION, Sr- - - - - - -	**Sr= 103%**	
LOSS ON IGNITION - - - - - - - -	FOC= 38.0%	

EXHIBIT 3

WEIGHT VOLUME RELATIONSHIPS OF SOIL

PROJECT NAME:	Powerton Station	**PROJECT NO:**	21448
SAMPLE LOCATION:	SW Basin - North	**DATE:**	6/14/21
SOIL CLASSIFICATION:	Black SILT with Sand, ML	**CLIENT:**	KPRG Wisconsin

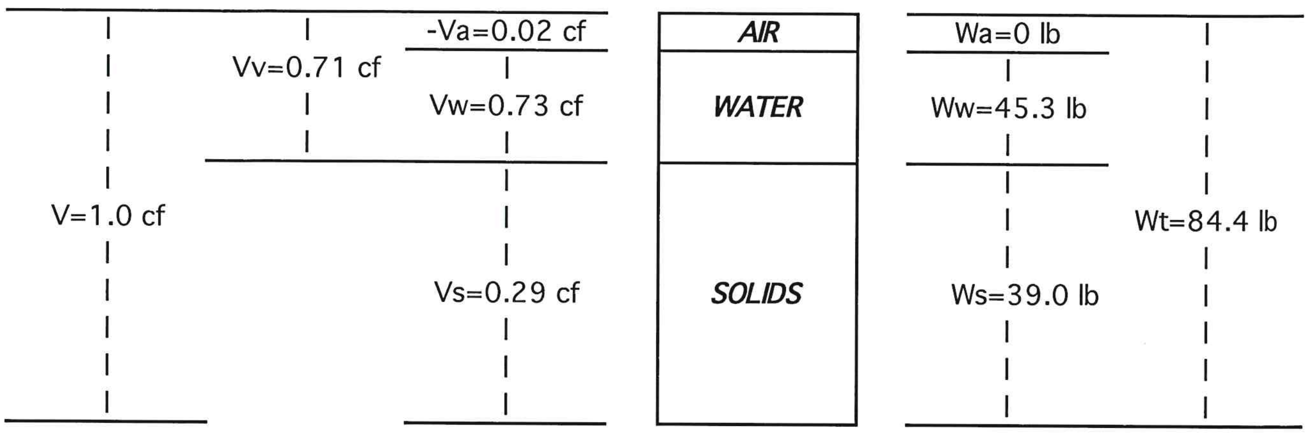


ENTER LABORATORY MOISTURE CONTENT, %- -	Mc= 107.3
ENTER SAMPLE WEIGHT, grams- - - - - - - -	W= 109.13
ENTER SAMPLE DIAMETER, inches- - - - - - -	Ds=
ENTER SAMPLE LENGTH, inches- - - - - - - -	Ls=
ENTER ESTIMATED/KNOWN SPECIFIC GRAVITY,Gs	Gs= 2.136
SAMPLE VOLUME, cubic inches- - - - - - - - -	V= 4.86 ((Ds/
WET DENSITY, #/cu ft- - - - - - - - - - - -	Wt= 85.5
WEIGHT OF SOLIDS, pounds- - - - - - - - - - -	Ws= 41.2
WEIGHT OF WATER, pounds- - - - - - - - - - -	Ww= 44.2
VOLUME OF SOLIDS, cubic feet- - - - - - - - -	Vs= 0.31
VOLUME OF WATER, cubic feet- - - - - - - - -	Vw= 0.71
VOLUME OF AIR, cubic feet- - - - - - - - - - -	Va= -0.02
VOLUME OF VOIDS, cubic feet- - - - - - - - -	Vv= 0.69
POROSITY, n- - - - - - - - - - - - - -	**n= 0.69**
VOID RATIO, e- - - - - - - - - - - - - -	**e= 2.23**
DEGREE OF SATURATION, Sr- - - - - - -	**Sr= 103%**
LOSS ON IGNITION - - - - - - - -	FOC= 37.3%

EXHIBIT 3

WEIGHT VOLUME RELATIONSHIPS OF SOIL

PROJECT NAME:	Powerton Station	**PROJECT NO:**	21448
SAMPLE LOCATION:	SW Basin - West	**DATE:**	6/14/21
SOIL CLASSIFICATION:	Black SILT, ML	**CLIENT:**	KPRG Wisconsin



ENTER LABORATORY MOISTURE CONTENT, %- -	Mc=	116.1
ENTER SAMPLE WEIGHT, grams- - - - - - - -	W=	107.73
ENTER SAMPLE DIAMETER, inches- - - - - - -	Ds=	
ENTER SAMPLE LENGTH, inches- - - - - - - -	Ls=	
ENTER ESTIMATED/KNOWN SPECIFIC GRAVITY,Gs	Gs=	2.136
SAMPLE VOLUME, cubic inches- - - - - - - - -	V=	4.86
WET DENSITY, #/cu ft- - - - - - - - - - - -	Wt=	84.4
WEIGHT OF SOLIDS, pounds- - - - - - - - - - -	Ws=	39.0
WEIGHT OF WATER, pounds- - - - - - - - - - -	Ww=	45.3
VOLUME OF SOLIDS, cubic feet- - - - - - - - -	Vs=	0.29
VOLUME OF WATER, cubic feet- - - - - - - - -	Vw=	0.73
VOLUME OF AIR, cubic feet- - - - - - - - - - -	Va=	-0.02
VOLUME OF VOIDS, cubic feet- - - - - - - - -	Vv=	0.71
POROSITY, n- - - - - - - - - - - - - -	**n=**	**0.71**
VOID RATIO, e- - - - - - - - - - - - -	**e=**	**2.41**
DEGREE OF SATURATION, Sr- - - - - - -	**Sr=**	**103%**
LOSS ON IGNITION - - - - - - - -	FOC=	39.1%

((Ds/

EXHIBIT 3

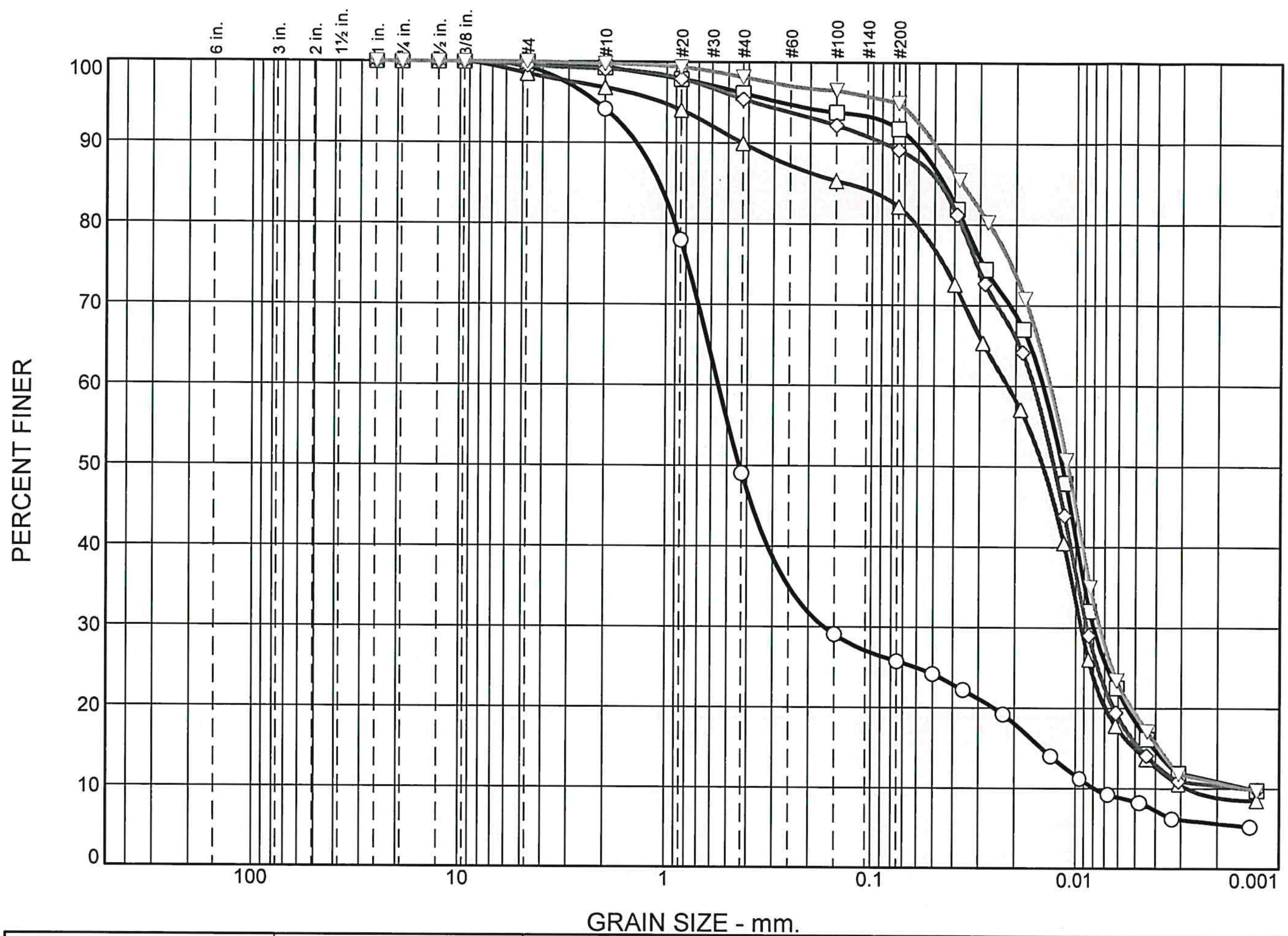
WEIGHT VOLUME RELATIONSHIPS OF SOIL

PROJECT NAME:	Powerton Station	**PROJECT NO:**	21448
SAMPLE LOCATION:	SW Basin - Center	**DATE:**	6/14/21
SOIL CLASSIFICATION:	Black SILT, ML	**CLIENT:**	KPRG Wisconsin

Total volume	Voids	Component volume	Phase	Component weight	Total weight
V=1.0 cf	Vv=0.68 cf	Va=0.11 cf	*AIR*	Wa=0 lb	Wt=85.4 lb
		Vw=0.58 cf	*WATER*	Ww=35.9 lb	
		Vs=0.32 cf	*SOLIDS*	Ws=49.4 lb	

ENTER LABORATORY MOISTURE CONTENT, %- -	Mc=	72.7
ENTER SAMPLE WEIGHT, grams- - - - - - - -	W=	109.02
ENTER SAMPLE DIAMETER, inches- - - - - - -	Ds=	
ENTER SAMPLE LENGTH, inches- - - - - - - -	Ls=	
ENTER ESTIMATED/KNOWN SPECIFIC GRAVITY,Gs	Gs=	2.494
SAMPLE VOLUME, cubic inches- - - - - - - - -	V=	4.86 ((Ds/
WET DENSITY, #/cu ft- - - - - - - - - - - -	Wt=	85.4
WEIGHT OF SOLIDS, pounds- - - - - - - - - - -	Ws=	49.4
WEIGHT OF WATER, pounds- - - - - - - - - - -	Ww=	35.9
VOLUME OF SOLIDS, cubic feet- - - - - - - - -	Vs=	0.32
VOLUME OF WATER, cubic feet- - - - - - - - -	Vw=	0.58
VOLUME OF AIR, cubic feet- - - - - - - - - - -	Va=	0.11
VOLUME OF VOIDS, cubic feet- - - - - - - - -	Vv=	0.68
POROSITY, n- - - - - - - - - - - - - -	**n=**	**0.68**
VOID RATIO, e- - - - - - - - - - - - - -	**e=**	**2.15**
DEGREE OF SATURATION, Sr- - - - - - -	**Sr=**	**84%**
LOSS ON IGNITION - - - - - - - -	FOC=	40.3%

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

MATERIAL DATA					
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○		SW Basin		Black Silty SAND	SM
		East			
□		SW Basin		Black SILT	ML
		West			
△		SW Basin		Black SILT with Sand	ML
		North			
◇		SW Basin		Black SILT	ML
		South Outle			
▽		SW Basin		Black SILT	ML

MIDLAND STANDARD ENGINEERING & TESTING, INC. "Our work is beneath you" MSET

Client: KRPG And Associates, Inc.
Project: Powerton Station 15020.1

Project No.: 21448 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

7/15/2021

Client: KRPG And Associates, Inc.
Project: Powerton Station 15020.1
Project Number: 21448
Location: South West Basin - East
Sample Number: SW Basin East
Material Description: Black Silty SAND
USCS: SM

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
274.46	0.00	0.00	1"	0.00	100.0
			3/4"	0.00	100.0
			1/2"	0.00	100.0
			3/8"	0.00	100.0
			#4	1.89	99.3
			#10	16.03	94.2
51.04	0.00	0.00	#20	8.77	78.0
			#40	24.45	49.1
			#100	35.28	29.1
			#200	37.08	25.8

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 94.2
Weight of hydrometer sample =51.04
Hygroscopic moisture correction:
Moist weight and tare = 103.36
Dry weight and tare = 100.44
Tare weight = 31.37
Hygroscopic moisture = 4.2%
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -5.5
Meniscus correction only = 0.0
Specific gravity of solids = 2.494
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 x Rm

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer
1.00	24.5	16.5	12.1	0.0136	16.5	13.6	0.0501	24.2
2.00	24.5	15.5	11.1	0.0136	15.5	13.8	0.0356	22.2
5.00	24.5	14.0	9.6	0.0136	14.0	14.0	0.0227	19.2
15.00	24.5	11.4	7.0	0.0136	11.4	14.4	0.0133	14.0
30.00	24.5	10.0	5.6	0.0136	10.0	14.7	0.0095	11.2
60.00	24.5	9.0	4.6	0.0136	9.0	14.8	0.0067	9.2
120.00	24.5	8.5	4.1	0.0136	8.5	14.9	0.0048	8.2
250.00	24.5	7.5	3.1	0.0136	7.5	15.1	0.0033	6.2
1440.00	24.5	7.0	2.6	0.0136	7.0	15.1	0.0014	5.2

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.7	0.7	5.1	45.1	23.3	73.5	20.2	5.6	25.8

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0079	0.0147	0.0252	0.1682	0.3168	0.4358	0.5531	0.9030	1.0814	1.4018	2.1988

Fineness Modulus	C_u	C_c
1.87	69.76	6.45

GRAIN SIZE DISTRIBUTION TEST DATA

7/15/2021

Client: KRPG And Associates, Inc.
Project: Powerton Station 15020.1
Project Number: 21448
Location: South West Basin - North
Sample Number: SW Basin North
Material Description: Black SILT with Sand
USCS: ML

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
176.62	0.00	0.00	1"	0.00	100.0
			3/4"	0.00	100.0
			1/2"	0.00	100.0
			3/8"	0.00	100.0
			#4	2.59	98.5
			#10	5.66	96.8
50.58	0.00	0.00	#20	1.44	94.0
			#40	3.58	89.9
			#100	5.98	85.4
			#200	7.64	82.2

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 96.8
Weight of hydrometer sample =50.58
Hygroscopic moisture correction:
  Moist weight and tare = 52.47
  Dry weight and tare = 50.69
  Tare weight = 31.36
  Hygroscopic moisture = 9.2%
Automatic temperature correction
  Composite correction (fluid density and meniscus height) at 20 deg. C = -5.5
Meniscus correction only = 0.0
Specific gravity of solids = 2.136
Hydrometer type = 152H
  Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer
1.00	24.5	39.5	35.1	0.0156	39.5	9.8	0.0488	85.9
2.00	24.5	36.0	31.6	0.0156	36.0	10.4	0.0355	77.3
5.00	24.5	32.0	27.6	0.0156	32.0	11.0	0.0231	67.5
15.00	24.5	24.0	19.6	0.0156	24.0	12.4	0.0141	48.0
30.00	24.5	17.0	12.6	0.0156	17.0	13.5	0.0104	30.8
60.00	24.5	13.0	8.6	0.0156	13.0	14.2	0.0076	21.1
120.00	24.5	11.0	6.6	0.0156	11.0	14.5	0.0054	16.2
250.00	24.5	9.5	5.1	0.0156	9.5	14.7	0.0038	12.5
1440.00	24.5	8.5	4.1	0.0156	8.5	14.9	0.0016	10.1

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	1.5	1.5	1.7	6.9	7.7	16.3	73.4	8.8	82.2

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0028	0.0050	0.0070	0.0093	0.0114	0.0146	0.0219	0.0613	0.1327	0.4290	1.0567

Fineness Modulus	C_u	C_c
0.43	7.77	1.42

GRAIN SIZE DISTRIBUTION TEST DATA

7/15/2021

Client: KRPG And Associates, Inc.
Project: Powerton Station 15020.1
Project Number: 21448
Location: South West Basin - West
Sample Number: SW Basin West
Material Description: Black SILT
USCS: ML

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
163.65	0.00	0.00	1"	0.00	100.0
			3/4"	0.00	100.0
			1/2"	0.00	100.0
			3/8"	0.00	100.0
			#4	0.00	100.0
			#10	1.21	99.3
50.72	0.00	0.00	#20	0.70	97.9
			#40	1.59	96.1
			#100	2.78	93.8
			#200	3.81	91.8

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 99.3
Weight of hydrometer sample =50.72
Hygroscopic moisture correction:
  Moist weight and tare = 51.03
  Dry weight and tare = 49.30
  Tare weight = 31.24
  Hygroscopic moisture = 9.6%
Automatic temperature correction
  Composite correction (fluid density and meniscus height) at 20 deg. C = -5.5
Meniscus correction only = 0.0
Specific gravity of solids = 2.136
Hydrometer type = 152H
  Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer
1.00	24.5	43.0	38.6	0.0156	43.0	9.2	0.0473	96.9
2.00	24.5	39.5	35.1	0.0156	39.5	9.8	0.0345	88.1
5.00	24.5	36.0	31.6	0.0156	36.0	10.4	0.0224	79.4
15.00	24.5	27.0	22.6	0.0156	27.0	11.9	0.0138	56.8
30.00	24.5	19.5	15.1	0.0156	19.5	13.1	0.0103	37.9
60.00	24.5	15.0	10.6	0.0156	15.0	13.8	0.0075	26.6
120.00	24.5	12.0	7.6	0.0156	12.0	14.3	0.0054	19.1
250.00	24.5	10.0	5.6	0.0156	10.0	14.7	0.0038	14.1
1440.00	24.5	9.0	4.6	0.0156	9.0	14.8	0.0016	11.6

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.7	3.2	4.3	8.2	81.0	10.8	91.8

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0014	0.0041	0.0054	0.0080	0.0098	0.0118	0.0147	0.0358	0.0448	0.0620	0.2758

Fineness Modulus	C_u	C_c
0.16	10.34	3.08

GRAIN SIZE DISTRIBUTION TEST DATA

7/15/2021

Client: KRPG And Associates, Inc.
Project: Powerton Station 15020.1
Project Number: 21448
Location: South West Basin - South Outlet
Sample Number: SW Basin South Outle
Material Description: Black SILT
USCS: ML

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
169.33	0.00	0.00	1"	0.00	100.0
			3/4"	0.00	100.0
			1/2"	0.00	100.0
			3/8"	0.00	100.0
			#4	0.77	99.5
			#10	1.52	99.1
50.56	0.00	0.00	#20	0.60	97.9
			#40	1.88	95.4
			#100	3.51	92.2
			#200	5.06	89.2

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 99.1
Weight of hydrometer sample =50.56
Hygroscopic moisture correction:
- **Moist weight and tare =** 53.43
- **Dry weight and tare =** 51.44
- **Tare weight =** 31.43
- **Hygroscopic moisture =** 9.9%

Automatic temperature correction
- **Composite correction (fluid density and meniscus height) at 20 deg. C =** -5.5

Meniscus correction only = 0.0
Specific gravity of solids = 2.136
Hydrometer type = 152H
- **Hydrometer effective depth equation: L =** 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer
1.00	24.5	42.5	38.1	0.0156	42.5	9.3	0.0475	96.1
2.00	24.5	38.5	34.1	0.0156	38.5	10.0	0.0348	86.1
5.00	24.5	34.5	30.1	0.0156	34.5	10.6	0.0227	76.0
15.00	24.5	25.0	20.6	0.0156	25.0	12.2	0.0140	52.0
30.00	24.5	18.0	13.6	0.0156	18.0	13.3	0.0104	34.3
60.00	24.5	13.5	9.1	0.0156	13.5	14.1	0.0075	23.0
120.00	24.5	11.0	6.6	0.0156	11.0	14.5	0.0054	16.7
250.00	24.5	9.5	5.1	0.0156	9.5	14.7	0.0038	12.9
1440.00	24.5	9.0	4.6	0.0156	9.0	14.8	0.0016	11.6

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.5	0.5	0.4	3.7	6.2	10.3	78.8	10.4	89.2

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0015	0.0048	0.0063	0.0087	0.0107	0.0129	0.0163	0.0371	0.0470	0.0880	0.3760

Fineness Modulus	C_u	C_c
0.19	10.89	3.09

GRAIN SIZE DISTRIBUTION TEST DATA

7/15/2021

Client: KRPG And Associates, Inc.
Project: Powerton Station 15020.1
Project Number: 21448
Location: South West Basin - Center
Sample Number: SW Basin Center
Material Description: Black SILT
USCS: ML

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
160.94	0.00	0.00	1"	0.00	100.0
			3/4"	0.00	100.0
			1/2"	0.00	100.0
			3/8"	0.00	100.0
			#4	0.00	100.0
			#10	0.42	99.7
51.93	0.00	0.00	#20	0.20	99.4
			#40	0.83	98.1
			#100	1.66	96.6
			#200	2.48	95.0

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 99.7
Weight of hydrometer sample =51.93
Hygroscopic moisture correction:
  Moist weight and tare = 52.35
  Dry weight and tare = 50.28
  Tare weight = 31.28
  Hygroscopic moisture = 10.9%
Automatic temperature correction
  Composite correction (fluid density and meniscus height) at 20 deg. C = -5.5
Meniscus correction only = 0.0
Specific gravity of solids = 2.494
Hydrometer type = 152H
  Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer
1.00	24.5	45.0	40.6	0.0136	45.0	8.9	0.0405	89.9
2.00	24.5	42.5	38.1	0.0136	42.5	9.3	0.0293	84.4
5.00	24.5	38.0	33.6	0.0136	38.0	10.1	0.0193	74.4
15.00	24.5	28.5	24.1	0.0136	28.5	11.6	0.0120	53.4
30.00	24.5	21.0	16.6	0.0136	21.0	12.9	0.0089	36.8
60.00	24.5	15.5	11.1	0.0136	15.5	13.8	0.0065	24.6
120.00	24.5	12.5	8.1	0.0136	12.5	14.2	0.0047	17.9
250.00	24.5	10.0	5.6	0.0136	10.0	14.7	0.0033	12.4
1440.00	24.5	9.0	4.6	0.0136	9.0	14.8	0.0014	10.2

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.3	1.6	3.1	5.0	84.2	10.8	95.0

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0015	0.0039	0.0052	0.0074	0.0092	0.0110	0.0135	0.0271	0.0368	0.0502	0.0757

Fineness Modulus	C_u	C_c
0.08	9.29	2.80

Exhibit E

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	AS 2021-002
Petition of Midwest Generation	)	
for an Adjusted Standard from 845.740(a)	)	
and Finding of Inapplicability of Part 845	)	(Adjusted Standard)
(Powerton Station)	)	

AFFIDAVIT OF MELINDA K. SHAW

I, Melinda K. Shaw, certify under penalty of perjury pursuant to Section 1-109 of the Illinois Code of Civil Procedure, 735 ILCS 5/1-109, that the statements set forth in this affidavit are true and correct, and further state that if called upon to testify in this matter, I would competently testify as follows:

1. I am an Environmental Protection Geologist employed by the Illinois Environmental Protection Agency (the "Illinois EPA") in the Bureau of Water, Groundwater Section, Hydrogeology and Compliance Unit ("HCU"), and I am located in Springfield, Illinois. Cumulatively, I have worked for the Illinois EPA for approximately eight years in various remediation programs.

2. As an Environmental Protection Geologist in the HCU, my duties include, but are not limited to, working on the development and implementation of rules and regulations related protecting, monitoring, and restoring groundwater in Illinois, and providing technical expertise to the Bureau of Water Permit Section on groundwater issues. As part of these duties, I served as a witness on behalf of the Groundwater Section in support of Illinois EPA's proposed Part 845 throughout the Illinois Pollution Control Board's rulemaking proceedings in R2020-019.

3. I have reviewed the Petition for an Adjusted Standard from Section 845.740(a) and Finding of Inapplicability of Part 845 for the Powerton Station ("Petition") filed by Midwest Generation, LLC ("MWG").

4. I have personal knowledge of the facts set forth in Illinois EPA's Recommendation to the Board as to Petitioner's request for a finding that Part 845 does not apply to the Service Water Basin located at the Powerton Station.

5. Attached to the Recommendation as Exhibit A ("Rec. Ex. A") is an Illinois EPA Division of Water Pollution Control invoice related to Powerton Generating Station, dated December 16, 2019. This invoice is kept by the Illinois EPA in the regular course of business, and it was the regular course of business of the Illinois EPA to transmit the information thereof to be included in such a record. Illinois EPA Division of Water Pollution Control invoice related to Powerton Generating Station, dated December 16, 2019, and attached to the Recommendation as Exhibit A, is an exact duplicate of the original.

6. Attached to the Recommendation as Exhibit B ("Rec. Ex. B") is a March 25, 2020 Illinois EPA letter to MWG. The March 25, 2020 letter is kept by the Illinois EPA in the regular course of business, and it was the regular course of business of the Illinois EPA to transmit the information thereof to be included in this record. The March 25, 2020 letter, attached to the Recommendation as Exhibit B, is an exact duplicate of the original.

7. Attached to the Recommendation as Exhibit C ("Rec. Ex. C) is Violation Notice ("VN") W-2012-00042. This violation notice is kept by the Illinois EPA in the regular course of business, and it was the regular course of business of the Illinois EPA to transmit the information thereof to be included in this record. VN W-2012-00042, attached to the Recommendation as Exhibit A, is an exact duplicate of the original.

8. Attached to the Recommendation as Exhibit G ("Rec. Ex. G) is a MWG letter to Illinois EPA, dated November 25, 2020, with a KRPG Memorandum re: Evaluation of Sediment Quantities in Joliet Generating Station's Pond 1 and Pond 3 and Powerton Generating Station's

Service Water Basin, dated November 19, 2020, enclosed. This letter was submitted to Illinois EPA as a written response to Rec. Ex. C. It is kept by the Illinois EPA in the regular course of business, and it was the regular course of business of the Illinois EPA to transmit the information thereof to be included in this record. The November 25, 2020 letter and its enclosures, attached to the Recommendation as Exhibit G, are exact duplicates of the originals.

9. Attached to the Recommendation as Exhibit L ("Rec. Ex. L") is the Standard Test Methods for Determining the Water (Moisture) Content, Ash Content and Organic Material of Peat and Other Organic Soils, ASTM International, Inc., accessed by Illinois EPA pursuant to License Agreement on March 9, 2021. The ASTM Methods, attached to the Recommendation as Exhibit L,[1] is an exact duplicate of the original obtained by Illinois EPA on March 9, 2021.

10. Attached to the Recommendation as Exhibit M ("Rec. Ex. M") is a MWG letter to Illinois EPA, dated March 9, 2021, with Exhibits 1 through 9 attached. This letter is kept by the Illinois EPA in the regular course of business, and it was the regular course of business of the Illinois EPA to transmit the information thereof to be included in this record. The March 9, 2021 letter and its exhibits, attached to the Recommendation as Exhibit M, are exact duplicates of the originals.

11. In December 2019, Illinois EPA identified the Service Water Basin as a CCR surface impoundment based on historic records on file. The Agency sent a fee invoice to MWG dated December 16, 2019. *See* Rec. Ex. A. MWG did not agree that the Service Water Basin was a CCR surface impoundment and began discussions with the Agency in response. MWG did not pay the fees as invoiced by the due date of January 31, 2020. In its March 25, 2020 letter, Illinois

[1] Illinois EPA's license agreement with ASTM prohibits electronic reproduction of methods obtained under the agreement. Rec. Ex. L is served to the Board and Petitioner in hard copy with the Recommendation. Rec. Ex. L is redacted for electronic filing.

EPA provided an allowance for MWG to demonstrate that the Service Water Basin does not contain CCR; however, the fees were still due at that time. *See* Rec. Ex. B.

12. Illinois EPA issued MWG a Violation Notice on July 28, 2020 (VN W-2020-00042) for failure to pay the initial fee. *See* Rec. Ex. C. The VN process yielded several meetings in which I participated, as well as written responses from MWG on the matter of demonstrating that the Service Water Basin is not a CCR surface impoundment.

13. MWG submitted several documents in support of its demonstration that the Service Water Basin is not a CCR surface impoundment. Many of the submittals were sent in response to Agency questions and requests for additional information. In summary, the submittals contained a bathymetric survey, calculation of estimated sediment in the bottom of the Service Water Basin, laboratory analysis of samples from the Service Water Basin, and comparison of the samples to CCR from the Ash Surge Basin at the Powerton Station.

14. I have reviewed the Agency's Recommendation, as well as the submittals and information upon which the Recommendation is based, and further state the following in support.

15. The bathymetric survey provides no indication of sediment accumulation or a delta-like alluvial structure in the basin. Based on my knowledge and experience, if CCR had been sluiced in, even incidentally, since 2013, the Agency would expect to see some measurable accumulation of sediment and/or a delta-like alluvial structure in the Service Water Basin.

16. In addition to the bathymetric survey, I reviewed historic aerial photos of the Service Water Basin taken between 1995 and 2017. The Service Water Basin does not change in appearance throughout the review period. There are no deltas present, nor visible changes in the unit, in over twenty years. In contrast, other known CCR surface impoundments at the Powerton

Station had various changes in appearance, including deltas and removals, throughout the same time period.

17. MWG provided an estimated calculation of sediment within the Service Water Basin, which yielded 52 cubic yards ("CY") of material in the bottom of the unit. *See* Pet. Ex. 19 and 20. The Agency asked for a comparison of this amount to that of an amount removed in a known CCR surface impoundment of similar size at the Powerton Station. On August 18, 2021, MWG replied in a letter that 310 CY was removed from the Bypass Basin in the most recent removal. *See* Rec. Ex. F. Comparing the amount of material in the Service Water Basin, which has not been emptied since 2013, to a known CCR surface impoundment at the Powerton Station provides support that the Service Water Basin does not contain enough material in it to indicate any appreciable amounts of CCR.

18. MWG took five sediment samples located at various points in the Service Water Basin, including near the inlet of the basin. The sediment samples were sent to a geotechnical laboratory to (1) determine grain size, (2) conduct a weight to volume relationship analysis, and (3) compare moisture, inorganic and organic content utilizing ASTM method 2974. CCR from MWG's Joliet 9 Station and, per my request, CCR from MWG's Powerton Station, were also subjected to these analyses for comparison.

19. The laboratory analyses differed significantly between the sediment in the Service Water Basin and the CCR from both the Joliet 9 and Powerton Stations. I reviewed the laboratory data contained in the submittals dated November 25, 2020 (Rec. Ex. G), February 26, 2021 (Rec. Ex. H), and July 27, 2021 (Rec. Ex. D), and information on the sampling methodology contained in the submittals dated November 25, 2020 (Rec. Ex. G), February 26, 2021 (Rec. Ex. H), May 12, 2021 (Rec. Ex. I), and July 27, 2021 (Rec. Ex. D).

20. Grain size analysis reports describe the sediment from the Service Water Basin to be brown silty sand with some black sandy silt. *See* Pet Ex. 19, p.6 and Ex. G, encl. p 6. The Powerton CCR sample was described as black sand with silt. *See* Rec. Ex. J. The differences between the sediment and the Powerton CCR are better illustrated in the actual laboratory results provided as Revised Table 3, which contains the sediment and CCR samples quantified by standardized particle sizes. *See* Rec. Ex. J. The grain size analysis indicates that the small amount of material in the Service Water Basin is not CCR.

21. MWG compared moisture, inorganic and organic content utilizing the ASTM 2974 method to estimate how much of the solids were organic versus inorganic in nature. The ASTM 2974 method reports the inorganic material as "ash." This ASTM method does not determine that a material is coal ash or CCR; rather, it is a more general term used to describe something cooked in a furnace and completely burned. *See* Rec. Ex. H, p. 4. Illinois EPA confirmed this description of the method by obtaining the ASTM 2974 method. *See* Rec. Ex. L. MWG used this analysis to estimate the percentage of organic and inorganic material in the Service Water Basin, in an effort to compare the tonnage of inorganic sediment to atmospheric deposition using the Soil Loss Equation. *See* Rec. Ex. G, p. 5.

22. MWG uses a Soil Loss Equation based on erosion of farm fields and construction sites as an estimate for atmospheric deposition. *See* Petition, p.13 and Ex. 21 ("Predicting Rainfall Erosion Losses"); *see also* Rec. Ex. G (November 25, 2020), Rec. Ex. H (February 26, 2021), Rec. Ex. M (March 9, 2021), Rec. Ex. I (May 12, 2021), and Rec. Ex. D (July 27, 2021). Two tons/acre/year of soil loss is appropriately utilized in a soil loss evaluation, but the Agency does not agree with its application to atmospheric deposition in unclosed surface impoundments. Accordingly, I did not rely on the atmospheric deposition estimation during the review of the

various submittals and the development of the Agency's recommendation; rather, I focused and relied upon the bathymetric survey, the volume of material estimated in the Service Water Basin and grain size distribution to evaluate whether: (1) appreciable amount of material is present in the Service Water Basin; and (2) if that material is CCR.

FURTHER AFFIANT SAYETH NOT

Melinda K. Shaw

MELINDA K. SHAW

9/22/21

DATE

State of Illinois
County of Sangamon

Subscribed and Sworn to before
me this 22nd day of September 2021.

Dawn A. Hollis

Notary Public

OFFICIAL SEAL
DAWN A. HOLLIS
NOTARY PUBLIC, STATE OF ILLINOIS
MY COMMISSION EXPIRES 03-21-2025

Exhibit F

Midwest Generation, LLC
Powerton Generating Station
13082 E. Manito Road
Pekin, IL 61554

August 18, 2021

VIA EMAIL

Illinois EPA
Division of Public Water Supplies
Attn: Gabriel Neibergall
P.O. Box 19276
Springfield, IL 62794-9276
Gabriel.Neibergall@illinois.gov

Re: Violation Notice Nos.: W-2020-00042 and W-2020-00083 (Powerton Generating Station)

Dear Mr. Neibergall:

This letter provides answers to the Illinois Environmental Protection Agency ("Illinois EPA" or the "Agency") questions regarding the Service Water Basin and the Bypass Basin at Powerton Generating Station. Midwest Generation, LLC ("MWG") removed approximately 420 tons of ash from the Bypass Basin during the most recent removal, which equates to about 310 cubic yards. MWG removed the ash from the Bypass Basin because of the Illinois CCR Rule and Federal CCR Rule requirement to cease using the basin in April 2021. Thus, it is not clear that the 420 tons in the pond represents the pond as "full." It was merely the amount of material in the basin at that time. In comparison, the Service Water Basin contains 52 cubic yards and has not been emptied since it was relined in 2013. Before it was relined, it had not been emptied since it was built in the 1970's.

In answer to your request for the measurements of the two basins. The information is not readily available in the petition for adjusted standard for the Service Water Basin. According to our consultant, the dimensions of the Service Water Basin are: 445 ft x 255 ft x 17.5 ft. The dimensions of the Bypass Basin can be seen in the drawings in Ex. 14 to the Powerton Petition for an Adjusted Standard. The dimensions of the bypass basin are 250 ft x 160 ft x 11 ft.

We believe this information addresses your questions.

Very truly yours,

Dale Green
Plant Manager
Powerton Generating Station

cc: Kristen Gale (via email)
Sharene Shealey (via email

Exhibit G

NIJMAN · FRANZETTI LLP

10 South LaSalle Street · Suite 3600 · Chicago, Illinois 60603
312.251.5250 · fax 312.251.4610 · www.nijmanfranzetti.com

Kristen Laughridge Gale
kg@nijmanfranzetti.com
312.262.5524

November 25, 2020

VIA OVERNIGHT AND EMAIL
Illinois EPA
Division of Public Water Supplies
Attn: Andrea Rhodes, CAS #19
P.O. Box 19276
Springfield, IL 62794-9276

Re: Violation Notice Nos.: W-2020-00035 (Waukegan Generating Station); W-2020-00045 (Will County Generating Station); W-2020-00042 (Powerton Generating Station); W-2020-00044 (Joliet 29 Station).

Dear Ms. Rhodes:

This letter is a supplemental response to the above-referenced Violation Notices ("VNs") following the meeting between the Illinois Environmental Protection Agency ("Illinois EPA or the "Agency") and Midwest Generation, LLC ("MWG") on October 14, 2020.[1] MWG appreciates the opportunity to discuss the VNs and the underlying allegations with the Agency. The participation at the October 14th meeting by Agency personnel was productive and helped clarify key issues. MWG also appreciates the Agency's agreement to extend the date to submit this response to November 25th, which allowed MWG to collect information to respond to the questions the Agency posed on October 14th. This supplemental response does not repeat all of the information contained in MWG's September 2020 responses to the VNs. It focuses on responding to the questions raised by the Agency during the meeting. The additional information presented in this response provides further support for MWG's position that the ponds at issue are not CCR surface impoundments.

This letter constitutes MWG's supplemental response to the Violation Notices W-2020-00035, W-2020-00045, W-2020-00042, W-2020-00044. MWG also reserves the right to raise additional defenses and mitigation arguments as may be necessary, in defense of the allegations listed in the Violation Notices in the event of any future enforcement. By submitting this supplemental response, MWG does not waive any of its original objections to the VNs raised in our September 11, 2020 and September 16, 2020 VN Responses. Moreover, MWG does not, by submitting this supplemental response, make any admissions of fact or law, or waive any of its defenses to those alleged violations.

[1] The August 14, 2012 meeting was held at the request of MWG, pursuant to Section 31(a)(4) of the Illinois Environmental Protection Act. 415 ILCS 5/31(a)(4).

I. Supplemental Response to Alleged Violations in the VNs

The discussion at the October 14th meeting primarily focused on the three process water ponds located at the Joliet 29 Generating Station ("Joliet 29") and the Powerton Generating Station ("Powerton") given the Agency's stated preference not to discuss in detail the area at Waukegan (the Grassy Field) and the two areas at Will County (1N and 1S). As requested by the Agency, MWG conducted additional analysis and sampling of the contents of the three process water basins at Joliet 29 and Powerton. The results of the analysis demonstrate that none of the process water ponds contain CCR, and are not "CCR surface impoundments" as that term is defined in Section 3.143 of the Act. 415 ILCS 5/3.143.

II. The Materials in the Base of Joliet 29 Pond 1, Joliet 29 Pond 3, and Powerton Service Water Basin are not Coal Combustion Residuals

MWG engaged KPRG & Associates ("KPRG") to conduct an analysis and evaluation of the contents of the Ponds 1 and 3 at Joliet 29 and the Service Water Basin at Powerton. A report of KPRG's analysis and results, which are discussed herein, is attached. Based upon KPRG's analysis, the three ponds contain a small accumulation of material that is not CCR, but rather is material from other station processes that generate flow to the ponds and from stormwater runoff and air dispersion.

a. <u>The Material at the Base of Pond 1 is Sediment and Fines from the Station Operations, Runoff, and Air Dispersion</u>

As MWG stated in its September 16th VN Response letter, MWG removed all of the CCR from Pond 1 and cleaned Pond 1 for reuse as a process water basin in 2015. According to the Joliet 29 NPDES Flow Diagram, various processes at Joliet 29 flow into Pond 1 including the reverse-osmosis ("RO") sand filter backwash, the west area basin runoff, the former coal pile runoff pump discharge, and the plant drains, including the Station floor drains, roof drains and area drains, and the sewage treatment plant. In particular, the RO sand filter backwash contains sand that is used to pull the silt and fines from the well water that the station uses for its processes. When the sand filter is full, the Station backwashes the sand filter to suspend the sediments caught in the filter into the water. The resuspended sediments, likely including some sand, drain into Pond 1. According to the personnel at the Station, the RO sand filter backwash water is very dirty. Similarly, there is little doubt that the sewage treatment plant, the various plant drains and the area storm drains would pick up sediments and silt, including soils and dust, all of which drain into Pond 1. Moreover, stormwater flows from the gravel road and the unpaved areas surrounding the pond also likely contribute to the sediments found at the base of the pond. None of these processes generate or are sources of CCR.

KPRG engaged a surveying company to conduct a bathymetric survey of the pond. One of the many indications that the pond does not contain CCR is that the surveyors could not use a physical survey rod in the pond, because the material at the base was not sufficiently dense to determine an accurate depth. Instead, the surveyors were forced to use an electric depth finder, which found approximately 1.5 feet of material. KPRG also collected a sample of the material in the pond. KPRG observed that the material was very different from CCR, finding that it was "sticky/pasty in consistency" with a silty/clayey feel, and it also had a sewage odor. By comparison, CCR is sandy and does not have a smell. KPRG also calculated the average air dispersion of material that settled into Pond 1 based upon the estimated average of 2 tons/acre/year that falls from the air onto land.[2] Accordingly, from the date Pond 1 was emptied in 2015 until the present, it is estimated that approximately 29.7 tons of material has fallen into the pond from the air.

The Pond 1 sample was analyzed for a weight-to-volume relationship, grain size, and organic and non-organic matter. The weight-to-volume relationship analysis showed that 86% of the material was water, which explains why the surveyors could not use the physical rod to determine the depth. Instead, because the material is 86% water, the material is actually floating at the base on the pond, and the rod passed through the material. Because of the high volume of water in the material and that the material is floating, it is likely that if the pond were emptied, the 1.5 feet depth of floating material would decrease to a depth of less than three inches. Of the 14% solids in the material, 32% was organic solids, which is not CCR. Accordingly, of the volume of material calculated to be at the base of Pond 1 (5,174 CY), only 9.5% (489 CY) is non-organic solids. Using the density of the material, the total tonnage of solid non-organic material in Pond 1 is approximately 136 tons. Based upon the station processes and drains that flow into Pond 1, and stormwater runoff, it is more likely than not that the approximately 136 tons of non-organic solids in Pond 1 are sediments from the station processes and not CCR.

The grain analysis KPRG conducted on the non-organic material also supports the conclusion that the sediment and silt at the base of the pond is not CCR. KPRG compared the grain size of the material taken from Pond 1 to the CCR that had been generated at Joliet 29 when it burned coal. The grain size analysis showed that the Pond 1 material was approximately 91% fine sand and fines and only 7.8% gravel and course to medium sand. In comparison, the grain size of the Joliet 29 CCR was approximately 60% gravel and course to medium sand. The small grain size of the material is also consistent with the observation that the material was floating at the base, as opposed to being so heavy that it falls to the bottom. The material's almost entire composition of fine sand and fines is consistent with Pond 1's non-CCR purpose and function, namely the collection of sediments from the sand filter, the station drains, stormwater and air dispersion.

The sampling and analysis of the Pond 1 material clearly establishes it is not a CCR surface impoundment. The material in Pond 1 is physically different than CCR, including a different smell and texture. The material is composed of fine sand and fines that float in a matrix that is primarily water, which is not characteristic of CCR. The station processes that discharge into the pond and contribute sediments do not generate CCR. This data shows that Pond 1 does not contain CCR.

b. <u>The Material in Pond 3 is Suspended Solids from Station Processes, the Wastewater Treatment Plant, Runoff and Air Dispersion</u>

MWG also conducted a similar analysis to Joliet 29 Pond 1 for Pond 3 at Joliet 29. Not surprisingly, the results of the Pond 3 analysis are substantially the same as those for Pond 1. As MWG has stated (see September 16, 2020 MWG response letter), Pond 3 was never used as a CCR surface impoundment. Instead, it was a finishing pond for Ponds 1 and 2 and also collected wastewater from the wastewater treatment plant.[3] Stormwater from the gravel road and soil surrounding three sides of the pond also flows

[2] KPRG used the 2 t/ac/yr calculation, which is used to offset potential soil erosion calculated for maintenance of landfill covers. The lost soil is replaced by natural processes at a rate that is the same or greater than the tolerance level (2/t/ac/yr).
[3] Pond 2 is currently empty.

into Pond 3. Pond 3 collects so little material that when it was emptied for the first time in 2013, it had been operating since the late 1970's, a period of more than three decades.

Before water enters Pond 3, a coagulant chemical, called "alum", is added as a flocculant to remove smaller suspended solids. The alum neutralizes the negative charge of the non-settleable solids, such as clay, which allows the neutralized particles to stick together. As the particles stick together, they form larger particles, and this continues until large enough particles form that settle out from the water.

Similar to Pond 1, the surveyor could not use a physical rod to estimate the depth of the material at the base of Pond 3 because there was insufficient material. Instead, the surveyor used the electric depth finder and found that there was about 2.4 feet of suspended material at the base of the pond. KPRG also collected a sample of the material and observed that the material was similar to the material in Pond 1. It was black, sticky and pasty, with a silty/clayey feel, unlike the sandy consistency of CCR. The material also had a sewage smell. KPRG calculated the air dispersion that landed in Pond 3 since 2013, using the general applicable calculation of 2 tons/acre/year. KPRG's calculation shows that from 2013 to present, approximately 29.4 tons of material fell into the pond.

KPRG sent the sample from Pond 3 for a weight-to-volume relationship, grain size, and organic and non-organic matter analysis. The weight-to-volume relationship analysis showed that 92% of the material was water. Similar to Pond 1, because the material was primarily water, a physical rod could not be used to determine the depth. Like the material in Pond 1, the very low (8%) solids composition of the material allows it to float at the base of the pond. As KRPG explains in its report, the addition of alum and the flocculation particles explains the nature of the material in Pond 3, particularly that it floats and is primarily composed of water. In fact, KPRG characterizes the material as more like suspended solids contained in a wastewater treatment plant's basins. Because of the volume of water in the material and that the material is floating, it is likely that if MWG emptied Pond 3 of all the water, the 2.5 feet of floating material would decrease to about 1 inch in depth. The analysis of the material showed that of the 8% solid material, 28% was organic solids, which is similar to the organic concentration of the solids in Pond 1. In total, based on the volume of material calculated to be at the base of the pond (7,392 CY), only 5.7% (423 CY) is non-organic solids. Using the density of the material sampled from the base of the pond, the total tonnage of solid non-organic material in Pond 3 is estimated to be approximately 69 tons.

The grain analysis conducted on the Pond 3 material also supports the conclusion that the material at the base of the pond is not CCR but instead is from the wastewater treatment system, the other ponds, stormwater runoff, and fines from air dispersion. Like the Pond 1 analysis, KPRG compared the grain size of the material in Pond 3 to the CCR from Joliet 29. The grain size analysis described the Pond 3 material as black organic silty sand, compared with the Joliet 29 CCR's brown silty sand with gravel grain size characteristics. The Pond 3 material was approximately 73.4% fine sand and fines and only 26% coarse sand and gravel. By comparison, the Joliet 29 CCR was 60% gravel and coarse to medium sand. The small grain size of the material is also consistent with the observation that the material was so lightweight that it was floating, rather than settling, at the base of the pond. That the material is almost entirely composed of fine sand and fines is consistent with Pond 3's purpose and function of collecting sediments from the wastewater treatment plant, runoff from Ponds 1 and 2, stormwater and air dispersion.

In sum, because the material is physically very different from CCR, including having a different smell and texture, a composition of fine sand and fines that float in a matrix consisting primarily of water, and because other non-CCR processes, including the wastewater treatment plant, and stormwater discharge into the pond, the technical data demonstrates that the material in Pond 3 is not CCR.

c. The Material at the Base of the Powerton Service Water Basin is from Air Dispersion and Stormwater Runoff

KPRG also conducted an investigation to determine the presence of any material in the Service Water Basin at Powerton. The investigation found there was little to no material present. The very small amount of material in the basin is to be expected based on a comparison of the calculated volume of material at the base of the Service Water Basin to the expected volume of material that would fall into the Service Water Basin from air dispersion and stormwater flow. Those calculations show that the amount of material present in the basin is almost equal to the contributions of material expected from those two non-CCR sources. Therefore, the evidence shows that this basin is not a CCR surface impoundment because it does not contain CCR.

The Service Water Basin is in the northern area of the Station at the end of a gravel road that runs between the Ash Surge Basin and the Metal Cleaning Basin. A topographic map shows that the surface topography of the Powerton Station gradually slopes towards the north and the road slopes into the Service Water Basin, and all of that stormwater runoff flows into the Service Water Basin.

The bathymetric survey of the Service Water Basin showed that a measurable quantity of material was either marginally present or not present at all at the bottom of the basin. In fact, the average bottom elevation was only 0.2 feet, or about 2.4 inches of material. Based upon the size of the pond, KPRG calculated that the total volume of material in the pond was 52 CY. A sample of the material was taken at the base of the pond; however, the person collecting the sample did not note the consistency or smell. Based upon the guideline that 2 tons/acre/year falls onto the land, KPRG calculated that approximately 23.7 tons of material fell into the basin since it was emptied in 2013.

The weight-to-volume relationship analysis showed that the material in the Service Water Basin was 48% water and 52% solids. Of the 52% solids approximately 92% was non-organic matter. Accordingly, based upon the total volume of 52 CY, 24.8 CY is non-organic material, which is approximately 28.7 tons. Moreover, if MWG were to empty the pond, there would only be on average approximately 1 inch of material (52% of 2.4 inches).

The grain size comparison showed that material at the base of the Service Water Basin was not similar to CCR.[4] The material in the Service Water Basin was black/gray silty sand and 46% fine sand and fines. In comparison, the Joliet 9 CCR was classified as brown sand and was 80% gravel and course to medium sand.

Like the conclusions drawn from the investigation and analysis of the material in Ponds 1 and 3, the results of the investigation and analysis of the Service Water Basin support the conclusion that it is not a CCR surface impoundment. The 23.7 calculated tons of material from air dispersion, coupled with the sediments deposited from stormwater runoff, and the different classification and grain size fully explains the 28.7 tons of material found at the base of the pond and supports the conclusion that none of the material is CCR.

[4] KPRG used Joliet 9 CCR for the analysis. The Joliet 9 coal and burning process are identical, so the CCR would be similar.

III. The Waukegan Grassy Field and Ponds 1N and 1S at Will County Are Not CCR Surface Impoundments

At the October 14, 2020 meeting, MWG briefly discussed why the Grassy Field at the Waukegan Station and Ponds 1N and 1S at Will County are not CCR surface impoundments as defined in Section 3.143 of the Act. 415 ILCS 5/3.143. MWG asked Illinois EPA whether there was any additional information that help Illinois EPA to determine that these areas are not CCR surface impoundments. Illinois EPA indicated that it was not ready to discuss these three areas and so it did not know what information it may require. Since that meeting, in MWG's subsequent outreach on this issue, the Agency confirmed that the status of its review had not changed.

MWG maintains that the Grassy Field at Waukegan is not a CCR Surface Impoundment because it is not a depression or excavation, nor is it designed to hold CCR and liquids. No CCR or CCR slurry water is directed at the Grassy Field, and because it is not a depression, it cannot accumulate liquid. For similar reasons, Pond 1N and 1S are not CCR surface impoundments because they are not designed to hold an accumulation of CCR and liquid. In 2013, MWG redesigned the ponds and the redesign also did not allow them to hold an accumulation of liquid. MWG continues to maintain that before and since 2013, neither of the ponds have accumulated liquids.

IV. The Agency Should Delay Any Further Enforcement Until the Illinois CCR Rulemaking is Finalized

The Illinois Pollution Control Board ("Board") is currently considering new rules to regulate CCR surface impoundments, *In the Matter of: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments: Proposed New 35 Ill.Adm.Code 845*, PCB R20-19 ("Illinois CCR Rulemaking"). Depending on the Board's final decision, all of the areas in dispute may not be regulated CCR surface impoundments. Accordingly, the Agency should hold off on making any final decisions on further enforcement until the Board has issued its Final Order in the Illinois CCR Rulemaking.

During the rulemaking, the Board's Chief Environmental Scientist, Anand Rao, asked Dynegy Midwest Generation, LLC, *et al*. (collectively "Dynegy") to suggest language to clarify Part 845's applicability to *de minimis* units. PCB R20-19 9/29/20 Tr. 185:15-186:12. Per Mr. Rao's request, Dynegy proposed a new definition for *"De minimis* Unit" in its Post-Hearing Brief. Dynegy's definition stated that a *de minimis* unit is:

> "including but not limited to process water or cooling water ponds, that only received CCR incidentally and does not contain an amount of CCR and liquid presenting a reasonable probability of adverse effects on human health or the environment. De minimis surface impoundments are not CCR surface impoundments."

Dynegy's Post Hearing Comments, PCB R20-19, Oct. 30, 2020, p. 16. Dynegy further stated that exclusion of units containing *de minimis* quantities of CCR was consistent with the U.S.EPA Federal CCR Rule, because U.S.EPA stated clearly in the preamble that units containing *de minimis* quantities of CCR are unlikely to present significant risks. *Id.* p. 14. Alternatively, if the Board decided not to adopt the definition, Dynegy requested that the Board explain in its final order that Part 845 does not apply to units containing *de minimis* amounts of CCR. *Id.* p. 16. MWG supported Dynegy's proposed definition of a "*de minimis unit*." MWG's Second Post-Hearing Comments, PCB20-19, Oct. 30, 2020, p. 27. Illinois EPA objected to Dynegy's proposed definition claiming that the proposed definition excluding *de miminis* units from the definition of CCR surface impoundments was inconsistent with the U.S.EPA Federal CCR Rule, but also proposed an alternative. Illinois EPA Response to Final Post Hearing Comments, PCB R20-19, Nov. 6, 2020, pp. 5, 7.

Dynegy also proposed a modification to the definition of "inactive CCR surface impoundment" that could have a direct impact on this dispute. Illinois EPA's proposed definition of "inactive CCR surface impoundment" included any units that contain CCR, regardless of whether the unit contains liquid. PCB R20-19, Proposed 845.120. As Dynegy explained to the Board, the Illinois EPA's definition proposed definition improperly expanded the scope of Part 845 beyond the statutory mandate under Section 22.59 of the Act, 415 ILCS 5/22.59. Dynegy's Post-Hearing Comments, Oct. 30, 2020, p. 8. Because units that contain CCR but do not impound liquid do not pose the type of risks that need to be mitigated, Dynegy proposed that the Board modify the definition to only include units that contain "both CCR and liquid." *Id*. p. 9. Illinois EPA also opposed this modification. Illinois EPA Response to Final Post Hearing Comments, PCB R20-19, Nov. 6, 2020, p. 7.

MWG maintains that Ponds 1 and 3 at Joliet 29 and the Service Water Basin are not CCR surface impoundments because none contain any CCR. Similarly, MWG maintains that the Waukegan Grassy Area and Ponds 1N and 1S at Will County do not fall within the definition of "CCR surface impoundment" because none can accumulate liquid. If the Board were to adopt Dynegy's definition for "*de minimis* unit" or "inactive CCR surface impoundments, then there would be little doubt that all of the MWG units at issue are not regulated CCR surface impoundments. Because the Board may address and resolve some or all of these issues, and do so in a manner that would result in the clear exclusion of one or more of the ponds and areas at issue here, it would be reasonable and prudent for the Illinois EPA to refrain from any further enforcement activity on the subject violation notices until the Board issues its final decision.

V. Conclusion

We believe that this supplemental response is responsive to the Agency's requests for information regarding the process water ponds at Joliet 29 and Powerton. MWG also believes that it has provided Illinois EPA with all the relevant information regarding the Grassy Field at Waukegan and two areas at the Will County Station. However, should you have any additional questions or concerns, please do not hesitate to contact me.

Very truly yours,

Kristen L. Gale
Counsel for Midwest Generation, LLC

Enclosures

cc: Sharene Shealey, Midwest Generation, LLC (via email)
Gabbriel H. Neibergall (via email)

K P R G

ENVIRONMENTAL CONSULTATION & REMEDIATION

KPRG and Associates, Inc.

MEMORANDUM

FROM: Joshua D. Davenport, P.E., KPRG and Associates, Inc.

DATE: November 19, 2020

SUBJECT: Evaluation of Sediment Quantities in Joliet Generating Station's Pond 1 and Pond 3 and Powerton Generating Station's Service Water Basin

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Pond 1 and Pond 3 at the Joliet 29 Generating Station and the Service Water Basin at the Powerton Generating Station were evaluated the contents and approximate volume of the contents in the ponds.

SECTION 1-INTRODUCTION

Joliet 29 – Pond 1 and Pond 3

The Joliet 29 Generating Station previously burned coal to generate steam to produce electricity. The Joliet 29 station ceased burning coal on March 18, 2016 and began burning natural gas on May 31, 2016.

All of the coal combustion residual ("CCR") material in Pond 1 was cleaned out in the summer of 2015. The CCR material was removed all the way down to the warning layer of the pond, the liner was power-washed, and any damage to the liner was repaired. After it was cleaned out, Pond 1 did not receive any bottom ash sluice water. Rather, the pond only receives service water/low volume wastewater from the RO sand filter backwash, the west area basin, the former coal pile runoff pump discharge, and the plant drains, including the Station floor drains, and roof drains and area drains. (See Joliet 29 Flow Diagram, Ex. 1). None of these processes produce nor discharge coal ash. Pond 3 is a finishing pond for the process water from Ponds 1 and 2. (Ex. 1). Pond 3 also receives water from the wastewater treatment plant. *Id*. Finally, both ponds receive rainwater from the area surrounding the ponds.

All of the water flow processes and stormwater flow contain sand sized and smaller sized particles. The RO sand filter backwash contains the suspended solids removed by the stations water treatment system, which would be sand, silt, and some clay sized because the treatment system is filtering water removed from the ground by the station's water well so it can be used as process water. The RO sand filter backwash has been described as visually 'dirty' by the Station's personnel, which is expected because the backwash is intended to regenerate the sand filters by removing the solids that accumulate as part of the filtration process. The Station floor drains, roof drains, and area drains, are likely to contain small particles and silt from operations and runoff during storm events. Similarly, the runoff pumped from the coal pile area retention pond contains sand, silt and clay sized particles into Pond 1. These particles would come from the surrounding area through stormwater runoff that drains into the coal pile area retention pond. The areas on the north and east sides of Pond 1 and west, east, and north sides of Pond 3 are slightly elevated and there is a gravel road near the ponds and adjacent soil. Stormwater runoff from the gravel road and soil likely contains sand, silt, and clay sized particles that flow into both ponds. Moreover, the discharge from the wastewater treatment plant drains directly into Pond 3. Based upon sampling directly before discharge into Pond 3, the wastewater treatment plant is also a contributor of solids into Pond 3.

Powerton – Service Water Basin

The Powerton Generating Station burns coal to generate steam to produce electricity. The Service Water Basin (SW Basin) is the end of the wastewater treatment system. The Service Water Basin receives water from the ash surge basin, the ash bypass basin, and rainwater from the property. The CCR material produced by the Powerton coal burning process is the same as what was produced by the Joliet 9 coal burning process because both stations use the same coal and the same coal burning process. Therefore, the CCR material from Joliet 9 was used as the comparison material against the Service Water Basin material.

SECTION 2-EVALUATION PROCESS

The evaluation of each surface impoundment was performed based on the following steps.

The current elevation of the bottom of the surface impoundment was determined with a bathymetric survey. During the bathymetric surveys, samples were collected from the material in each surface impoundment.

The bathymetric surveys were performed by Ruettiger, Tonelli & Associates, Inc (RT&A). RT&A is an Illinois licensed surveying company. The Joliet 29 Pond 1 survey was performed on July 6, 2020, the Pond 3 survey was performed on August 17, 2020, and the SW Basin survey was performed on July 14, 2020. The surveys were performed by navigating each surface impoundment using a boat and electronic depth finder to determine the depth from the water to the bottom of the surface impoundment at the time of the survey. The water elevation in feet above mean sea level at the time of the survey was determined using the appropriate state plane horizontal and vertical data.

The bathymetric surveys were performed using an electronic depth finder instead of a physical survey rod. The physical survey rod was attempted to determine the depth from the water surface to the material in Pond 1, Pond 3, and the SW Basin. However, because the material in the pond lacked sufficient density to create a solid enough surface to place the survey rod and determine an accurate depth, the survey rod was not reliable.

The results of the bathymetric survey was compared to the known existing conditions of the surface impoundment to determine if material had accumulated to a measurable quantity above the known base of the surface impoundment. If a measurable quantity was present, the quantity was calculated.

Samples of the sediment were analyzed for grain size, weight-to-volume relationship of the sediment, and ASTM 2974. The analyses results were used to refine the quantity of the material identified in the surface impoundment.

SECTION 3- SURFACE IMPOUNDMENT EVALUATIONS

JOLIET POND 1

Calculation of the Volume of Material in Pond 1

The bathymetric survey of Pond 1 showed that the water surface elevation was at 532.0 feet above mean sea level (ft amsl) and showed an average depth of material present was 1.5 feet. Based upon the average depth and the contours of Pond 1 from the survey conducted when the pond was relined, the total quantity of material at the base was calculated to be approximately 5,124 cubic yards (CY). The comparison was performed using AutoCAD Civil 3D 2020 to calculate the volume that is occupied between the surface of the survey and the surface of the existing pond conditions.

The material sampled in Pond 1 was black in color, was sticky/pasty in consistency and had a silty/clayey feeling when rubbed between your fingers. Some of the material identified was white in color and was 1/8-inch to ¼-inch in size. It should be noted that the warning layer in Pond 1 consists of limestone screenings. Limestone screenings are typically white in color and consist of material sizes that range from 1/8-inch to ¼-inch in size. The material also had a sewer odor.

The weight-to-volume relationship analysis showed that the material in Pond 1 was fourteen percent (14%) solids and eighty-six percent (86%) water. (See weight-to-volume ratio analysis attached as Exhibit 2). The ASTM 2974 test showed that about thirty-two percent (32%) of the solids in Pond 1 are organic matter and about 68% of the solids are non-organic matter. (See ASTM 2974 results, attached as Exhibit 3). Accordingly, of the volume of the 5,124 CY material in Pond 1, 717 CY is solids (14% of 5,124 CY), and only 489 CY is non-organic matter (68% of 717 CY). The weight-to-volume relationship analysis showed that the density of the material in the pond (not including the water) is 20.6 lbs/cubic feet. (Ex. 2). Based upon that, the tonnage of solid non-organic material in Pond 1 is approximately 136 tons. (*See* Table 1 attached as Ex. 4).

With open topped ponds, about two tons per acre per year (2 tons/acre/year) of matter will accumulate in the bottom of a pond from air dispersion.[1] Pond 1 was last cleaned out during

[1] The 2 t/ac/yr is actually the calculation used to offset potential soil erosion calculated for maintenance of landfill covers. The lost soil is replaced by natural processes at a rate that is the same or greater than the tolerance level (2/t/ac/yr).

the summer of 2015 and the bathymetric survey that determined the volume of material in the pond was performed on July 6, 2020. The amount of time that has passed between these two dates is 1,771.25 days or 4.9 years. The surface area of the pond is approximately 133,372 square feet (3.06 acres) based on the surface area at the top of the pond slope. Based on the above amount of time and above surface area the matter that has accumulated in Pond 1 from air is about 29.7 tons. (Ex. 4).

Grain Size Comparison of the Material In Pond 1

A comparison of the grain size analysis of the material in Pond 1 compared to the grain size of the Joliet 29 CCR shows that the sediments are not the same. (Ex. 4). The analysis shows that the Joliet 29 CCR is described as brown to dark brown silty sand with gravel, whereas the Pond 1 material was black sandy silt. Moreover, the grain size analysis of the material in Pond 1 shows that the material consists primarily of fine sand and silt/clay fines. In comparison, the Joliet 29 CCR is primarily fine gravel and sand. In particular, the Joliet 29 CCR material contains 19% gravel and about 40% course and medium sand, totaling approximately 60% gravel and course to medium sand. In comparison, the material in Pond 1 was approximately 24.9% fine sand and 67.2% fines. In other words, the material in Pond 1 is 92.2% fine sand and fines, and only 7.8% is gravel, and course to medium sand. The difference in the description of the material and in the coarse and medium sand sized particles between the Joliet 29 CCR and the Pond 1 material indicates that the composition of the material in Pond 1 is not CCR material.

JOLIET POND 3

Calculation of the Volume of Material in Pond 3

The bathymetric survey of Pond 3 showed that the water surface elevation was at 526.1 feet above mean sea level (ft amsl), the average depth of material present was 2.4 feet, and the total quantity of material was calculated to be approximately 7,392 cubic yards (CY). The comparison was performed using AutoCAD Civil 3D 2020 to calculate the volume that is occupied between the surface of the survey and the surface of the existing pond conditions.

The material sampled in Pond 3 was black in color, was sticky/pasty in consistency and had a silty/clayey feeling when rubbed between your fingers. The material stuck to the gloves of the sampler during the sampling process. The material also had a sewer odor.

The weight-to-volume relationship analysis showed that the material in Pond 3 was eight percent (8%) solids and ninety-two percent (92%) water. (Ex. 2) Based on the ASTM 2974 test results, about twenty-eight (28%) percent of the solids in Pond 3 are organic matter and about seventy-two percent (72%) of the solids are non-organic matter. (Ex. 3). Accordingly, of the volume of the 7,392 CY material in Pond 3, 591 CY is solids (8% of 7,392 CY), and 423 CY is non-organic matter (72% of 591 CY). The weight-to-volume relationship analysis showed that the density of the material in the pond (not including the water) is 12.1 lbs/cubic feet. (Ex. 2). Based upon that, the tonnage of solid non-organic material in Pond 3 is approximately 69 tons. (Ex. 4).

Using the same calculation to estimate the air dispersion of solids into Pond 3, approximately 29.4 tons of material accumulated in Pond 3 from air dispersion. (Ex. 4).

Grain Size Comparison of the Material in Pond 3

Similar to Pond 1, a comparison of the grain size analysis of the material in Pond 3 compared to the grain size of the Joliet 29 CCR shows that the sediments are not the same. (Ex. 4). The material in Pond 3 was identified as a black organic silty sand, dissimilar from the Joliet 29 CCR, which is brown silty sand with gravel. In addition, the grain size analysis shows that the material in Pond 3 is unlike the Joliet 29 CCR. The material in Pond 3 consists of approximately 73.4% fine sand and fines, and only 26.6% is of coarser material. The Joliet 29 CCR is the opposite.

Prior to the inlet of Pond 3, a coagulant chemical, alum, is added as a flocculant to remove the suspended solids from the Pond 3 influent water. The alum neutralizes the negative charge of the non-settleable solids, such as clay, which allows the neutralized particles to stick together. As the particles stick together, they form larger particles, and this continues until large enough particles form that settle from the water. The addition of alum and the flocculation particles explains the presence and the nature of the material in Pond 3 and why it lacks the density to create a surface against which a survey rod could be placed on. Even with the alum, the density of the particles are not enough to settle completely to the bottom of Pond 3, but are heavy enough to settle and not be passed through the discharge structure. The weight-to-volume relationship of the material also explains this by the fact that the material was identified as only eight percent solids compared to 92% water. It should be noted that the characteristics of the material in Pond 3 are similar to that of suspended solids contained in a wastewater treatment plant.

The nature of the settling of the material in Pond 3 also indicates that the material is not CCR. The material in Pond 3 settles farther away from the inlet when compared to the CCR material in Pond 1 and Pond 2, which settles at the inlet of the pond, which is expected because of the medium sand to gravel particle size. When CCR material was placed in Pond 2 prior to it being cleaned out in 2019, the CCR depth at the inlet extended from the bottom of the pond to about 10 feet in height and lesser heights closer to the pond outlet. The depth of the material in Pond 3 is only 1 feet at the inlet and the depth of the material is about 3 feet on the east side of the pond.

SERVICE WATER BASIN

Calculation of the Volume of Material in the Service Water Basin

The bathymetric survey of the Service Water Basin ("SW Basin") showed that a measurable quantity of material was marginally present or not present. Reviewing the as-built drawings of the basin from when it was re-lined in 2013, the bottom elevation is ±441 ft amsl. The bottom elevations from the bathymetric survey average ±440.80 ft amsl. Based on comparing the bottom elevation from the as-built drawings and the bottom elevations from the bathymetric survey, minimal material is present or not present to a point, which causes minimal change in the bottom elevation determined during the survey. AutoCAD Civil 3D 2020 was also used to compare the as-built drawings with the survey performed by RT&A. The AutoCAD Civil 3D 2020 comparison was performed with the bottom elevations of the survey and the bottom elevations of the as-built drawings considered equal. This comparison determined a volume of about 52 CY.

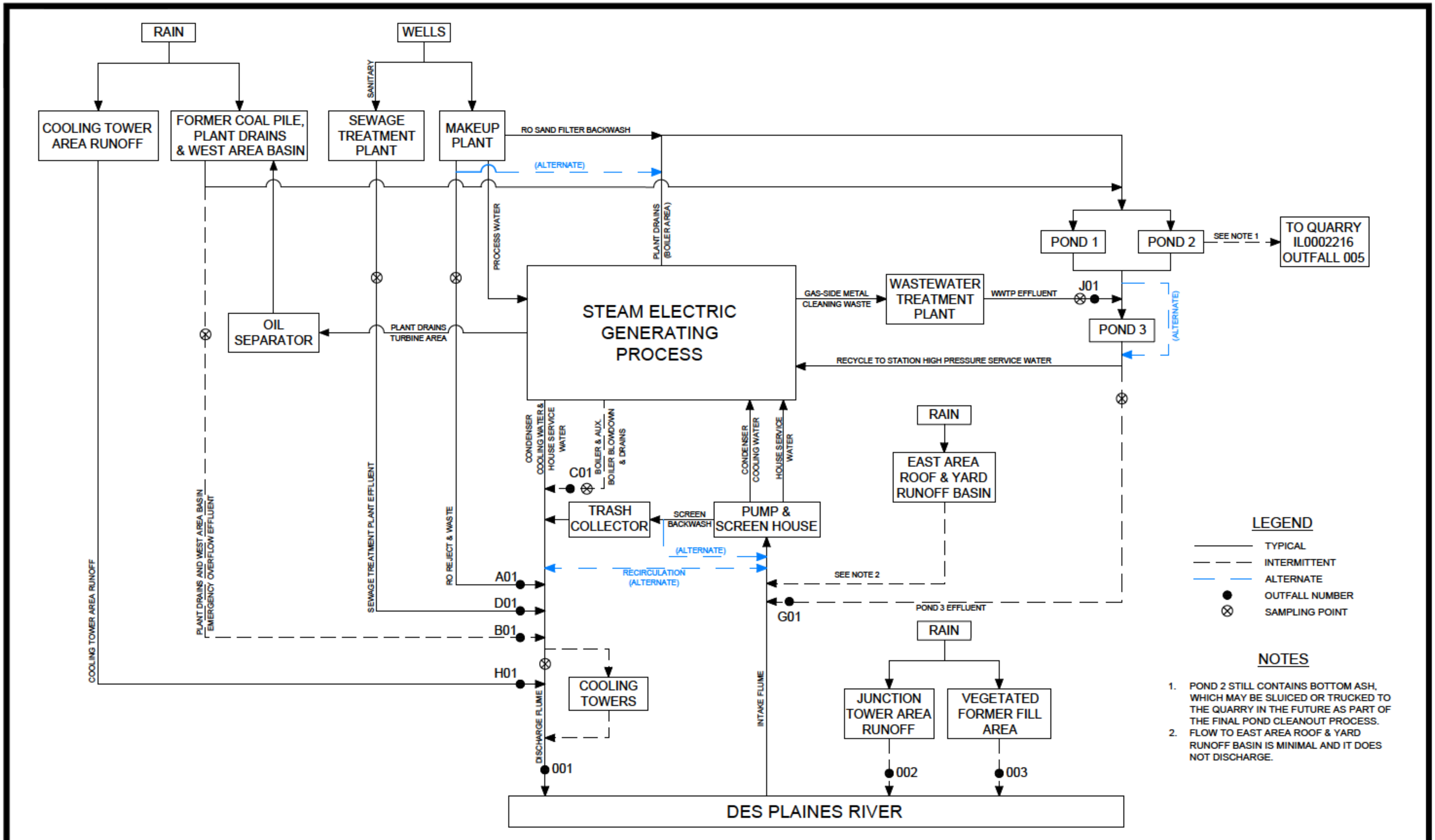
The weight-to-volume relationship analysis showed that the material in the SW Basin was 52% solids. (Ex. 5) Based on the ASTM 2974 test results, about 8.2% of the solids in the SW Basin are organic matter and about 91.8% are non-organic matter. (Ex. 3). Accordingly, of the volume of the 52 CY material, 27 CY is solids and 24.8 CY is non-organic matter. The weigh-to-volume relationship analysis showed that the density of the material in the pond (not including the water) is 85.8 lbs/cubic feet. (Ex. 2). Based upon that, the tonnage of solid non-organic material in SW Basin is approximately 28.7 tons. (*See* Table 3 attached as Ex. 4).

With open topped ponds, about two tons per acre per year (2 tons/acre/year) of matter will accumulate in the bottom of a pond from air dispersion.[2] The SW Basin was last cleaned out during the spring of 2013 and the bathymetric survey that determined the volume of material in the pond was performed on July 14, 2020. The amount of time that has passed between these two dates is 2,257.25 days or 6.2 years. The surface area of the pond is approximately 87,791 square feet (2.02 acres) based on the surface area at the top of the pond slope. Based on the above amount of time and above surface area the matter that has accumulated in SW Basin from air is about 24.9 tons. (Ex. 4, Table 3).

<u>Grain Size Comparison of the Material in SW Basin</u>

Enough material could be collected from the SW Basin to submit a sample for analysis. The sample was analyzed for the grain size, weight–to-volume relationship of the material, and ASTM 2974. The material in the SW Basin was identified as a black/gray silty sand whereas the Joliet 9 CCR was classified as brown sand. The grain size analysis shows that the material in the SW Basin consists of approximately 46.5% fine sand and fines. (Ex. 4, Table 3). By comparison, the grain size of the Joliet 9 CCR consists of approximately 16.9% fine sand and fines and the remainder consists of gravel and coarse to medium sand (approximately 83.1%).

[2] The 2 t/ac/yr is actually the calculation used to offset potential soil erosion calculated for maintenance of landfill covers. The lost soil is replaced by natural processes at a rate that is the same or greater than the tolerance level (2/t/ac/yr).



APTIM Environmental & Infrastructure, Inc.

APTIM

MIDWEST GENERATION, LLC
JOLIET 29 GENERATING STATION

GENERAL FLOW DIAGRAM WITH NPDES OUTFALLS
NPDES PERMIT NO. IL0064254

DRAWN BY: ORC	APPROVED BY: SZF	PROJ. NO.: 631237225	DATE: APRIL 2019

WEIGHT VOLUME RELATIONSHIPS OF SOIL

PROJECT NAME:	Pond 3 Sediments	**PROJECT NO:**	20543
SAMPLE LOCATION:	Pond 1 Sample 1	**DATE:**	10/23/20
SOIL CLASSIFICATION:	Black Sandy SILT	**CLIENT:**	KPRG Wisconsin

V=1.0 cf	Vv=0.86 cf	Va=0.00 cf	***AIR***	Wa=0 lb	Wt=74.4 lb
		Vw=0.86 cf	***WATER***	Ww=53.8 lb	
		Vs=0.14 cf	***SOLIDS***	Ws=20.6 lb	

ENTER LABORATORY MOISTURE CONTENT, %- -	Mc=	261.0	
ENTER SAMPLE WEIGHT, grams- - - - - - - -	W=	118.58	
ENTER SAMPLE DIAMETER, inches- - - - - - -	Ds=		
ENTER SAMPLE LENGTH, inches- - - - - - - -	Ls=		
ENTER ESTIMATED/KNOWN SPECIFIC GRAVITY,Gs	Gs=	2.443	
SAMPLE VOLUME, cubic inches- - - - - - - - -	V=	6.07	((Ds/
WET DENSITY, #/cu ft- - - - - - - - - - - -	Wt=	74.4	
WEIGHT OF SOLIDS, pounds- - - - - - - - - - -	Ws=	20.6	
WEIGHT OF WATER, pounds- - - - - - - - - - -	Ww=	53.8	
VOLUME OF SOLIDS, cubic feet- - - - - - - - -	Vs=	0.14	
VOLUME OF WATER, cubic feet- - - - - - - - -	Vw=	0.86	
VOLUME OF AIR, cubic feet- - - - - - - - - - -	Va=	0.00	
VOLUME OF VOIDS, cubic feet- - - - - - - - -	Vv=	0.86	
POROSITY, n- - - - - - - - - - - - - -	**n=**	**0.86**	
VOID RATIO, e- - - - - - - - - - - - -	**e=**	**6.40**	
DEGREE OF SATURATION, Sr- - - - - - -	**Sr=**	**100%**	
LOSS ON IGNITION - - - - - - - -	**FOC=**	**15.60%**	

WEIGHT VOLUME RELATIONSHIPS OF SOIL

PROJECT NAME:	Pond 3 Sediments	**PROJECT NO:**	20543
SAMPLE LOCATION:	Pond 3 Sample 1	**DATE:**	8/19/20
SOIL CLASSIFICATION:	Black organic Silty SAND	**CLIENT:**	KPRG Wisconsin

Total volume	Void volume	Phase volume	Phase	Phase weight	Total weight
V=1.0 cf	Vv=0.92 cf	Va=0.00 cf	***AIR***	Wa=0 lb	Wt=69.8 lb
		Vw=0.92 cf	***WATER***	Ww=57.7 lb	
		Vs=0.08 cf	***SOLIDS***	Ws=12.1 lb	

ENTER LABORATORY MOISTURE CONTENT, %- -	Mc=	475.0
ENTER SAMPLE WEIGHT, grams- - - - - - - -	W=	111.34
ENTER SAMPLE DIAMETER, inches- - - - - - -	Ds=	
ENTER SAMPLE LENGTH, inches- - - - - - - -	Ls=	
ENTER ESTIMATED/KNOWN SPECIFIC GRAVITY,Gs	Gs=	2.418
SAMPLE VOLUME, cubic inches- - - - - - - - -	V=	6.07 ((Ds/
WET DENSITY, #/cu ft- - - - - - - - - - - -	Wt=	69.8
WEIGHT OF SOLIDS, pounds- - - - - - - - - - -	Ws=	12.1
WEIGHT OF WATER, pounds- - - - - - - - - - -	Ww=	57.7
VOLUME OF SOLIDS, cubic feet- - - - - - - - -	Vs=	0.08
VOLUME OF WATER, cubic feet- - - - - - - - -	Vw=	0.92
VOLUME OF AIR, cubic feet- - - - - - - - - - -	Va=	0.00
VOLUME OF VOIDS, cubic feet- - - - - - - - -	Vv=	0.92
POROSITY, n- - - - - - - - - - - - - -	**n=**	**0.92**
VOID RATIO, e- - - - - - - - - - - - -	**e=**	**11.43**
DEGREE OF SATURATION, Sr- - - - - - -	**Sr=**	**101%**
LOSS ON IGNITION - - - - - - - -	**FOC=**	**28.46%**
pH - - - - - - - - - -	**pH=**	

WEIGHT VOLUME RELATIONSHIPS OF SOIL

PROJECT NAME:	Powerton Station	**PROJECT NO:**	20588
SAMPLE LOCATION:	Service Water Basin Sludge	**DATE:**	9/24/20
SOIL CLASSIFICATION:	Black / grey Silty SAND	**CLIENT:**	KPRG Wisconsin

Total volume	Voids	Volumes	Phase	Weights	Total weight
V=1.0 cf	Vv=0.48 cf	Va=0.00 cf	*AIR*	Wa=0 lb	Wt=115.7 lb
		Vw=0.48 cf	*WATER*	Ww=29.9 lb	
		Vs=0.52 cf	*SOLIDS*	Ws=85.8 lb	

ENTER LABORATORY MOISTURE CONTENT, %- -	Mc=	34.9	
ENTER SAMPLE WEIGHT, grams- - - - - - - -	W=	184.55	
ENTER SAMPLE DIAMETER, inches- - - - - - -	Ds=		
ENTER SAMPLE LENGTH, inches- - - - - - - -	Ls=		
ENTER ESTIMATED/KNOWN SPECIFIC GRAVITY,Gs	Gs=	2.625	
SAMPLE VOLUME, cubic inches- - - - - - - - -	V=	6.07	((Ds/
WET DENSITY, #/cu ft- - - - - - - - - - - -	Wt=	115.7	
WEIGHT OF SOLIDS, pounds- - - - - - - - - - -	Ws=	85.8	
WEIGHT OF WATER, pounds- - - - - - - - - - -	Ww=	29.9	
VOLUME OF SOLIDS, cubic feet- - - - - - - - -	Vs=	0.52	
VOLUME OF WATER, cubic feet- - - - - - - - -	Vw=	0.48	
VOLUME OF AIR, cubic feet- - - - - - - - - - -	Va=	0.00	
VOLUME OF VOIDS, cubic feet- - - - - - - - -	Vv=	0.48	
POROSITY, n- - - - - - - - - - - - - - -	**n=**	**0.48**	
VOID RATIO, e- - - - - - - - - - - - - -	**e=**	**0.91**	
DEGREE OF SATURATION, Sr- - - - - - -	**Sr=**	**101%**	
LOSS ON IGNITION - - - - - - - -	FOC=	8.24%	

MIDLAND STANDARD ENGINEERING TESTING, INC.
410 NOLEN DRIVE, SOUTH ELGIN, IL 60177 P(847) 844-1895 F(847) 844-3875

Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
ASTM 2974

Project #: 20543
Project Name: Pond 3- Sediments
Sample Description: Black Sediment

Date Received: 8/19/2020
Date Tested: 8/21/2020
Tested by: JDS

METHOD D, 750°C

METHOD C, 440°C

	SAMPLE ID	Pond 3	Pond 1	
	SPECIMEN #	Sediments	Middle Water	
	TEST DATE:	8/21/2020	8/21/2020	
	TEST TEMP:	440°C	440°C	
1. wt of crucible, no cover	1	53.79	49.42	
2. wt. of crucible & unburnt sample, no	2	68.69	56.20	
3. wt. of crucible & burned sample, no c	3	64.45	54.04	
4. wt. of dry sample at start	B	14.9	6.78	
5. net wt. of ash	C	10.66	4.62	
6. ash content, %	D	71.54	68.22	
7. organic matter, %	OM,%	28.46	31.78	

SPF013

Ex. 3

MIDLAND STANDARD ENGINEERING TESTING, INC.
410 NOLEN DRIVE, SOUTH ELGIN, ILLINOIS 60177 P (847) 844-1895 F(847) 844-3875

Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
ASTM 2974

Project #: 20588
Project Name: Powerton Station
Sample Description: Black/grey Silty SAND
Location: Pekin, Illinois

Date Received: 9//2020
Date Tested: 9//2020
Tested by: JDS

METHOD D, 750°C

METHOD C, 440°C

	SAMPLE ID	SWB		
	SPECIMEN #			
	TEST DATE:			
	TEST TEMP:	440°C	440°C	440°C
1. wt of crucible, no cover	1	151.92		
2. wt. of crucible & unburnt sample, no cover	2	187.25		
3. wt. of crucible & burned sample, no cover	3	184.34		
4. wt. of dry sample at start	B	35.33		
5. net wt. of ash	C	32.42		
6. ash content, %	D	91.76337		
7. organic matter, %	OM,%	8.24		

EXHIBIT 4: Table 1: Comparison of Distribution of Particle Sizes for Joliet 29 CCR and Joliet's Pond 1 Material

Sample	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
Joliet 29 CCR	0.0	0.0	19.0	14.2	25.6	26.8	12.6	1.8
Pond 1 Material	0.0	0.0	1.5	2.7	3.6	24.9	61.3	6.0

Pond 1 surface at top of slope = 133,372 Sq.ft = 3.0618 acres

Material Quantities Based on 2 tons/ac/yr

Pond 1 surface at top of slope = 133,372 Sq.ft

Last clean out occurred between May and September 2015

Time between Clean out and survey is from 9/1/2015 and 7/6/2020 for a total of 1,771.75 days

Pond 1 top slope surface

$$3.0618 \text{ acres} \times \frac{2 \text{ tons}}{\text{ac/yr}} \times \frac{1771.75 \text{ days}}{365 \text{ days/yr}} = 29.7 \text{ tons}$$

EXHIBIT 4: Table 2: Comparison of Distribution of Particle Sizes for Joliet 29 CCR and Joliet's Pond 3 Material

Sample	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
Joliet 29 CCR	0.0	0.0	19.0	14.2	25.6	26.8	12.6	1.8
Pond 3 Material	0.0	0.0	1.8	10.1	14.7	33.0	23.8	16.6

Pond 3 surface at top of slope = 105578 Sq.ft = 2.42 acres

Material Quantities Based on 2 tons/ac/yr

Pond 3 surface at top of slope = 105578 Sq.ft

Last clean out occurred between May and September 2013

Time between Clean out and survey is from 9/1/2013 and 8/17/2020 for a total of 2,213.25 days

Pond 3 top slope surface

2.4237 acres	2 tons	2213.25 days	=	29.4 tons
	ac/yr	365 days/yr		

EXHIBIT 4: Table 3: Comparison of Distribution of Particle Sizes for Joliet 9 CCR and Powerton's Service Water Bas

Sample	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
Joliet 9 CCR	0.0	0.0	1.6	11.4	70.1	13.6	3.3	
SW Basin Material	0.0	0.0	2.0	8.0	43.5	23.8	18.7	4.0

SW Basin surface at top of slope = 87791.14 Sq.ft = 2.0154 acres

Material Quantities Based on 2 tons/ac/yr

Surface of SW Basin survey = 0 Sq.ft

SW Basin surface at top of slope = 87791.14 Sq.ft

Last clean out occurred between March and June 2013

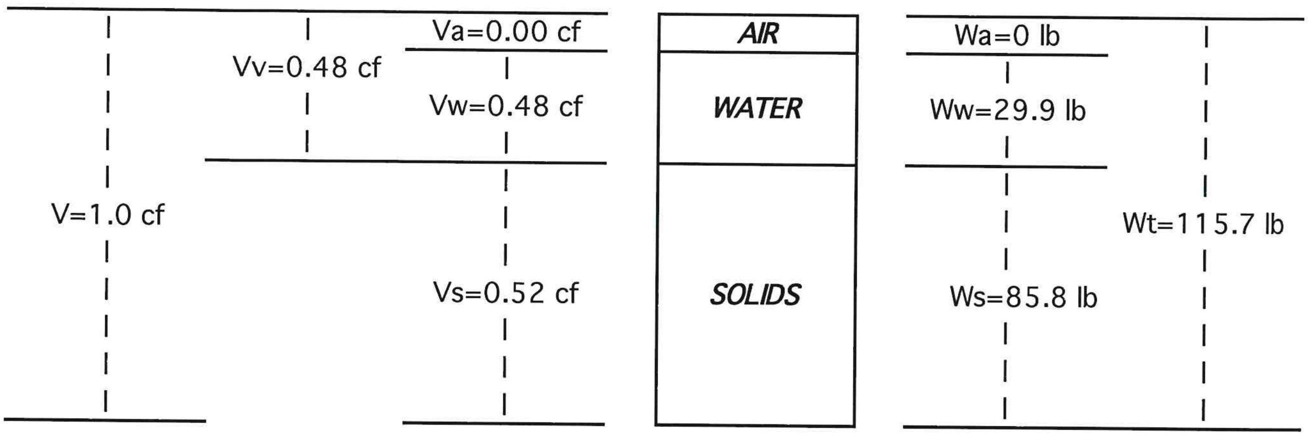
Time between Clean out and survey is from 6/15/2013 and 7/14/2020 for a total of 2,257.25 days

SW Basin top slope surface

2.0154 acres	2 tons	2257.25 days	=	24.9 tons
	ac/yr	365 days/yr		

WEIGHT VOLUME RELATIONSHIPS OF SOIL

PROJECT NAME:	Powerton Station	**PROJECT NO:**	20588
SAMPLE LOCATION:	Service Water Basin Sludge	**DATE:**	9/24/20
SOIL CLASSIFICATION:	Black / grey Silty SAND	**CLIENT:**	KPRG Wisconsin



ENTER LABORATORY MOISTURE CONTENT, %- -	Mc=	34.9	
ENTER SAMPLE WEIGHT, grams- - - - - - - -	W=	184.55	
ENTER SAMPLE DIAMETER, inches- - - - - - -	Ds=		
ENTER SAMPLE LENGTH, inches- - - - - - - -	Ls=		
ENTER ESTIMATED/KNOWN SPECIFIC GRAVITY,Gs	Gs=	2.625	
SAMPLE VOLUME, cubic inches- - - - - - - - -	V=	6.07	((Ds/
WET DENSITY, #/cu ft- - - - - - - - - - - -	Wt=	115.7	
WEIGHT OF SOLIDS, pounds- - - - - - - - - - -	Ws=	85.8	
WEIGHT OF WATER, pounds- - - - - - - - - - -	Ww=	29.9	
VOLUME OF SOLIDS, cubic feet- - - - - - - - -	Vs=	0.52	
VOLUME OF WATER, cubic feet- - - - - - - - -	Vw=	0.48	
VOLUME OF AIR, cubic feet- - - - - - - - - - -	Va=	0.00	
VOLUME OF VOIDS, cubic feet- - - - - - - - -	Vv=	0.48	
POROSITY, n- - - - - - - - - - - - - -	**n=**	**0.48**	
VOID RATIO, e- - - - - - - - - - - - - -	**e=**	**0.91**	
DEGREE OF SATURATION, Sr- - - - - - -	**Sr=**	**101%**	
LOSS ON IGNITION - - - - - - - - -	FOC=	8.24%	

Ex. 5

Exhibit

H

MEMORANDUM

FROM: Joshua D. Davenport, P.E., KPRG and Associates, Inc.

DATE: February 26, 2021

SUBJECT: Sampling Location Discussion as part of Evaluation of Sediment Quantities in Joliet Generating Station's Pond 1 and Pond 3 and Powerton Generating Station's Service Water Basin

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This memo provides a discussion of the sample locations for Pond 1 and Pond 3 at the Joliet 29 Generating Station and the Service Water Basin at the Powerton Generating Station. This memo is a follow up to the discussion with IEPA that occurred on February 17, 2021.

IEPA had questions regarding the total number of samples collected in each pond and what was the rationale for sample locations. The following provides this discussion with IEPA's initial question provided in italics.

Joliet 29 Generating Station

1) *Discussion must be provided about how sample locations were selected and the methodology of collecting the sample*

Samples in both Ponds 1 and 3 were collected using a clamshell sampler. Minimal material was able to be collected because mostly water was obtained using the clamshell. Not much material was collected during each drop of the clamshell. The ponds both had water in them during the sampling. Pond 1 had approximately 15-16 feet of water and Pond 3 had approximately 8-9 feet of water.

<u>Sample Collection Method</u>

The samples were collected from a boat using a clamshell sampler. The clamshell was lowered over the side of a boat using a rope with the clamshell held open by a spring. The spring on the clamshell releases once it hits the sediment and the rope is used to pull the sampler to the surface. The collection portion of the clamshell is approximately 2 quarts in volume. When collecting the sample, it requires multiple attempts to collect an adequate amount of sediment for laboratory analysis because the majority of the material collected during each drop is water, with some sediment.

The sample collection from a boat is different from collecting samples at a stationary point when collecting soil and/or groundwater samples. Each attempt to collect sediment using the clamshell will collect sediment from a different part of the pond because the boat naturally drifts on the water. Therefore, the sample locations depicted on the attached figures are more appropriately a sampling area as opposed to a singular point.

Pond 1

Knowing that Pond 1 was cleaned out in 2015, the center of the pond was chosen for Sample 1 to provide a broad representation of the type of material that may be in the pond and sediment would likely be present there if the pond contained any. Many collection attempts were performed in the center area of the pond to collect a sufficient quantity of sediment needed for the laboratory analyses. The sampling attempts were combined and submitted to the laboratory as one sample. The second Pond 1 sample area was collected near the edge of the pond, adjacent to the access road because it was safely accessible without a boat. As performed during the first sampling, several attempts were made to collect the quantity of sediment needed for the material analyses. The sampling attempts were combined and submitted to the laboratory as one sample. The second sampling was performed later to collect additional data. The additional data was warranted to provide further clarification on the type of sediment present in Pond 1 based on the results of the bathymetric survey and the grain size analysis. Because a boat was not available, the second sampling was collected by lowering the clamshell sampler from the side of the pond, releasing the spring, hauling the sampler back up, and collecting the sediment in a jar. Because the samplings were performed at different times, they were submitted to the laboratory at two different times.

The attached Figure 1 shows the sampling areas where the sediment was collected and the bathymetric survey surface in comparison to the existing pond surface/liner. The contours of the pond are based on the as-built drawings and the contours of the bathymetric survey are based on that survey. The attached Figure 2 shows the survey surface in comparison to the existing pond surface/liner. The bathymetric survey contours show approximately 1-2 feet of material is present, which, as noted in our previous submittal, consists of 14% percent sediment and 86% water.

Pond 3

Sediment within Pond 3 was collected from three different sampling areas and combined into one sample that was submitted for laboratory analysis. The three sampling areas were located near the center of the pond, near the pond inlet, and from the side slope of the access road. The inlet sampling area was chosen because if CCR material was likely to be present in the pond, it would be at the inlet because of the CCR's particle size (approximately sand sized) and its tendency to settle from the water first, prior to smaller silt and clay sized particles. The inlet had a minimal quantity of material and most of what was collected was the stone warning layer and not sediment. The center of the pond was chosen because it was more likely to find sediment present at this area and was likely to contain a broad representation of the types and sizes of material in the pond. The third area where sediment was collected was from the side slope of the access road. This area was chosen because the water level in the pond was low enough that this material was exposed and was collected by hand and placed in a plastic bag.

The inlet and center samplings were performed from a boat with the clamshell sampler using the method as was discussed above. The sample next to the access road was collected by hand.

The attached Figure 1 shows the locations where the sediment was collected. Also shown on Figure 1 is the contours of the pond based on the as-built drawings and the contours of the bathymetric survey. The attached Figure 2 shows the bathymetric survey surface in comparison to the existing pond surface/liner. The contours show that approximately 2-3 feet of material is present, which as noted in our previous submittal, consists of 8% percent sediment and 92% water.

Powerton's Service Water Basin

1) *Provide how sample location was selected and obtained*

The sample collected from the Service Water Basin was not collected by KPRG, but was collected by a process engineer that works at the Powerton Generating Station. KPRG spoke with the process engineer and the following is from our conversation.

The water level was low enough that the sample material was collected by hand. The plant personnel walked down the south side of the liner, collected the material with a plastic scoop, and put it in a container. The sample was collected from the south side of the basin. The south side was not chosen for any particular reason, it happened to be the side that was chosen by the plant personnel. The plant engineer noted the following observation, "the sample material was sticky and was stuck to side of basin and did not fall off with a lower water level." It was noted that the basin still contained water and the bottom was not visible. The sediment did not have appear to have a noticeable odor. The plant personnel containerized the sediment sample and shipped it to the same geotechnical testing firm that performed the Pond 1 and Pond 3 samples analyzes. KPRG provided the plant personnel with the name of the testing firm, its address, and the tests that should be performed on the sample.

The attached Figure 3 shows the approximate location where the sediment was collected. Also shown on Figure 3 is the contours of the pond based on the as-built drawings and the contours of the bathymetric survey. The attached Figure 4 shows the bathymetric survey surface in comparison to the existing pond surface/liner. The contours show the bottom of the pond based on the as-built drawings is approximately the same elevation determined by the bathymetric survey.

The comparison of the contours on Figure 4 is based on the as-built survey performed in 2013 prior to the geomembrane liner installation and the 2020 bathymetric survey. The extent of the bathymetric survey on Figure 4 goes beyond the extent of the basin as-built contours. This discrepancy is likely due to changes that occurred following installation of the liner in 2013.

In addition, the profile drawing also has an exaggerated vertical scale to make the vertical differences easier to see because the vertical distances on cross sections are typically much smaller than horizontal distances and they can be hard to see.

Despite the difference, the intent of the drawing still shows that minimal to no sediment is present along the bottom of the basin.

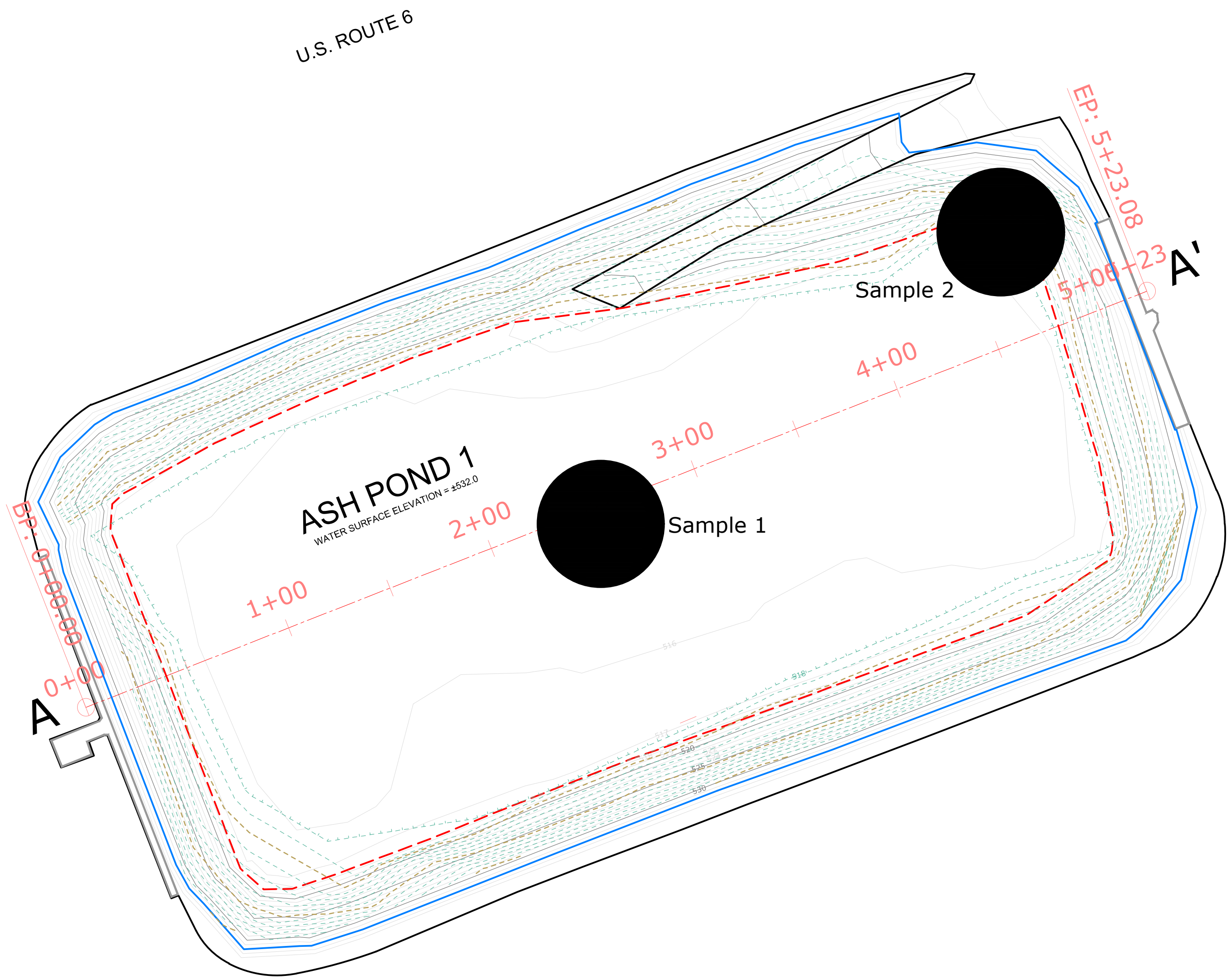
<u>ASTM Method</u>

ASTM D2974 was chosen to determine the organic versus non-organic content of the sediment based on a discussion with the geotechnical company performing the other sediment analyses. The following is a brief summary of the test method described in the ASTM standard.

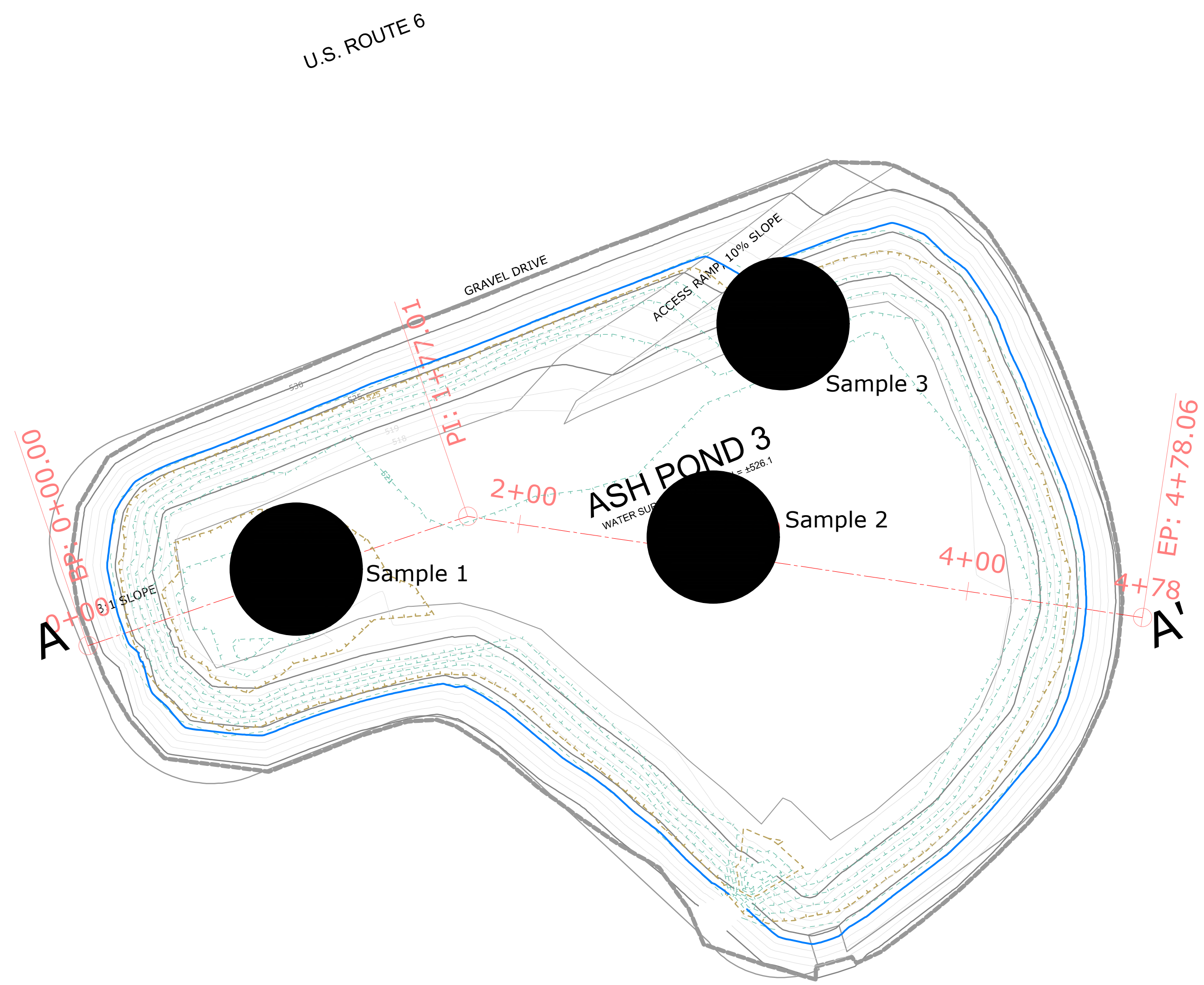
1. The soil sample is dried in an oven at approximately 110°C for a minimum of 16 hours. The sample is allowed to cool and the mass is determined.
2. The sample is then heated in a furnace where the temperature is gradually raised to approximately 440°C. The sample is then heated at this temperature for at least 1 hour. The sample is heated until the entire contents are considered "completely ashed." The sample is considered completely ashed once there is no change in mass.
3. The sample is allowed to cool and the mass is determined.

The test method does not determine if any particular soil sample contains coal ash. The use of the term ash is in the generic after something has been cooked in a furnace and is completely burned. This test method is used for classification purposes when wanting to determine the organic content of soil.

POND 1



POND 3



N

LEGEND

5-FOOT INCREMENT CONTOUR FROM AS-BUILT DRAWINGS
1-FOOT INCREMENT CONTOUR FROM AS-BUILT DRAWINGS
5-FOOT INCREMENT CONTOUR FROM SURVEY
1-FOOT INCREMENT CONTOUR FROM SURVEY

SAMPLE 1 ● POND SAMPLE LOCATION

0 80'
APPROXIMATE SCALE

ENVIRONMENTAL CONSULTATION & REMEDIATION
KPRG
KPRG and Associates, inc.
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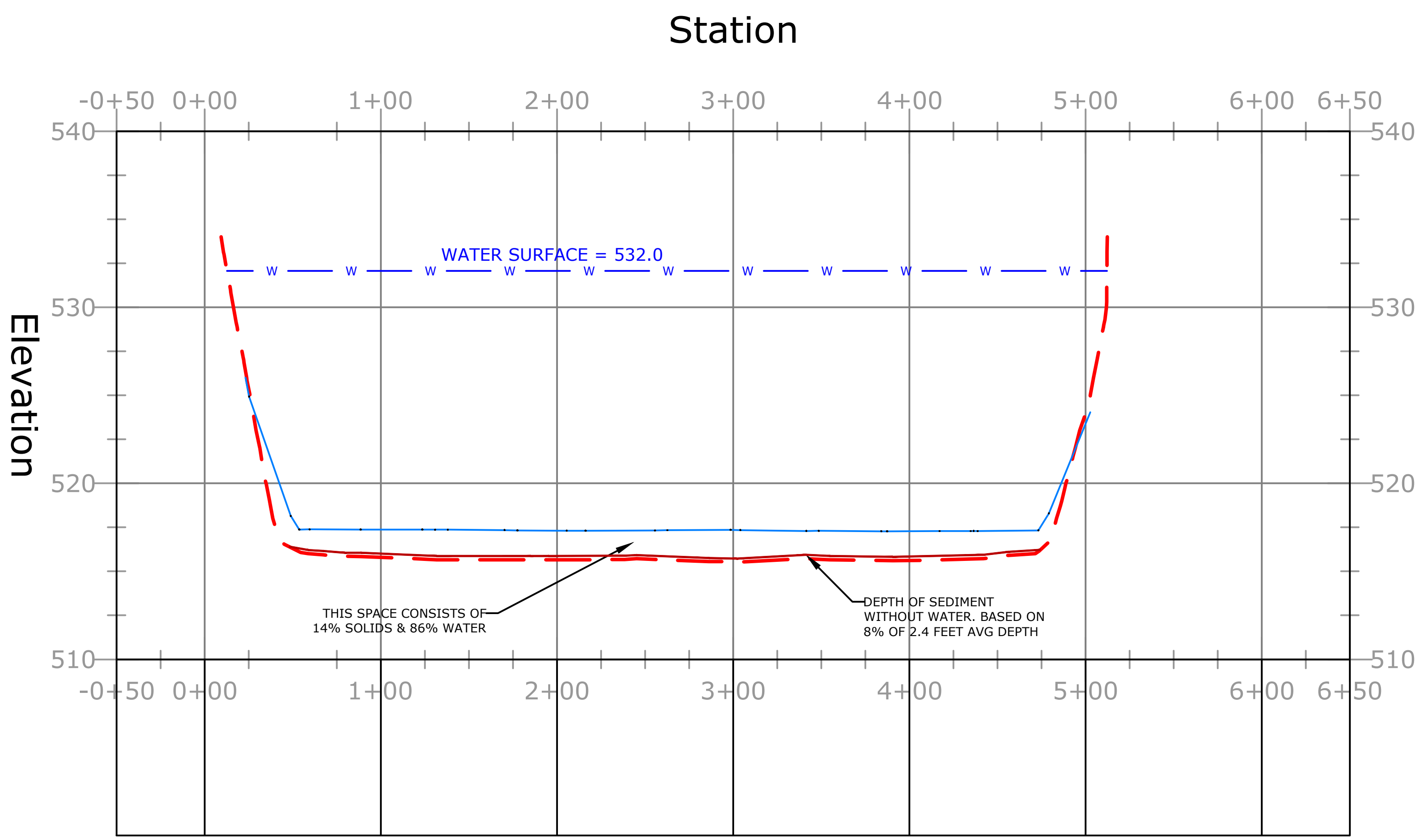
414 Plaza Drive, Suite 106 Westmont, Illinois 60559 Telephone 630-325-1300 Facsimile 630-325-1593

POND 1 AND POND 3 SEDIMENT SAMPLE LOCATIONS

JOLIET 29 GENERATING STATION
JOLIET, ILLINOIS

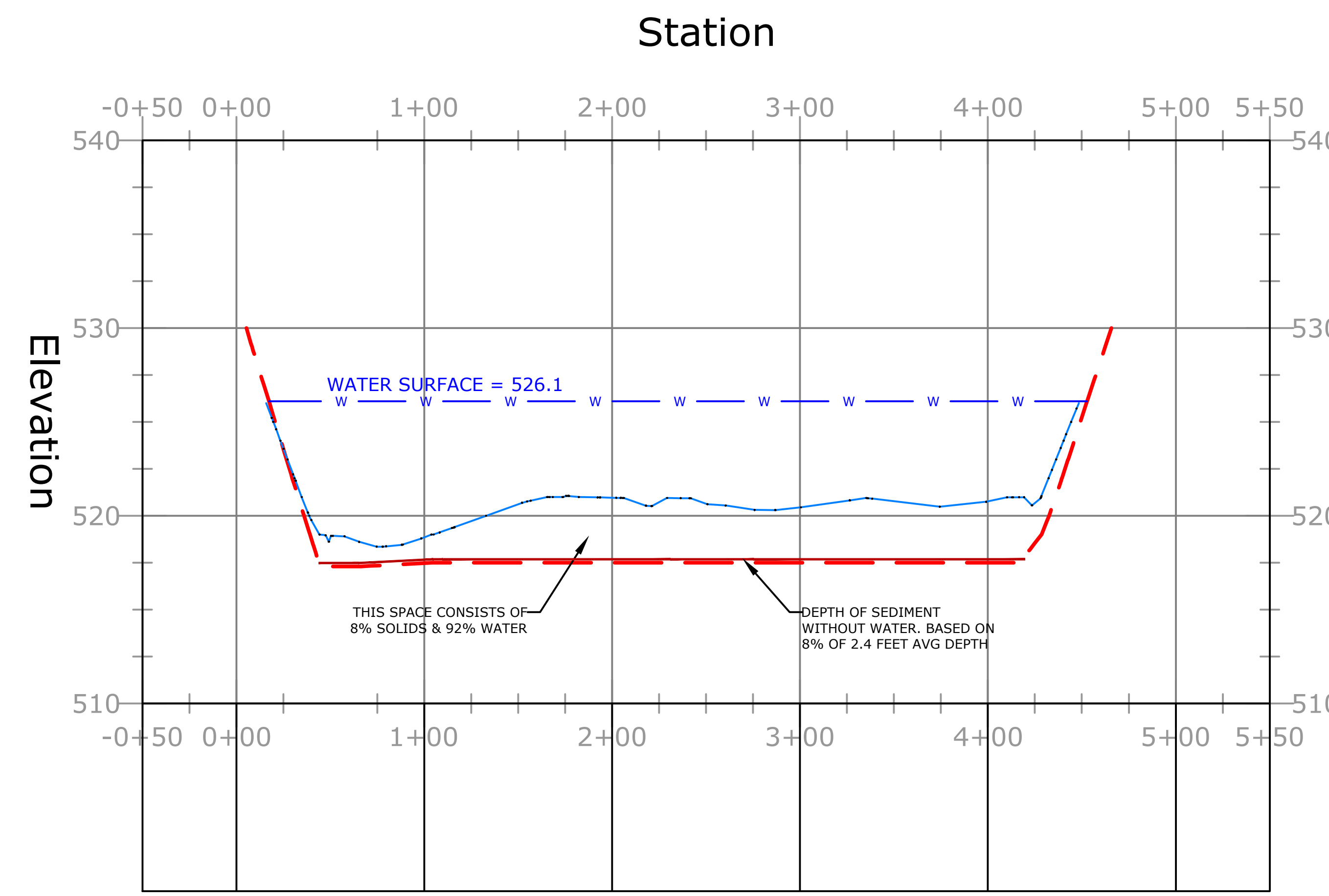
Scale: 1" = 80'	Date: February 26, 2021
KPRG Project No. 15020	FIGURE 1

Pond 1 A-A' PROFILE



POND 1

Pond 3 A-A' PROFILE



POND 3

LEGEND

EXISTING POND LINER SURFACE

SURVEYED SEDIMENT/WATER SURFACE

ESTIMATED SEDIMENT SURFACE W/OUT WATER

10'

100' 0'

APPROXIMATE SCALE

ENVIRONMENTAL CONSULTATION & REMEDIATION

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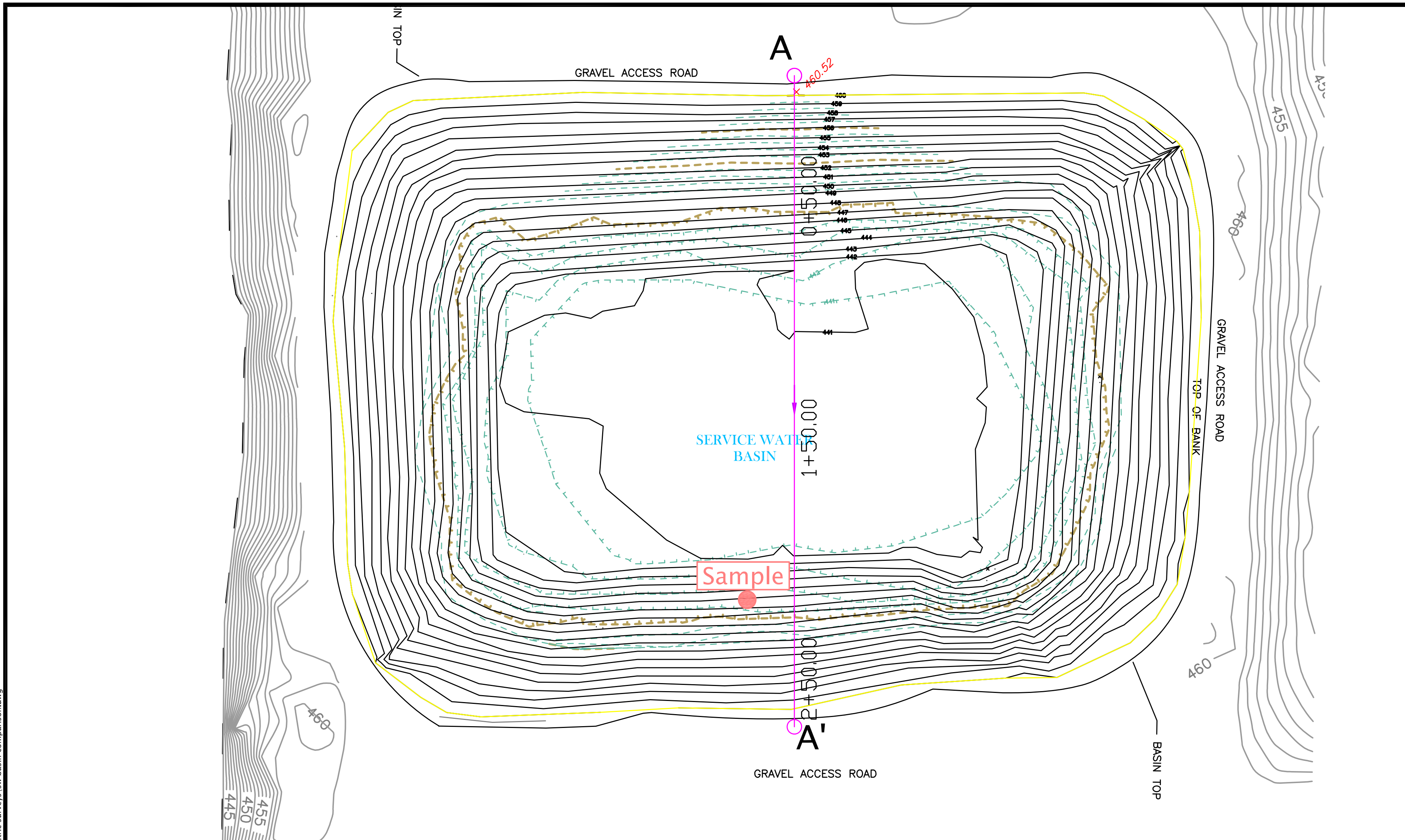
POND 1 AND POND 3 PROFILES

JOLIET 29 GENERATING STATION
JOLIET, ILLINOIS

Scale: 1" = 100'	Date: February 25, 2021
KPRG Project No. 15020	FIGURE 2



LEGEND

- Sample — POND SAMPLE LOCATION
- 1-FOOT INCREMENT CONTOUR FROM AS-BUILT DRAWINGS
- 5-FOOT INCREMENT CONTOUR FROM SURVEY
- 1-FOOT INCREMENT CONTOUR FROM SURVEY

0 60'
APPROXIMATE SCALE

E N V I R O N M E N T A L C O N S U L T A T I O N & R E M E D I A T I O N

KPRG

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SERVICE WATER BASIN SAMPLE LOCATION

POWERTON GENERATING STATION
PEKIN, ILLINOIS

Scale: 1" = 60'
Date: February 26, 2021

KPRG Project No. 15020
FIGURE 3

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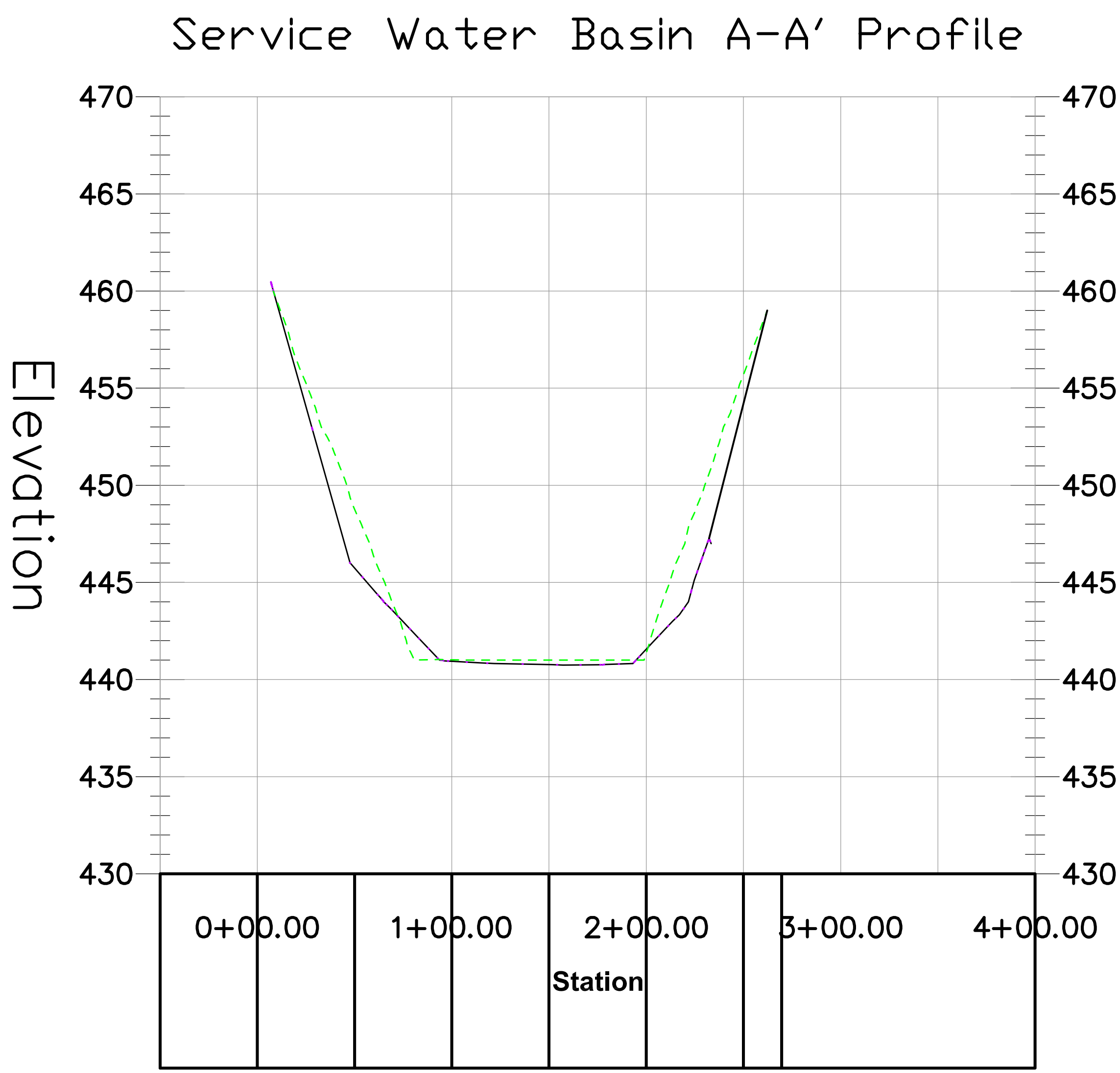
Electronic Filing: Received, Clerk's Office 09/22/2021



LEGEND

EXISTING POND SURFACE

SURVEY SURFACE

0 100'

APPROXIMATE SCALE

E N V I R O N M E N T A L C O N S U L T A T I O N & R E M E D I A T I O N

K P R G

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SERVICE WATER BASIN PROFILE A–A'

POWERTON GENERATING STATION
PEKIN, ILLINOIS

Scale: 1" = 60'

Date: February 25, 2021

KPRG Project No. 15020

FIGURE 4

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Exhibit

I

KPRG

ENVIRONMENTAL CONSULTATION & REMEDIATION

KPRG and Associates, Inc.

MEMORANDUM

FROM: Joshua D. Davenport, P.E., KPRG and Associates, Inc.

TO: Kristen Laughridge Gale, Nijman Franzetti, LLP

DATE: May 12, 2021

SUBJECT: Additional Sampling Location Discussion for Powerton Generating Station's Service Water Basin

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This memo provides a discussion of the additional sample locations for the Service Water Basin at the Powerton Generating Station. This memo is a follow up to the previous memo dated February 26, 2021 that was submitted to IEPA as part of evaluating whether the Service Water Basin is a CCR surface impoundment.

IEPA has expressed a desire to have additional sediment samples collected from within the Service Water Basin beyond the one sample that was previously collected. This memo discusses the proposed locations and rational for the additional samples to be collected from the Service Water Basin.

One sample was previously collected from the Service Water Basin. This sample was collected from the south side of the basin. The proposed sample locations discussed in this memo would be in addition to the previous sample collected. The proposed samples would be tested for the same geotechnical parameters as the previous sample.

This memo proposes collecting two additional samples in the Service Water Basin and attempting a third sample. The proposed sample locations are shown on Figure 1. This would put the total number of samples collected from the basin at three (3) or four (4) depending on the third sample attempt. Three samples were collected from Pond 3 and two samples were collected from Pond 1 at the Joliet 29 generating station.

<u>Sample Location Rationale</u>

The proposed sample locations are based on the Service Water Basin bathymetric survey performed on July 14, 2020. As stated in the previous submittal discussing the potential quantity of the CCR material in the basin, the contours of the as-built survey performed in 2013 prior to the geomembrane liner installation was compared to the 2020 bathymetric survey. This comparison identified that minimal to no sediment is present along the bottom of the basin. This comparison did identify that a minimal amount of sediment is present at the area where the edge of the basin bottom meets the north side slope. The previously provided Figure 4, which is included with this memo, shows this. The first proposed sample will occur at this location along the north side of the basin and is identified as Sample1 on Figure 1.

The second proposed sample is at the inlet of the basin and is identified as Sample2 on Figure 1. In general, the CCR material generated at the Powerton Station is sand sized particles. Sand sized particles would be expected to fall out of suspension from the sluice water relatively quickly because it has a higher settling velocity than organic material and less dense particle sizes such as silt and clay. Therefore, if CCR material were present within the sluice water entering the Service Water Basin, it would accumulate near the inlet of the basin.

The center of the basin is chosen for a sampling attempt to provide a broad representation of the type of material that may be in the basin and sediment would likely be present there if the basin contained any.

Water in Basin Sample Collection Method

If the basin has water in it, the samples will be collected from a boat using a clamshell sampler. The clamshell will be lowered over the side of a boat using a rope with the clamshell held open by a spring. The spring on the clamshell releases once it hits the sediment and the rope is used to pull the sampler to the surface. The collection portion of the clamshell is approximately 2 quarts in volume. When collecting the sample, it requires multiple attempts to collect an adequate amount of sediment for laboratory analysis because the majority of the material collected during each drop is water, with some sediment.

The sample collection from a boat is different from collecting samples at a stationary point when collecting soil and/or groundwater samples. Each attempt to collect sediment using the clamshell will collect sediment from a different part of the pond because the boat naturally drifts on the water. Therefore, the sample locations depicted on the attached figures are more appropriately a sampling area as opposed to a singular point.

When the basin has water in it, it is typically 10 to 20 feet deep compared to the discharge elevations of the basin and the basin bottom elevation. Therefore, the samples will be collected with water that will be approximately 10 to 20 feet deep. Requiring a boat and the clamshell to collect the samples makes sample collection more difficult than sampling if the pond does not contain water.

Minimal Water in Basin Sample Collection Method

This section discusses the proposed sampling method if the water level is lower in the basin than the water level in the above section. If the operation of the generating station is able to allow the water level in the basin to be lowered so the material in the basin is exposed, then the material will be sampled differently than discussed above. A lower water level will allow the service basin to be safely entered by personnel for sampling. If sediment is exposed, then it will be collected by hand and placed into containers that will be submitted for analysis.

If the water level is lower than discussed above, but not low enough to expose the sediment, then the basin will be entered and the sediment collected using a Dipper or similar device. A Dipper is a cup on the end of a long steel rod that is able to be lowered into water and scoop up any sediment encountered.

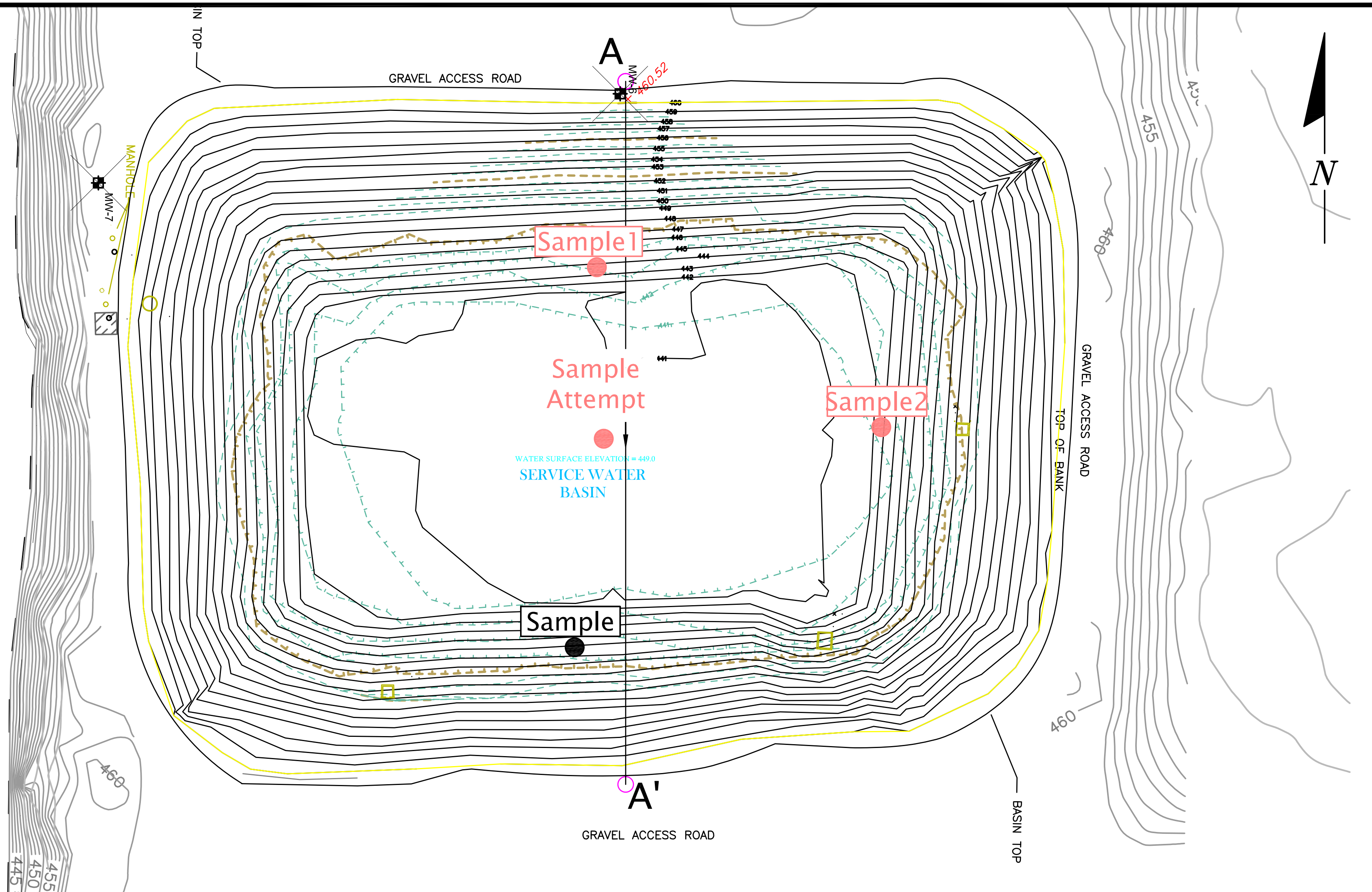
Laboratory Analysis

The collected samples will be submitted separately to the same geotechnical laboratory where the previous samples were submitted. The samples will be analyzed for grain size, weight-to-volume relationship of the sediment, and ASTM 2974. Once the results are received, they will be reviewed and evaluated using the same techniques as the previous basin sample was.

As part of reviewing and evaluating the sediment results, a sample of the Powerton CCR material will be analyzed for grain size analysis, which will be used in the evaluation techniques.

Margin of Error

As mentioned in previous submittals, the bathymetric surveys were performed using a depth finder and a GPS survey unit. The depth finder used is a Lowrance Elite-3x that determines the depth of the water using sonar and provides the depth to one-tenth of a foot accuracy as shown on page 3 in the depth finder's operation manual, which is attached. The GPS survey unit is a Trimble R8 with a vertical accuracy of ±20mm based on Kinematic surveying (RTK), which is what was used during the bathymetric surveys. The accuracy is listed on page 2 of the Trimble GPS unit data sheet, which is attached.



LEGEND

- Sample (black dot) — PROPOSED POND SAMPLE LOCATION
- Sample (red dot) — PREVIOUS POND SAMPLE LOCATION
- 1-FOOT INCREMENT CONTOUR FROM AS-BUILT DRAWINGS
- 5-FOOT INCREMENT CONTOUR FROM SURVEY
- 1-FOOT INCREMENT CONTOUR FROM SURVEY

0 — 60'
APPROXIMATE SCALE

ENVIRONMENTAL CONSULTATION & REMEDIATION

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PROPOSED ADDITIONAL SERVICE WATER BASIN SAMPLE LOCATIONS

POWERTON GENERATING STATION
PEKIN, ILLINOIS

Scale: 1" = 60'	Date: April 16, 2021
KPRG Project No. 15020	FIGURE 1

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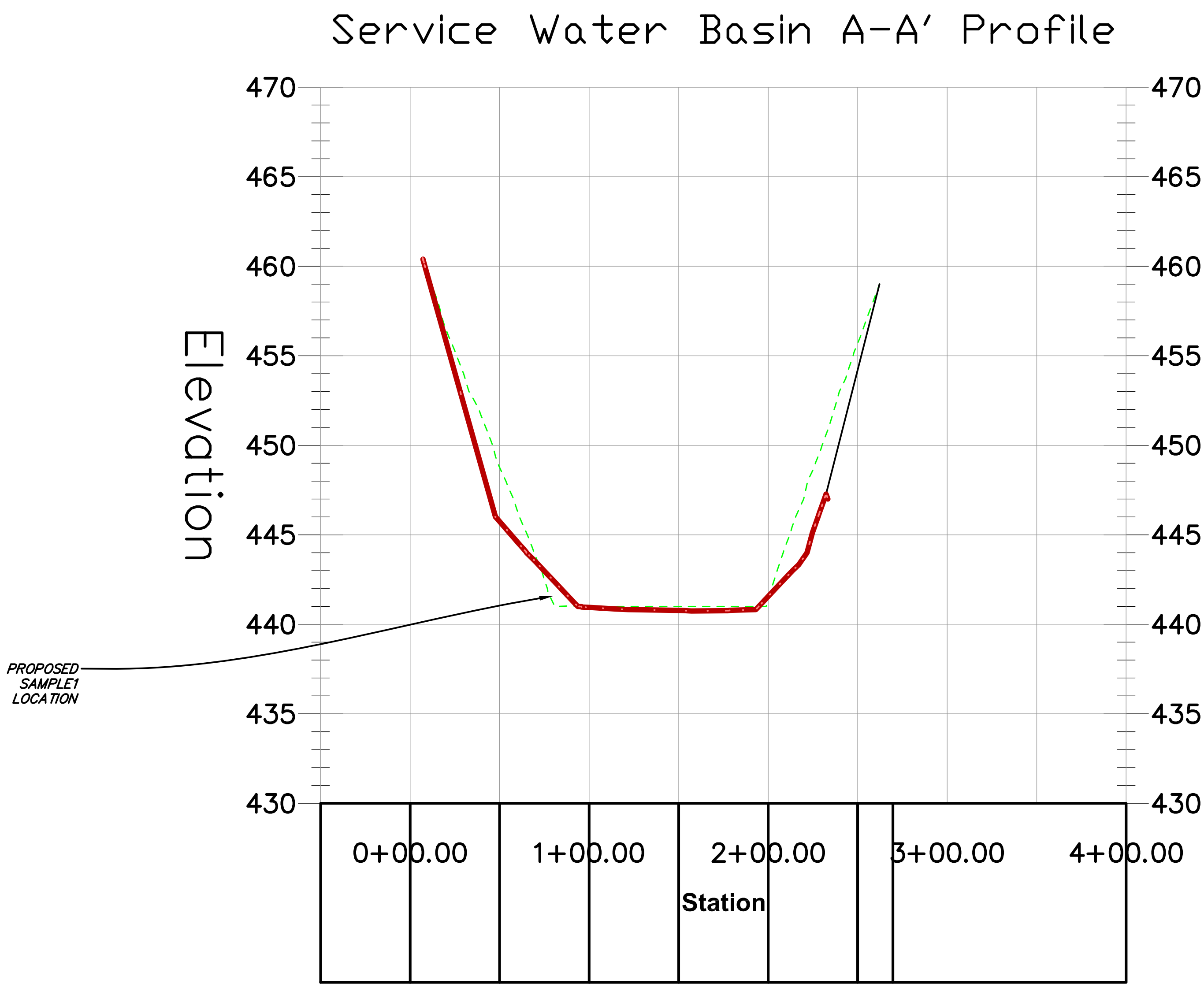

LEGEND

- - - - EXISTING POND SURFACE
—— SURVEY SURFACE

0 100'
APPROXIMATE SCALE

E N V I R O N M E N T A L C O N S U L T A T I O N & R E M E D I A T I O N

K P R G

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PROPOSED SAMPLE1 SHOWN ON SERVICE WATER BASIN PROFILE A-A'	
POWERTON GENERATING STATION PEKIN, ILLINOIS	
Scale: 1" = 60'	Date: April 16, 2021
KPRG Project No. 15020	FIGURE 4

DATASHEET

TRIMBLE R8 GNSS SYSTEM

KEY FEATURES

Trimble R-Track technology for GNSS support

Advanced receiver technology and proven system design combined

Wireless technologies for flexibility and cable-free convenience

Base and rover communication options to suit any application

An important component of the Connected Survey Site model

The Trimble® R8 GNSS System is a multi-channel, multi-frequency GNSS (Global Navigation Satellite System) receiver, antenna, and data-link radio combined in one compact unit. The Trimble R8 combines advanced receiver technology and a proven system design to provide maximum accuracy and productivity.

TRIMBLE R-TRACK TECHNOLOGY FOR COMPREHENSIVE GNSS SUPPORT

Powered by an enhanced RTK engine, Trimble R-Track technology supports both the modernized GPS L2C and L5 signals and GLONASS L1/L2 signals. The GNSS signals are capable of providing surveying professionals with real field benefits.

With the world's GNSS's in constant development, surveying businesses small and large can be confident that investment in a Trimble GNSS system is protected[1]. Trimble, already proven in GPS technology, will continue to lead the industry in GNSS support.

PROVEN SYSTEM DESIGN

From the powerful Trimble field software to the receiver itself, the Trimble R8 GNSS system's overall design has been tried, tested, and proven. As a rover it is rugged, lightweight and cable free for unsurpassed ergonomics in the field. As a base it is flexible and also cable free: use the Trimble R8 as a base or rover according to each job's needs.

The Trimble R8 GNSS system's flexible communication options include:

- An internal 450 MHz radio option for use as a cable-free base station
- An internal GSM/GPRS option for Internet connectivity and use as a rover in a Trimble VRS™ network

Simply choose the Trimble R8 model that best suits your needs.

THE ORIGINAL INTEGRATED SURVEYING SOLUTION AND BEYOND

The Trimble R8 GNSS system is designed to support Trimble's original Integrated Surveying™ solution. Combine your GPS and optical data in one job file in powerful Trimble field software such as Trimble Survey Controller™. Transfer the job file seamlessly to your Trimble office software for processing.

The Trimble R8 can also be used as part of a Trimble® IS Rover. Simply add a prism to the rover pole and partner the Trimble R8 with a robotic optical system such as the Trimble® S6 Total Station. This integrated solution enables you to maximize the best of both surveying techniques for even greater efficiency in the field.

Whenever you're facing a new surveying challenge, your partnership with Trimble places the right tools and techniques, including GNSS technology, at your fingertips. Each Trimble system seamlessly integrates via shared workflows and technologies, making your everyday job site a place where the whole is greater than the sum of its parts: Welcome to the Connected Survey Site.

1. In addition, Trimble research and development divisions are already working closely with Galileo satellite system teams to ensure delivery of the benefits of this new GNSS in advance of the system being operational.

Trimble

PERFORMANCE SPECIFICATIONS

Measurements

- Trimble R-Track technology
- Advanced Trimble Maxwell™ Custom Survey GNSS Chip
- High precision multiple correlator for GNSS pseudorange measurements
- Unfiltered, unsmoothed pseudorange measurements data for low noise, low multipath error, low time domain correlation and high dynamic response
- Very low noise GNSS carrier phase measurements with <1 mm precision in a 1 Hz bandwidth
- Signal-to-Noise ratios reported in dB-Hz
- Proven Trimble low elevation tracking technology
- 72 Channels:
  - GPS L1 C/A Code, L2C, L1/L2/L5 Full Cycle Carrier
  - GLONASS L1 C/A Code, L1 P Code, L2 P Code, L1/L2 Full Cycle Carrier
  - SBAS WAAS/EGNOS support[1]

Code differential GPS positioning[2]

Horizontal	±0.25 m + 1 ppm RMS
Vertical	±0.50 m + 1 ppm RMS
WAAS differential positioning accuracy[3]	typically <5 m 3DRMS

Static and FastStatic GPS surveying[2]

Horizontal	±5 mm + 0.5 ppm RMS
Vertical	±5 mm + 1 ppm RMS

Kinematic surveying[2]

Horizontal	±10 mm + 1 ppm RMS
Vertical	±20 mm + 1 ppm RMS
Initialization time	typically <10 seconds
Initialization reliability[4]	typically >99.9%

HARDWARE

Physical

Dimensions (W×H)	19 cm × 11.2 cm (7.5 in x 4.4 in), including connectors
Weight	1.35 kg (2.97 lb) with internal battery, internal radio, standard UHF antenna. 3.71 kg (8.18 lb) entire RTK rover including batteries, range pole, controller and bracket
Temperature[5]	
Operating	–40 °C to +65 °C (–40 °F to +149 °F)
Storage	–40 °C to +75 °C (–40 °F to +167 °F)
Humidity	100%, condensing
Waterproof	IPX7 for submersion to depth of 1 m (3.28 ft)
Shock and vibration	Tested and meets the following environmental standards:
Shock	Non-operating: Designed to survive a 2 m (6.6 ft) pole drop onto concrete. Operating: to 40 G, 10 msec, sawtooth
Vibration	MIL-STD-810F, FIG.514.5C-1

Electrical

- Power 11 to 28 V DC external power input with over-voltage protection on Port 1 (7-pin Lemo)
- Rechargeable, removable 7.4 V, 2.4 Ah Lithium-Ion battery in internal battery compartment. Power consumption is <3.1 W, in RTK mode with internal radio. Operating times on internal battery:
  - 450 MHz receive only option 5.3 hours, varies with temperature
  - 450 MHz receive/transmit option 3.5 hours, varies with temperature and wireless data rate
  - GSM/GPRS 3.8 hours, varies with temperature
- Certification Class B Part 15, 22, 24 FCC certification, 850/1900 MHz. Class 10 GSM/GPRS module. CE Mark approval, and C-tick approval

Communications and Data Storage

- 3-wire serial (7-pin Lemo) on Port 1. Full RS-232 serial on Port 2 (Dsub 9 pin)
- Fully Integrated, fully sealed internal 450 MHz receiver/transmitter option:
  - Transmit power: 0.5 W
  - Range[6] : 3–5 km typical / 10 km optimal
- Fully integrated, fully sealed internal GSM/GPRS option[7]
- Fully integrated, fully sealed 2.4 GHz communications port (Bluetooth®)[7]
- External cellphone support for GSM/GPRS/CDPD modems for RTK and VRS operations
- Data storage on 11 MB internal memory: 302 hours of raw observables based on recording data from 6 satellites at 15 second intervals
- 1 Hz, 2 Hz, 5 Hz, and 10 Hz positioning
- CMRII, CMR+, RTCM 2.1, RTCM 2.3, RTCM 3.0 Input and Output
- 16 NMEA outputs. GSOF and RT17 outputs. Supports BINEX and smoothed carrier

1 The availability of the L5 signal is dependent on the US Government.
2 Accuracy and reliability may be subject to anomalies such as multipath, obstructions, satellite geometry, and atmospheric conditions. Always follow recommended survey practices.
3 Depends on WAAS/EGNOS system performance.
4 May be affected by atmospheric conditions, signal multipath, and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.
5 Receiver will operate normally to –40 °C, Bluetooth module and internal batteries are rated to –20 °C.
6 Varies with terrain and operating conditions.
7 Bluetooth and GSM type approvals are country specific. Contact your local Trimble authorized distribution partner for more information.

Specifications subject to change without notice.

TRIMBLE AUTHORIZED DISTRIBUTION PARTNER

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+65-6348-2232 Fax

www.trimble.com

Exhibit J

EXHIBIT 1: Table 3: Comparison of Distribution of Particle Sizes for Powerton CCR and Powerton's Service Water Basin Material

Sample	% +3"	% Gravel		% Sand			% Fines		Soil Classification
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay	
Powerton CCR	0.0	0.0	0.0	13.2	70.1	10.8	3.3	2.6	Black SAND w/ silt
SW Basin South	0.0	0.0	2.0	8.0	43.5	23.8	18.7	4.0	Black/gray silty SAND
SW Basin East	0.0	0.0	0.7	5.1	45.1	23.3	20.2	5.6	Black Silty SAND
SW Basin North	0.0	0.0	1.5	1.7	6.9	7.7	73.4	8.8	Black SILT with sand
SW Basin Center	0.0	0.0	0.0	0.3	1.6	3.1	84.2	10.8	Black SILT
SW Basin West	0.0	0.0	0.0	0.7	3.2	4.3	81.0	10.8	Black SILT
SW Basin S. Outlet	0.0	0.0	0.5	0.4	3.7	6.2	78.8	10.4	Black SILT

SW Basin surface at top of slope = 87,791.1 Sq.ft = 2.0154 acres

Material Quantities Based on 2 tons/ac/yr

SW Basin surface at top of slope = 87791.14 Sq.ft

Last clean out occurred between March and June 2013

Time between Clean out and survey is from 6/15/2013 and 7/14/2020 for a total of 2,257.25 days

SW Basin top slope surface

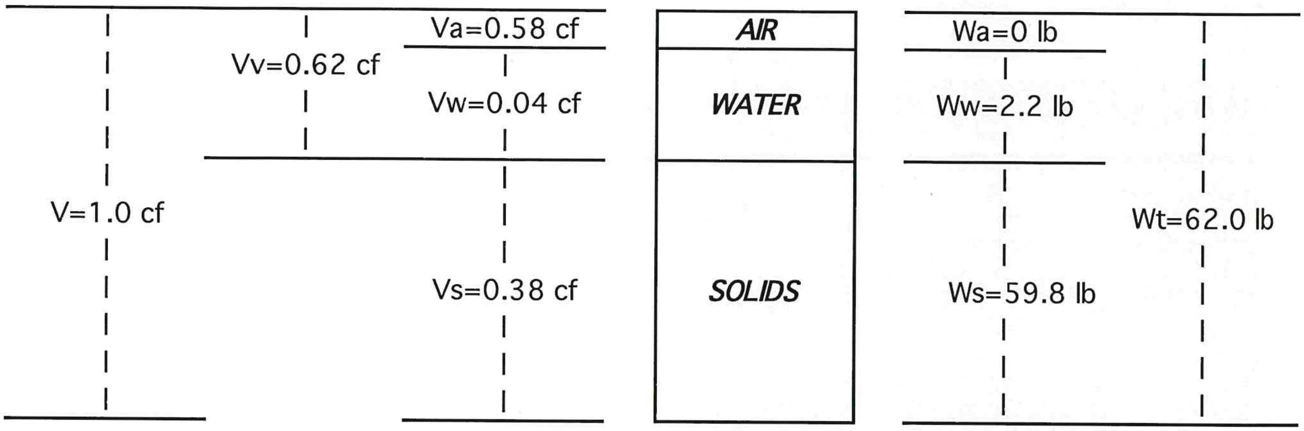
2.0154 acres	2 tons	2257.25 days	=	24.9 tons
	ac/yr	365 days/yr		

6.2 years

Exhibit
K

WEIGHT VOLUME RELATIONSHIPS OF SOIL

PROJECT NAME:	Powerton Station SW Basin	**PROJECT NO:**	21511
SAMPLE LOCATION:	Ash Surge Basin	**DATE:**	7/26/21
SOIL CLASSIFICATION:	Black SAND with Silt	**CLIENT:**	KPRG Wisconsin



ENTER LABORATORY MOISTURE CONTENT, %- -	Mc=	3.7
ENTER SAMPLE WEIGHT, grams- - - - - - - -	W=	98.87
ENTER SAMPLE DIAMETER, inches- - - - - - -	Ds=	
ENTER SAMPLE LENGTH, inches- - - - - - - -	Ls=	
ENTER ESTIMATED/KNOWN SPECIFIC GRAVITY,Gs	Gs=	2.519
SAMPLE VOLUME, cubic inches- - - - - - - - -	V=	6.07 ((Ds/
WET DENSITY, #/cu ft- - - - - - - - - - - -	Wt=	62.0
WEIGHT OF SOLIDS, pounds- - - - - - - - - - -	Ws=	59.8
WEIGHT OF WATER, pounds- - - - - - - - - - -	Ww=	2.2
VOLUME OF SOLIDS, cubic feet- - - - - - - - -	Vs=	0.38
VOLUME OF WATER, cubic feet- - - - - - - - -	Vw=	0.04
VOLUME OF AIR, cubic feet- - - - - - - - - - -	Va=	0.58
VOLUME OF VOIDS, cubic feet- - - - - - - - -	Vv=	0.62
POROSITY, n- - - - - - - - - - - - - -	**n=**	**0.62**
VOID RATIO, e- - - - - - - - - - - - -	**e=**	**1.63**
DEGREE OF SATURATION, Sr- - - - - - -	**Sr=**	**6%**
LOSS ON IGNITION - - - - - - - -	FOC=	18.9%

MIDLAND STANDARD ENGINEERING TESTING, INC.
410 NOLEN DRIVE, SOUTH ELGIN, IL 60177 P(847) 844-1895 F(847) 844-3875

Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
ASTM 2974

Project # 21511
Project Name: Powerton Station SW Basin
Sample Description: Black SAND with Silt

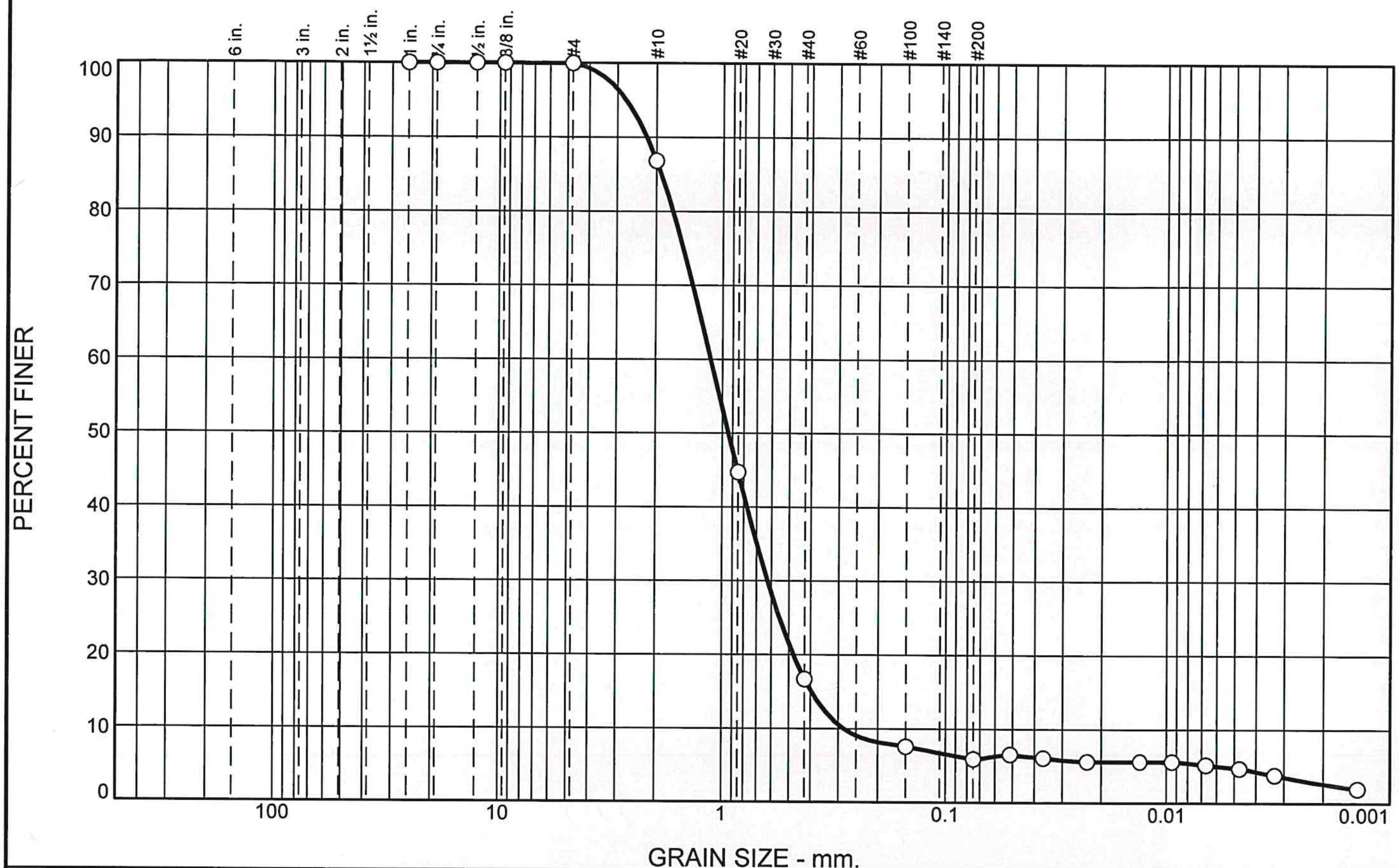
Date Received: 7/23/21
Date Tested: 7/26/21
Tested by: JDS
page 1 of 1

Southwest Basin

METHOD D, 750°C
METHOD C, 440°C

	SAMPLE ID	Ash Surge Basin		
	SPECIMEN #	B-1, S-1		
	TEST DATE:	7/26/21		
	TEST TEMP:	440°C		
1. wt of crucible, no cover	1	151.93		
2. wt. of crucible & unburnt sample, r	2	180.92		
3. wt. of crucible & burned sample, n	3	175.44		
4. wt. of dry sample at start	B	28.99		
5. net wt. of ash	C	23.51		
6. ash content, %	D	81.10		
7. organic matter, %	OM,%	**18.90**		

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	13.2	70.1	10.8	3.3	2.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	100.0		
1/2"	100.0		
3/8"	100.0		
#4	100.0		
#10	86.8		
#20	44.7		
#40	16.7		
#100	7.6		
#200	5.9		
0.0514 mm.	6.5		
0.0365 mm.	6.1		
0.0231 mm.	5.6		
0.0134 mm.	5.6		
0.0094 mm.	5.6		
0.0067 mm.	5.2		
0.0047 mm.	4.7		
0.0033 mm.	3.8		
0.0014 mm.	1.9		

* (no specification provided)

Soil Description

Black poorly graded SAND with Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 2.2108 D_{85}= 1.9028 D_{60}= 1.1312
D_{50}= 0.9398 D_{30}= 0.6237 D_{15}= 0.3961
D_{10}= 0.2841 C_u= 3.98 C_c= 1.21

Classification

USCS= SP-SM AASHTO= A-1-b

Remarks

Black Flyash

Location: Ash Surge Basin
Sample Number: S-1

Date: 7/26/21

MIDLAND STANDARD ENGINEERING & TESTING, INC. "Our work is beneath you" MSET

Client: KPRG and Associates, Inc.
Project: Powerton Station SW Basin

Project No: 21511 **Figure**

Tested By: JDS **Checked By:** WDP

GRAIN SIZE DISTRIBUTION TEST DATA

8/5/2021

Client: KPRG and Associates, Inc.
Project: Powerton Station SW Basin
Project Number: 21511
Location: Ash Surge Basin
Sample Number: S-1
Material Description: Black poorly graded SAND with Silt
Date: 7/26/21 **PL:** NP **LL:** NV **PI:** NP
USCS Classification: SP-SM **AASHTO Classification:** A-1-b
Testing Remarks: Black Flyash
Tested by: JDS **Checked by:** WDP

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
160.42	0.00	0.00	1"	0.00	100.0
			3/4"	0.00	100.0
			1/2"	0.00	100.0
			3/8"	0.00	100.0
			#4	0.06	100.0
			#10	21.16	86.8
101.50	0.00	0.00	#20	49.22	44.7
			#40	82.00	16.7
			#100	92.64	7.6
			#200	94.62	5.9

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 86.8
Weight of hydrometer sample =101.50
Hygroscopic moisture correction:
Moist weight and tare = 56.94
Dry weight and tare = 56.02
Tare weight = 31.37
Hygroscopic moisture = 3.7%
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -5.0
Meniscus correction only = 0.0
Specific gravity of solids = 2.509
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer
1.00	24.5	11.0	7.1	0.0135	11.0	14.5	0.0514	6.5
2.00	24.5	10.5	6.6	0.0135	10.5	14.6	0.0365	6.1
5.00	24.5	10.0	6.1	0.0135	10.0	14.7	0.0231	5.6
15.00	24.5	10.0	6.1	0.0135	10.0	14.7	0.0134	5.6
30.00	24.5	10.0	6.1	0.0135	10.0	14.7	0.0094	5.6
60.00	24.5	9.5	5.6	0.0135	9.5	14.7	0.0067	5.2
120.00	24.5	9.0	5.1	0.0135	9.0	14.8	0.0047	4.7
250.00	24.5	8.0	4.1	0.0135	8.0	15.0	0.0033	3.8
1440.00	24.5	6.0	2.1	0.0135	6.0	15.3	0.0014	1.9

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	13.2	70.1	10.8	94.1	3.3	2.6	5.9

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.0059	0.2841	0.3961	0.4773	0.6237	0.7744	0.9398	1.1312	1.6842	1.9028	2.2108	2.7376

Fineness Modulus	C_u	C_c
3.00	3.98	1.21

Exhibit

L

Exhibit L
REDACTED

Exhibit M

NIJMAN · FRANZETTI LLP

10 South LaSalle Street · Suite 3600 · Chicago, Illinois 60603
312.251.5250 · fax 312.251.4610 · www.nijmanfranzetti.com

Kristen Laughridge Gale
kg@nijmanfranzetti.com
312.262.5524

March 9, 2021

VIA OVERNIGHT MAIL AND EMAIL

Illinois EPA
Division of Public Water Supplies
Attn: Andrea Rhodes, CAS #19
P.O. Box 19276
Springfield, IL 62794-9276

Re: Violation Notice Nos.: W-2020-00075 (Waukegan Generating Station); W-2020-00086 (Will County Generating Station); W-2020-00083 (Powerton Generating Station); W-2020-00085 (Joliet 29 Station).

Dear Ms. Rhodes:

This letter is a supplemental response to the above-referenced Violation Notices following the meeting between the Illinois Environmental Protection Agency ("Illinois EPA or the "Agency") and Midwest Generation, LLC ("MWG") on February 17, 2021.[1] The above-referenced Violation Notices allege that MWG did not submit the annual fees due for certain ponds and areas at its Stations. These Violation Notices are related to Illinois EPA VNs W-2020-00035, W-2020-00045, W-2020-00042, W-2020-00044, which alleged that MWG did not submit the initial fees due for the same ponds and areas at its Stations. Because of the almost identical allegations and defenses, MWG and Illinois EPA have treated the two sets of VNs as one dispute. Therefore, they are collectively referenced here as "the VNs."

The February 17, 2021 meeting was helpful in moving this process forward and MWG appreciates the effort the Agency made to do so. We are responding here to the Agency's additional questions and requests for clarification of the information MWG provided regarding the service water basins located at the Joliet 29 Generating Station ("Joliet 29") and the Powerton Generating Station ("Powerton"). We believe the additional information presented in this response provides further support for MWG's position that the service water basins are not CCR surface impoundments. MWG also maintains that the Grassy Field at the Waukegan Generating Station ("Waukegan") is not a CCR surface impoundment and relies upon the information provided in its September 16, 2020 VN Response.

Since submitting MWG's prior VN responses on the Will County Generating Station ("Will County") Ponds 1N and 1S, the Illinois Pollution Control Board issued its Second Notice

[1] The February 17, 2021 meeting was held at the request of MWG, pursuant to Section 31(a)(4) of the Illinois Environmental Protection Act. 415 ILCS 5/31(a)(4).

Opinion in the CCR rulemaking, which includes the definition of "Inactive CCR Surface Impoundment." Based on this legal development, MWG is withdrawing its objections to Illinois EPA's designation that Ponds 1N and 1S at Will County are CCR surface impoundments. MWG is preparing payment of the initial and annual fees for both ponds, and will submit it as soon as it is available.

MWG reserves the right to raise additional defenses and mitigation arguments as may be necessary, in defense of the allegations listed in the VNs in the event of any future enforcement. By submitting this supplemental response, MWG does not waive any of its original objections to the VNs raised in our January 27, 2021, November 25, 2020, September 16, 2020 and September 11, 2020 VN Responses. Moreover, MWG does not, by submitting this supplemental response, make any admissions of fact or law, or waive any of its defenses to those alleged violations.

I. Supplemental Response to Alleged Violations in the VNs

The February 17th discussion focused on the three service water basins located at Joliet 29 and Powerton and addressed Illinois EPA's questions and requests for clarifications of MWG's November 25, 2021 Supplemental Response and the KPRG Report attached to the response. As requested, on February 26, 2021, MWG submitted to the Illinois EPA a supplemental report by KPRG describing the methodology used to collect representative samples of the material at the base of the three service water basins. Along with the sample collection methodology, MWG submitted maps showing the approximate locations of the samples and bathymetric surveys maps showing the approximate height of the material at the base of each basin. The KPRG supplemental report is also attached here as Exhibit 1, to ensure that your file is complete. Additionally, per Illinois EPA's request, attached please find the as-built drawings for Ponds 1 and 3 at Joliet 29 and the Service Water Basin at Powerton as Exhibit 2. The Agency's additional questions and requests for information identified during our meeting are addressed below.

a. The Air Dispersion Reference

Illinois EPA requested the citation or reference for the "two tons per acre per year" volume of atmospheric deposits referenced in KPRG's report. The estimate of two tons per acre per year is based upon the U.S. Dept. of Agriculture Report soil loss equation in the Department's "Predicting Rainfall Erosion Losses", December 1978, attached as Exhibit 3. The 2 tons per acre per year is the maximum amount of erosion (soil loss tolerance) that can be tolerated without losing the long term functionality of the soil to grow a crop. According to the soil loss equation, the lost soil is replaced by natural processes at a rate that is the same or greater than the tolerance level of two to five tons per acre per year. *See* Ex. 3, p. 3. Michigan has codified this atmospheric rate of deposits in its Solid Waste Landfill Rules, to ensure that the slopes and covers of landfills are sufficiently maintained. *See* Michigan Dept. of Environmental Quality, Solid Waste Management, Part 115, R 299.4425 (8), attached as Exhibit 4.

John Seymour, an expert in solid waste landfills and CCR surface impoundments from Geosyntec, Inc., testified during a citizen suit about CCR surface impoundments in front of the Illinois Pollution Control Board that the atmospheric deposits dust at the rate of two tons per acre per year, and that this explained the source of the material found at the base of the service water basins. *See* Exhibit 5, excerpt of February 1, 2020 Transcript, *Sierra Club et al. v. Midwest Generation, LLC,* PCB13-15.

b. Topographic Map of the Powerton Service Water Basin

Illinois EPA requested a copy of the topographic map of the Service Water Basin at the Powerton Station. Because the topographic maps maintained at Powerton were relatively old, MWG engaged a consulting firm to conduct a new survey to confirm the topographic contours. The updated topographic map is attached as Exhibit 6. As shown in the topographic map, the topography of the paved road on the south side of the Service Water Basin flows directly into the Service Water Basin. The USGS topographic map, also attached, shows that the topography at the Powerton Station, including the paved road, flows to the north towards the Illinois River, further supporting the conclusion that stormwater from the station flows into the Service Water Basin. The USGS topographic map is attached as Exhibit 7.

c. Comparison of the Material in the Service Water Basin to the Joliet 9 CCR

Illinois EPA also requested an explanation for why KPRG compared the CCR from the Joliet 9 Station to the material found in the Service Water Basin at the Powerton Station. KPRG analyzed the Joliet 9 CCR as opposed to the Powerton CCR because the Joliet 9 CCR and the Joliet 29 CCR are both in the Lincoln Stone Quarry. Knowing that the Joliet 9 CCR and Powerton CCR were effectively the same, collecting the sample from the Joliet 9 CCR was the most expeditious method to collect the sample so the results could be provided to Illinois EPA as soon as possible. The MWG coal-burning stations like Joliet 9 and Powerton burn the same coal. Both the Joliet 9 Station and the Powerton Station generate electricity and burn coal using cyclone boilers. Because the stations burn the same coal using the same method, the resulting CCR is so similar that CCR data from one station can be used comparatively as it was here. While the Joliet 9 CCR sample is reliably comparative, should the IEPA require analysis of a sample from Powerton in order to resolve this matter, arrangements could be made to do so.

d. The Service Water Ponds in Series Do Not Collect CCR

During the February 17, 2021 meeting, it seemed the Illinois EPA believes that if a service water basin is in series with a CCR surface impoundment, the Agency assumes that the service water basin would also have collected CCR. But this is not a correct assumption as demonstrated by the evaluations of the service water basins. The bathymetric surveys and the analysis of the material at the base of the ponds show that little material collects in the ponds and that this material is not CCR. *See* KPRG Nov. 25, 2020 Report, and February 26, 2021 Supplemental Report and maps. These evaluations are consistent with past observations by Station personnel regarding the basins. Even though the service water basins had not been emptied for thirty years, when the basins were emptied for relining the ponds in 2013, Station personnel observed little material at the base of the ponds and that material was not CCR. MWG attached the relevant testimony of Mark Kelly concerning these observations of the Service Water Basin at Powerton to its September 11, 2020 Response to the Powerton VN, and has reattached it here as Exhibit 8. Similarly, former MWG employee Maria Race testified that there were not any solids in Pond 3 at Joliet 29 when it was relined in 2013. *See* excerpt of January 28, 2020 Transcript, *Sierra Club et al. v. Midwest Generation, LLC,* PCB13-15, Exhibit 9. In short, KPRG's investigation and the Station personnel firsthand observations demonstrate that the CCR settles out in the primary basin. CCR does not travel to the service water basins that are in series after the primary basin.

II. The Waukegan Grassy Field Is Not A CCR Surface Impoundment

MWG maintains that the Grassy Field at the Waukegan Station is not a CCR surface impoundment as defined in Section 3.143 of the Act. 415 ILCS 5/3.143. As MWG stated in its September 16, 2020 VN Response letter, the Grassy Field is not a depression or excavation, nor is it designed to hold CCR and liquids. No CCR or CCR slurry water is directed at the Grassy Field. Further, because the Grassy Field is not a depression, it cannot accumulate liquid. Moreover, the Grassy Field was never a CCR surface impoundment and was never designed to accumulate CCR and liquids. MWG's September 16, 2020 Response and the exhibits attached provides an in depth discussion and explanation of why the Grassy Field is not a CCR surface impoundment.

III. **Conclusion**

We trust this supplemental response is responsive to the Agency's requests for information regarding the service water basins at Joliet 29 and Powerton. It should enable the Agency to determine that Ponds 1 and 3 at Joliet 29 and the Service Water Basin at Powerton are not CCR surface impoundments because none contain any CCR. Similarly, we believe the factual evidence presented on the Waukegan Grassy Area should persuade the Agency that it does not fall within the definition of "CCR surface impoundment" because it cannot accumulate liquid, it does not accumulate CCR and liquid, and it was never designed to accumulate CCR or liquid. As noted above, consistent with the Illinois Pollution Control Board's Second Notice Opinion in the CCR rulemaking, MWG is withdrawing its objections to Illinois EPA's designation that Ponds 1N and 1S at Will County are CCR surface impoundments, and is arranging for payment of the fees.

Should you have any additional questions or concerns, please do not hesitate to contact me.

Very truly yours,

Kristen L. Gale
Counsel for Midwest Generation, LLC

Enclosures

cc: Sharene Shealey, Midwest Generation, LLC (via email)
Gabbriel H. Neibergall (via email)

EXHIBIT 1

MEMORANDUM

FROM: Joshua D. Davenport, P.E., KPRG and Associates, Inc.

DATE: February 26, 2021

SUBJECT: Sampling Location Discussion as part of Evaluation of Sediment Quantities in Joliet Generating Station's Pond 1 and Pond 3 and Powerton Generating Station's Service Water Basin

---

This memo provides a discussion of the sample locations for Pond 1 and Pond 3 at the Joliet 29 Generating Station and the Service Water Basin at the Powerton Generating Station. This memo is a follow up to the discussion with IEPA that occurred on February 17, 2021.

IEPA had questions regarding the total number of samples collected in each pond and what was the rationale for sample locations. The following provides this discussion with IEPA's initial question provided in italics.

Joliet 29 Generating Station

1) *Discussion must be provided about how sample locations were selected and the methodology of collecting the sample*

Samples in both Ponds 1 and 3 were collected using a clamshell sampler. Minimal material was able to be collected because mostly water was obtained using the clamshell. Not much material was collected during each drop of the clamshell. The ponds both had water in them during the sampling. Pond 1 had approximately 15-16 feet of water and Pond 3 had approximately 8-9 feet of water.

<u>Sample Collection Method</u>

The samples were collected from a boat using a clamshell sampler. The clamshell was lowered over the side of a boat using a rope with the clamshell held open by a spring. The spring on the clamshell releases once it hits the sediment and the rope is used to pull the sampler to the surface. The collection portion of the clamshell is approximately 2 quarts in volume. When collecting the sample, it requires multiple attempts to collect an adequate amount of sediment for laboratory analysis because the majority of the material collected during each drop is water, with some sediment.

The sample collection from a boat is different from collecting samples at a stationary point when collecting soil and/or groundwater samples. Each attempt to collect sediment using the clamshell will collect sediment from a different part of the pond because the boat naturally drifts on the water. Therefore, the sample locations depicted on the attached figures are more appropriately a sampling area as opposed to a singular point.

Pond 1

Knowing that Pond 1 was cleaned out in 2015, the center of the pond was chosen for Sample 1 to provide a broad representation of the type of material that may be in the pond and sediment would likely be present there if the pond contained any. Many collection attempts were performed in the center area of the pond to collect a sufficient quantity of sediment needed for the laboratory analyses. The sampling attempts were combined and submitted to the laboratory as one sample. The second Pond 1 sample area was collected near the edge of the pond, adjacent to the access road because it was safely accessible without a boat. As performed during the first sampling, several attempts were made to collect the quantity of sediment needed for the material analyses. The sampling attempts were combined and submitted to the laboratory as one sample. The second sampling was performed later to collect additional data. The additional data was warranted to provide further clarification on the type of sediment present in Pond 1 based on the results of the bathymetric survey and the grain size analysis. Because a boat was not available, the second sampling was collected by lowering the clamshell sampler from the side of the pond, releasing the spring, hauling the sampler back up, and collecting the sediment in a jar. Because the samplings were performed at different times, they were submitted to the laboratory at two different times.

The attached Figure 1 shows the sampling areas where the sediment was collected and the bathymetric survey surface in comparison to the existing pond surface/liner. The contours of the pond are based on the as-built drawings and the contours of the bathymetric survey are based on that survey. The attached Figure 2 shows the survey surface in comparison to the existing pond surface/liner. The bathymetric survey contours show approximately 1-2 feet of material is present, which, as noted in our previous submittal, consists of 14% percent sediment and 86% water.

Pond 3

Sediment within Pond 3 was collected from three different sampling areas and combined into one sample that was submitted for laboratory analysis. The three sampling areas were located near the center of the pond, near the pond inlet, and from the side slope of the access road. The inlet sampling area was chosen because if CCR material was likely to be present in the pond, it would be at the inlet because of the CCR's particle size (approximately sand sized) and its tendency to settle from the water first, prior to smaller silt and clay sized particles. The inlet had a minimal quantity of material and most of what was collected was the stone warning layer and not sediment. The center of the pond was chosen because it was more likely to find sediment present at this area and was likely to contain a broad representation of the types and sizes of material in the pond. The third area where sediment was collected was from the side slope of the access road. This area was chosen because the water level in the pond was low enough that this material was exposed and was collected by hand and placed in a plastic bag.

The inlet and center samplings were performed from a boat with the clamshell sampler using the method as was discussed above. The sample next to the access road was collected by hand.

The attached Figure 1 shows the locations where the sediment was collected. Also shown on Figure 1 is the contours of the pond based on the as-built drawings and the contours of the bathymetric survey. The attached Figure 2 shows the bathymetric survey surface in comparison to the existing pond surface/liner. The contours show that approximately 2-3 feet of material is present, which as noted in our previous submittal, consists of 8% percent sediment and 92% water.

Powerton's Service Water Basin

1) Provide how sample location was selected and obtained

The sample collected from the Service Water Basin was not collected by KPRG, but was collected by a process engineer that works at the Powerton Generating Station. KPRG spoke with the process engineer and the following is from our conversation.

The water level was low enough that the sample material was collected by hand. The plant personnel walked down the south side of the liner, collected the material with a plastic scoop, and put it in a container. The sample was collected from the south side of the basin. The south side was not chosen for any particular reason, it happened to be the side that was chosen by the plant personnel. The plant engineer noted the following observation, "the sample material was sticky and was stuck to side of basin and did not fall off with a lower water level." It was noted that the basin still contained water and the bottom was not visible. The sediment did not have appear to have a noticeable odor. The plant personnel containerized the sediment sample and shipped it to the same geotechnical testing firm that performed the Pond 1 and Pond 3 samples analyzes. KPRG provided the plant personnel with the name of the testing firm, its address, and the tests that should be performed on the sample.

The attached Figure 3 shows the approximate location where the sediment was collected. Also shown on Figure 3 is the contours of the pond based on the as-built drawings and the contours of the bathymetric survey. The attached Figure 4 shows the bathymetric survey surface in comparison to the existing pond surface/liner. The contours show the bottom of the pond based on the as-built drawings is approximately the same elevation determined by the bathymetric survey.

The comparison of the contours on Figure 4 is based on the as-built survey performed in 2013 prior to the geomembrane liner installation and the 2020 bathymetric survey. The extent of the bathymetric survey on Figure 4 goes beyond the extent of the basin as-built contours. This discrepancy is likely due to changes that occurred following installation of the liner in 2013.

In addition, the profile drawing also has an exaggerated vertical scale to make the vertical differences easier to see because the vertical distances on cross sections are typically much smaller than horizontal distances and they can be hard to see.

Despite the difference, the intent of the drawing still shows that minimal to no sediment is present along the bottom of the basin.

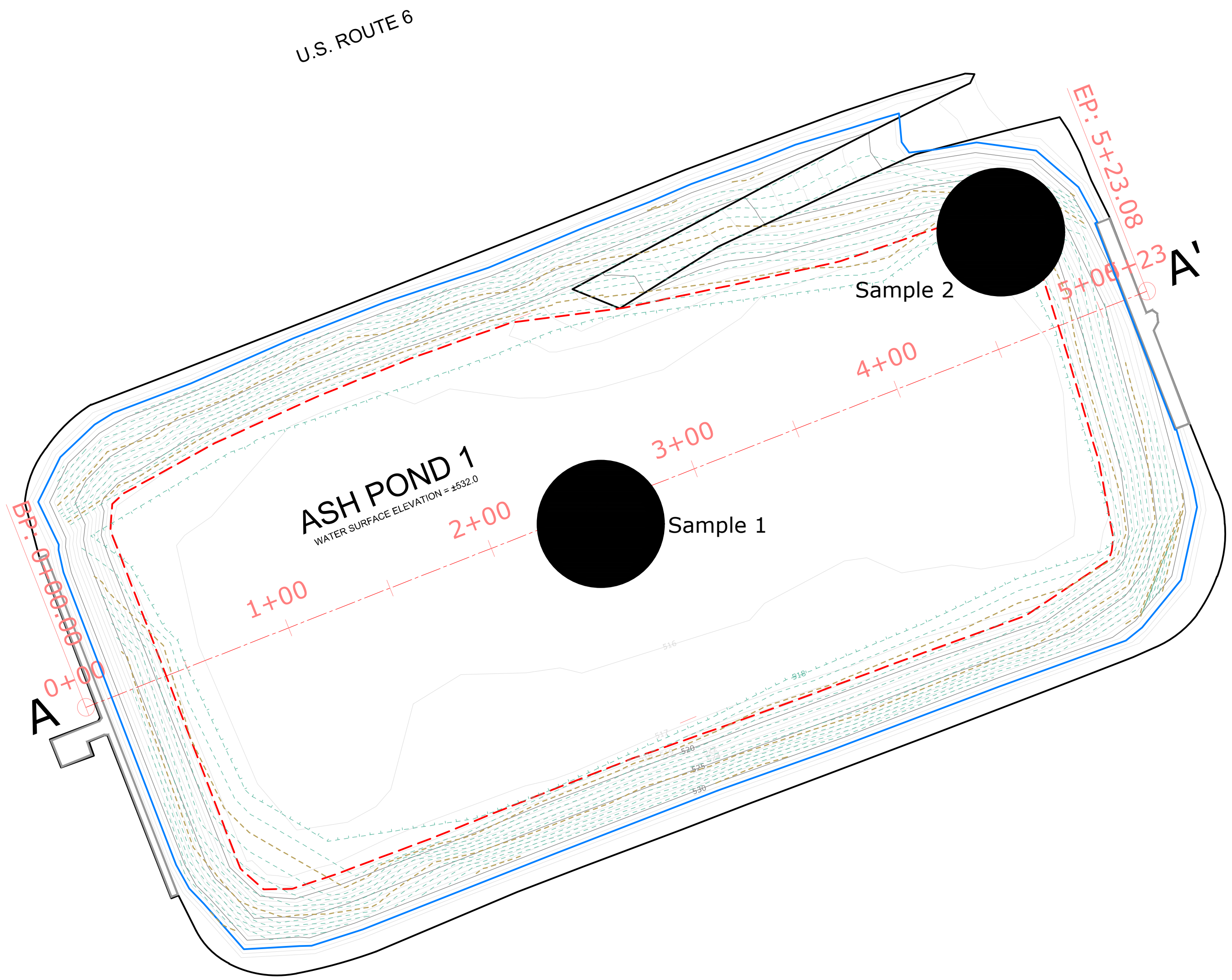
ASTM Method

ASTM D2974 was chosen to determine the organic versus non-organic content of the sediment based on a discussion with the geotechnical company performing the other sediment analyses. The following is a brief summary of the test method described in the ASTM standard.

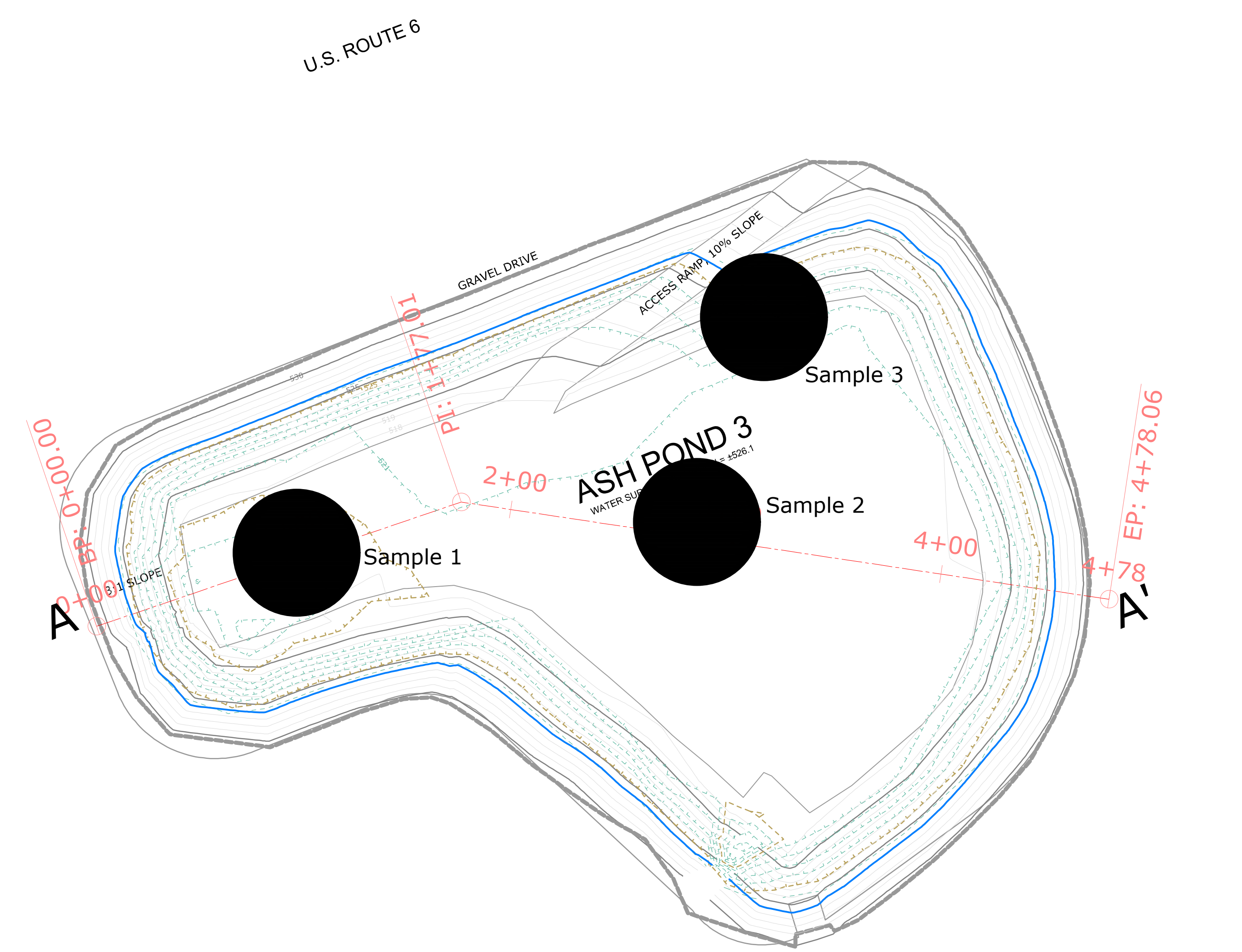
1. The soil sample is dried in an oven at approximately 110°C for a minimum of 16 hours. The sample is allowed to cool and the mass is determined.
2. The sample is then heated in a furnace where the temperature is gradually raised to approximately 440°C. The sample is then heated at this temperature for at least 1 hour. The sample is heated until the entire contents are considered "completely ashed." The sample is considered completely ashed once there is no change in mass.
3. The sample is allowed to cool and the mass is determined.

The test method does not determine if any particular soil sample contains coal ash. The use of the term ash is in the generic after something has been cooked in a furnace and is completely burned. This test method is used for classification purposes when wanting to determine the organic content of soil.

POND 1



POND 3



LEGEND

5-FOOT INCRENEMT CONTOUR FROM AS-BUILT DRAWINGS
1-FOOT INCREMENT CONTOUR FROM AS-BUILT DRAWINGS
5-FOOT INCREMENT CONTOUR FROM SURVEY
1-FOOT INCREMENT CONTOUR FROM SURVEY

SAMPLE 1 ● POND SAMPLE LOCATION

0 80'
APPROXIMATE SCALE

ENVIRONMENTAL CONSULTATION & REMEDIATION

KPRG

KPRG and Associates, inc.

14665 West Lisbon Road, Suite 1A Brookfield, Wisconsin 53005 Telephone 262-781-0475 Facsimile 262-781-0478

414 Plaza Drive, Suite 106 Westmont, Illinois 60559 Telephone 630-325-1300 Facsimile 630-325-1593

POND 1 AND POND 3 SEDIMENT SAMPLE LOCATIONS	
JOLIET 29 GENERATING STATION JOLIET, ILLINOIS	
Scale: 1" = 80'	Date: February 26, 2021
KPRG Project No. 15020	FIGURE 1

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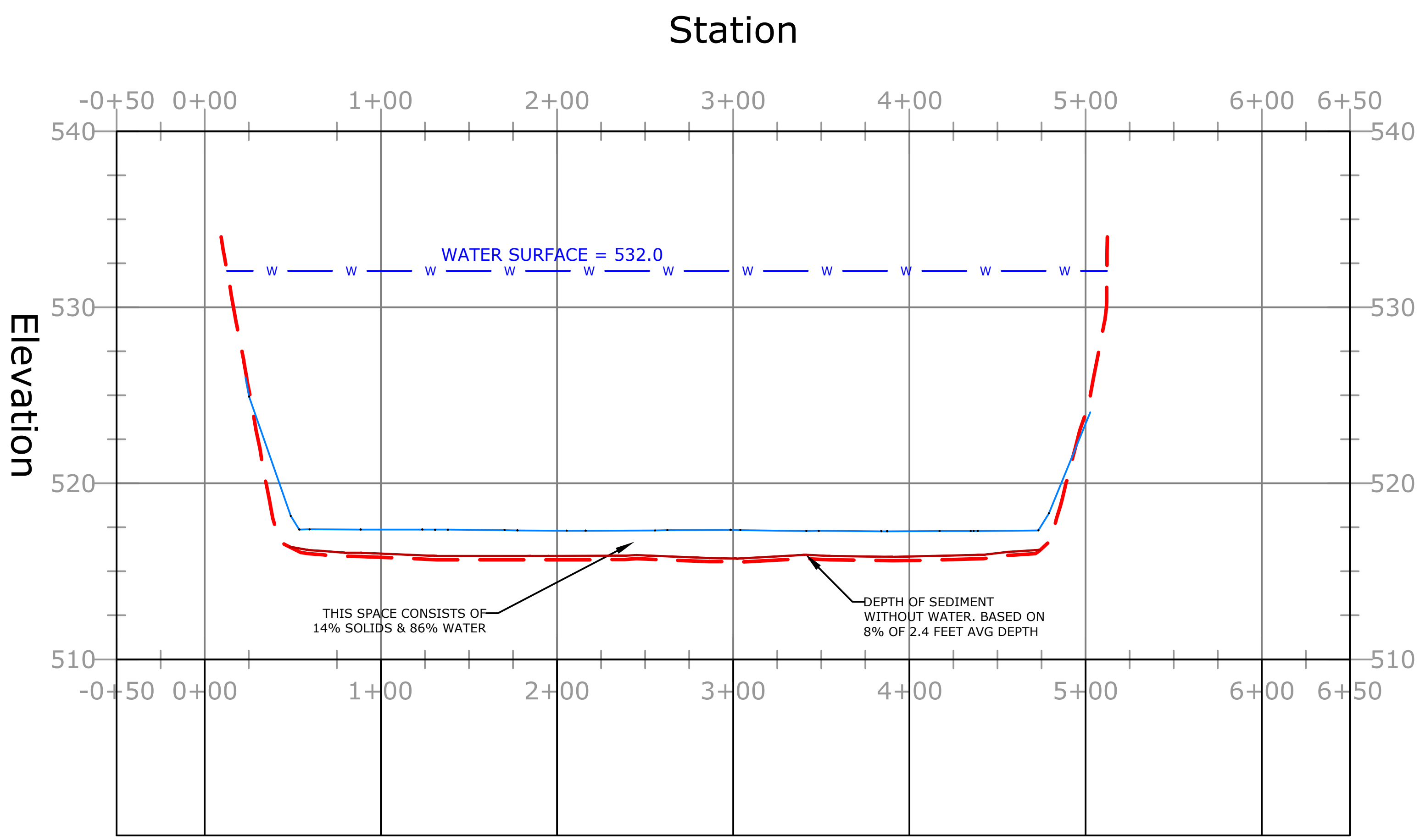
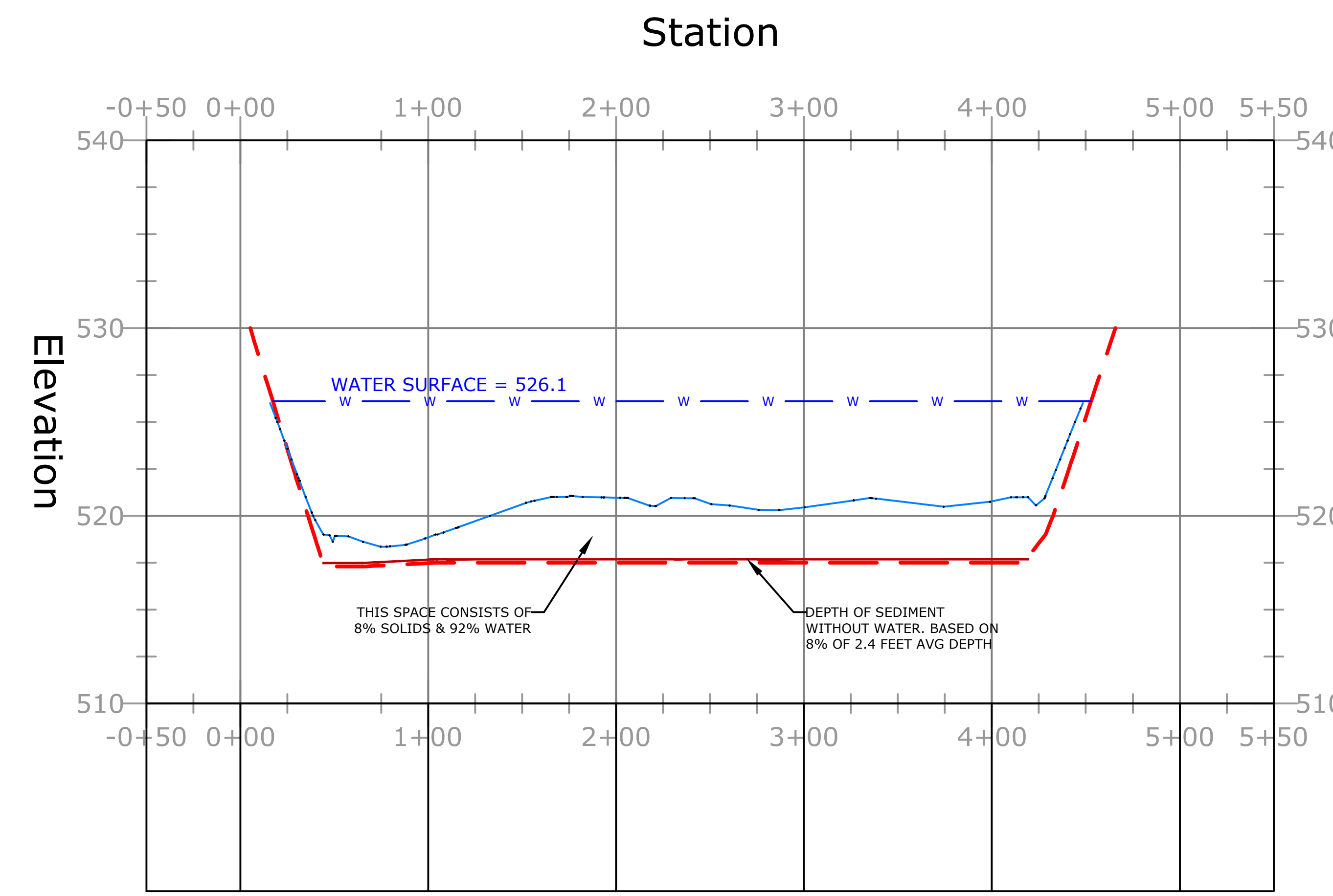
Electronic Filing: Received, Clerk's Office 09/22/2021

Pond 1 A-A' PROFILE



POND 1

Pond 3 A-A' PROFILE



POND 3

LEGEND

- EXISTING POND LINER SURFACE
- SURVEYED SEDIMENT/WATER SURFACE
- ESTIMATED SEDIMENT SURFACE W/OUT WATER

10'
100' 0'
APPROXIMATE SCALE

ENVIRONMENTAL CONSULTATION & REMEDIATION

KPRG

KPRG and Associates, inc.

14665 West Lisbon Road, Suite 1A Brookfield, Wisconsin 53005 Telephone 262-781-0475 Facsimile 262-781-0478

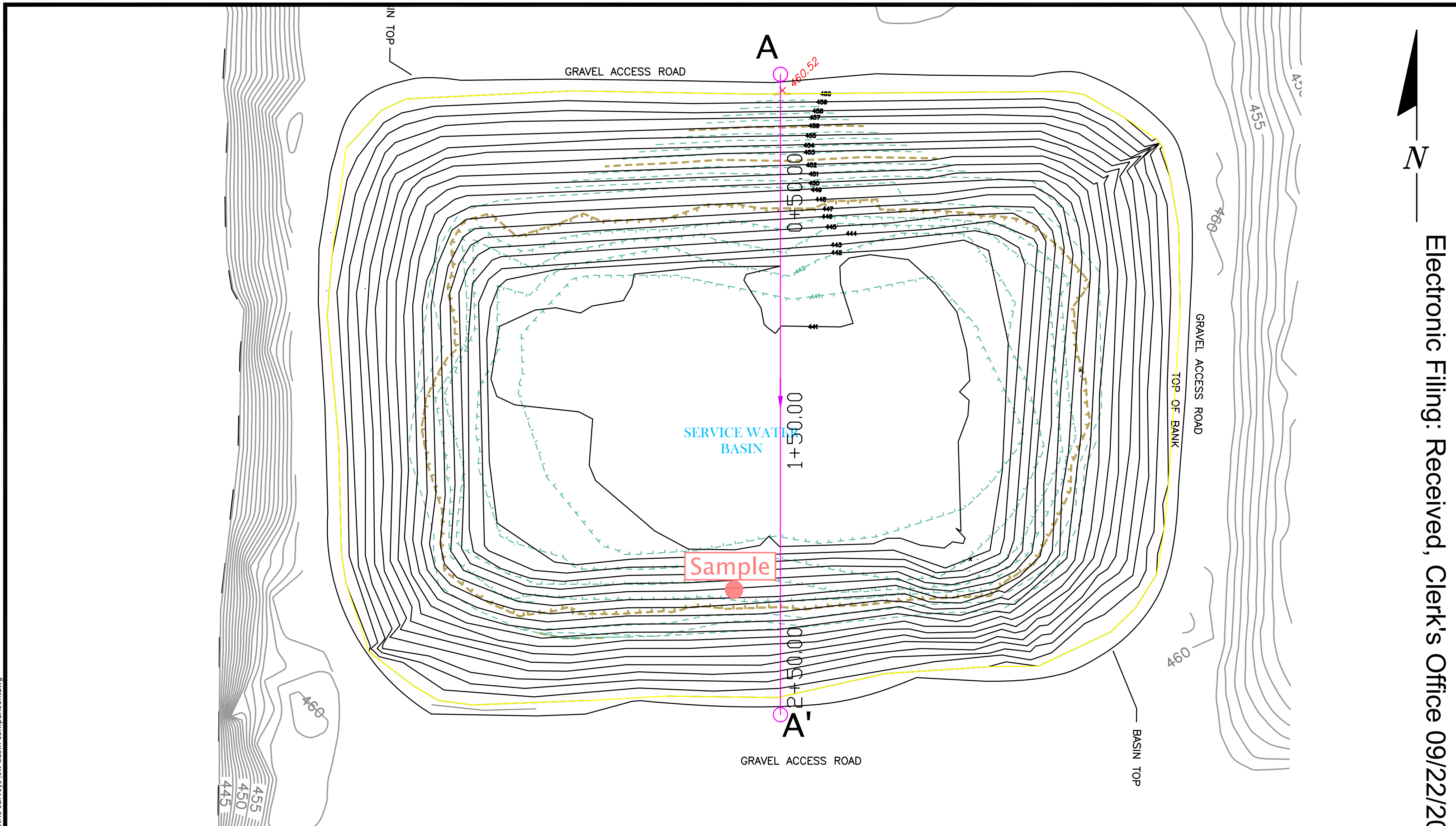
414 Plaza Drive, Suite 106 Westmont, Illinois 60559 Telephone 630-325-1300 Facsimile 630-325-1593

POND 1 AND POND 3 PROFILES

JOLIET 29 GENERATING STATION
JOLIET, ILLINOIS

Scale: 1" = 100'	Date: February 25, 2021
KPRG Project No. 15020	FIGURE 2

W:\c:\projects\project folder\file name.dwg



LEGEND

Sample (red dot)	POND SAMPLE LOCATION
solid line	1-FOOT INCREMENT CONTOUR FROM AS-BUILT DRAWINGS
dashed line	5-FOOT INCREMENT CONTOUR FROM SURVEY
dashed line	1-FOOT INCREMENT CONTOUR FROM SURVEY

0 60'
APPROXIMATE SCALE

E N V I R O N M E N T A L C O N S U L T A T I O N & R E M E D I A T I O N

K P R G

KPRG and Associates, inc.

14665 West Lisbon Road, Suite 1A Brookfield, Wisconsin 53005 Telephone 262-781-0475 Facsimile 262-781-0478

414 Plaza Drive, Suite 106 Westmont, Illinois 60559 Telephone 630-325-1300 Facsimile 630-325-1593

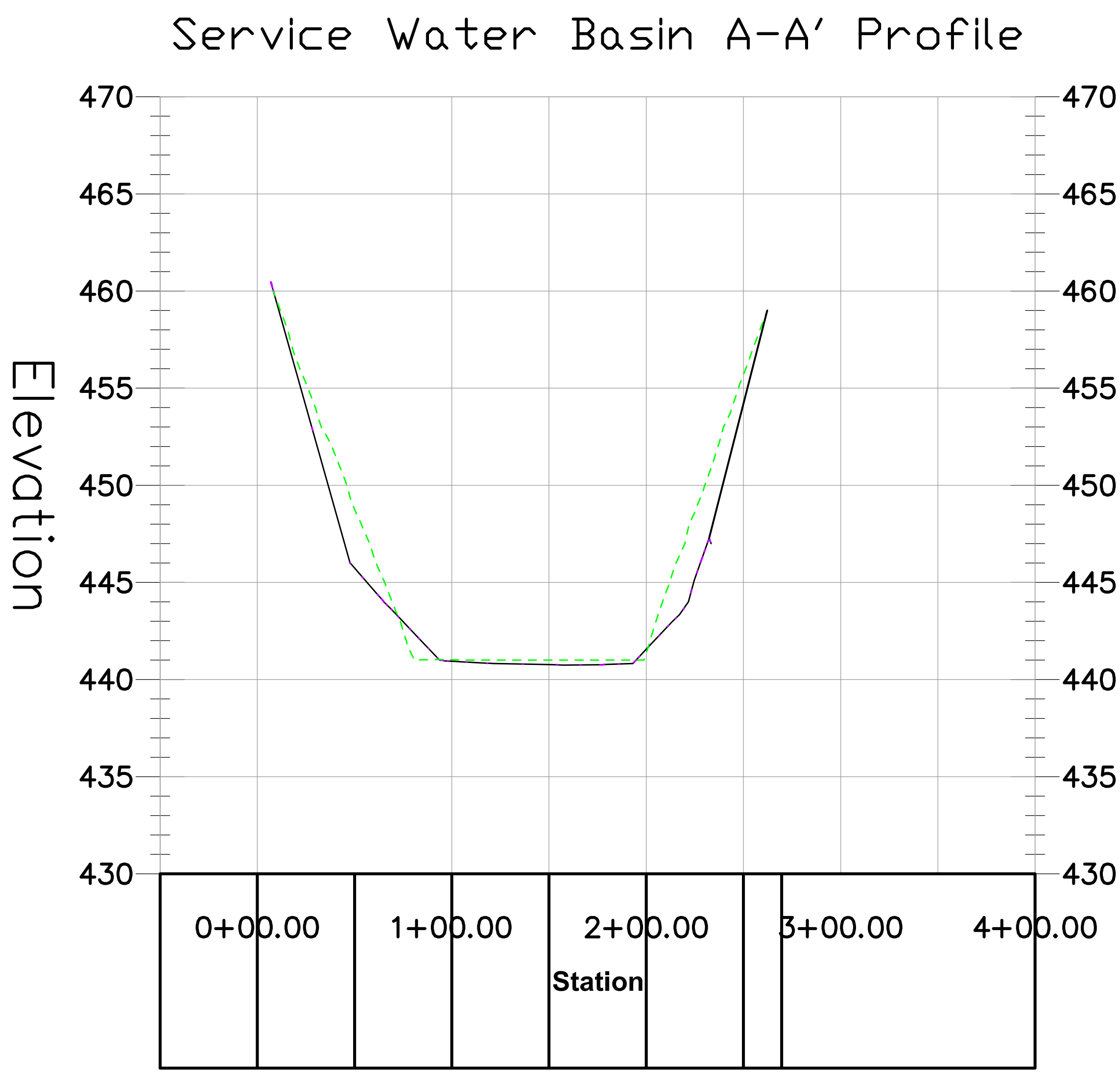
SERVICE WATER BASIN SAMPLE LOCATION

POWERTON GENERATING STATION
PEKIN, ILLINOIS

Scale: 1" = 60' | Date: February 26, 2021

KPRG Project No. 15020 | FIGURE 3

W:\projects\midwest gen\attorney client privilege\pond drawings\bathymetric surveys\sw basin comparison.dwg



LEGEND

- - - - EXISTING POND SURFACE
—— SURVEY SURFACE

0 100'
APPROXIMATE SCALE

E N V I R O N M E N T A L C O N S U L T A T I O N & R E M E D I A T I O N

KPRG

KPRG and Associates, inc.

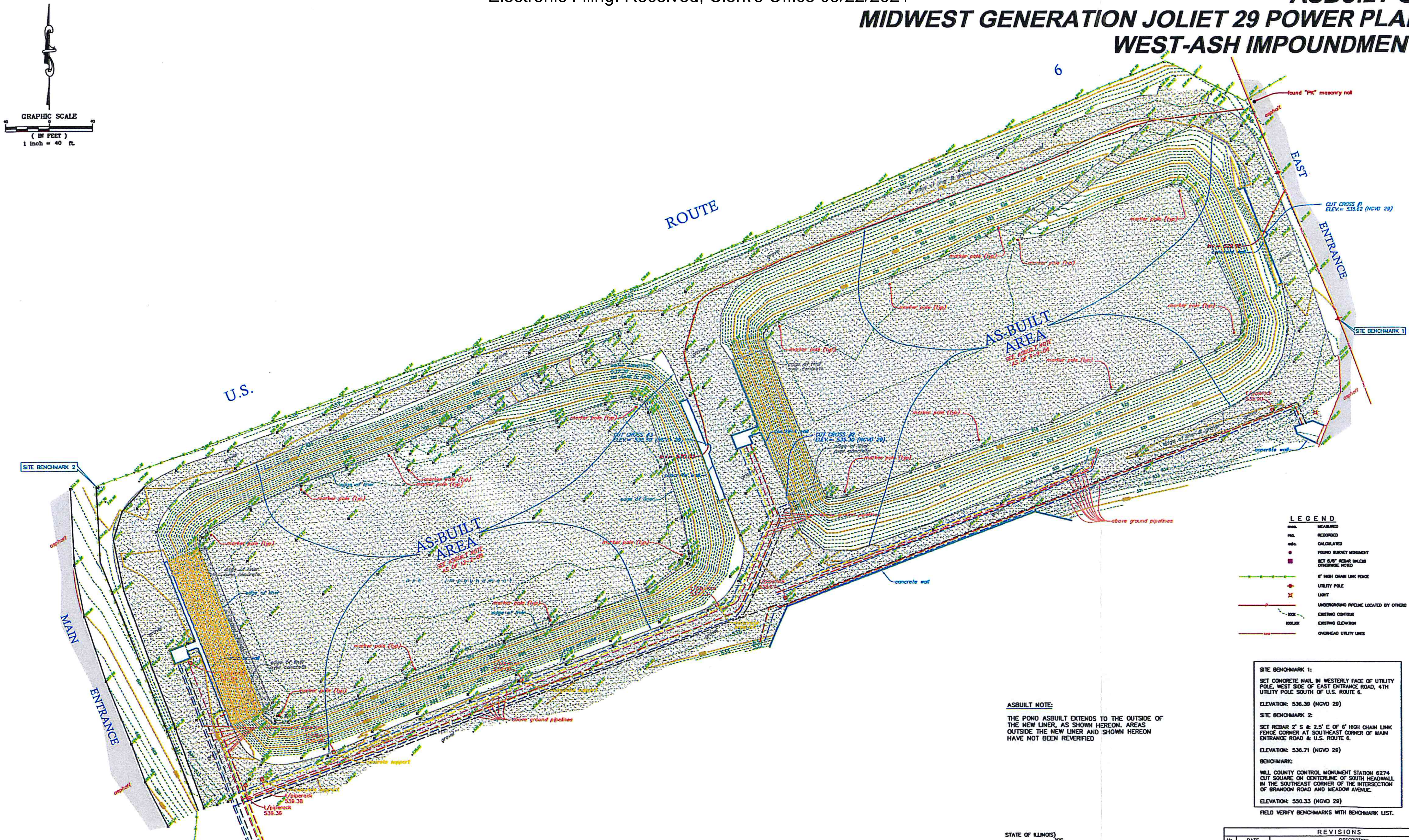
14665 West Lisbon Road, Suite 1A Brookfield, Wisconsin 53005 Telephone 262-781-0475 Facsimile 262-781-0478
414 Plaza Drive, Suite 106 Westmont, Illinois 60559 Telephone 630-325-1300 Facsimile 630-325-1593

SERVICE WATER BASIN PROFILE A-A'	
POWERTON GENERATING STATION PEKIN, ILLINOIS	
Scale: 1" = 60'	Date: February 25, 2021
KPRG Project No. 15020	FIGURE 4

W:\projects\midwest generation\attorney client privilege\pond drawings\bathymetric surveys\sw basin comparison.dwg

EXHIBIT 2

ASBUILT OF MIDWEST GENERATION JOLIET 29 POWER PLANT WEST-ASH IMPOUNDMENTS



ASBUILT NOTE:

THE POND ASBUILT EXTENDS TO THE OUTSIDE OF THE NEW LINER, AS SHOWN HEREON. AREAS OUTSIDE THE NEW LINER AND SHOWN HEREON HAVE NOT BEEN REVERIFIED

LEGEND

mea.	MEASURED
rec.	RECORDED
calc.	CALCULATED
●	FOUND SURVEY MONUMENT
■	SET 5/8" REBAR UNLESS OTHERWISE NOTED
—x—x—x—	6' HIGH CHAIN LINK FENCE
	UTILITY POLE
	LIGHT
——P——	UNDERGROUND PIPELINE LOCATED BY OTHERS
XXX	EXISTING CONTOUR
XXX.XX	EXISTING ELEVATION
——OHU——	OVERHEAD UTILITY LINES

SITE BENCHMARK 1:

SET CONCRETE NAIL IN WESTERLY FACE OF UTILITY POLE, WEST SIDE OF EAST ENTRANCE ROAD, 4TH UTILITY POLE SOUTH OF U.S. ROUTE 6.

ELEVATION: 536.39 (NGVD 29)

SITE BENCHMARK 2:

SET REBAR 2' S & 2.5' E OF 6' HIGH CHAIN LINK FENCE CORNER AT SOUTHEAST CORNER OF MAIN ENTRANCE ROAD & U.S. ROUTE 6.

ELEVATION: 536.71 (NGVD 29)

BENCHMARK:

WILL COUNTY CONTROL MONUMENT STATION 6274 CUT SQUARE ON CENTERLINE OF SOUTH HEADWALL IN THE SOUTHEAST CORNER OF THE INTERSECTION OF BRANDON ROAD AND MEADOW AVENUE.

ELEVATION: 550.33 (NGVD 29)

FIELD VERIFY BENCHMARKS WITH BENCHMARK LIST.

STATE OF ILLINOIS)
)SS
COUNTY OF WILL)

RUETTIGER, TONELLI & ASSOCIATES, INC., ILLINOIS PROFESSIONAL DESIGN FIRM No. 184-001251, HEREBY CERTIFIES THAT IT HAS TOPOGRAPHICALLY SURVEYED THE POND AREA NOTED HEREON AND AS SHOWN ON THE ANNEXED PLAT, WHICH IS A TRUE AND CORRECT REPRESENTATION OF SAID TOPOGRAPHY.

SURVEY FIELD WORK COMPLETED 10/20/08

GIVEN UNDER MY HAND AND SEAL THIS 10th DAY OF MAY, 2008.

BY ______________________

ILLINOIS PROFESSIONAL LAND SURVEYOR (MY LICENSE EXPIRES 11-30-2008)

REVISIONS

No	DATE	DESCRIPTION	BY
1	12/2/08	ADDED NEW ASBUILT INFORMATION	MJ

Ruettiger, Tonelli & Associates, Inc.
Surveyors • Engineers • Planners • Landscape Architects • GIS Consultants
2174 ONEIDA STREET, JOLIET, ILLINOIS 60435, PH. (815) 744-6600 FAX (815) 744-0101
2603 S. WASHINGTON STREET - SUITE 170, NAPERVILLE, ILLINOIS 60565, PH. (630) 420-7740 FAX (630) 420-7741

DATE: 6/9/08	SCALE: 1" = 40'	DRAWN BY: MJ	CHECKED BY: EC

PREPARED FOR: BREISER CONSTRUCTION COMPANY
24101 S. MUNICIPAL DRIVE
CHANNAHON, IL

FIELD BOOK: MIDWEST GEN
PAGE: 11-13

DRAWING No.: 308-0363 ASBUILT WEST-ASH IMP.

DRAWING TITLE: ASBUILT

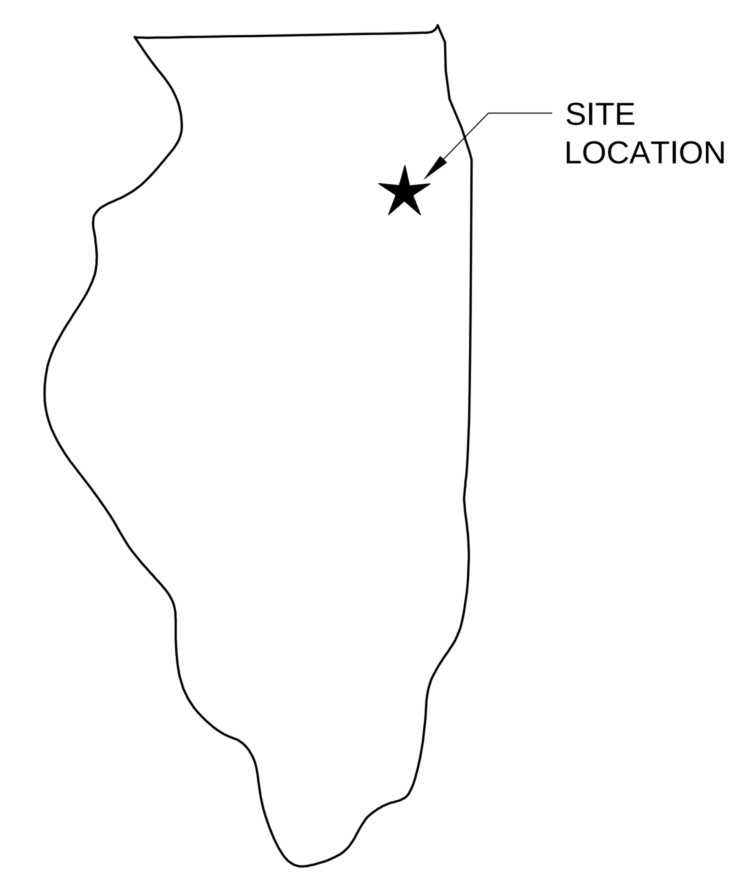
SOUTH POND #3 LINER REPLACEMENT DOCUMENTATION
JOLIET GENERATING STATION NO. 29
MIDWEST GENERATION
JOLIET, ILLINOIS

LIST OF DRAWINGS

SHEET NO.	TITLE	DRAWING NO.
TS	TITLE SHEET	D21133TS-02
C010	PRE-CONSTRUCTION SITE CONDITIONS	D21133C010-02
C020	LINER SUBGRADE PREPARATION	D21133C020-02
C021	GEOMEMBRANE PANEL LAYOUT	D21133C021-00
C030	WARNING LAYER PLAN	D21133C030-02
C031	DETAILS AND SECTIONS	D21133C031-02
C032	DETAILS AND SECTIONS	D21133C032-02

RECORD DRAWING LEGEND

~~PROPOSED~~	CROSSED OUT TEXT INDICATES CHANGES FROM THE FINAL DESIGN TO RECORD CONSTRUCTION
PRE-CONSTRUCTION	UNDERLINED TEXT INDICATES ADDED NOTES OR COMMENTS, AND DOCUMENTS CHANGES FROM THE FINAL DESIGN TO RECORD CONSTRUCTION
	"CLOUDS" DOCUMENT ADDTIONS AND/OR CHANGES FROM THE FINAL DESIGN TO RECORD CONSTRUCTION
X	"CROSS OUTS" DOCUMENT OBJECTS REMOVED FROM THE FINAL DESIGN TO RECORD CONSTRUCTION



ILLINOIS

PREPARED FOR:

MIDWEST GENERATION, LLC
1800 CHANNAHON ROAD
JOLIET, ILLINOIS 60436

JULY 2014

TITLE SHEET

SOUTH POND #3 LINER REPLACEMENT DOCUMENTATION
MIDWEST GENERATION
JOLIET GENERATING STATION NO. 29
JOLIET, ILLINOIS

SHEET NO. TS

PROJECT NO. 2113.3
DRAWN BY: RLH 12/11/12
CHECKED BY: RJG 12/11/12
APPROVED BY: RJB 07/09/14
DRAWING NO. D21133TS-02
REFERENCE: .

NATURAL RESOURCE TECHNOLOGY

REVISION:	DATE:	APP'D BY:
6.		
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2. ISSUED FOR RECORD DOCUMENTATION	07/07/14	RJB
1. ISSUED FOR BID	04/09/13	HMS
0. ISSUED FOR PERMIT	01/03/13	HMS

Jul 14, 2014 9:23am PLOTTED BY: dduda SAVED BY: dduda
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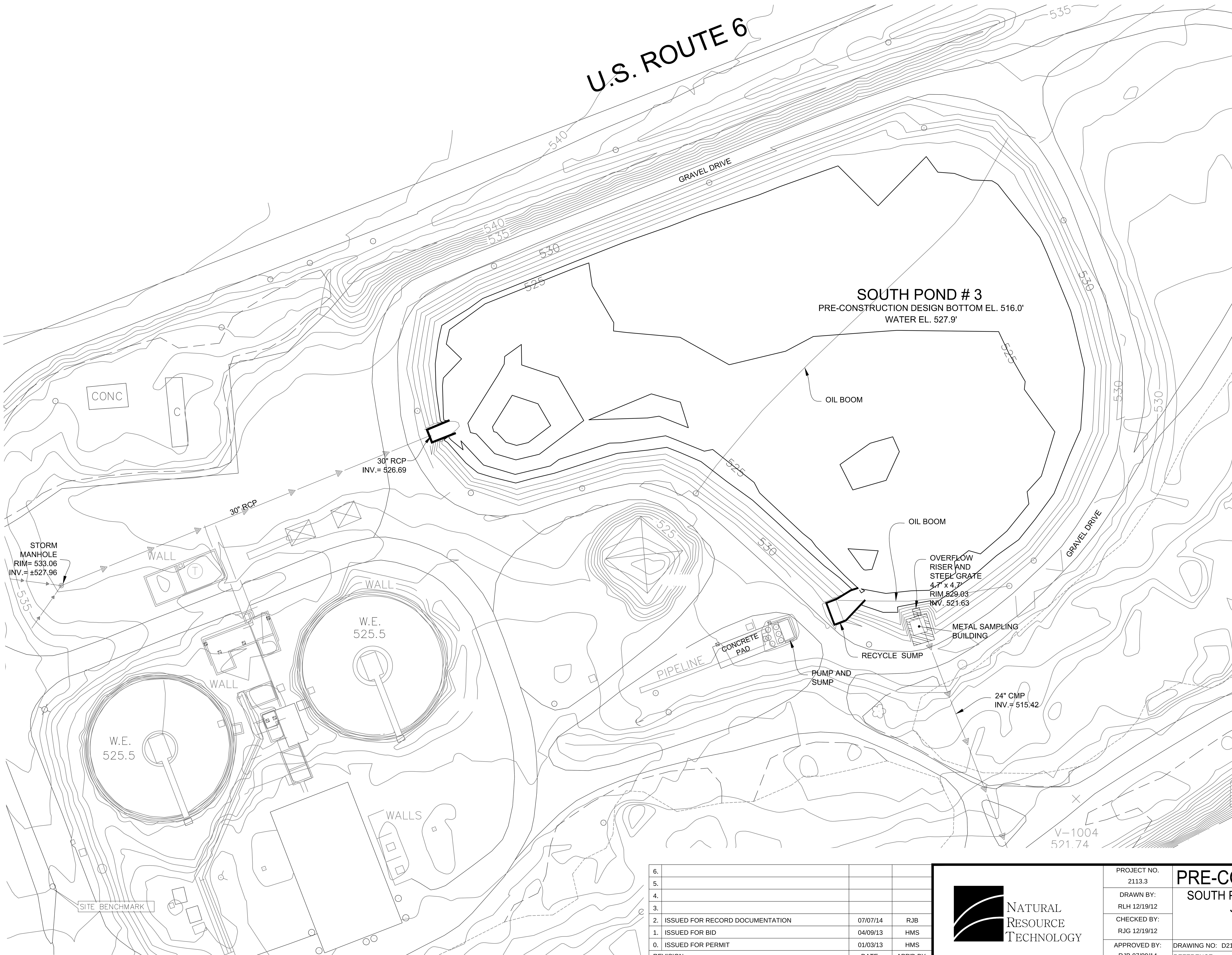

530	PRE-CONSTRUCTION SURFACE CONTOURS
525	TOP OF SEDIMENT
	TRANSMISSION TOWER
	UTILITY POLE
	UNDERGROUND WATER PIPE

NOTES:
1. SITE BENCHMARK 1 IS A NAIL LOCATED ON WESTERLY FACE OF UTILITY POLE, WEST SIDE OF EAST ENTRANCE ROAD, 4TH UTILITY POLE SOUTH OF U.S. ROUTE 6 AT ELEVATION 536.39 FEET (NGVD 29).

CONTRACTOR NOTES: COMPLETED DURING CONSTRUCTION
1. ~~ACCUMULATED ASH, SLUDGE/SEDIMENT, AND DEBRIS TO BE REMOVED FROM BASIN BY OTHERS.~~
2. ~~SURVEY TO BE CONDUCTED BY OTHERS PRIOR TO COMMENCEMENT OF LINER CONSTRUCTION WORK TO CONFIRM SLOPE GRADES.~~

HORIZONTAL DATUM:
ILLINOIS STATE PLANE COORDINATE SYSTEM, EAST ZONE, NAD83 FEET.

SOURCE NOTES:
1. ASH POND SURVEY BY RUETTIGER, TONELLI & ASSOCIATES, INC., DATED 11-13-2012, DRAWING NO.312-1153-E01.
2. TOPOGRAPHIC SURVEY BY AERO-METRIC, INC. DATED 6-19-2008, PROJECT NO. 1080609, PROVIDED BY MIDWEST GENERATION. VERTICAL DATUM: NAVD88

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SCALE IN FEET

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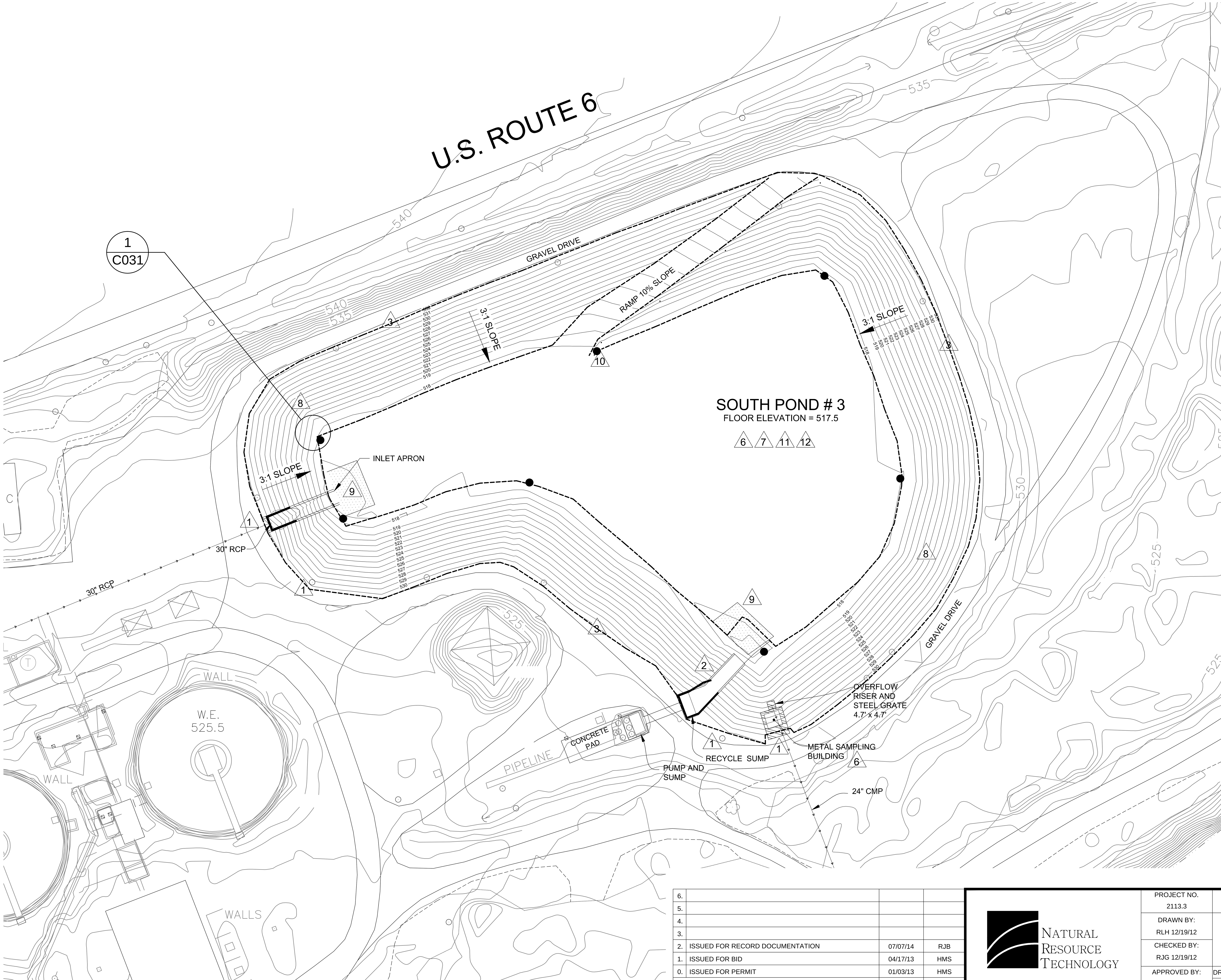
2.	ISSUED FOR RECORD DOCUMENTATION	07/07/14	RJB
1.	ISSUED FOR BID	04/09/13	HMS
0.	ISSUED FOR PERMIT	01/03/13	HMS
REVISION:		DATE:	APP'D BY:

NATURAL RESOURCE TECHNOLOGY

PROJECT NO. 2113.3	PRE-CONSTRUCTION SITE CONDITIONS
DRAWN BY: RLH 12/19/12	SOUTH POND #3 LINER REPLACEMENT DOCUMENTATION JOLIET GENERATING STATION NO. 29 MIDWEST GENERATION JOLIET, ILLINOIS
CHECKED BY: RJG 12/19/12	
APPROVED BY: RJB 07/09/14	DRAWING NO: D21133C010-02 REFERENCE: .
SHEET NO.	C010

Jul 14, 2014 9:24am PLOTTED BY: dduda SAVED BY: dduda
Y:\AAData\Projects\21\2113\21133_Joliet\RECORD DWGS\FINAL 070314\D21133C010-02.dwg C010
IMAGES:
XREFS:



GROUND SURFACE CONTOURS

TRANSMISSION TOWER

UTILITY POLE

UNDERGROUND WATER PIPE

SUBGRADE CONTOURS

MARKER POST LOCATION

POZ-O-PAC REMOVAL AREA

TOE OF SLOPE

CONTRACTOR NOTES: COMPLETED DURING CONSTRUCTION

1. CONTRACTOR SHALL FIELD VERIFY LOCATION OF UNDERGROUND PIPES WITH ASSISTANCE OF OWNER'S UTILITY LOCATOR.
2. CONTRACTOR SHALL FIELD VERIFY LOCATION OF STRUCTURES AND ABOVE GROUND PIPING.
3. CLEAR AND GRUB ALL BRUSH ALONG TOP OF SLOPE OF BASIN.
4. CONTRACTOR SHALL STORE ALL GEOSYNTHETICS AND SUBGRADE MATERIALS IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS.
5. CONTRACTOR SHALL STORE AND STAGE EQUIPMENT AT LOCATION APPROVED BY OWNER.
6. PROTECT ALL CONCRETE AND UTILITY STRUCTURES TO REMAIN IN PLACE THROUGHOUT PROJECT DURATION. METAL SAMPLING BUILDING TO BE TEMPORARILY RELOCATED BY CONTRACTOR.
7. CONTRACTOR SHALL REMOVE AND DISPOSE ALL VEGETATION, ROCKS, SOIL, AND OTHER DEBRIS FROM BASIN SIDE SLOPES IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS.
8. CONTRACTOR SHALL RESHAPE SIDE SLOPES, AS NECESSARY TO MAINTAIN 3:1 SIDE SLOPES, AND REMOVE "SOFT" SUBGRADE MATERIAL AS DIRECTED BY OWNER AND/OR ENGINEER. BACKFILL AREAS WITH RECONSTRUCTED BANK MATERIAL IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS.
9. CONTRACTOR SHALL REMOVE AT LEAST 18" OF POZ-O-PAC LAYER AND SUBGRADE MATERIAL AT BASE OF INLET AND DISCHARGE STRUCTURES. GRADE AN AREA APPROXIMATELY 20' X 30' AT THE BASE OF THE STRUCTURES AT A 1% SLOPE. SEE DETAIL ON SHEET C032.
10. CONTRACTOR SHALL INSTALL MARKER POSTS ALONG THE TOE OF SLOPE AS SHOWN AND IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS AND DETAIL 1 ON SHEET C031.
11. SUBGRADE MUST BE APPROVED BY OWNER AND/OR ENGINEER PRIOR TO INSTALLATION OF GEOMEMBRANE.
12. CONTRACTOR SHALL PROVIDE MEANS TO PROTECT SUBGRADE LAYER FROM EROSION, STORM WATER, AND HEAVY EQUIPMENT TRAFFIC. DAMAGE TO SUBGRADE LAYER SHALL BE REPAIRED AT THE CONTRACTOR'S EXPENSE.

SOURCE NOTES:

1. ASH POND SURVEY BY RUETTIGER, TONELLI & ASSOCIATES, INC., DATED 11-13-12, DRAWING NO.312-1153-E01.
2. TOPOGRAPHIC SURVEY BY AERO-METRIC, INC. DATED 6-19-2008, PROJECT NO. 1080609, PROVIDED BY MIDWEST GENERATION.
3. SOUTH POND #3 SUBGRADE CONTOURS FROM DRAWING NO. 7023PL-AB, BY DLZ INDUSTRIAL, LLC BURNS HARBOR, INDIANA, DATED SEPTEMBER 23, 2013.

HORIZONTAL DATUM:
ILLINOIS STATE PLANE COORDINATE SYSTEM, EAST ZONE, NAD83 FEET.

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SCALE IN FEET

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2.	ISSUED FOR RECORD DOCUMENTATION	07/07/14	RJB
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REVISION:		DATE:	APP'D BY:

NATURAL RESOURCE TECHNOLOGY

PROJECT NO. 2113.3
DRAWN BY: RLH 12/19/12
CHECKED BY: RJG 12/19/12
APPROVED BY: RJB 07/09/14

LINER SUBGRADE PREPARATION

SOUTH POND #3 LINER REPLACEMENT DOCUMENTATION
JOLIET GENERATING STATION NO. 29
MIDWEST GENERATION
JOLIET, ILLINOIS

DRAWING NO: D21133C020-02
REFERENCE: .

SHEET NO. C020

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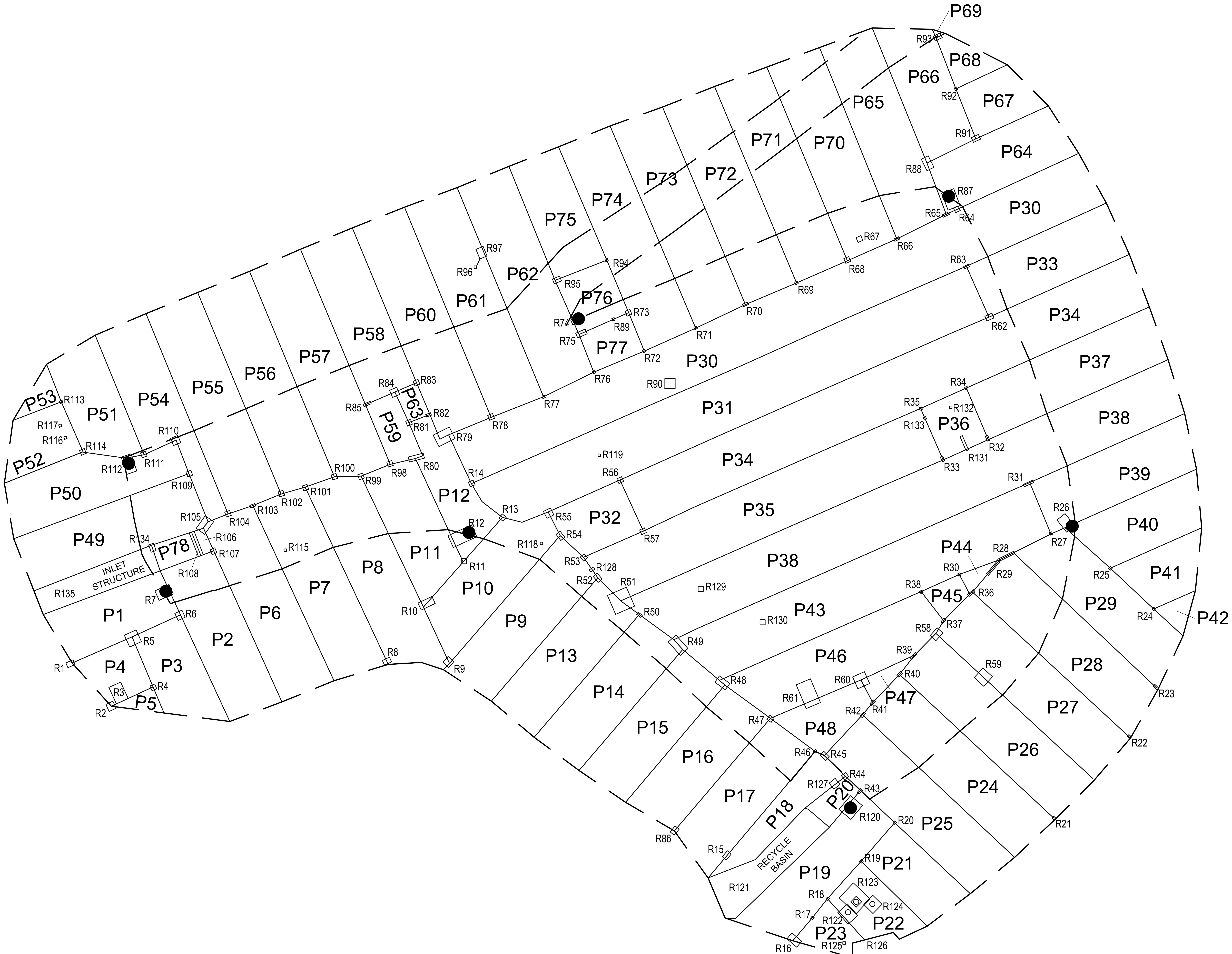


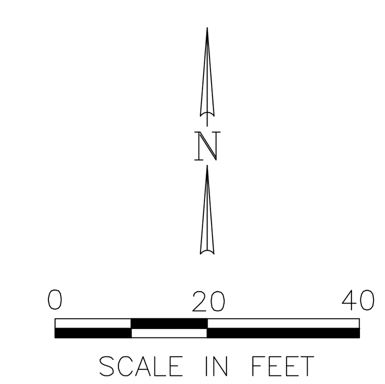
TOE OF SLOPE

GEOMEMBRANE PANEL SEAM

P23 — GEOMEMBRANE PANEL AND PANEL NUMBER

R87 — GEOMEMBRANE REPAIR LOCATION (NOT TO SCALE)

MARKER POST LOCATION



SOURCE NOTES:

1. THIS FIGURE WAS DEVELOPED FROM SURVEY FILE 7023PL-AB.dwg, DATED SEPTEMBER 23, 2013, BY DLZ INDUSTRIAL SURVEYING, INC., JOLIET, ILLINOIS.

REVISION:		DATE:	APP'D BY:
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NATURAL RESOURCE TECHNOLOGY

PROJECT NO. 2113.3

DRAWN BY: RLH 12/03/13

CHECKED BY: RJB 12/03/13

APPROVED BY: RJB 07/09/14

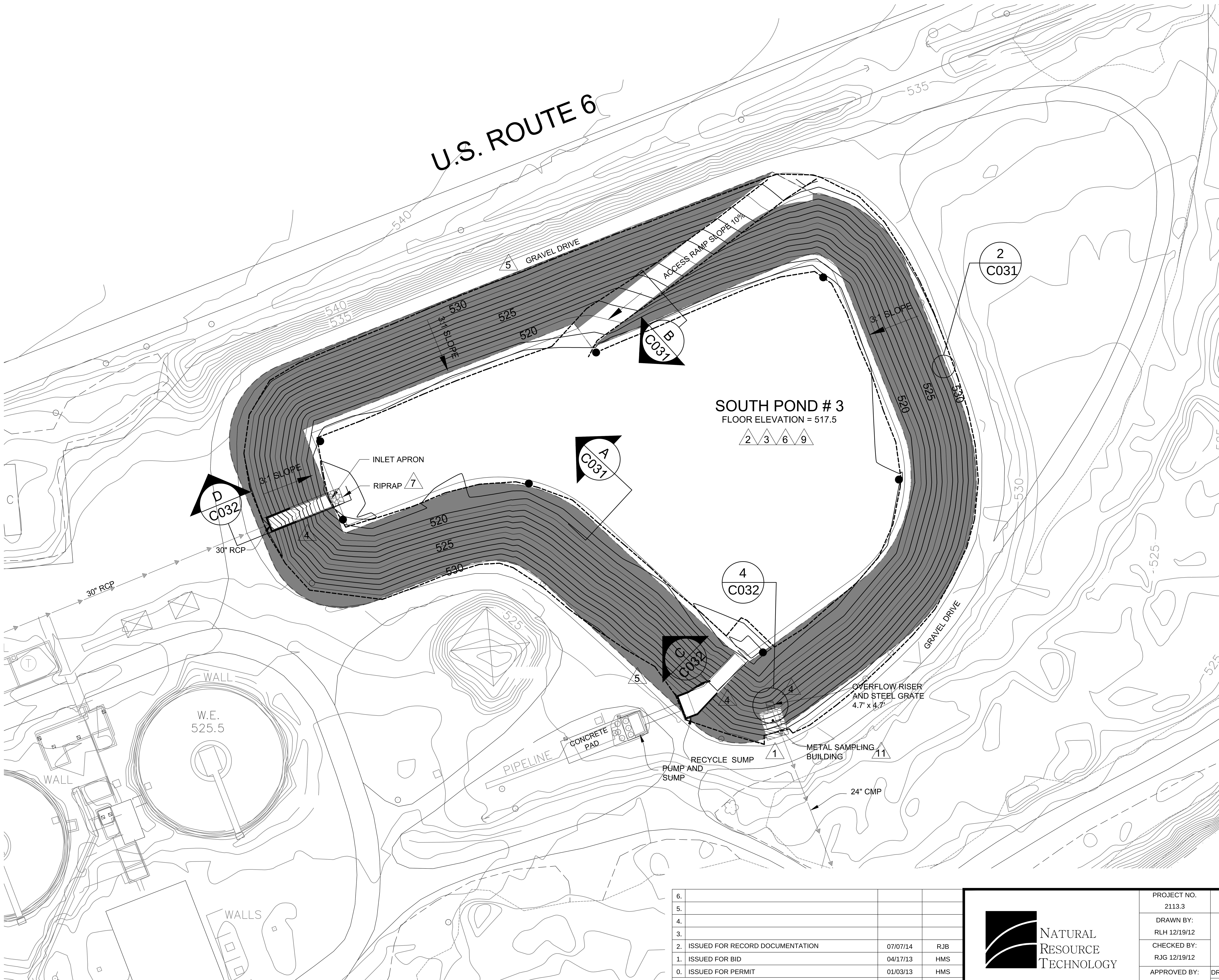
GEOMEMBRANE PANEL LAYOUT

SOUTH POND #3 LINER REPLACEMENT DOCUMENTATION
JOLIET GENERATING STATION NO. 29
MIDWEST GENERATION
JOLIET, ILLINOIS

DRAWING NO: D21133C021-00

REFERENCE: .

SHEET NO. C021



530	GROUND SURFACE CONTOURS
	TRANSMISSION TOWER
	UTILITY POLE
	UNDERGROUND WATER PIPE
520	FINAL ~~DESIGN~~ CONTOURS
	MARKER POST LOCATION
	ANCHOR TRENCH
	16 OZ. NONWOVEN GEOTEXTILE
	EXPOSED HDPE GEOMEMBRANE
	TOE OF SLOPE

CONTRACTOR NOTES: △ COMPLETED DURING CONSTRUCTION

1. PRIOR TO GEOMEMBRANE INSTALLATION CONTRACTOR SHALL DESIGN AND INSTALL FOUR CONCRETE CIRCULAR FOUNDATIONS AND SUPPORT SLAB FOR SAMPLING BUILDING PLATFORM. GEOMEMBRANE SHALL BE ATTACHED TO CIRCULAR FOUNDATION USING A HDPE BOOT IN ACCORDANCE WITH TECHNICAL SPECIFICATIONS AND SHEET C031 AND C032.
2. CONTRACTOR SHALL PLACE 16 OZ. NONWOVEN GEOTEXTILE OVER THE SUBGRADE IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS.
3. CONTRACTOR SHALL INSTALL 60 MIL HDPE, WHITE, TEXTURED GEOMEMBRANE IN ACCORDANCE WITH THE TECHNICAL SPECIFICATION PRIOR TO PLACEMENT OF THE WARNING LAYER. CONTRACTOR SHALL PROVIDE AND FOLLOW AN APPROVED GEOMEMBRANE LAYOUT PLAN.
4. CONTRACTOR SHALL ATTACH GEOMEMBRANE TO STRUCTURES IN ACCORDANCE WITH THE TECHNICAL SPECIFICATION AND DETAILS ON SHEET C031 AND C032.
5. GEOMEMBRANE SHALL BE ANCHORED INTO 2.5 FEET DEEP TRENCHES ALONG TOP OF BANK, AS SHOWN ON SHEET C031. CONTRACTOR SHALL ADVISE OWNER AND/OR ENGINEER IF PROPOSED LOCATION FOR ANCHOR TRENCH IS NOT FEASIBLE.
6. CONTRACTOR SHALL PLACE 16-OZ. NONWOVEN GEOTEXTILE, CUSHION MATERIAL AND WARNING LAYER MATERIAL OVER THE GEOMEMBRANE AT BASE AND 4 FEET ON SIDE SLOPES, AND ALONG PREPARED RAMP SURFACE FOLLOWING ENGINEER APPROVAL AND PASSING QUALITY CONTROL RESULTS IN ACCORDANCE WITH TECHNICAL SPECIFICATIONS (SEE SHEET C031).
7. CONTRACTOR SHALL PLACE AN 18-INCH LAYER OF 4 TO 12 INCH DIAMETER RIPRAP AT THE BASE OF THE INLET APRON FOLLOWING ENGINEER APPROVAL AND PASSING QUALITY CONTROL RESULTS IN ACCORDANCE WITH TECHNICAL SPECIFICATIONS. (SEE SHEET C032)
8. CONTRACTOR SHALL PROVIDE SURVEY DOCUMENTATION OF THE ITEMS LISTED IN THE TECHNICAL SPECIFICATIONS.
9. CONTRACTOR SHALL PERFORM A LEAK LOCATION SURVEY IN ACCORDANCE WITH TECHNICAL SPECIFICATIONS.
10. RESTORE AREAS DISTURBED BY EQUIPMENT AND MATERIAL LAYDOWN.
11. REINSTALL SAMPLING BUILDING AND PLATFORM.

SOURCE NOTES:

1. TOPOGRAPHIC SURVEY BY AERO-METRIC, INC. DATED 6-19-2008, PROJECT NO. 1080609, PROVIDED BY MIDWEST GENERATION.
2. SOUTH POND #3 WARNING LAYER CONTOURS FROM DRAWING NO. 7023PL-AB, BY DLZ INDUSTRIAL, LLC BURNS HARBOR, INDIANA, DATED SEPTEMBER 30, 2013.

HORIZONTAL DATUM:
ILLINOIS STATE PLANE COORDINATE SYSTEM, EAST ZONE, NAD83 FEET.

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SCALE IN FEET

REVISION:		DATE:	APP'D BY:
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2.	ISSUED FOR RECORD DOCUMENTATION	07/07/14	RJB
1.	ISSUED FOR BID	04/17/13	HMS
0.	ISSUED FOR PERMIT	01/03/13	HMS

NATURAL RESOURCE TECHNOLOGY

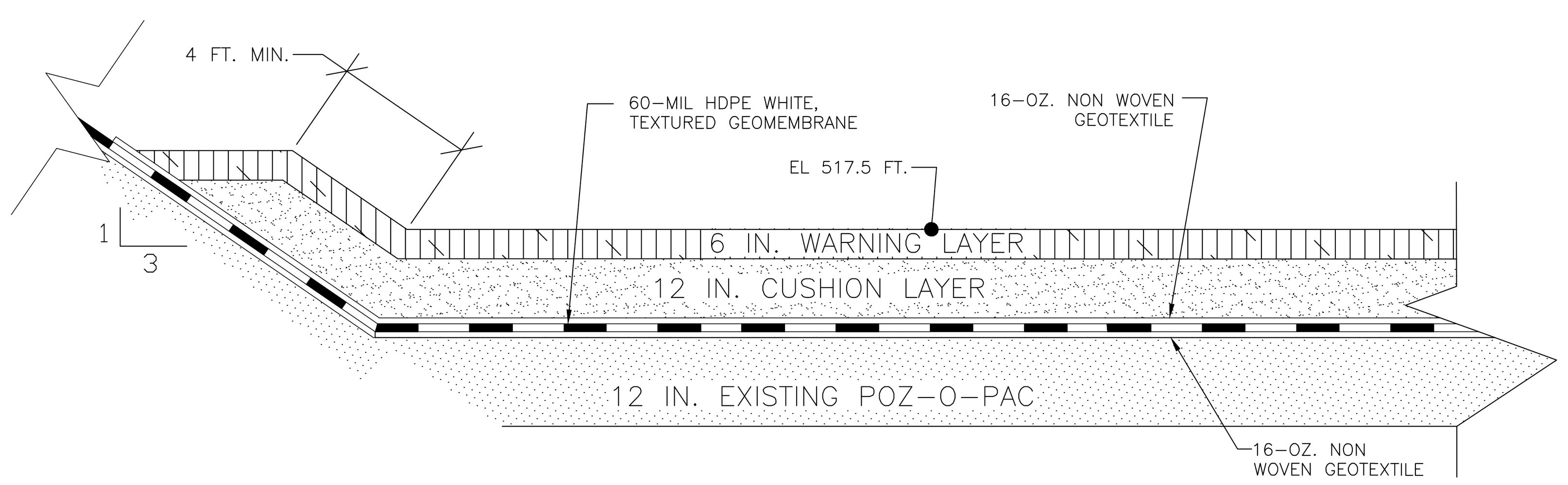
PROJECT NO.	2113.3
DRAWN BY:	RLH 12/19/12
CHECKED BY:	RJG 12/19/12
APPROVED BY:	RJB 07/09/14

WARNING LAYER PLAN

SOUTH POND #3 LINER REPLACEMENT DOCUMENTATION
JOLIET GENERATING STATION NO. 29
MIDWEST GENERATION
JOLIET, ILLINOIS

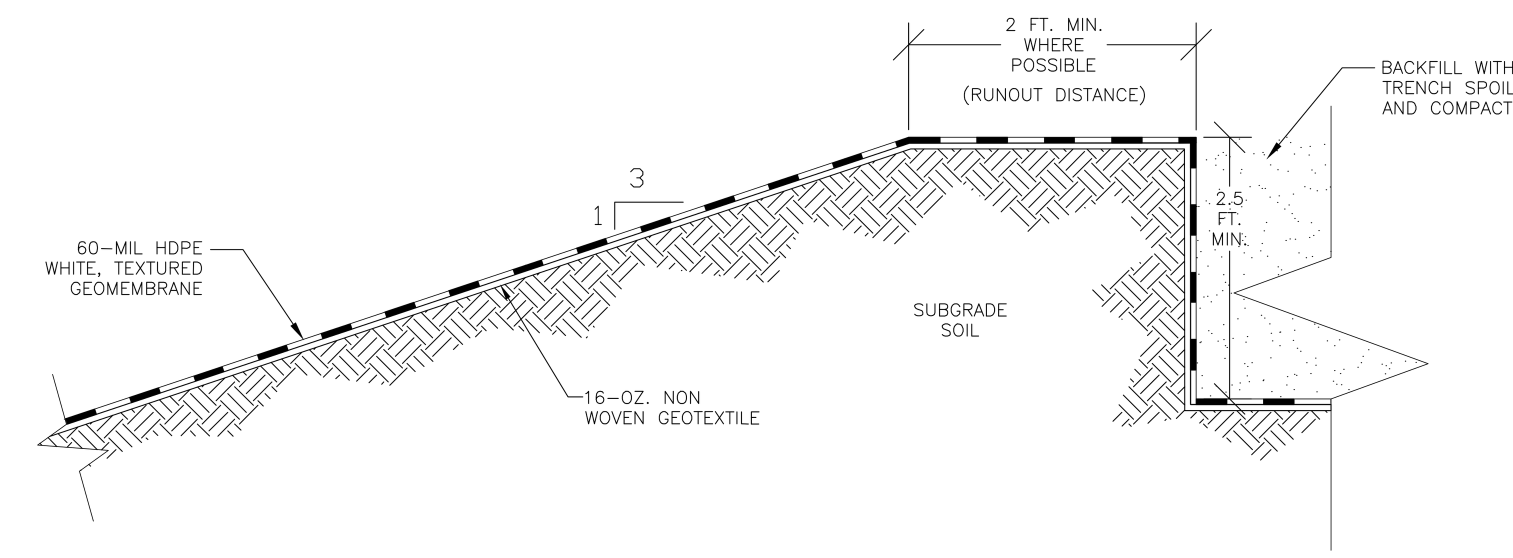
DRAWING NO: D21133C030-02
REFERENCE: .

SHEET NO. C030

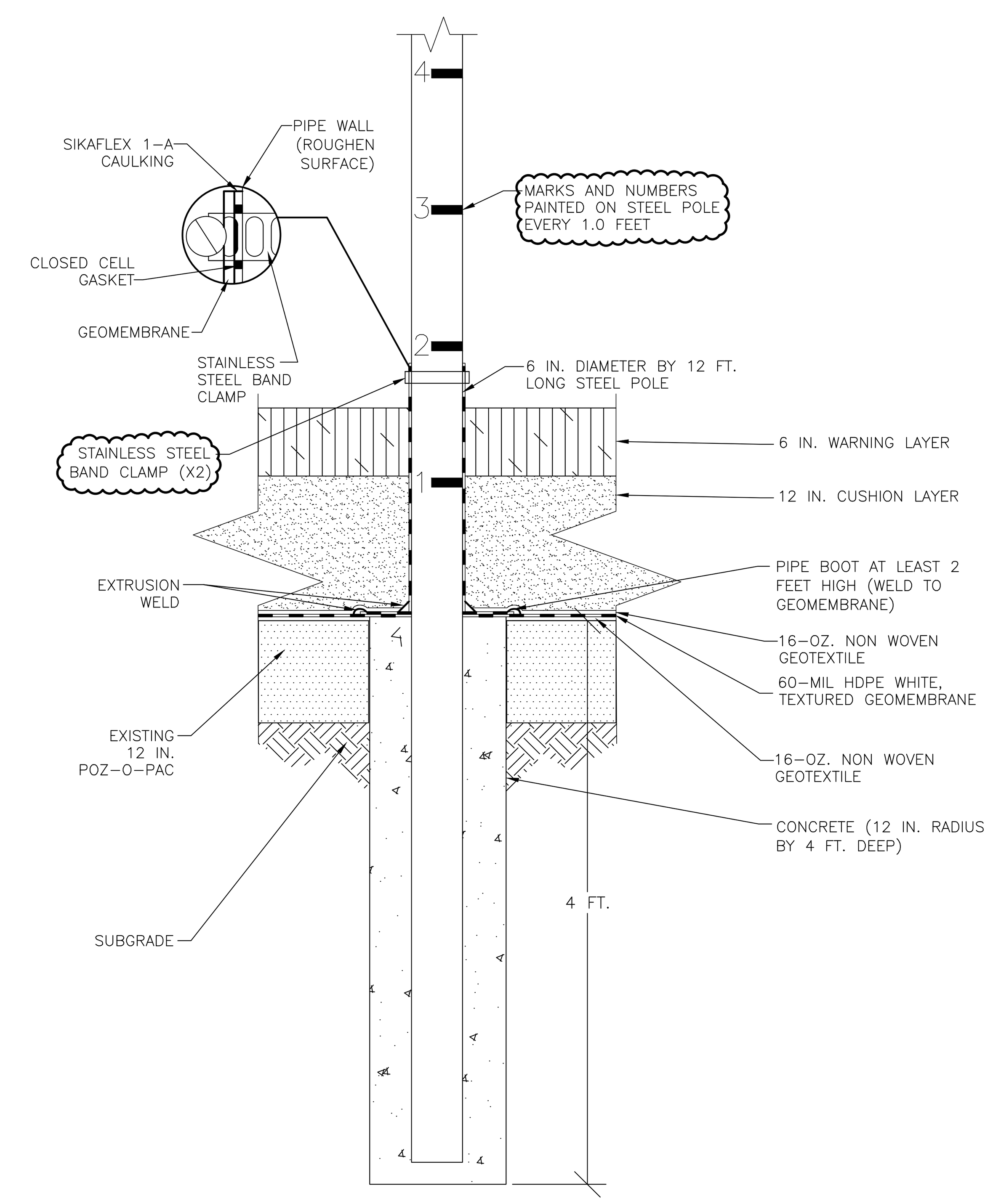


NOTE: COMPLETED DURING CONSTRUCTION
1. GEOMEMBRANE SEAMS SHALL BE PLACED 2 TO 5 FT. FROM TOE OF SLOPE AT A MINIMUM.

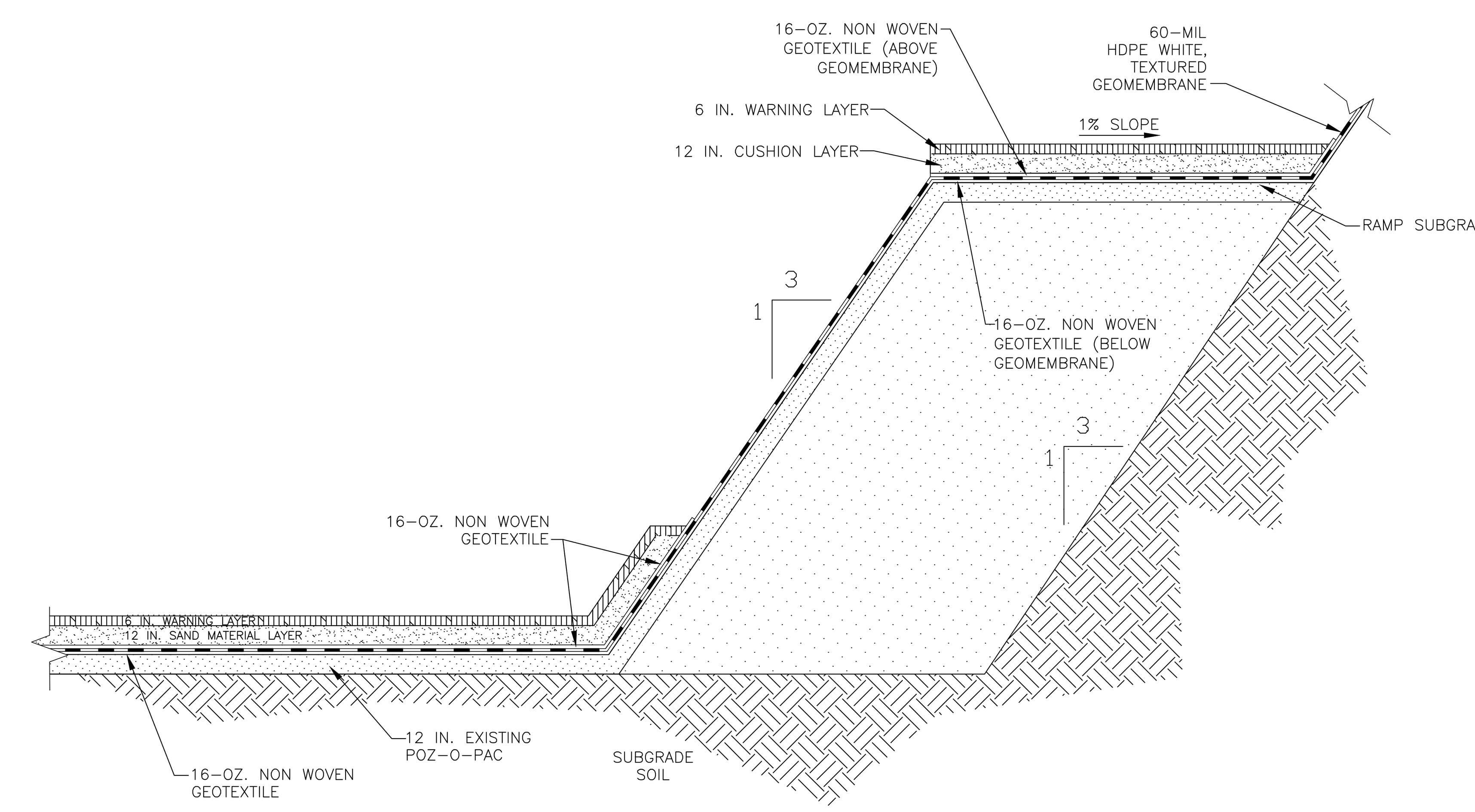
A / C030 SLOPE TRANSITION SECTION
NOT TO SCALE



2 / C030 ANCHOR TRENCH DETAIL
NOT TO SCALE



1 / C020 MARKER POST DETAIL
NOT TO SCALE



B / C030 RAMP SECTION
NOT TO SCALE

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REVISION:		DATE:	APP'D BY:

NATURAL RESOURCE TECHNOLOGY

PROJECT NO. 2113.3	DETAILS AND SECTIONS
DRAWN BY: RLH 12/18/12	SOUTH POND #3 LINER REPLACEMENT DOCUMENTATION
CHECKED BY: RJG 12/18/12	JOLIET GENERATING STATION NO. 29 / MIDWEST GENERATION / JOLIET, ILLINOIS
APPROVED BY: RJB 07/09/14	DRAWING NO: D21133C031-02 / REFERENCE: . / SHEET NO. C031

Jul 14, 2014 9:25am PLOTTED BY: dduda SAVED BY: dduda
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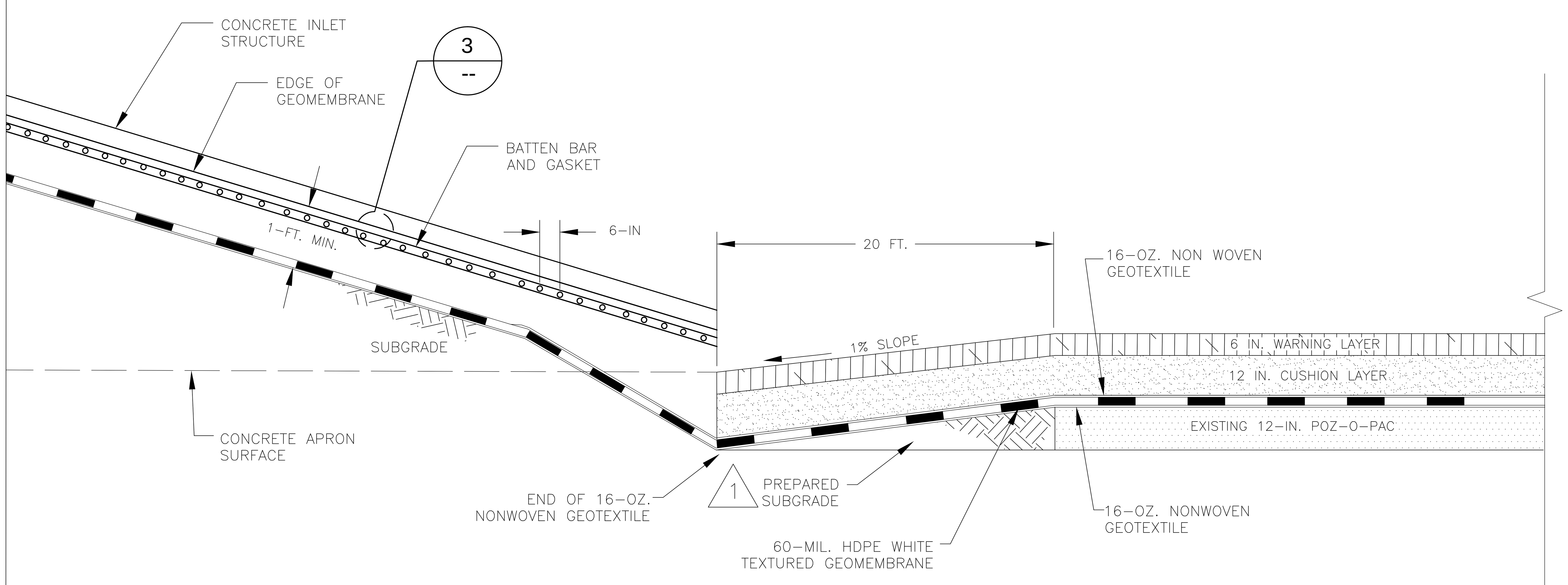
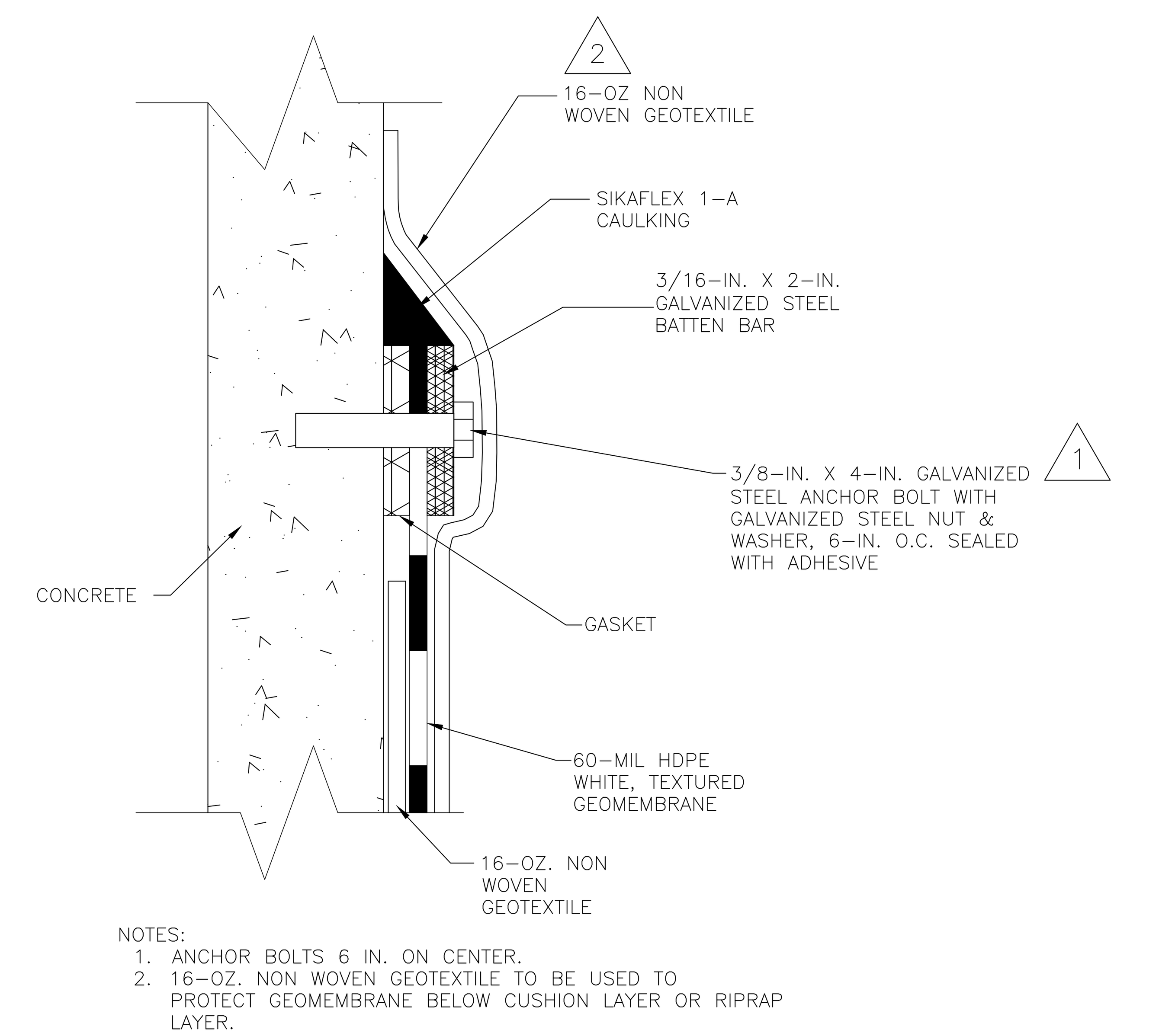


C
C030
CONCRETE RECYCLE SUMP SECTION
NOT TO SCALE



NOTES:
1. ANCHOR BOLTS 6 IN. ON CENTER.
2. 16-OZ. NON WOVEN GEOTEXTILE TO BE USED TO PROTECT GEOMEMBRANE BELOW CUSHION LAYER OR RIPRAP LAYER.

3
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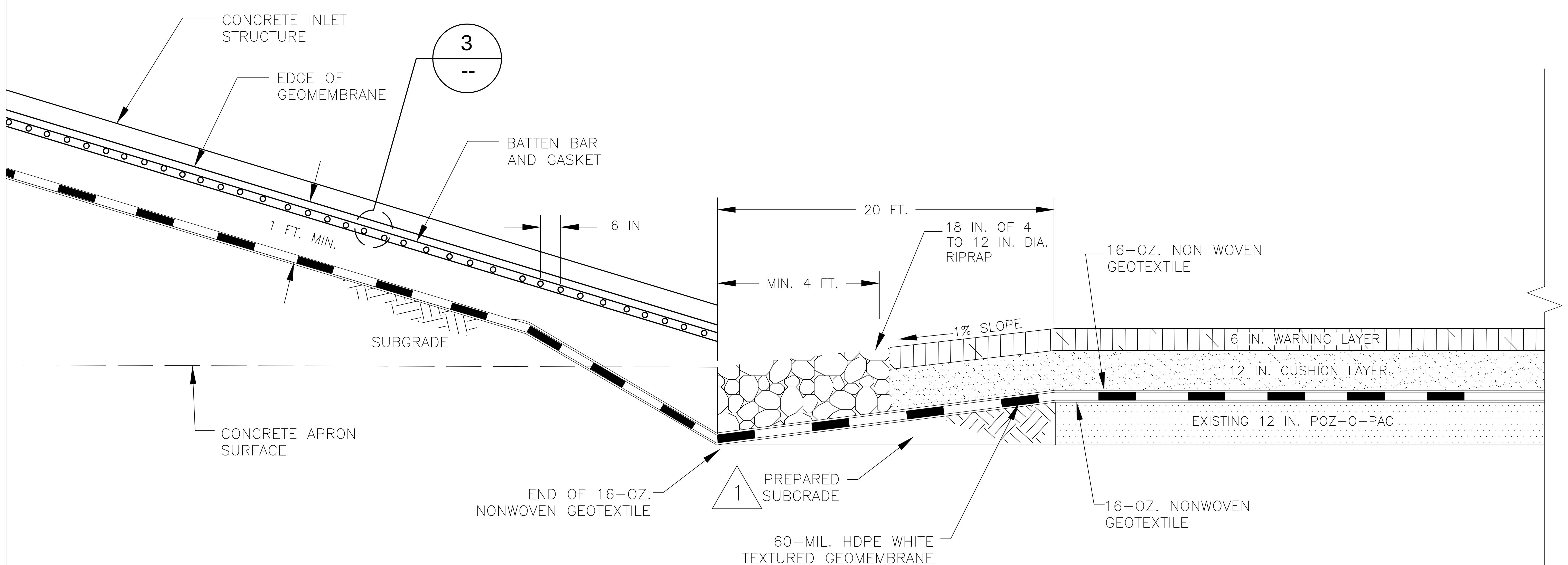
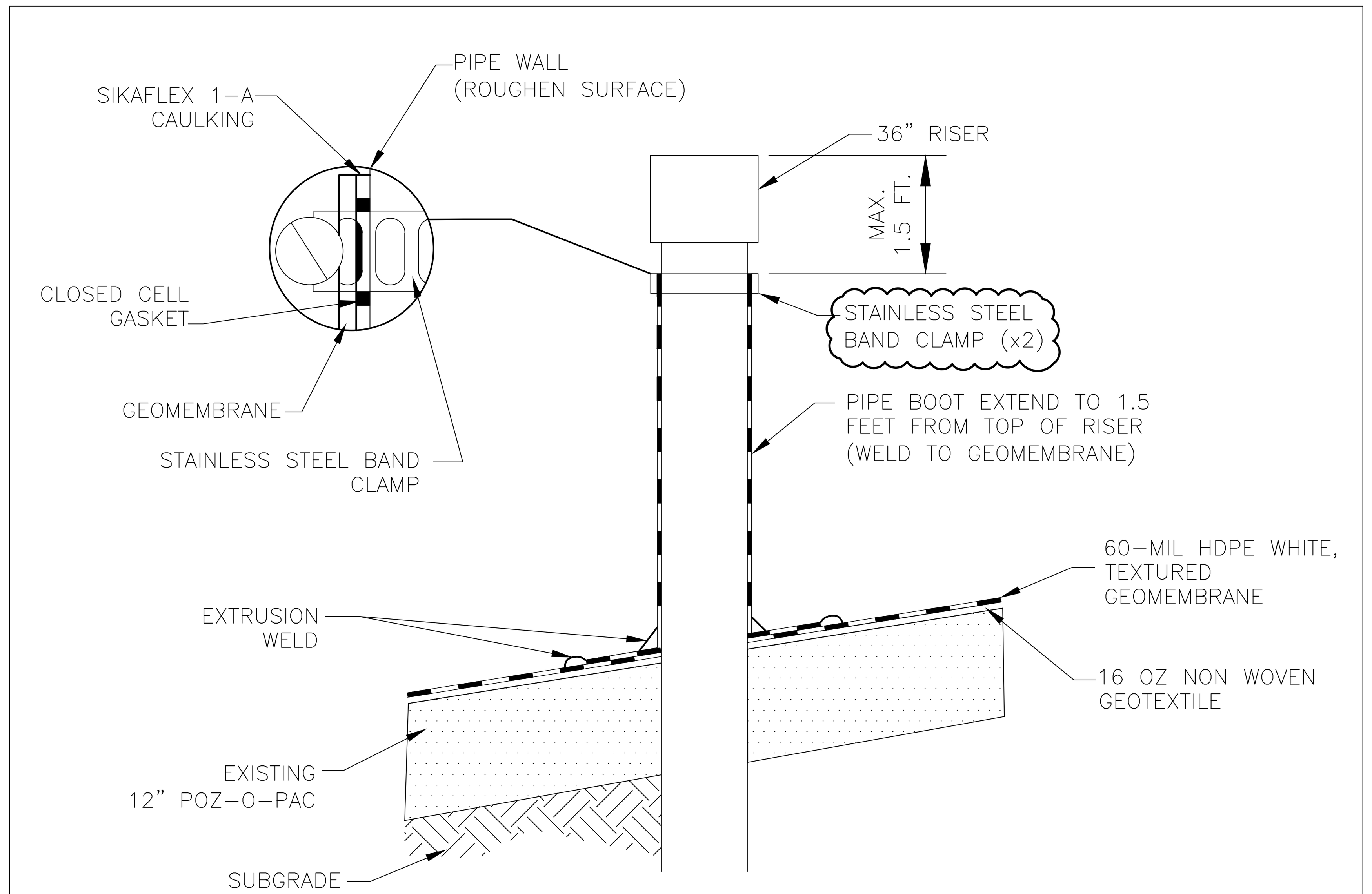
BATTEN BAR ATTACHMENT
NOT TO SCALE



D
C030
CONCRETE INLET SECTION
NOT TO SCALE



4
C030
OVERFLOW RISER DETAIL
NOT TO SCALE

CONTRACTOR NOTES:
1. CONTRACTOR SHALL REMOVE 12 INCH POZ-O-PAC LAYER AND ADDITIONAL 6 INCHES OF SUBGRADE MATERIAL AT BASE OF STRUCTURE. GRADE SUBGRADE AT A 1% SLOPE.

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2.	ISSUED FOR RECORD DOCUMENTATION	07/07/14	RJB
1.	ISSUED FOR BID	04/09/13	HMS
0.	ISSUED FOR PERMIT	01/03/13	HMS
REVISION:		DATE:	APP'D BY:

NATURAL RESOURCE TECHNOLOGY

PROJECT NO. 2113.3
DRAWN BY: RLH 12/13/12
CHECKED BY: RJG 12/13/12
APPROVED BY: RJB 07/09/14

DETAILS AND SECTIONS
SOUTH POND #3 LINER REPLACEMENT DOCUMENTATION
JOLIET GENERATING STATION NO. 29
MIDWEST GENERATION
JOLIET, ILLINOIS

DRAWING NO: 21133C032-02
REFERENCE: .
SHEET NO. C032

Jul 14, 2014 9:25am PLOTTED BY: dduda SAVED BY: dduda
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IMAGES:
XREFS:

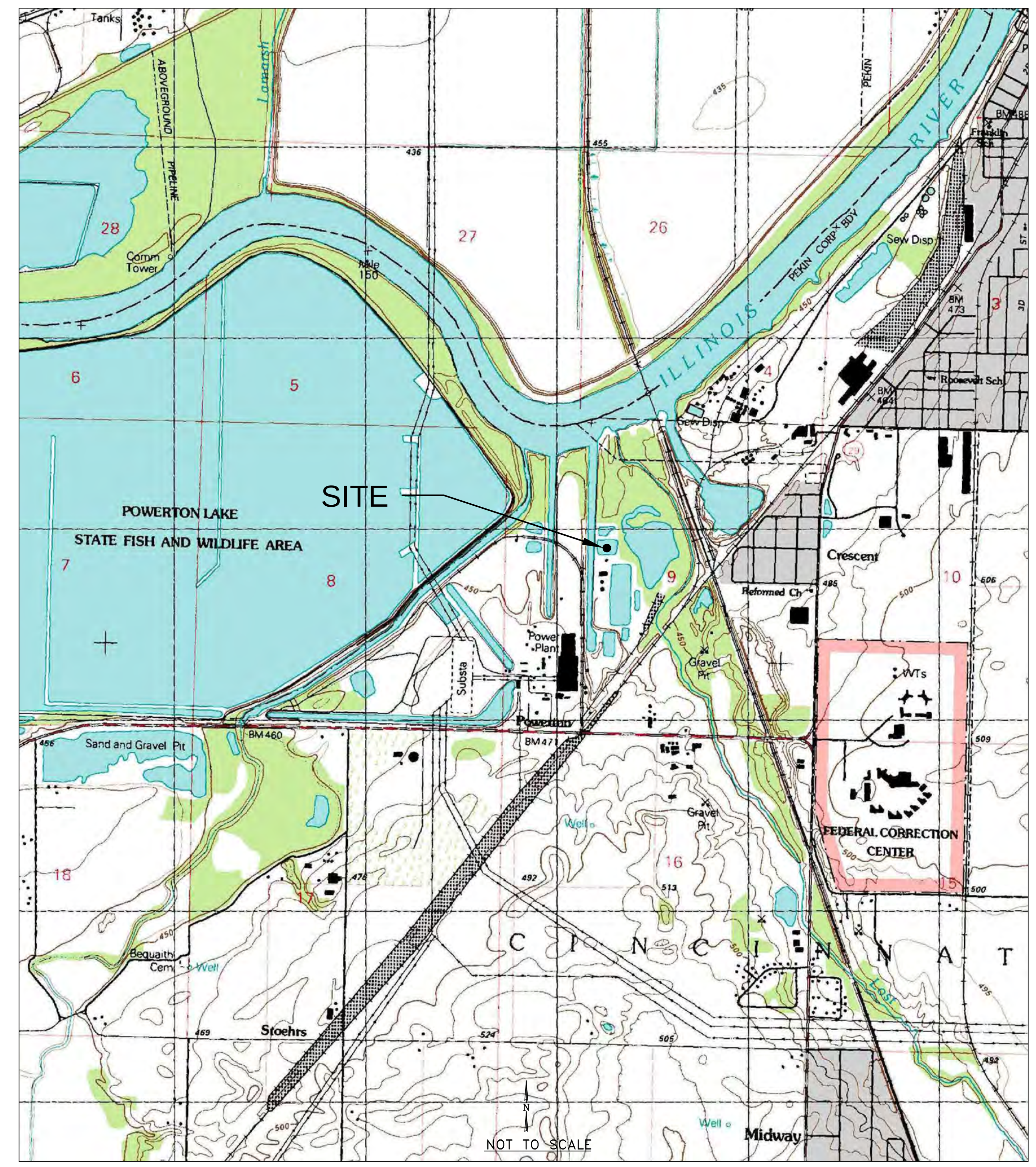
SECONDARY ASH SETTLING BASIN LINER REPLACEMENT
MIDWEST GENERATION
POWERTON POWER STATION
PEKIN, ILLINOIS

LIST OF DRAWINGS

RECORD DRAWING LEGEND

~~PROPOSED~~	CROSSED OUT TEXT INDICATES CHANGES FROM THE FINAL DESIGN TO RECORD REMEDIAL CONSTRUCTION
PRE-CONSTRUCTION	UNDERLINED TEXT INDICATES ADDED NOTES OR COMMENTS, AND DOCUMENTS CHANGES FROM THE FINAL DESIGN TO RECORD REMEDIAL CONSTRUCTION
	"CLOUDS" DOCUMENT ADDITIONS AND/OR CHANGES FROM THE FINAL DESIGN TO RECORD REMEDIAL CONSTRUCTION
X	"CROSS OUTS" DOCUMENT OBJECTS REMOVED FROM THE FINAL DESIGN TO RECORD REMEDIAL CONSTRUCTION

ILLINOIS



SITE LOCATION

PREPARED FOR:
MIDWEST GENERATION POWERTON POWER STATION
13082 EAST MANITO RAOD
PEKIN, IL 61554

JULY 2014

REVISION:		DATE:	APP'D BY:
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2.	ISSUED FOR RECORD DOCUMENTATION	06/27/14	EJT
1.	ISSUED FOR CONSTRUCTION	03/11/13	HMS
0.	ISSUED FOR BID	12/12/12	HMS

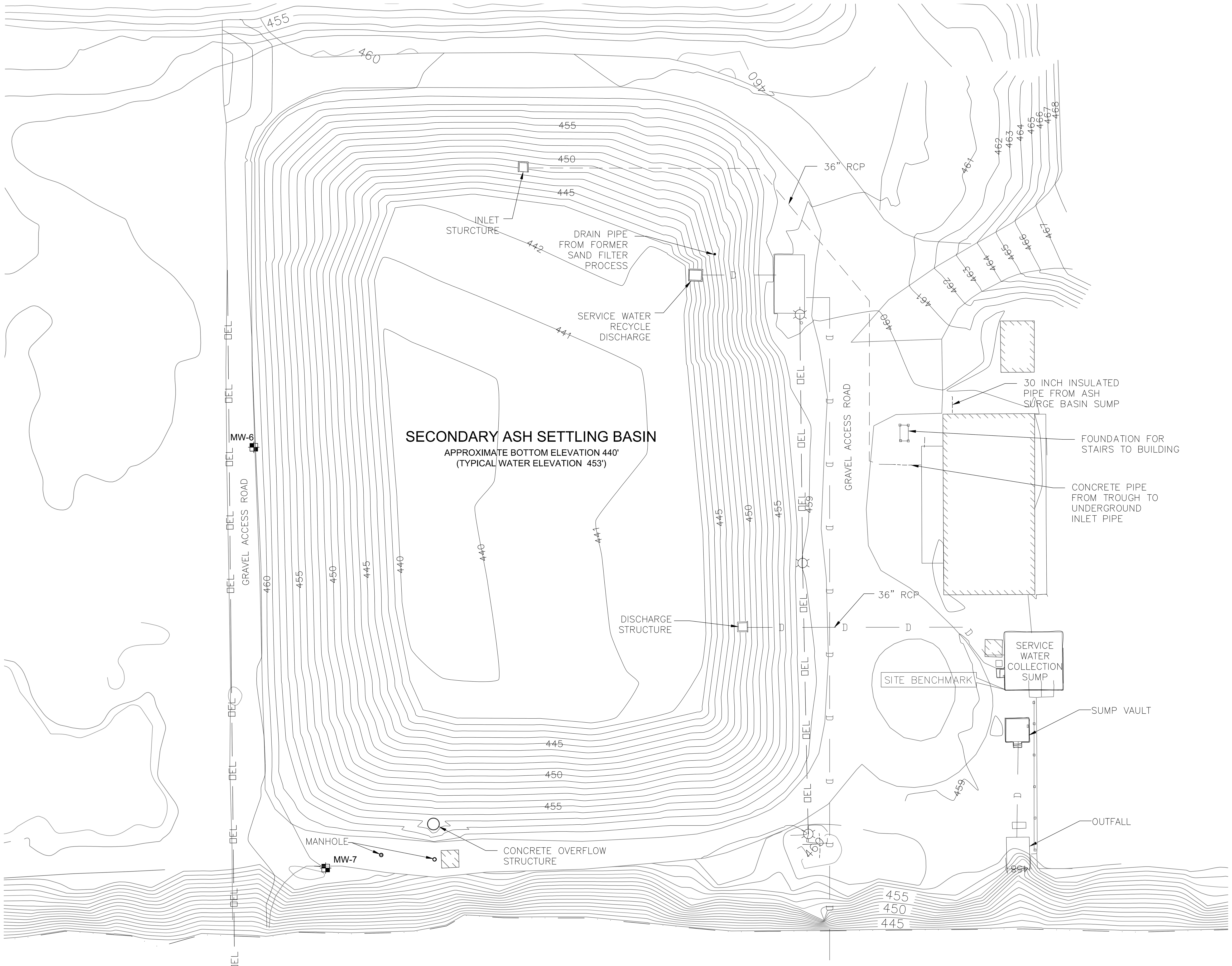
NATURAL RESOURCE TECHNOLOGY

PROJECT NO. 2113.2/3.3
DRAWN BY: RLH 12/06/12
CHECKED BY: JRR 12/06/12
APPROVED BY: HMS 12/12/12

TITLE SHEET
SECONDARY ASH SETTLING BASIN LINER REPLACEMENT
POWERTON POWER STATION
MIDWEST GENERATION
PEKIN, ILLINOIS

DRAWING NO: D21132TS-02
REFERENCE: .

SHEET NO. TS



MW-7	MONITORING WELL LOCATION
—— DEL ——	OVERHEAD ELECTRICAL LINE
—— D ——	UNDERGROUND DISCHARGE PIPE
— — — —	UNDERGROUND INLET PIPE
	ELECTRICAL UTILITY POLE
460	EXISTING GROUND SURFACE CONTOUR
	BUILDING

NOTES:
1. SITE BENCHMARK #401 IS A CHISELED SQUARE AT THE NW CORNER OF SUMP AT ELEVATION 460.65 FEET (NGVD 29).

HORIZONTAL DATUM:
ILLINOIS STATE PLANE COORDINATE SYSTEM, WEST ZONE, NAD83.

VERTICAL DATUM:
LOCAL PLANT DATUM

SOURCE NOTES:
1. SECONDARY ASH SETTLING BASIN CONTOURS, LOCATION OF BASIN PIPES AND STRUCTURES, AND SURROUNDING AREA DETAILS TAKEN FROM A SURVEY BY MAURER-STUTZ, INC., NOVEMBER 28, 2012.
2. OTHER DETAILS TAKEN FROM A SURVEY BY AERO-METRIC, INC. DATED 6-19-2008, PROJECT NO. 1080611, PROVIDED BY MIDWEST GENERATION.

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SCALE IN FEET

REVISION:		DATE:	APP'D BY:
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3.	ISSUED FOR FINAL DOCUMENTATION	06/27/14	EJT
2.	ISSUED FOR CONSTRUCTION	03/12/13	HMS
1.	ISSUED FOR BID	12/12/12	HMS
0.	ISSUED FOR PERMIT	12/22/09	HMS

NATURAL RESOURCE TECHNOLOGY

PROJECT NO. 2113.2/3.3	
DRAWN BY: KNW 11/18/09	
CHECKED BY: RJG 11/18/09	
APPROVED BY: HMS 12/22/09	

PRECONSTRUCTION CONDITIONS
SECONDARY ASH SETTLING BASIN LINER REPLACEMENT
POWERTON POWER STATION
MIDWEST GENERATION
PEKIN, ILLINOIS

DRAWING NO: D21132C010-03
REFERENCE: .
SHEET NO. C010

Jul 21, 2014 12:33pm PLOTTED BY: dduda SAVED BY: dduda
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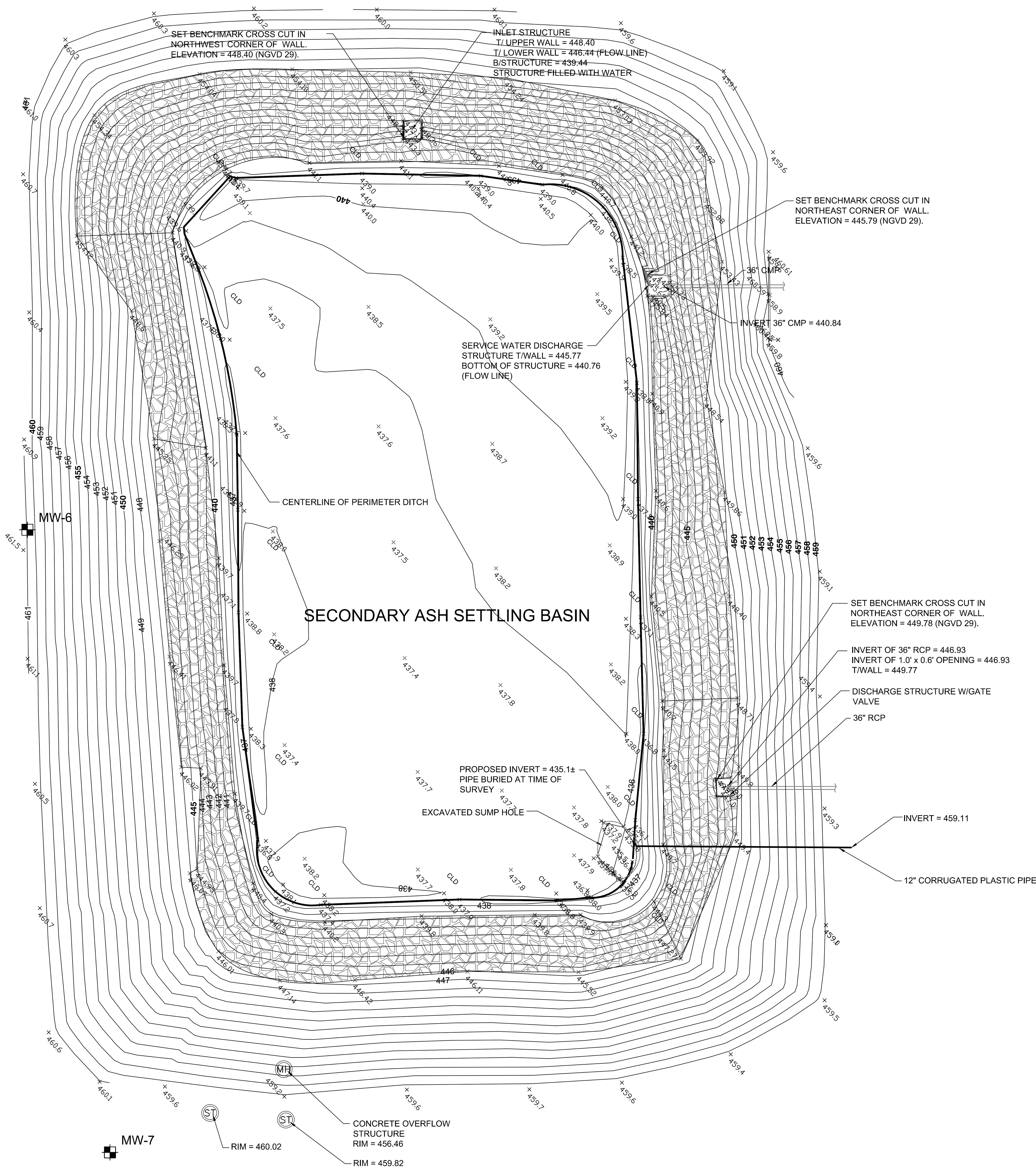
IMAGES:
XREFS:

465	SUBGRADE SURFACE CONTOUR
	RIPRAP
	MONITORING WELL LOCATION
MH	MANHOLE
ST	STORM MANHOLE



SOURCE NOTES:

1. SUBGRADE CONTOURS AND FEATURE LOCATIONS FROM SURVEY BY RIDGELINE CONSULTANTS, PROJECT NUMBER 2013-0099, DATED MAY 28, 2013, PROVIDED BY TERRA CONTRACTING SERVICES, LLC

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0.	ISSUED FOR RECORD DOCUMENTATION	07/21/14	EJT
REVISION:		DATE:	APP'D BY:

NATURAL RESOURCE TECHNOLOGY

PROJECT NO. 2113.2/3.3	UNDERDRAIN SUBGRADE ELEVATIONS
DRAWN BY: DMD 06/27/14	SECONDARY ASH SETTLING BASIN LINER REPLACEMENT
CHECKED BY: EJT 07/17/14	POWERTON POWER STATION MIDWEST GENERATION PEKIN, ILLINOIS
APPROVED BY: EJT 07/21/14	DRAWING NO: D21132C015-00 REFERENCE: .
SHEET NO.	C015

Jul 21, 2014 12:31pm PLOTTED BY: dduda SAVED BY: dduda
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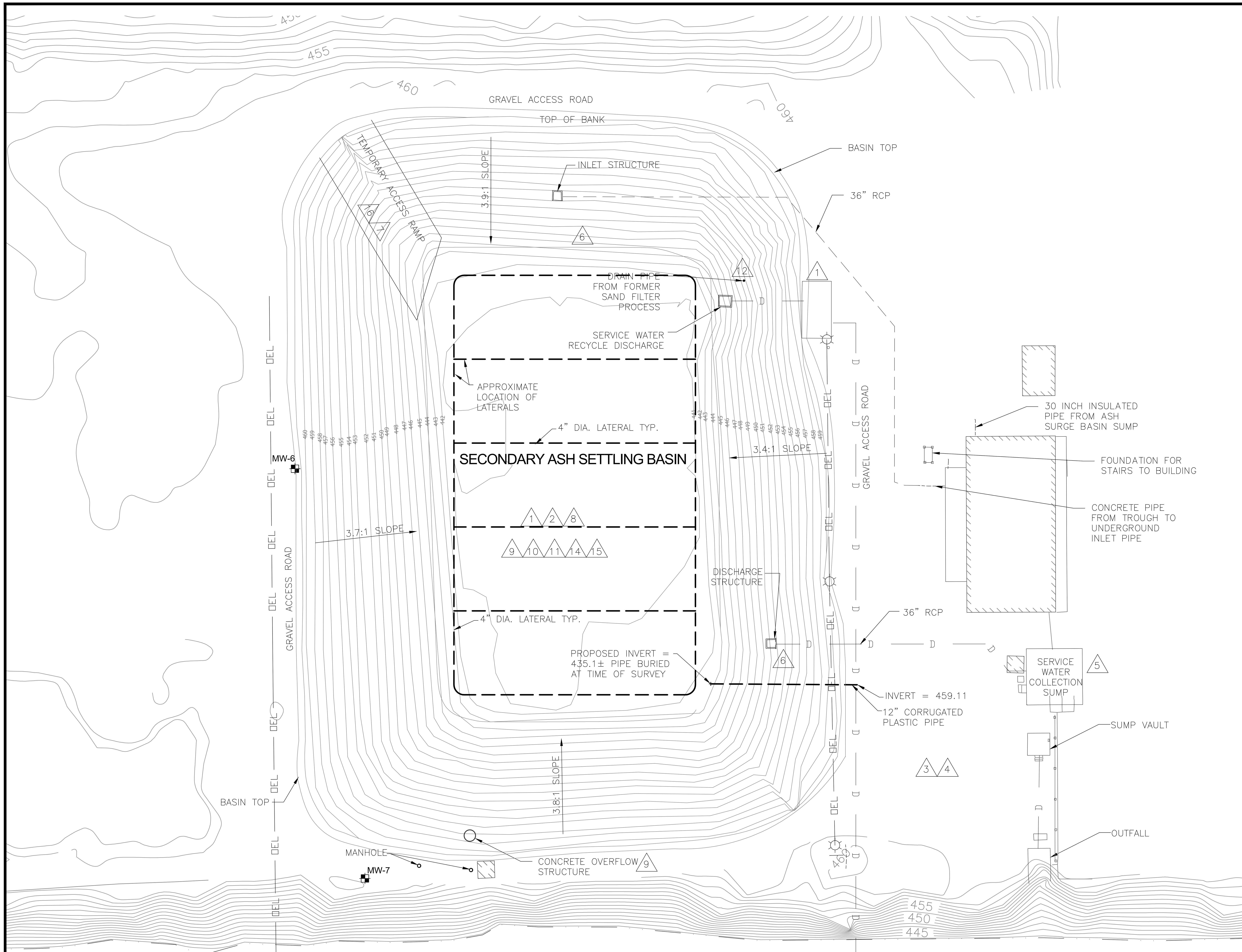
XREFS:



458	SUBGRADE SURFACE CONTOUR
MW-7	MONITORING WELL LOCATION
	UNDERDRAIN PIPE
D	UNDERGROUND DISCHARGE PIPE
	UNDERGROUND INLET PIPE
DEL	OVERHEAD ELECTRICAL LINE
	ELECTRICAL UTILITY POLE
460	~~EXISTING~~ PREVIOUS GROUND SURFACE CONTOUR
	BUILDING

CONTRACTOR NOTES: △ COMPLETED DURING CONSTRUCTION

1. CONTRACTOR SHALL FIELD VERIFY LOCATION OF UNDERGROUND PIPES WITH ASSISTANCE OF OWNER'S UTILITY LOCATOR.
2. CONTRACTOR SHALL FIELD VERIFY LOCATION OF CONCRETE STRUCTURES AND ABOVE GROUND PIPING.
3. CONTRACTOR SHALL STORE ALL GEOSYNTHETICS AND SUBGRADE MATERIALS IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS.
4. CONTRACTOR SHALL STORE AND STAGE EQUIPMENT AT LOCATION APPROVED BY OWNER AND/OR ENGINEER.
5. CONTRACTOR SHALL DESIGN, INSTALL, AND OPERATE A PUMP SYSTEM TO CONVEY WATER FROM ASH SURGE BASIN TO THE SERVICE WATER COLLECTION SUMP TO BYPASS FLOW FROM THE SECONDARY ASH SETTLING BASIN. MAINTAIN OPERATION OF SYSTEM THROUGHOUT PROJECT DURATION.
6. CONTRACTOR SHALL TEMPORARILY PLUG THE SECONDARY ASH BASIN INLET AND OUTLET PIPES AS PART OF BYPASS FLOW SYSTEM. REMOVE PLUGS AT PROJECT COMPLETION.
7. CONTRACTOR SHALL CONSTRUCT A TEMPORARY ACCESS RAMP AT A MINIMUM 6H:1V SLOPE, IF NEEDED.
8. CONTRACTOR SHALL CLEAR AND GRUB ALL BRUSH ALONG TOP OF SLOPE OF BASIN.
9. CONTRACTOR SHALL PROTECT ALL CONCRETE AND UTILITY STRUCTURES THROUGHOUT PROJECT DURATION.
10. CONTRACTOR SHALL REMOVE ALL ACCUMULATED ASH AND SEDIMENT AT BASE OF BASIN AND ALL VEGETATION, ROCKS, AND OTHER DEBRIS FROM EXISTING LINER AND DISPOSE OF IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS. APPROXIMATELY 4 FEET OF ASH SEDIMENT, AND SLUDGE ALONG BOTTOM OF BASIN IS ANTICIPATED.
11. CONTRACTOR SHALL REMOVE EXISTING HYPALON LINER AND DISPOSE OF IT OFFSITE.
12. CONTRACTOR SHALL CUT AND PERMANENTLY CAP PIPE. PIPE SHALL BE CUT SO THAT A MINIMUM OF 4 TO 6 INCHES OF SUBGRADE IS IN PLACE BETWEEN PIPE AND SLOPE SURFACE.
13. CONTRACTOR SHALL REMOVE UNSUITABLE EXISTING SUBGRADE MATERIAL AND TRANSPORT MATERIAL TO ONSITE LOCATION DESIGNATED BY OWNER AND/OR ENGINEER. PLACE AND COMPACT AREAS WITH CUSHION MATERIAL AND REGRADE TO 3H:1V SLOPE IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS. CONTRACTOR SHALL PROVIDED ENGINEER WITH COMPACTION TEST RESULTS AT LEAST TWO DAYS PRIOR TO FINAL SUBGRADE INSPECTION IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS.
14. SUBGRADE SHALL BE APPROVED BY OWNER AND/OR ENGINEER PRIOR TO INSTALLATION OF GEOMEMBRANE.
15. CONTRACTOR SHALL PROVIDE MEANS TO PROTECT SUBGRADE FROM EROSION, STORM WATER, AND HEAVY EQUIPMENT TRAFFIC. DAMAGE TO SUBGRADE SHALL BE REPAIRED AT THE CONTRACTOR'S EXPENSE.
16. IF CONSTRUCTED CONTRACTOR SHALL REMOVE TEMPORARY ACCESS RAMP ONCE SUBGRADE IS COMPLETE AND APPROVED.

HORIZONTAL DATUM:
ILLINOIS STATE PLANE COORDINATE SYSTEM, WEST ZONE, NAD83.

VERTICAL DATUM:
LOCAL PLANT DATUM

SOURCE NOTES:

1. ~~SECONDARY ASH SETTLING BASIN CONTOURS,~~ LOCATION OF BASIN PIPES AND STRUCTURES, AND SURROUNDING AREA DETAILS TAKEN FROM A SURVEY BY MAURER-STUTZ, INC., NOVEMBER 28, 2012.
2. OTHER DETAILS TAKEN FROM A SURVEY BY AERO-METRIC, INC. DATED 6-19-2008, PROJECT NO. 1080611, PROVIDED BY MIDWEST GENERATION.
3. SUBGRADE CONTOURS SURVEYED BY RIDGELINE CONSULTANTS, PROJECT NUMBER 2013-0099, DATED JUNE 14, 2013, PROVIDED BY TERRA CONTRACTING SERVICES, LLC
4. UNDERDRAIN LATERALS FROM DESIGN SKETCH PROVIDED BY MIDWEST GENERATION.

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3.	ISSUED FOR RECORD DOCUMENTATION	07/21/14	EJT
2.	ISSUED FOR CONSTRUCTION	03/12/13	HMS
1.	ISSUED FOR BID	12/12/12	HMS
0.	ISSUED FOR PERMIT	12/22/09	HMS

NATURAL RESOURCE TECHNOLOGY

PROJECT NO.	2113.2/3.3
DRAWN BY:	RLH 11/18/09
CHECKED BY:	RJG 11/18/09
APPROVED BY:	HMS 12/22/09

LINER SUBGRADE PREPARATION

SECONDARY ASH SETTLING BASIN LINER REPLACEMENT
POWERTON POWER STATION
MIDWEST GENERATION
PEKIN, ILLINOIS

DRAWING NO: D21132C020-03
REFERENCE: .

SHEET NO. C020

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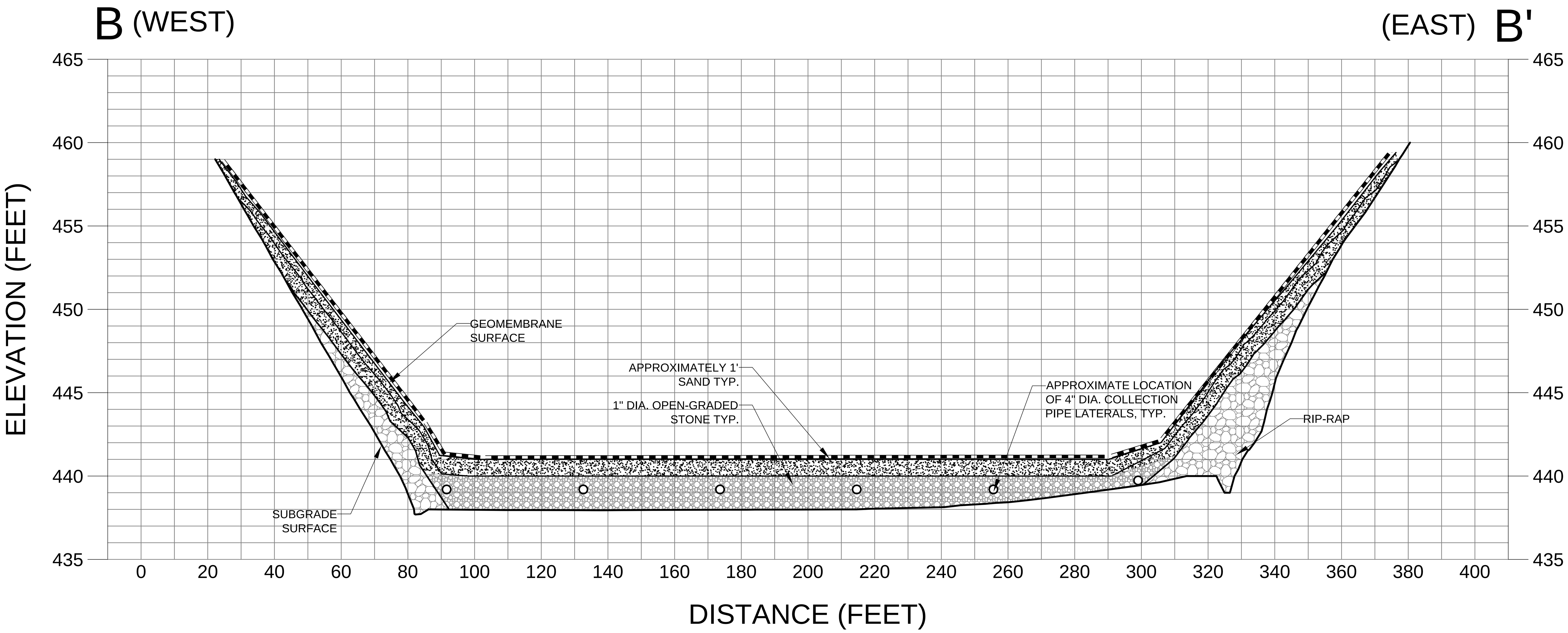
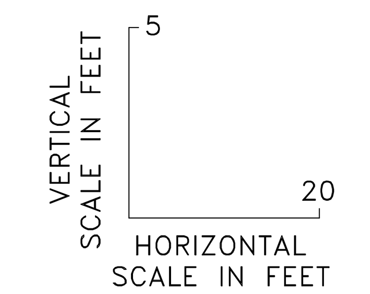


SOURCE NOTES:

1. UNDERDRAIN AND GEOMEMBRANE SUBGRADE ELEVATIONS SURVEYED BY RIDGELINE CONSULTANTS, PROJECT NUMBER - 2013-0099, MAY 23, 2013 (UNDERDRAIN SUBGRADE) AND JUNE 14, 2013 (GEOMEMBRANE SUBGRADE), PROVIDED BY TERRA CONTRACTING SERVICES, LLC.
2. UNDERDRAIN LATERALS AND BEDDING FROM DESIGN SKETCH PROVIDED BY MIDWEST GENERATION. ELEVATIONS ARE APPROXIMATE.



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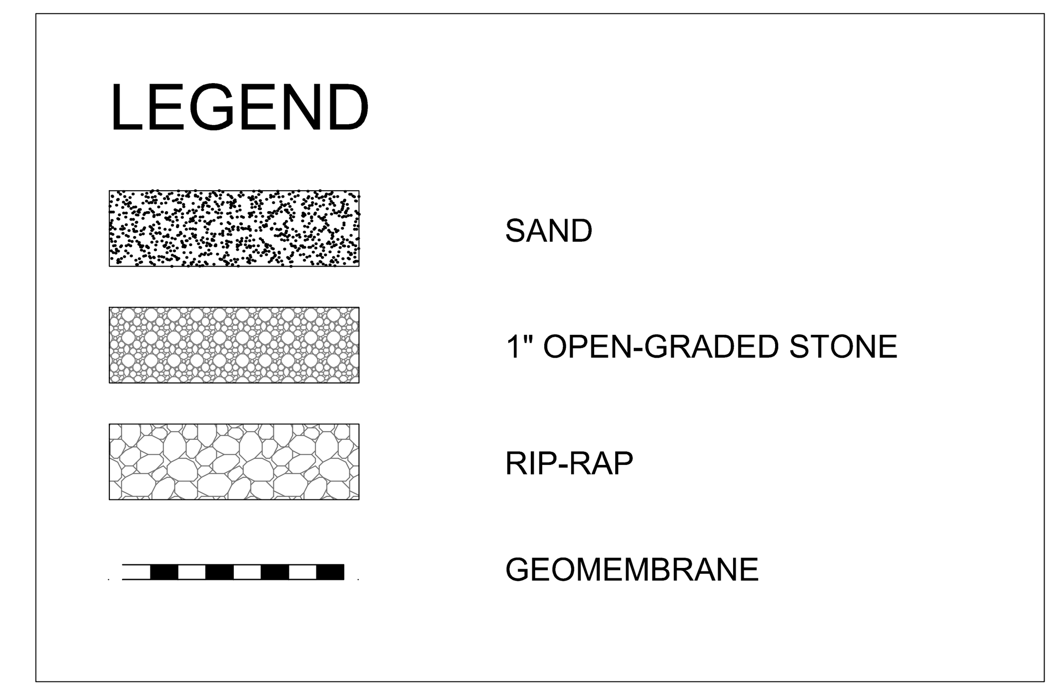

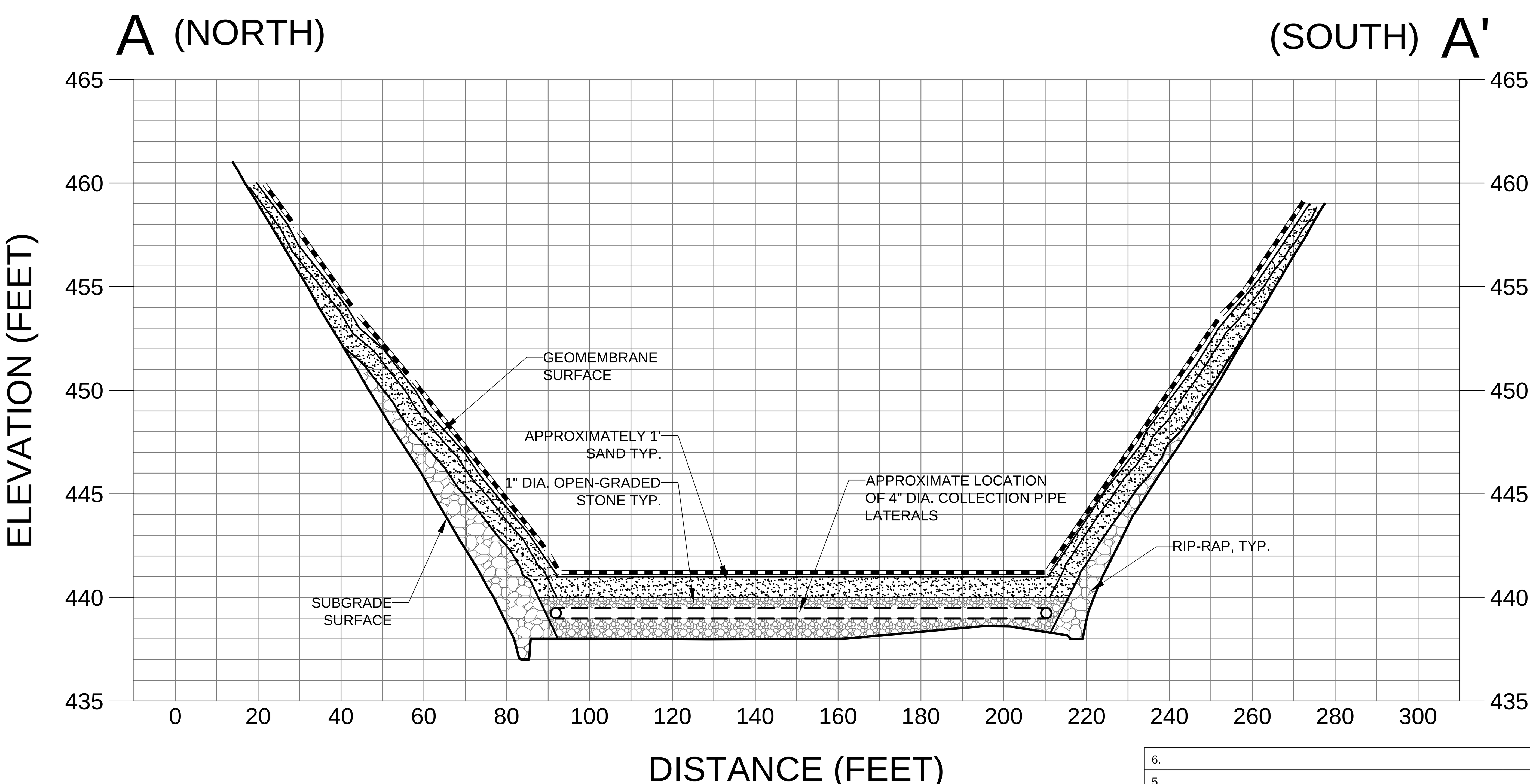

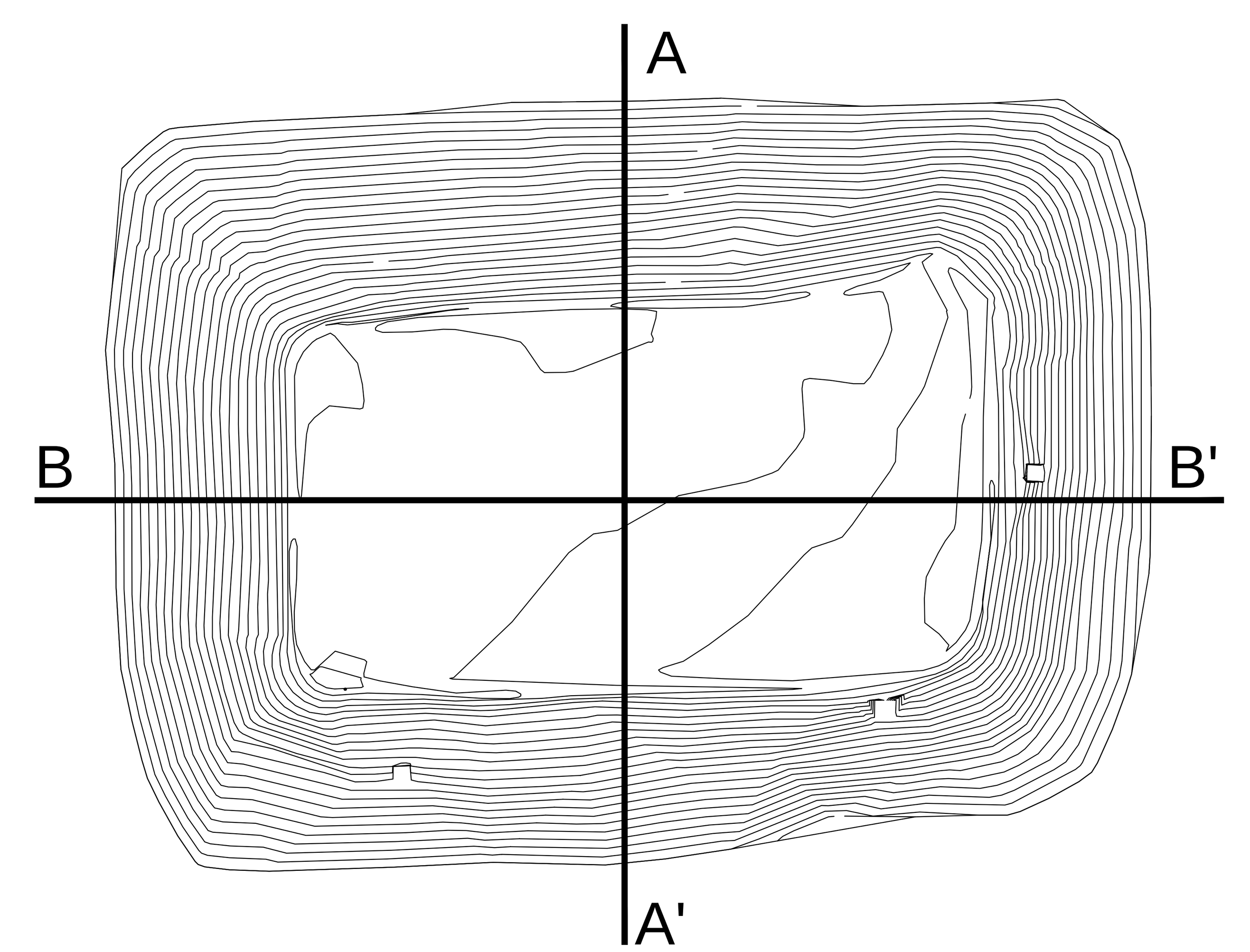

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0.	ISSUED FOR RECORD DOCUMENTATION	07/21/14	EJT
REVISION:		DATE:	APP'D BY:

NATURAL RESOURCE TECHNOLOGY

PROJECT NO. 2113.2/3.3	**LINER SUBGRADE CROSS SECTIONS**
DRAWN BY: DMD 06/30/14	SECONDARY ASH SETTLING BASIN LINER REPLACEMENT POWERTON POWER STATION MIDWEST GENERATION PEKIN, ILLINOIS
CHECKED BY: EJT 07/18/14	
APPROVED BY: EJT 07/21/14	DRAWING NO: D21132C021-03 REFERENCE: .
	SHEET NO. C021

Jul 21, 2014 12:28pm PLOTTED BY: dduda SAVED BY: dduda
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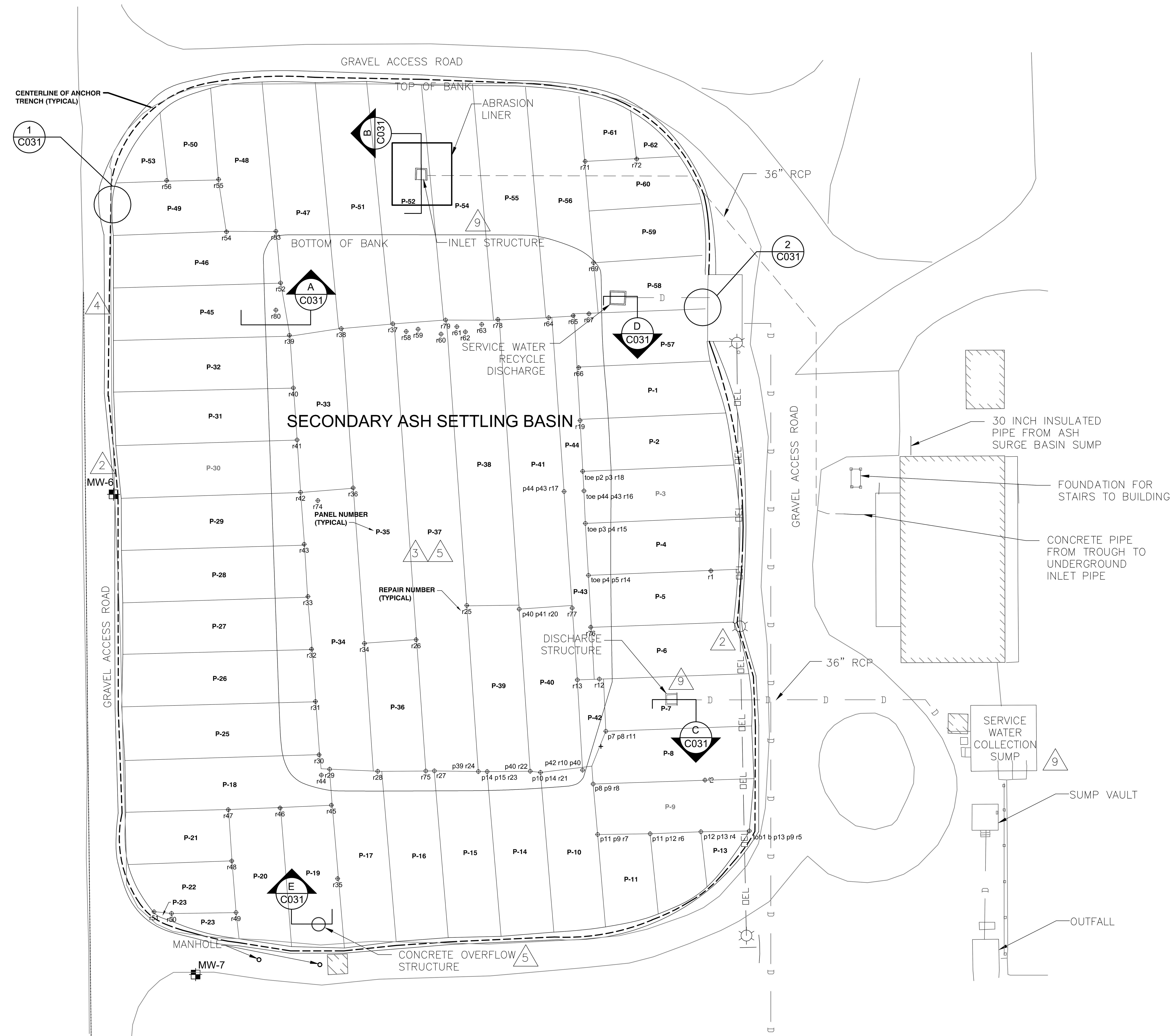

MW-7	MONITORING WELL LOCATION
—— DEL ——	OVERHEAD ELECTRICAL LINE
—— D ——	UNDERGROUND DISCHARGE PIPE
— — — —	UNDERGROUND INLET PIPE
- - - - - -	CENTERLINE OF ANCHOR TRENCH
☼	ELECTRICAL UTILITY POLE

CONTRACTOR NOTES: △ COMPLETED DURING CONSTRUCTION

1. CONTRACTOR SHALL ~~INSTALL 16 OZ/SY NONWOVEN~~ GEOTEXTILE ON REGRADED BASIN SLOPE.
2. CONTRACTOR SHALL INSTALL GEOMEMBRANE BOOT AROUND MONITORING WELL AND ASSOCIATED BALLASTS, AND ELECTRICAL UTILITY POLE.
3. CONTRACTOR SHALL INSTALL 60 MIL HDPE, WHITE, TEXTURED GEOMEMBRANE IN ACCORDANCE WITH THE TECHNICAL SPECIFICATION. CONTRACTOR SHALL PROVIDE AND FOLLOW AN APPROVED GEOMEMBRANE LAYOUT PLAN.
4. GEOMEMBRANE SHALL BE ANCHORED INTO 2.5 FEET DEEP TRENCHES ALONG TOP OF BASIN BANK, AS SHOWN ON SHEET C031. CONTRACTOR SHALL ADVISE OWNER AND/OR ENGINEER IF PROPOSED LOCATION FOR ANCHOR TRENCH IS NOT POSSIBLE.
5. CONTRACTOR SHALL RESTORE AREAS DISTURBED BY EQUIPMENT AND MATERIAL LAYDOWN.
6. CONTRACTOR SHALL PROVIDE SURVEY DOCUMENTATION OF THE ITEMS LISTED IN THE TECHNICAL SPECIFICATIONS.
7. CONTRACTOR SHALL PERFORM A LEAK LOCATION SURVEY IN ACCORDANCE WITH TECHNICAL SPECIFICATIONS.
8. CONTRACTOR SHALL COMPLETE ALL WORK ON SECONDARY ASH SETTLING BASIN BETWEEN 03/15/13 AND ~~04/18/13~~ 06/15/13.
9. CONTRACTOR SHALL REMOVE TEMPORARY PLUGS AND BYPASS PUMP SYSTEM AT PROJECT COMPLETION, AS APPROVED BY OWNER AND/OR ENGINEER.

SOURCE NOTES:

1. ~~SECONDARY ASH SETTLING BASIN CONTOURS~~, LOCATION OF BASIN PIPES AND STRUCTURES, AND SURROUNDING AREA DETAILS TAKEN FROM A SURVEY BY MAURER-STUTZ, INC., NOVEMBER 28, 2012.
2. OTHER DETAILS TAKEN FROM A SURVEY BY AERO-METRIC, INC. DATED 6-19-2008, PROJECT NO. 1080611, PROVIDED BY MIDWEST GENERATION.
3. GEOMEMBRANE PANEL LAYOUT SURVEYED BY RIDGELINE CONSULTANTS, JUNE 14, 2013. PROJECT NUMBER 2013-0099, PROVIDED BY TERRA CONTRACTING SERVICES, LLC.

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REVISION:		DATE:	APP'D BY:
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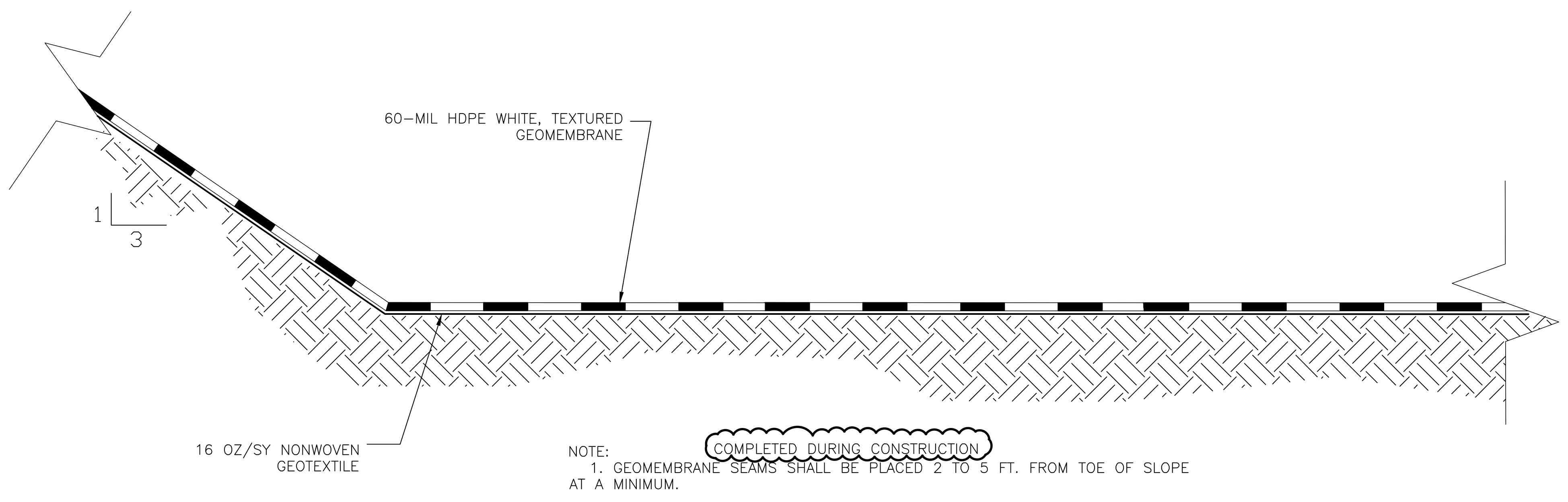
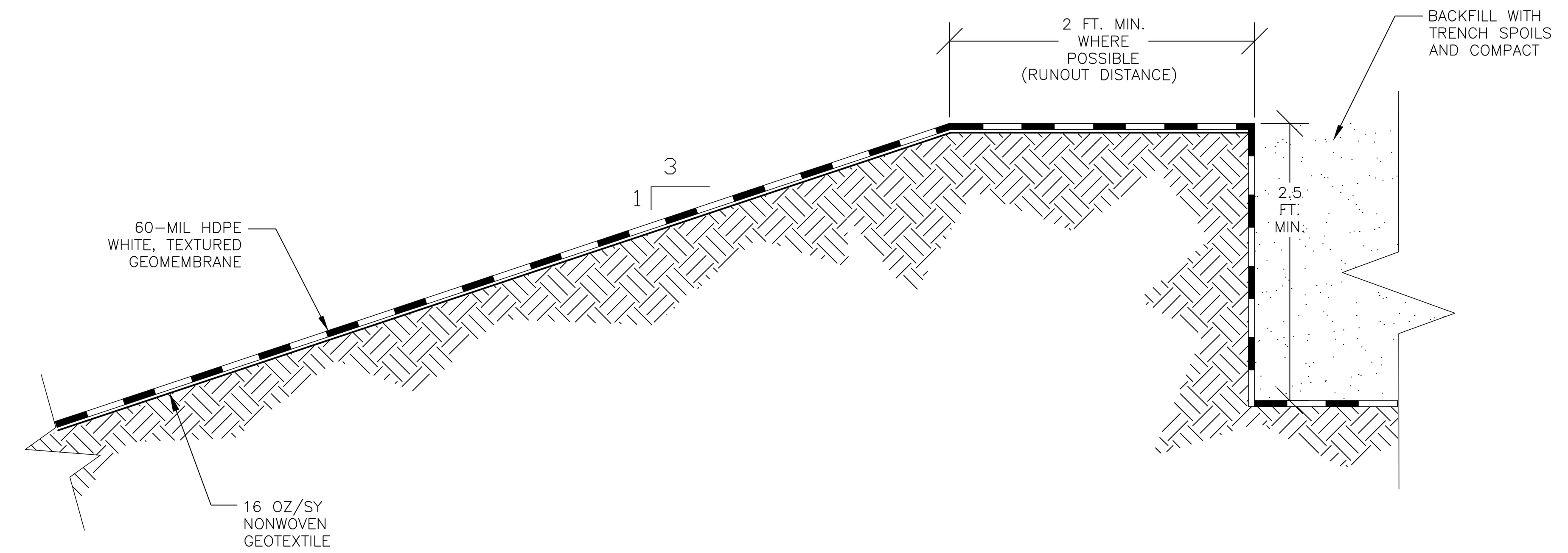
3.	ISSUED FOR RECORD DOCUMENTATION	7/21/14	EJT
2.	ISSUED FOR CONSTRUCTION	03/12/13	HMS
1.	ISSUED FOR BID	12/12/12	HMS
0.	ISSUED FOR PERMIT	12/22/09	HMS

NATURAL RESOURCE TECHNOLOGY

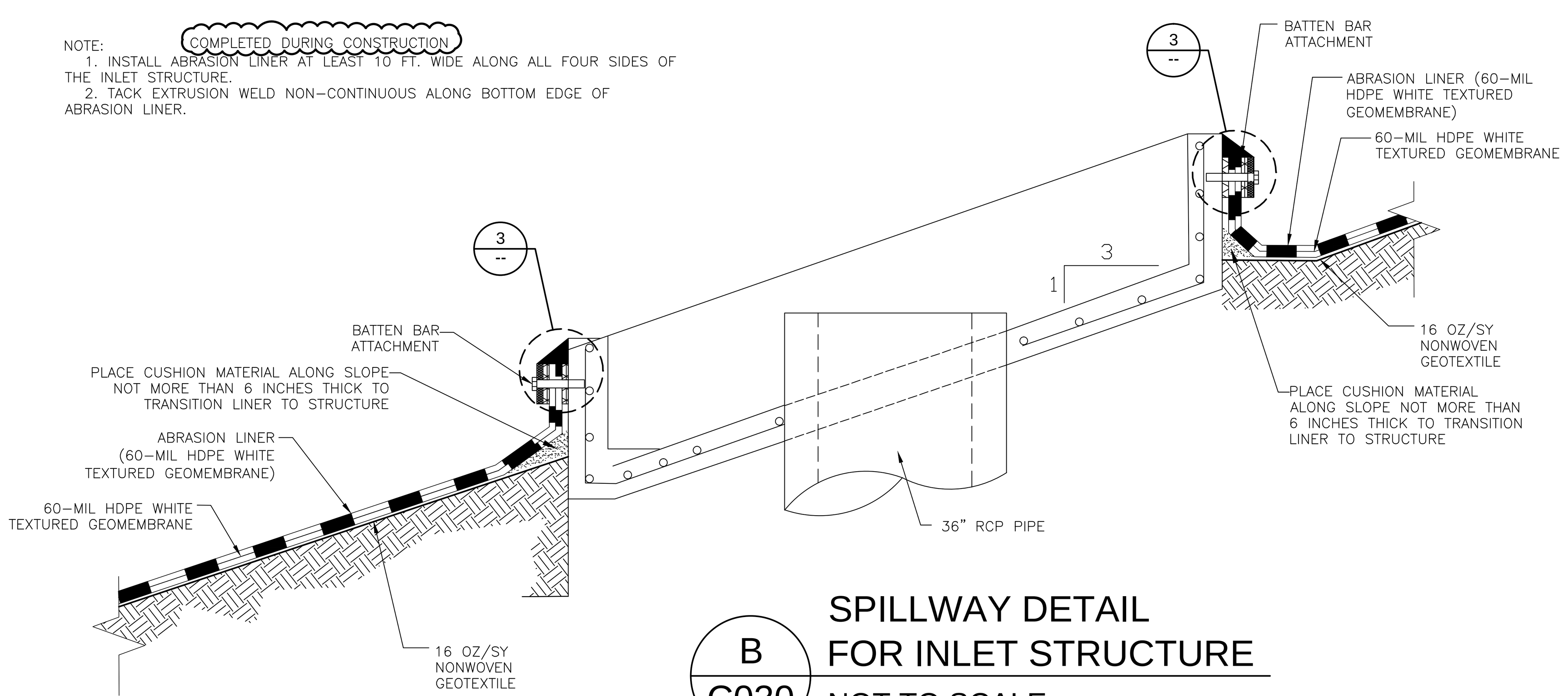
PROJECT NO. 2113.2/3.3	**GEOMEMBRANE PLAN**
DRAWN BY: KNW 11/25/09	SECONDARY ASH SETTLING BASIN LINER REPLACEMENT MIDWEST GENERATION POWERTON POWER STATION PEKIN, ILLINOIS
CHECKED BY: RJG 12/09/09	
APPROVED BY: HMS 12/22/09	DRAWING NO: D1965C030-00 / REFERENCE: \SECONDARY ASH SETTLING BASIN / SHEET NO. C030



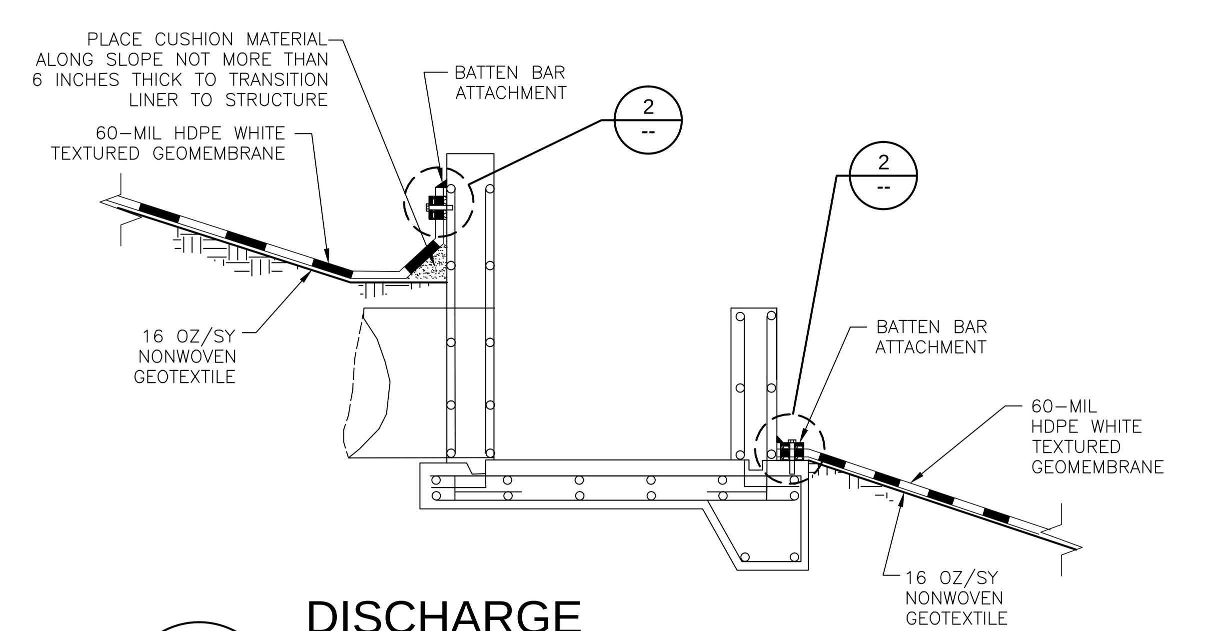
A
C030
SLOPE TRANSITION SECTION
NOT TO SCALE



1
C030
ANCHOR TRENCH DETAIL
NOT TO SCALE



B
C030
SPILLWAY DETAIL FOR INLET STRUCTURE
NOT TO SCALE



C
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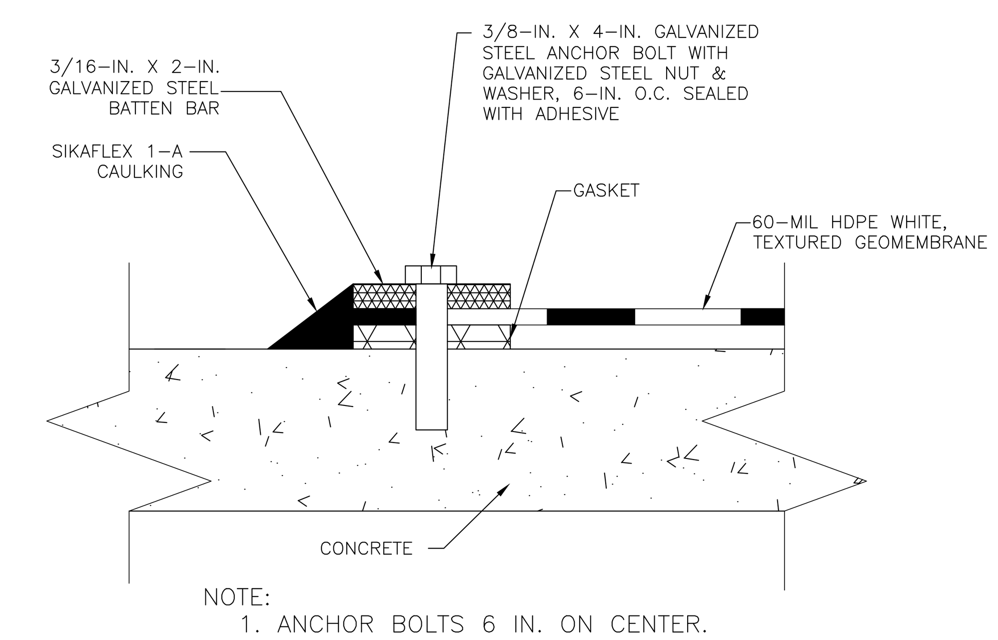
DISCHARGE STRUCTURE SECTION
NOT TO SCALE



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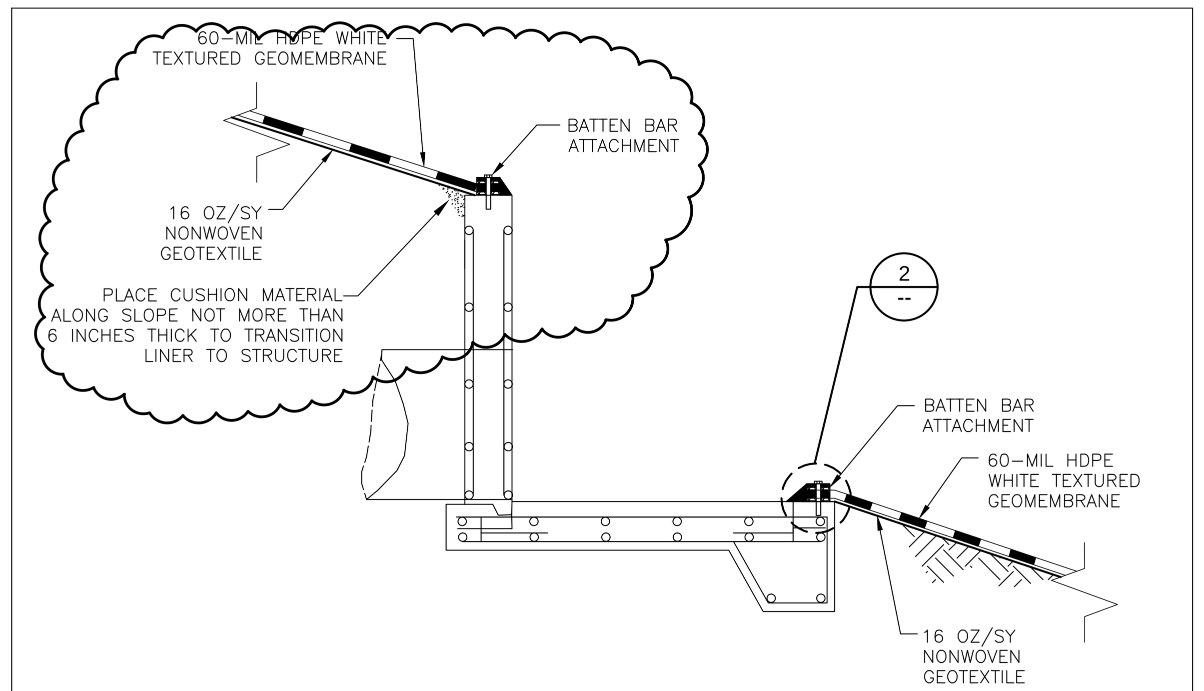
BATTEN BAR ATTACHMENT
NOT TO SCALE



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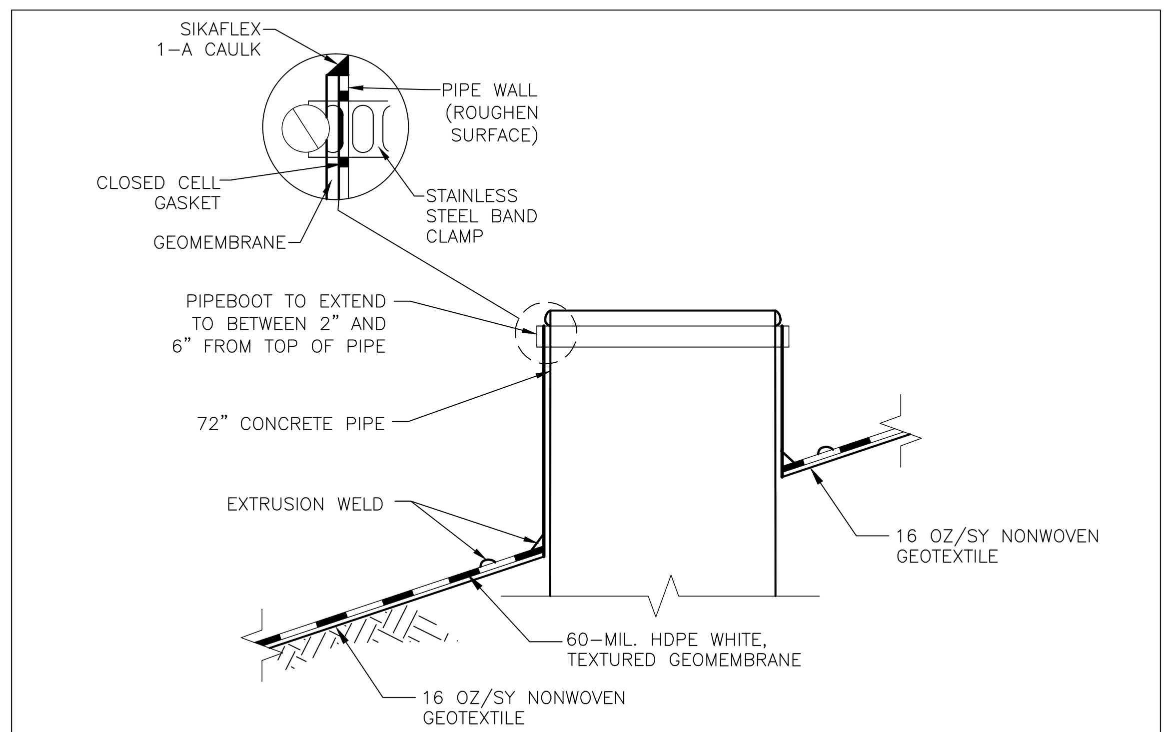
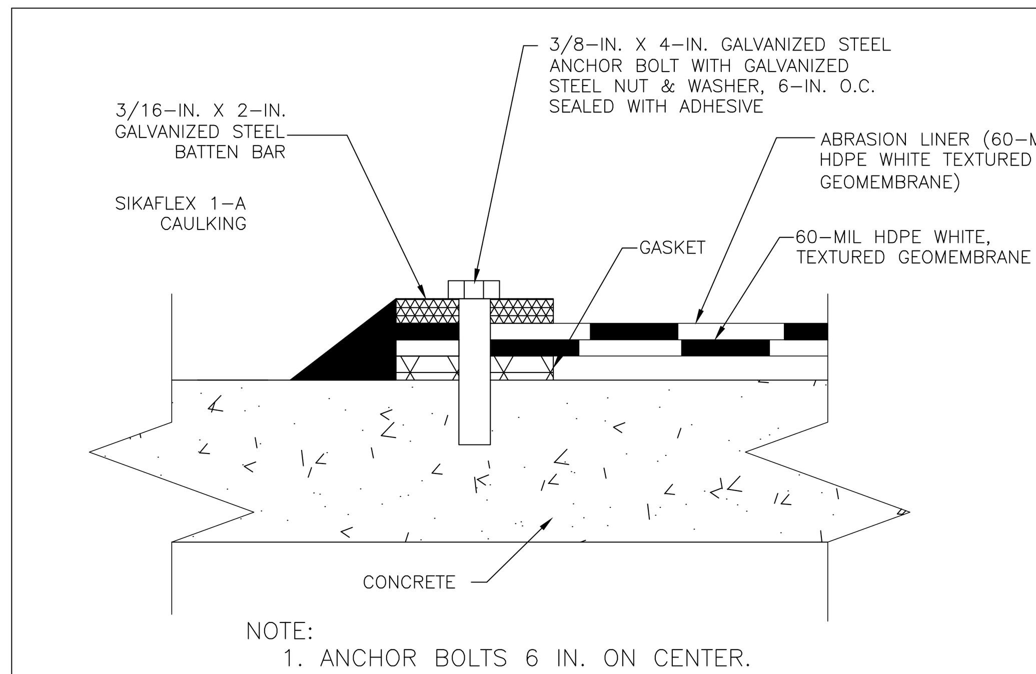
C030
SERVICE WATER RECYCLE DISCHARGE STRUCTURE
NOT TO SCALE



E
C030
OVERFLOW PIPE DETAIL
NOT TO SCALE



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BATTEN BAR ATTACHMENT WITH ABRASION LINER
NOT TO SCALE

REVISION:		DATE:	APP'D BY:
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3.	ISSUED FOR RECORD DOCUMENTATION	07/21/14	EJT
2.	ISSUED FOR CONSTRUCTION	03/12/13	HMS
1.	ISSUED FOR BID	12/12/12	HMS
0.	ISSUED FOR PERMIT	12/22/09	HMS

NATURAL RESOURCE TECHNOLOGY

PROJECT NO.	2113.2/3.3
DRAWN BY:	KNW 11/18/09
CHECKED BY:	RJG 11/18/09
APPROVED BY:	HMS 12/22/09

DETAILS AND SECTIONS

SECONDARY ASH SETTLING BASIN LINER REPLACEMENT
POWERTON POWER STATION
MIDWEST GENERATION
PEKIN, ILLINOIS

DRAWING NO: D2113-2C031-03
REFERENCE: .

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EXHIBIT 3

PREDICTING RAINFALL EROSION LOSSES

A GUIDE TO CONSERVATION PLANNING

UNITED STATES DEPARTMENT OF AGRICULTURE

AGRICULTURE HANDBOOK NUMBER 537

PREPARED BY SCIENCE AND EDUCATION ADMINISTRATION

PREDICTING RAINFALL EROSION LOSSES

A GUIDE TO CONSERVATION PLANNING

Supersedes Agriculture Handbook No. 282,
"Predicting Rainfall-Erosion Losses From Cropland East of the Rocky Mountains"

Note: See Supplement Dated January 1981 and the errata at the end of this document.

Science and Education Administration
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in cooperation with
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ABSTRACT

Wischmeier, W. H., and Smith, D.D. 1978. Predicting rainfall erosion losses—a guide to conservation planning. U.S. Department of Agriculture, Agriculture Handbook No. 537.

The Universal Soil Loss Equation (USLE) enables planners to predict the average rate of soil erosion for each feasible alternative combination of crop system and management practices in association with a specified soil type, rainfall pattern, and topography. When these predicted losses are compared with given soil loss tolerances, they provide specific guidelines for effecting erosion control within specified limits. The equation groups the numerous interrelated physical and management parameters that influence erosion rate under six major factors whose site-specific values can be expressed numerically. A half century of erosion research in many States has supplied information from which at least approximate values of the USLE factors can be obtained for specified farm fields or other small erosion prone areas throughout the United States. Tables and charts presented in this handbook make this information readily available for field use. Significant limitations in the available data are identified.

The USLE is an erosion model designed to compute longtime average soil losses from sheet and rill erosion under specified conditions. It is also useful for construction sites and other nonagricultural conditions, but it does not predict deposition and does not compute sediment yields from gully, streambank, and streambed erosion.

Keywords: Conservation practices, conservation tillage, construction sites, crop canopy, crop sequence, delivery ratios, erosion factors, erosion index, erosion prediction, erosion tolerances, erosivity, gross erosion, minimum tillage, no-till, rainfall characteristics, rainfall data, residue mulch, runoff, sediment, sediment delivery, slope effect, water quality, soil erodibility.

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PREDICTING RAINFALL EROSION LOSSES— A GUIDE TO CONSERVATION PLANNING

Walter H. Wischmeier and Dwight D. Smith[1]

PURPOSE OF HANDBOOK

Scientific planning for soil and water conservation requires knowledge of the relations between those factors that cause loss of soil and water and those that help to reduce such losses. Controlled studies on field plots and small watersheds have supplied much valuable information regarding these complex factor interrelations. But the greatest possible benefits from such research can be realized only when the findings are converted to sound practice on the numerous farms and other erosion prone areas throughout the country. Specific guidelines are needed for selecting the control practices best suited to the particular needs of each site.

The soil loss prediction procedure presented in this handbook provides such guidelines. The procedure methodically combines research information from many sources to develop design data for each conservation plan. Widespread field experience for more than two decades has proved it highly valuable as a conservation planning guide.

The procedure is founded on an empirical soil loss equation that is believed to be applicable wherever numerical values of its factors are available. Research has supplied information from which at least approximate values of the equation's factors can be obtained for specific farm fields or other small land areas throughout most of the United States. Tables and charts presented in this handbook make this information readily available for field use.

This revision of the 1965 handbook (*64*) updates the content and incorporates new material that has been available informally or from scattered research reports in professional journals. Some of the original charts and tables are revised to conform with additional research findings, and new ones are developed to extend the usefulness of the soil loss equation. In some instances, expanding a table or chart sufficiently to meet the needs for widespread field application required projection of empirical factor relationships appreciably beyond the physical limits of the data from which the relationships were derived. Estimates obtained in this manner are the best information available for the conditions they represent. However, the instances are identified in the discussions of the specific erosion factors, tables, and charts. Major research needs are suggested by these discussions and were recently summarized in an available publication by Stewart and others (*42*).

HISTORY OF SOIL LOSS EQUATIONS

Developing equations to calculate field soil loss began about 1940 in the Corn Belt. The soil loss estimating procedure developed in that region between 1940 and 1956 has been generally referred to as the slope-practice method. Zingg (*64*)[2] published an equation in 1940 relating soil loss rate to length and percentage of slope. The following year, Smith (*38, 39*) added crop and conservation practice factors and the concept of a specific soil loss limit, to develop a graphical method for

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[2] Numbers in parentheses refer to References p. 48.

determining conservation practices on Shelby and associated soils of the Midwest. Browning and associates (*6*) added soil and management factors and prepared a set of tables to simplify field use of the equation in Iowa. Research scientists and operations personnel of the Soil Conservation Service (SCS) in the North Central States worked together in developing the slope-practice equation for use throughout the Corn Belt.

A national committee met in Ohio in 1946 to adapt the Corn Belt equation to cropland in other regions. This committee reappraised the Corn Belt factor values and added a rainfall factor. The resulting formula, generally known as the Musgrave Equation (*31*), has been widely used for estimating gross erosion from watersheds in flood abatement programs. A graphical solution of the equation was published in 1952 (*19*) and used by the SCS in the Northeastern States.

The soil loss equation presented in this handbook has become known as the Universal Soil Loss Equation (USLE). Regardless of whether the designation is fully accurate, the name does distinguish this equation from the *regionally* based soil loss equations. The USLE was developed at the National Runoff and Soil Loss Data Center established in 1954 by the Science and Education Administration (formerly Agricultural Research Service) in cooperation with Purdue University. Federal-State cooperative research projects at 49 locations[3] contributed more than 10,000 plot-years of basic runoff and soil loss data to this center for summarizing and overall statistical analyses. After 1960, rainfall simulators (*23*) operating from Indiana, Georgia, Minnesota, and Nebraska were used on field plots in 16 states to fill some of the gaps in the data needed for factor evaluation.

Analyses of this large assembly of basic data provided several major improvements for the soil loss equation (*53*): (a) a rainfall erosion index evaluated from local rainfall characteristics; (b) a quantitative soil erodibility factor that is evaluated directly from soil property data and is independent of topography and rainfall differences; (c) a method of evaluating cropping and management effects in relation to local climatic conditions; and (d) a method of accounting for effects of interactions between crop system, productivity level, tillage practices, and residue management.

Developments since 1965 have expanded the use of the soil loss equation by providing techniques for estimating site values of its factors for additional land uses, climatic conditions, and management practices. These have included a soil erodibility nomograph for farmland and construction areas (*58*); topographic factors for irregular slopes (*12, 55*); cover factors for range and woodland (*57*); cover and management effects of conservation tillage practices (*54*); erosion prediction on construction areas (*61, 24, 25*); estimated erosion index values for the Western States and Hawaii (*5, 21, 55*); soil erodibility factors for benchmark Hawaii soils (*9*); and improved design and evaluation of erosion control support practices (*17, 36*).

Research is continuing with emphasis on obtaining a better understanding of the basic principles and processes of water erosion and sedimentation and development of fundamental models capable of predicting specific-storm soil losses and deposition by overland flow (*10, 11, 22, 26, 32*). The fundamental models have been helpful for understanding the factors in the field soil loss equation and for interpreting the plot data.

SOIL LOSS TOLERANCES

The term "soil loss tolerance" denotes the maximum level of soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely.

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[3] The data were contributed by Federal-State cooperative research projects at the following locations: Batesville, Ark.; Tifton and Watkinsville, Ga.; Dixon Springs, Joliet, and Urbana, Ill.; Lafayette, Ind.; Clarinda, Castana, Beaconsfield, Independence, and Seymour, Iowa; Hays, Kans.; Baton Rouge, La.; Presque Isle, Maine; Benton Harbor and East Lansing, Mich.; Morris, Minn.; Holly Springs and State College, Miss.; Bethany and McCredie, Mo.; Hastings, Nebr.; Beemerville, Marlboro, and New Brunswick, N.J.; Ithaca, Geneva, and Marcellus, N.Y.; Statesville and Raleigh, N.C.; Coshocton and Zanesville, Ohio; Cherokee and Guthrie, Okla.; State College, Pa.; Clemson and Spartanburg, S.C.; Madison, S.Dak.; Knoxville and Greeneville, Tenn.; Temple and Tyler, Tex.; Blacksburg, Va.; Pullman, Wash.; LaCrosse, Madison, and Owen, Wis.; and Mayaguez, P.R.

The major purpose of the soil loss equation is to guide methodical decisionmaking in conservation planning on a site basis. The equation enables the planner to predict the average rate of soil erosion for each of various alternative combinations of crop system, management techniques, and control practices on any particular site. When these predicted losses can be compared with a soil loss tolerance for that site, they provide specific guidelines for effecting erosion control within the specified limits. Any cropping and management combination for which the predicted erosion rate is less than the tolerance may be expected to provide satisfactory erosion control. From the satisfactory alternatives indicated by this procedure, the one best suited to a particular farm or other enterprise may then be selected.

Soil loss tolerances ranging from 5 to 2 t/A/year for the soils of the United States were derived by soil scientists, agronomists, geologists, soil conservationists, and Federal and State research leaders at six regional workshops in 1961 and 1962. Factors considered in defining these limits included soil depth, physical properties and other characteristics affecting root development, gully prevention, on-field sediment problems, seeding losses, soil organic matter reduction, and plant nutrient losses. A deep, medium-textured, moderately permeable soil that has subsoil characteristics favorable for plant growth has a greater tolerance than soils with shallow root zones or high percentages of shale at the surface. Widespread experience has shown these soil loss tolerances to be feasible and generally adequate for sustaining high productivity levels indefinitely. Some soils with deep favorable root zones may exceed the 5-t tolerance without loss of sustained productivity.

Soil loss limits are sometimes established primarily for water quality control. The criteria for defining field soil loss limits for this purpose are not the same as those for tolerances designed to preserve cropland productivity. Soil depth is not relevant for offsite sediment control, and uniform limits on erosion rates will allow a range in the quantities of sediment per unit area that are delivered to a river. Soil material eroded from a field slope may be deposited in the field boundaries, in terrace channels, in depressional areas, or on flat or vegetated areas traversed by the overland flow before it reaches a river. The erosion damages the cropland on which it occurs, but sediment deposited near its place of origin is not directly relevant for water quality control.

If the soil loss tolerance designed for sustained cropland productivity fails to attain the desired water quality standard, flexible limits that consider other factors should be developed rather than uniformly lowering the soil loss tolerance. These factors include distance of the field from a major waterway, the sediment transport characteristics of the intervening area, sediment composition, needs of the particular body of water being protected, and the probable magnitude of fluctuations in sediment loads (*42*). Limits of sediment yield would provide more uniform water quality control than lowering the limits on soil movement from field slopes. They would also require fewer restrictions on crop system selection for fields from which only small percentages of the eroded soil become off-farm sediment.

SOIL LOSS EQUATION

The erosion rate at a given site is determined by the particular way in which the levels on numerous physical and management variables are combined at that site. Physical measurements of soil loss for each of the large number of possible combinations in which the levels of these variable factors can occur under field conditions would not be feasible. Soil loss equations were developed to enable conservation planners to project limited erosion data to the many localities and conditions that have not been directly represented in the research.

The USLE is an erosion model designed to predict the longtime average soil losses in runoff from specific field areas in specified cropping and management systems. Widespread field use has substantiated its usefulness and validity for this purpose. It is also applicable for such nonagricultural conditions as construction sites.

With appropriate selection of its factor values, the equation will compute the average soil loss for a multicrop system, for a particular crop year in a rotation, or for a particular cropstage period within a crop year. It computes the soil loss for a given site as the product of six major factors whose most likely values at a particular location can be expressed numerically. Erosion variables reflected by these factors vary considerably about their means from storm to storm, but effects of the random fluctuations tend to average out over extended periods. Because of the unpredictable short-time fluctuations in the levels of influential variables, however, present soil loss equations are substantially less accurate for prediction of specific events than for prediction of longtime averages.

The soil loss equation is

$$A = R\,K\,L\,S\,C\,P \qquad (1)$$

where

A is the computed soil loss per unit area, expressed in the units selected for **K** and for the period selected for **R.** In practice, these are usually so selected that they compute **A** in tons per acre per year, but other units can be selected.

R, the rainfall and runoff factor, is the number of rainfall erosion index units, plus a factor for runoff from snowmelt or applied water where such runoff is significant.

K, the soil erodibility factor, is the soil loss rate per erosion index unit for a specified soil as measured on a unit plot, which is defined as a 72.6-ft length of uniform 9-percent slope continuously in clean-tilled fallow.

L, the slope-length factor, is the ratio of soil loss from the field slope length to that from a 72.6-ft length under identical conditions.

S, the slope-steepness factor, is the ratio of soil loss from the field slope gradient to that from a 9-percent slope under otherwise identical conditions.

C, the cover and management factor, is the ratio of soil loss from an area with specified cover and management to that from an identical area in tilled continuous fallow.

P, the support practice factor, is the ratio of soil loss with a support practice like contouring, stripcropping, or terracing to that with straight-row farming up and down the slope.

The soil loss equation and factor evaluation charts were initially developed in terms of the English units commonly used in the United States. The factor definitions are interdependent, and direct conversion of acres, tons, inches, and feet to metric units would not produce the kind of integers that would be desirable for an expression of the equation in that system. Therefore, only the English units are used in the initial presentation of the equation and factor evaluation materials, and their counterparts in metric units are given in the Appendix under **Conversion to Metric System.**

Numerical values for each of the six factors were derived from analyses of the assembled research data and from National Weather Service precipitation records. For most conditions in the United States, the approximate values of the factors for any particular site may be obtained from charts and tables in this handbook. Localities or countries where the rainfall characteristics, soil types, topographic features, or farm practices are substantially beyond the range of present U.S. data will find these charts and tables incomplete and perhaps inaccurate for their conditions. However, they will provide guidelines that can reduce the amount of local research needed to develop comparable charts and tables for their conditions.

The subsection on **Predicting Cropland Soil Losses,** page 40 illustrates how to select factor values from the tables and charts. Readers who have had no experience with the soil loss equation may wish to read that section first. After they have referred to the tables and figures and located the values used in the sample, they may move readily to the intervening detailed discussions of the equation's factors.

The soil loss prediction procedure is more valuable as a guide for selection of practices if the user has a general knowledge of the principles and factor interrelations on which the equation is based. Therefore, the significance of each factor is discussed before presenting the reference table or chart from which local values may be obtained. Limitations of the data available for evaluation of some of the factors are also pointed out.

RAINFALL AND RUNOFF FACTOR (R)

Rills and sediment deposits observed after an unusually intense storm have sometimes led to the conclusion that the significant erosion is associated with only a few storms, or that it is solely a function of peak intensities. However, more than 30 years of measurements in many States have shown that this is not the case (*51*). The data show that a rainfall factor used to estimate average annual soil loss must include the cumulative effects of the many moderate-sized storms, as well as the effects of the occasional severe ones.

The numerical value used for **R** in the soil loss equation must quantify the raindrop impact effect and must also provide relative information on the amount and rate of runoff likely to be associated with the rain. The rainfall erosion index derived by Wischmeier (*49*) appears to meet these requirements better than any other of the many rainfall parameters and groups of parameters tested against the assembled plot data. The local value of this index generally equals **R** for the soil loss equation and may be obtained directly from the map in figure 1. However, the index does not include the erosive forces of runoff from thaw, snowmelt, or irrigation. A procedure for evaluating **R** for locations where this type of runoff is significant will be given under the topic **R Values for Thaw and Snowmelt.**

Rainfall Erosion Index

The research data indicate that when factors other than rainfall are held constant, storm soil losses from cultivated fields are directly proportional to a rainstorm parameter identified as the **EI** (defined below) (*49*). The relation of soil loss to this parameter is linear, and its individual storm values are directly additive. The sum of the storm **EI** values for a given period is a numerical measure of the erosive potential of the rainfall within that period. The average annual total of the storm **EI** values in a particular locality is the rainfall erosion index for that locality. Because of apparent cyclical patterns in rainfall data (*33*), the published rainfall erosion index values were based on 22-year station rainfall records.

Rain showers of less than one-half inch and separated from other rain periods by more than 6 hours were omitted from the erosion index computations, unless as much as 0.25 in of rain fell in 15 min. Exploratory analyses showed that the **EI** values for such rains are usually too small for practical significance and that, collectively, they have little effect on monthly percentages of the annual **EI**. The cost of abstracting and analyzing 4,000 location-years of rainfall-intensity data was greatly reduced by adopting the 0.5-in threshold value.

EI Parameter

By definition, the value of **EI** for a given rainstorm equals the product, total storm energy (**E**) times the maximum 30-min intensity (I_{30}), where **E** is in hundreds of foot-tons per acre and I_{30} is in inches per hour (in/h). **EI** is an abbreviation for energy-times-intensity, and the term should not be considered simply an energy parameter. The data show that rainfall energy, itself, is not a good indicator of erosive potential. The storm energy indicates the volume of rainfall and runoff, but a long, slow rain may have the same **E** value as a shorter rain at much higher intensity. Raindrop erosion increases with intensity. The I_{30} component indicates the prolonged-peak rates of detachment and runoff. The product term, **EI**, is a statistical interaction term that reflects how total energy and peak inensity are combined in each particular storm. Technically, it indicates how particle detachment is combined with transport capacity.

The energy of a rainstorm is a function of the amount of rain and of all the storm's component intensities. Median raindrop size increases with rain intensity (*62*), and terminal velocities of free-falling waterdrops increase with increased dropsize (*13*). Since the energy of a given mass in motion is proportional to velocity-squared, rainfall energy is directly related to rain intensity. The relationship is expressed by the equation,

$$\mathbf{E} = 916 + 331 \log_{10} \mathbf{I}, \qquad (2)$$

where **E** is kinetic energy in foot-tons per acre-inch and **I** is intensity in inches per hour (*62*). A limit of 3 in/h is imposed on **I** by the finding that median dropsize does not continue to increase when intensities exceed 3 in/h (*7, 15*). The energy

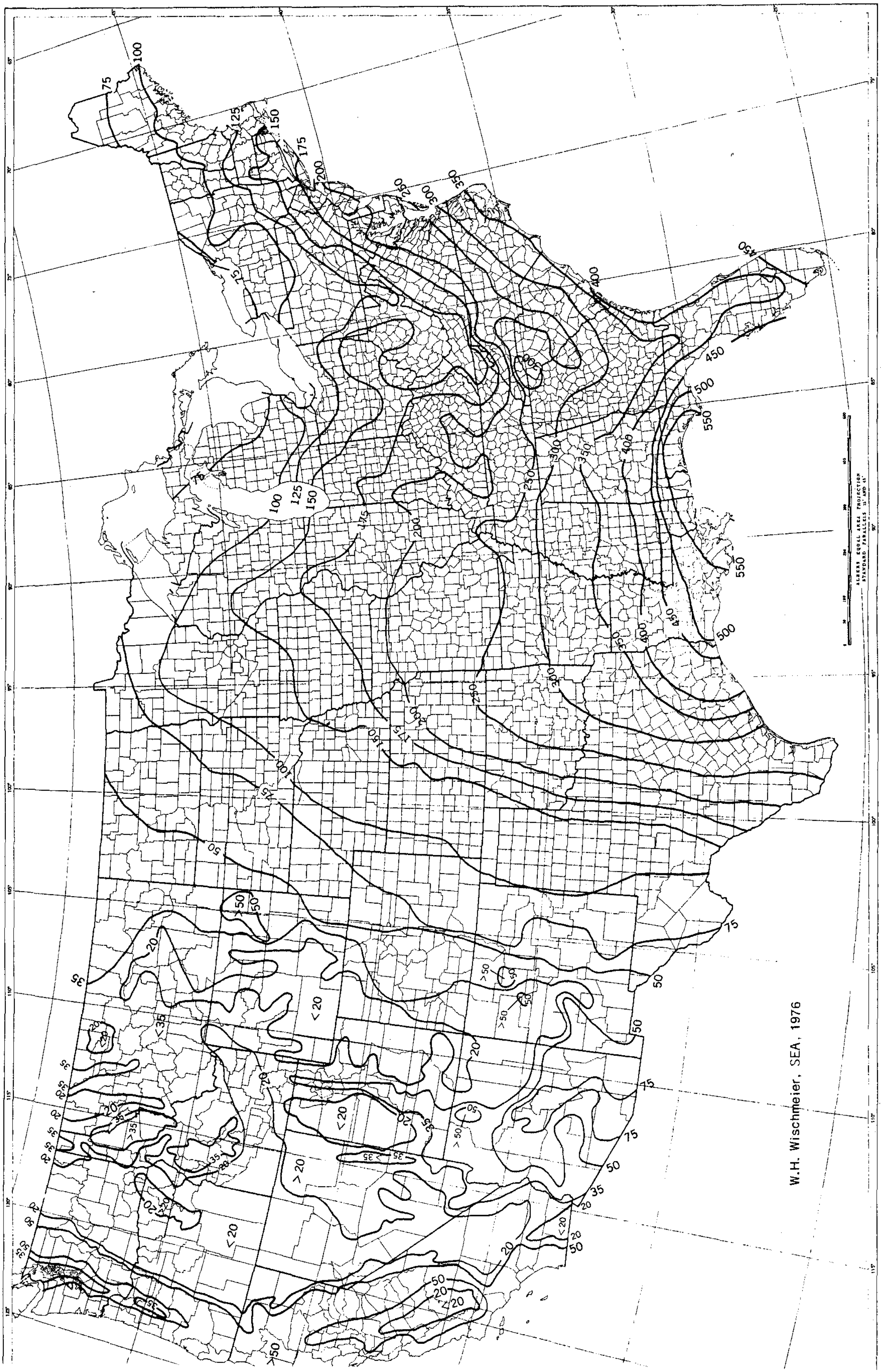

FIGURE 1.—Average annual values of the rainfall erosion index.

of a rainstorm is computed from recording-rain gage data. The storm is divided into successive increments of essentially uniform intensity, and a rainfall energy-intensity table derived from the above formula (app., table 19) is used to compute the energy for each increment. (Because the energy equation and energy-intensity table have been frequently published with energy expressed in foot-tons per acre-inch, this unit was retained in table 19. However, for computation of **EI** values, storm energy is expressed in hundreds of foot-tons per acre. Therefore, energies computed by the published formula or table 19 must be divided by 100 before multiplying by $\mathbf{I}_{30}$ to compute **EI**.)

Isoerodent Maps

Local values of the rainfall erosion index may be taken directly from the isoerodent maps, figures 1 and 2. The plotted lines on the maps are called isoerodents because they connect points of equal rainfall erosivity. Erosion index values for locations between the lines are obtained by linear interpolation.

The isoerodent map in the original version of this handbook (*64*) was developed from 22-year station rainfall records by computing the **EI** value for each storm that met the previously defined threshold criteria. Isoerodents were then located between these point values with the help of published rainfall intensity-frequency data (*47*) and topographic maps. The 11 Western States were omitted from the initial map because the rainfall patterns in this mountainous region are sporadic and not enough long-term, recording-rain gage records were available to establish paths of equal erosion index values.

The isoerodent map was extended to the Pacific Coast in 1976 by use of an estimating procedure. Results of investigations at the Runoff and Soil Loss Data Center at Purdue University showed that the known erosion index values in the Western Plains and North Central States could be approximated with reasonable accuracy by the quantity 27.38 $\mathbf{P}^{2.17}$, where **P** is the 2-year, 6-h rainfall amount (*55*). This relationship was used with National Weather Service isopluvial maps to approximate erosion index values for the Western States. The resulting isoerodents are compatible with the few point values that had been established within the 11 Western States and can provide helpful guides for conservation planning on a site basis. However, they are less precise than those computed for the 37-State area, where more data were available and rainfall patterns are less erratic. Also, linear interpolations between the lines will not always be accurate in mountain regions because values of the erosion index may change rather abruptly with elevation changes. The point values that were computed directly from long-term station rainfall records in the Western States are included in table 7, as reference points.

Figure 2 was developed by computing the erosion index for first-order weather stations in Hawaii and deriving the relation of these values to National Weather Service intensity-frequency data for the five major islands. When the present short-term, rainfall-intensity records have been sufficiently lengthened, more point values of the index should be computed by the standard procedure.

Figure 1 shows that local, average-annual values of the erosion index in the 48 conterminous States range from less than 50 to more than 500. The erosion index measures the combined effect of rainfall and its associated runoff. If the soil and topography were exactly the same everywhere, average annual soil losses from plots maintained in continuous fallow would differ in direct proportion to the erosion index values. However, this potential difference is partially offset by differences in soil, topography, vegetative cover, and residues. On fertile soils in the high rainfall areas of the Southern States, good vegetal cover protects the soil surface throughout most of the year and heavy plant residues may provide excellent cover also during the dormant season. In the regions where the erosion index is extremely low, rainfall is seldom adequate for establishing annual meadows and the cover provided by other crops is often for relatively short periods. Hence, serious soil erosion hazards exist in semiarid regions as well as in humid.

Frequency Distribution

The isoerodent maps present 22-year-average annual values of **EI** for the delineated areas. However, both the annual and the maximum-storm values at a particular location vary from year to year. Analysis of 181 station rainfall records showed that they tend to follow log-normal frequency distributions that are usually well defined by continuous records of from 20 to 25 years (*49*). Tables of specific probabilities of annual and maximum-storm **EI** values at the 181 locations are presented in the appendix (tables 17 and 18).

R Values for Thaw and Snowmelt

The standard rainfall erosion index estimates the erosive forces of the rainfall and its directly associated runoff. In the Pacific Northwest, as much as 90 percent of the erosion on the steeply rolling wheatland has been estimated to derive from runoff associated with surface thaws and snowmelt. This type of erosion is not accounted for by the rainfall erosion index but is considered either predominant or appreciable in much of the Northwest and in portions of the central Western States. A linear precipitation relationship would not account for peak losses in early spring because as the winter progresses, the soil becomes increasingly more erodible as the soil moisture profile is being filled, the surface structure is being broken down by repeated freezing and thawing, and puddling and surface sealing are taking place. Additional research of the erosion processes and means of control under these conditions is urgently needed.

In the meantime, the early spring erosion by runoff from snowmelt, thaw, or light rain on frozen soil may be included in the soil loss computations by adding a subfactor, $\mathbf{R_s}$, to the location's erosion index to obtain **R**. Investigations of limited data indicated that an estimate of $\mathbf{R_s}$ may be obtained by taking 1.5 times the local December-through-March precipitation, measured as inches of water. For example, a location in the North-

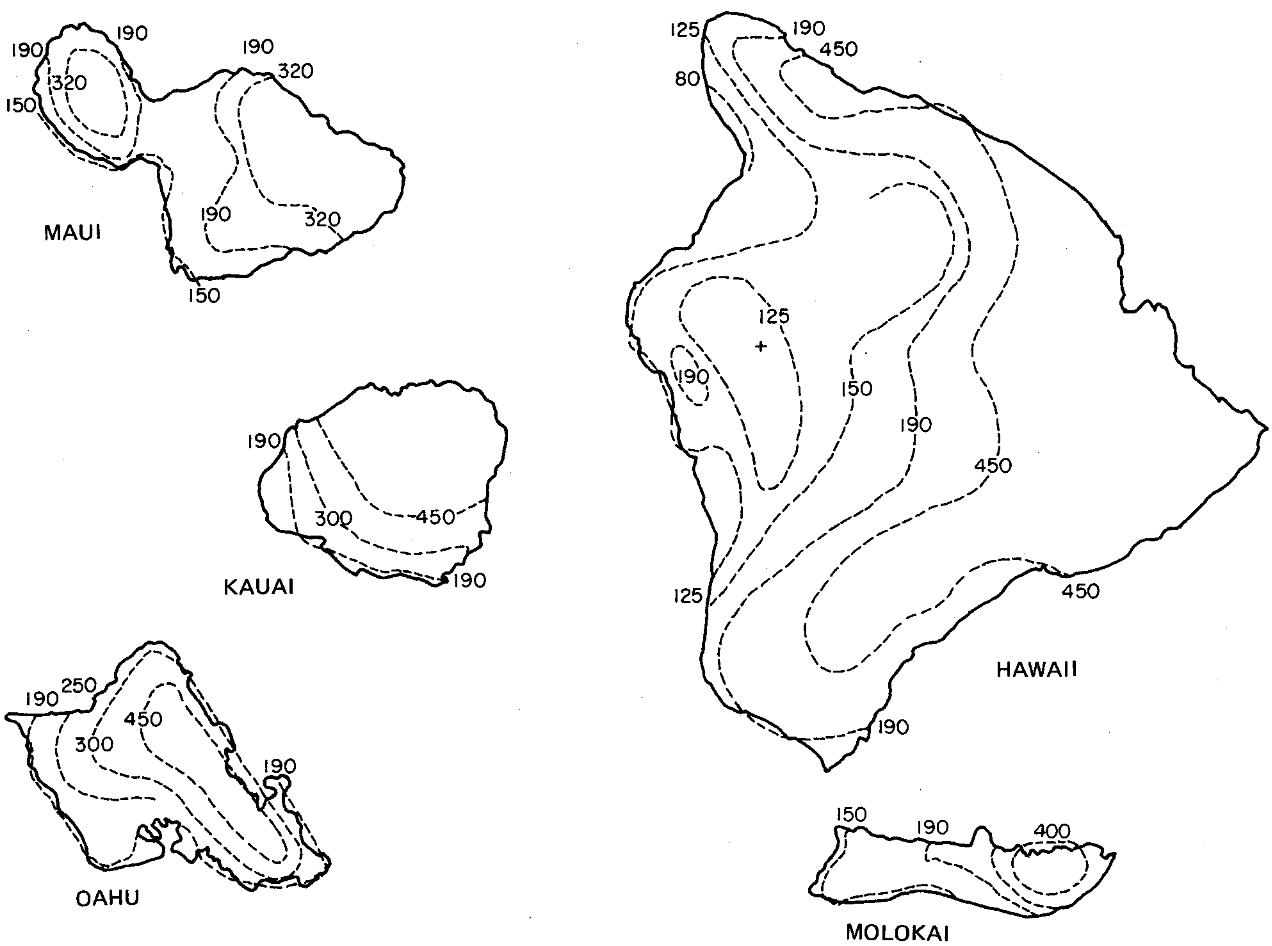

FIGURE 2.—Estimated average annual values of the rainfall erosion index in Hawaii.

west that has an erosion index of 20 (fig. 1) and averages 12 in of precipitation between December 1 and March 31 would have an estimated average annual **R** of 1.5(12) + 20, or 38.

This type of runoff may also be a significant factor in the northern tier of Central and Eastern States. Where experience indicates this to be the case, it should be included in **R** and also in the erosion index distribution curves as illustrated on page 27.

SOIL ERODIBILITY FACTOR (K)

The meaning of the term "soil erodibility" is distinctly different from that of the term "soil erosion." The rate of soil erosion, **A**, in the soil loss equation, may be influenced more by land slope, rainstorm characteristics, cover, and management than by inherent properties of the soil. However, some soils erode more readily than others even when all other factors are the same. This difference, caused by properties of the soil itself, is referred to as the soil erodibility. Several early attempts were made to determine criteria for scientific classifications of soils according to erodibility (*6, 18, 28, 35*), but classifications used for erosion prediction were only relative rankings.

Differences in the natural susceptibilities of soils to erosion are difficult to quantify from field observations. Even a soil with a relatively low erodibility factor may show signs of serious erosion when it occurs on long or steep slopes or in localities with numerous high-intensity rainstorms. A soil with a high natural erodibility factor, on the other hand, may show little evidence of actual erosion under gentle rainfall when it occurs on short and gentle slopes, or when the best possible management is practiced. The effects of rainfall differences, slope, cover, and management are accounted for in the prediction equation by the symbols **R, L, S, C,** and **P.** Therefore, the soil erodibility factor, **K,** must be evaluated independently of the effects of the other factors.

Definition of Factor K

The soil erodibility factor, **K,** in the USLE is a quantitative value experimentally determined. For a particular soil, it is the rate of soil loss per erosion index unit as measured on a "unit" plot, which has been arbitrarily defined as follows:

A unit plot is 72.6 ft long, with a uniform lengthwise slope of 9 percent, in continuous fallow, tilled up and down the slope. Continuous fallow, for this purpose, is land that has been tilled and kept free of vegetation for more than 2 years. During the period of soil loss measurements, the plot is plowed and placed in conventional corn seedbed condition each spring and is tilled as needed to prevent vegetative growth and severe surface crusting. When all of these conditions are met, **L, S, C,** and **P** each equal 1.0, and **K** equals **A/EI.**

The 72.6 ft length and 9 percent steepness were selected as base values for **L, S,** and **K** because they are the predominant slope length and about the average gradient on which past erosion measurements in the United States had been made. The designated management provides a condition that nearly eliminates effects of cover, management, and land use residual and that can be duplicated on any cropland.

Direct measurements of **K** on well-replicated, unit plots as described reflect the combined effects of all the soil properties that significantly influence the ease with which a particular soil is eroded by rainfall and runoff if not protected. However, **K** is an average value for a given soil, and direct measurement of the factor requires soil loss measurements for a representative range of storm sizes and antecedent soil conditions. (See **Individual Storm Soil Losses** under **APPLYING THE SOIL LOSS EQUATION.**) To evaluate **K** for soils that do not usually occur on a 9-percent slope, soil loss data from plots that meet all the other specified conditions are adjusted to this base by **S.**

Values of K for Specific Soils

Representative values of **K** for most of the soil types and texture classes can be obtained from tables prepared by soil scientists using the latest available research information. These tables are available from the Regional Technical Service Centers or State offices of SCS. Values for the exact

TABLE 1.—*Computed* **K** *values for soils on erosion research stations*

Soil	Source of data	Computed K
Dunkirk silt loam	Geneva, N.Y.	[1]0.69
Keene silt loam	Zanesville, Ohio	.48
Shelby loam	Bethany, Mo.	.41
Lodi loam	Blacksburg, Va.	.39
Fayette silt loam	LaCrosse, Wis.	[1].38
Cecil sandy clay loam	Watkinsville, Ga.	.36
Marshall silt loam	Clarinda, Iowa	.33
Ida silt loam	Castana, Iowa	.33
Mansic clay loam	Hays, Kans.	.32
Hagerstown silty clay loam	State College, Pa.	[1].31
Austin clay	Temple, Tex.	.29
Mexico silt loam	McCredie, Mo.	.28
Honeoye silt loam	Marcellus, N.Y.	[1].28
Cecil sandy loam	Clemson, S.C.	[1].28
Ontario loam	Geneva, N.Y.	[1].27
Cecil clay loam	Watkinsville, Ga.	.26
Boswell find sandy loam	Tyler, Tex.	.25
Cecil sandy loam	Watkinsville, Ga.	.23
Zaneis fine sandy loam	Guthrie, Okla.	.22
Tifton loamy sand	Tifton, Ga.	.10
Freehold loamy sand	Marlboro, N.J.	.08
Bath flaggy silt loam with surface stones > 2 inches removed	Arnot, N.Y.	[1].05
Albia gravelly loam	Beemerville, N.J.	.03

[1] Evaluated from continuous fallow. All others were computed from rowcrop data.

soil conditions at a specific site can be computed by use of the soil erodibility nomograph presented in the next subsection.

Usually a soil type becomes less erodible with decrease in silt fraction, regardless of whether the corresponding increase is in the sand fraction or the clay fraction. Overall, organic matter content ranked next to particle-size distribution as an indicator of erodibility. However, a soil's erodibility is a function of complex interactions of a substantial number of its physical and chemical properties and often varies within a standard texture class.

Values of **K** determined for 23 major soils on which erosion plot studies under natural rain were conducted since 1930 are listed in table 1. Seven of these values are from continuous fallow. The others are from row crops averaging 20 plot-years of record and grown in systems for which the cropping effect had been measured in other studies. Other soils on which valuable erosion studies have been conducted[4] were not included in the table because of uncertainties involved in adjustments of the data for effects of cropping and management.

Direct measurement of the erodibility factor is both costly and time consuming and has been feasible only for a few major soil types. To achieve a better understanding of how and to what extent each of various properties of a soil affects its erodibility, an interregional study was initiated in 1961. The study included the use of field-plot rainfall simulators in at least a dozen States to obtain comparative data on numerous soils, laboratory determinations of physical and chemical properties, and operation of additional fallow plots under natural rain. Several empirical erodibility equations were reported (*3, 60*). A soil erodibility nomograph for farmland and construction sites (*58*) provided a more generally applicable working tool. Approximate **K** values for 10 benchmark soils in Hawaii are listed in table 2.

[4] See footnote 3, p. 2.

TABLE 2.—*Approximate values of the soil erodibility factor,* **K**, *for 10 benchmark soils in Hawaii*

Order	Suborder	Great group	Subgroup	Family	Series	K
Ultisols	Humults	Tropohumults	Humoxic Tropohumults	Clayey, kaolinitic, isohyperthermic	Waikane	0.10
Oxisols	Torrox	Torrox	Typic Torrox	Clayey, kaolinitic, isohyperthermic	Molokai	.24
Oxisols	Ustox	Eutrustox	Tropeptic Eutrustox	Clayey, kaolinitic, isohyperthermic	Wahiawa	.17
Vertisols	Usterts	Chromusterts	Typic Chromusterts	Very fine, montmorillonitic, isohyperthermic	Lualualei	.28
					Kawaihae	.32
Aridisols	Orthids	Camborthids	Ustollic Camborthids	Medial, isohyperthermic	(Extremely stony phase)	
Inceptisols	Andepts	Dystrandepts	Hydric Dystrandepts	Thixotropic, isothermic	Kukaiau	.17
Inceptisols	Andepts	Eutrandepts	Typic Eutrandepts	Medial, isohyperthermic	Naolehu (Variant)	.20
Inceptisols	Andepts	Eutrandepts	Entic Eutrandepts	Medial, isohyperthermic	Pakini	.49
Inceptisols	Andepts	Hydrandepts	Typic Hydrandepts	Thixotropic, isohyperthermic	Hilo	.10
Inceptisols	Tropepts	Ustropepts	Vertic Ustropepts	Very fine, kaolinitic, isohyperthermic	Waipahu	.20

SOURCE: El-Swaify and Dangler (*9*).

Soil Erodibility Nomograph

The soil loss data show that very fine sand (0.05-0.10 mm) is comparable in erodibility to silt-sized particles and that mechanical-analysis data are much more valuable when expressed by an interaction term that describes the proportions in which the sand, silt, and clay fractions are combined in the soil. When mechanical analysis data based on the standard USDA classification are used for the nomograph in figure 3, the percentage of very fine sand (0.1-0.05 mm) must first be transferred from the sand fraction to the silt fraction. The mechanical analysis data are then effectively described by a particle-size parameter **M**, which equals percent silt (0.1-0.002 mm) times the quantity 100-minus-percent-clay. Where the silt fraction does not exceed 70 percent, erodibility varies approximately as the 1.14 power of this parameter, but prediction accuracy is improved by adding information on organic matter content, soil structure, and profile permeability class.

For soils containing less than 70 percent silt and very fine sand, the nomograph (fig. 3) solves the equation:

$$100\,K = 2.1\,M^{1.14}\,(10^{-4})\,(12 - a) + 3.25\,(b - 2) + 2.5\,(c - 3) \quad (3)$$

where

M = the particle-size parameter defined above,
a = percent organic matter,
b = the soil-structure code used in soil classification, and
c = the profile-permeability class.

The intersection of the selected percent-silt and percent-sand lines computes the value of **M** on the unidentified horizontal scale of the nomograph. (Percent clay enters into the computation as 100 minus the percentages of sand and silt.)

The data indicate a change in the relation of **M** to erodibility when the silt and very fine sand fraction exceeds about 70 percent. This change was empirically reflected by inflections in the percent-sand curves at that point but has not been described by a numerical equation.

Readers who would like more detail regarding the data and relationships underlying the nomograph equation may obtain this from journal articles (*58, 60*).

Nomograph Solution

With appropriate data, enter the scale at the left and proceed to points representing the soil's percent sand (0.10-2.0 mm), percent organic matter, structure code, and permeability class as illustrated by the dotted line on the nomograph. The horizontal and vertical moves must be made in the listed sequence. Use linear interpolations between plotted lines. The structure code and permeability classes are defined on the nomograph for reference.

Many agricultural soils have both fine granular topsoil and moderate permeability. For these soils, **K** may be read from the scale labeled "first approximation of **K**," and the second block of the graph is not needed. For all other soils, however, the procedure must be completed to the soil erodibility scale in the second half of the graph.

The mechanical analysis, organic matter, and structure data are those for the topsoil. For evaluation of **K** for desurfaced subsoil horizons, they pertain to the upper 6 in of the new soil profile. The permeability class is the profile permeability. Coarse fragments are excluded when determining percentages of sand, silt, and clay. If substantial, they may have a permanent mulch effect which can be evaluated from the upper curve of the chart on mulch and canopy effects (p. 19, fig. 6) and applied to the number obtained from the nomograph solution.

Confidence Limits

In tests against measured **K** values ranging from 0.03 to 0.69, 65 percent of the nomograph solutions differed from the measured **K** values by less than 0.02, and 95 percent of them by less than 0.04. Limited data available in 1971 for mechanically exposed **B** and **C** subsoil horizons indicated about comparable accuracy for these conditions. However, more recent data taken on desurfaced high-clay subsoils showed the nomograph solution to lack the desired sensitivity to differences in erodibilities of these soil horizons. For such soils the content of free iron and aluminum oxides ranks next to particle-size distribution as an indicator of erodibility (*37*). Some high-clay soils form what has been called irreversible aggregates on the surface when tilled. These behave like larger primary particles.

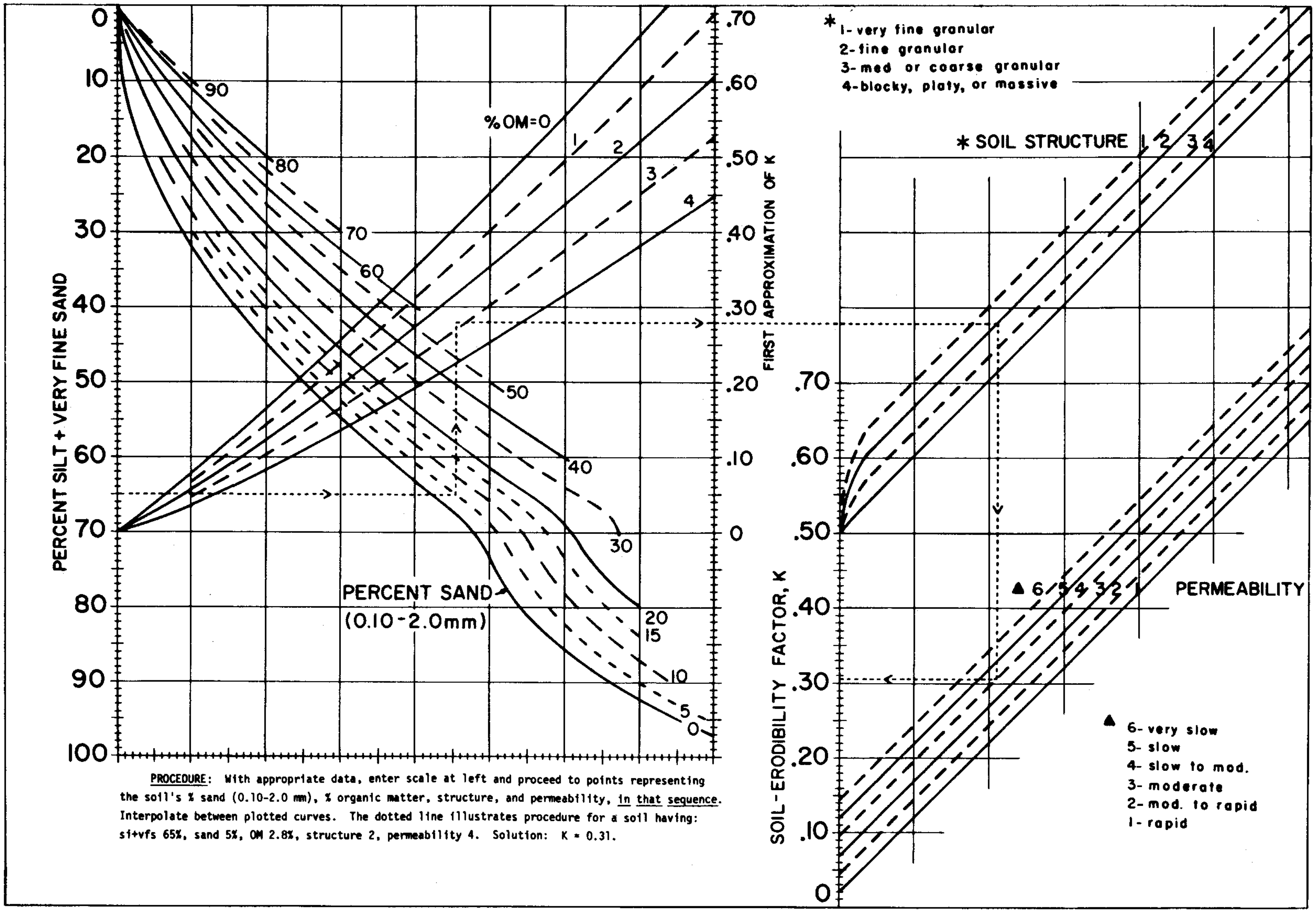

FIGURE 3.—The soil-erodibility nomograph. Where the silt fraction does not exceed 70 percent, the equation is $100\,K = 2.1\,M^{1.14}\,(10^{-4})\,(12 - a) + 3.25\,(b - 2) + 2.5\,(c - 3)$ where $M =$ (percent si + vfs) (100 — percent c), $a =$ percent organic matter, $b =$ structure code, and $c =$ profile permeability class.

TOPOGRAPHIC FACTOR (LS)

Both the length and the steepness of the land slope substantially affect the rate of soil erosion by water. The two effects have been evaluated separately in research and are represented in the soil loss equation by **L** and **S**, respectively. In field applications, however, considering the two as a single topographic factor, **LS**, is more convenient.

Slope-Effect Chart

LS is the expected ratio of soil loss per unit area from a field slope to that from a 72.6-ft length of uniform 9-percent slope under otherwise identical conditions. This ratio for specified combinations of field slope length and uniform gradient may be obtained directly from the slope-effect chart (fig. 4). Enter on the horizontal axis with the field slope length, move vertically to the appropriate percent-slope curve, and read **LS** on the scale at the left. For example, the **LS** factor for a 300-ft length of 10-percent slope is 2.4. Those who prefer a table may use table 3 and interpolate between listed values.

To compute soil loss from slopes that are appreciably convex, concave, or complex, the chart **LS** values need to be adjusted as indicated in the section **LS Values for Irregular Slopes.** Figure 4 and table 3 assume slopes that have essentially uniform gradient. The chart and table were derived by the equation

$$LS = (\lambda/72.6)^m \; (65.41 \sin^2 \theta + 4.56 \sin \theta + 0.065) \qquad (4)$$

where λ = slope length in feet;
θ = angle of slope; and
m = 0.5 if the percent slope is 5 or more, 0.4 on slopes of 3.5 to 4.5 percent, 0.3 on slopes of 1 to 3 percent, and 0.2 on uniform gradients of less than 1 percent.

The basis for this equation is given in the subsection discussing the individual effects of slope length and steepness. However, the relationships expressed by the equation were derived from data obtained on cropland, under natural rainfall, on slopes ranging from 3 to 18 percent in steepness and about 30 to 300 ft in length. How far beyond these ranges in slope characteristics the relationships derived from the data continue to be accurate has not been determined by direct soil loss measurements.

The Palouse Region of the Northwest represents

TABLE 3.—*Values of the topographic factor,* **LS**, *for specific combinations of slope length and steepness*[1]

Percent slope	Slope length (feet) 25	50	75	100	150	200	300	400	500	600	800	1,000
0.2	0.060	0.069	0.075	0.080	0.086	0.092	0.099	0.105	0.110	0.114	0.121	0.126
0.5	.073	.083	.090	.096	.104	.110	.119	.126	.132	.137	.145	.152
0.8	.086	.098	.107	.113	.123	.130	.141	.149	.156	.162	.171	.179
2	.133	.163	.185	.201	.227	.248	.280	.305	.326	.344	.376	.402
3	.190	.233	.264	.287	.325	.354	.400	.437	.466	.492	.536	.573
4	.230	.303	.357	.400	.471	.528	.621	.697	.762	.820	.920	1.01
5	.268	.379	.464	.536	.656	.758	.928	1.07	1.20	1.31	1.52	1.69
6	.336	.476	.583	.673	.824	.952	1.17	1.35	1.50	1.65	1.90	2.13
8	.496	.701	.859	.992	1.21	1.41	1.72	1.98	2.22	2.43	2.81	3.14
10	.685	.968	1.19	1.37	1.68	1.94	2.37	2.74	3.06	3.36	3.87	4.33
12	.903	1.28	1.56	1.80	2.21	2.55	3.13	3.61	4.04	4.42	5.11	5.71
14	1.15	1.62	1.99	2.30	2.81	3.25	3.98	4.59	5.13	5.62	6.49	7.26
16	1.42	2.01	2.46	2.84	3.48	4.01	4.92	5.68	6.35	6.95	8.03	8.98
18	1.72	2.43	2.97	3.43	4.21	3.86	5.95	6.87	7.68	8.41	9.71	10.9
20	2.04	2.88	3.53	4.08	5.00	5.77	7.07	8.16	9.12	10.0	11.5	12.9

[1] $LS = (\lambda/72.6)^m \; (65.41 \sin^2 \theta + 4.56 \sin \theta + 0.065)$ where λ = slope length in feet; m = 0.2 for gradients $<$ 1 percent, 0.3 for 1 to 3 percent slopes, 0.4 for 3.5 to 4.5 percent slopes, 0.5 for 5 percent slopes and steeper; and θ = angle of slope. (For other combinations of length and gradient, interpolate between adjacent values or see fig. 4.)

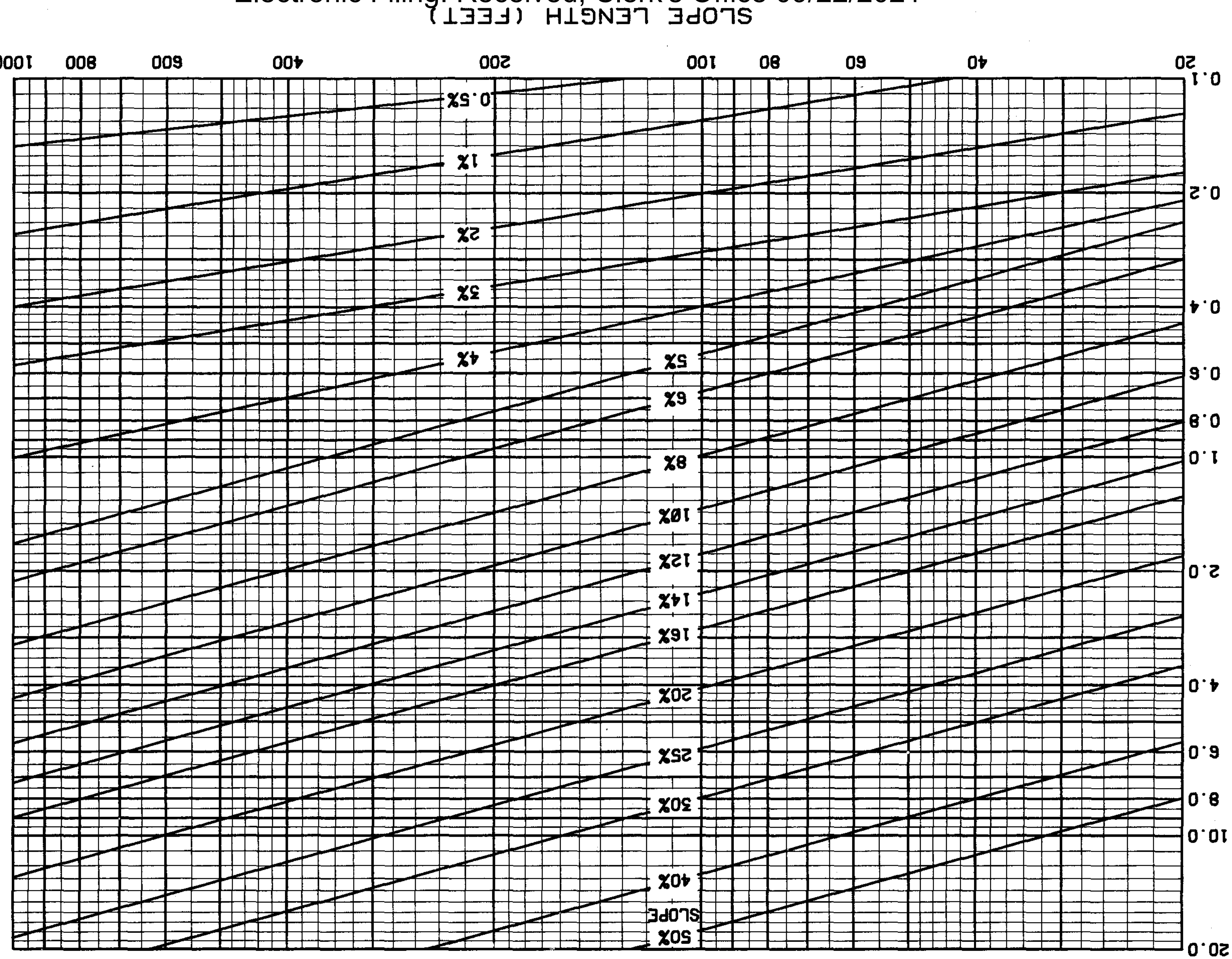

FIGURE 4.—Slope-effect chart (topographic factor, LS). $LS = (\lambda/72.6)^m\ (65.41\ \sin^2\theta + 4.56\ \sin\theta + 0.065)$ where λ = slope length in feet; θ = angle of slope; and m = 0.2 for gradients < 1 percent, 0.3 for 1 to 3 percent slopes, 0.4 for 3.5 to 4.5 percent slopes, and 0.5 for slopes of 5 percent or steeper.

a different situation. The rainfall erosion index is quite low because most of the rain comes as small drops and at low intensities. But many of the cropland slopes are long or steep, and substantial erosion occurs because of runoff from snowmelt or light rains over saturated soil surfaces. Limited erosion data from this region, mostly observational, strongly indicate that for this type of runoff (not accompanied by raindrop impact) the effects of percent and length of slope are of lower magnitude than indicated by the humid region data. Investigations designed to develop a more accurate **LS** equation for this region are underway at Pullman, Wash. (*21*). In the meantime, the researchers are temporarily recommending using a modified equation which computes **LS** values that are close to those that would be calculated by the equation given above if $\sin^{1.5}\theta$ were substituted for $\sin^2\theta$ and the length-exponent, **m**, were assumed to equal 0.3. Intuitively, these changes seem reasonable for the conditions under which about 90 percent of the erosion in this region occurs.

Slope-Length Effect

Slope length is defined as the distance from the point of origin of overland flow to the point where either the slope gradient decreases enough that deposition begins, or the runoff water enters a well-defined channel that may be part of a drainage network or a constructed channel (*40*). A change in land cover or a substantial change in gradient along a slope does not begin a new slope length for purposes of soil loss estimation.

The effect of slope length on annual *runoff* per unit area of cropland may generally be assumed negligible. In some of the studies runoff per unit area was slightly lower on the longer slopes during the growing season and slightly higher during the dormant season, but the differences were relatively small and neither of the relationships was consistent (*52*).

However, the *soil loss* per unit area generally increases substantially as slope length increases. The greater accumulation of runoff on the longer slopes increases its detachment and transport capacities.

The plot data showed average soil loss per unit area to be proportional to a power of slope length. Because **L** is the ratio of field soil loss to the corresponding loss from 72.6-ft slope length, its value may be expressed as $\mathbf{L} = (\lambda/72.6)^{\mathbf{m}}$, where λ is the field slope length in feet, and **m** assumes approximately the values given in the **LS** equation in the preceding section. These are average values of **m** and are subject to some variability caused by interaction effects which are not now quantitatively predictable.

The existing field plot data do not establish a general value greater than 0.5 for **m** on slopes steeper than 10 percent, as was suggested in 1965 (*64*). Although apparent values up to 0.9 were observed in some of the data (*63*), the higher values appear to have been related to soil, crop, and management variables rather than to greater slope steepness. However, basic modeling work has suggested that **m** may appreciably exceed 0.5 on steep slopes that are highly susceptible to rilling, like some construction slopes (*10*). Additional research data are greatly needed to quantify the significant interaction effects so that specific site values of **m** can be more precisely computed. Subdividing erosion between interrill (or sheet) erosion and rill erosion, being done in recent modeling work (*10, 11, 22*), promises to be quite helpful for solving this problem.

Some observations have indicated that the values of the length exponent that were derived from the plot data may overestimate soil loss when applied to lengths in the range of a quarter of a mile or more. This is logical because slopes of such lengths would rarely have a constant gradient along their entire length, and the slope irregularities would affect the amount of soil movement to the foot of the slope. By the definition of slope length quoted earlier, such slopes would usually consist of several lengths, between points where deposition occurs.

Slope length is difficult to determine for long slopes with an average gradient of less than 1 percent, unless they are precisely formed with a land leveler. On flat slopes, reflecting both the erosion and the deposition accurately by a length factor may not be possible. However, on a nearly zero-percent slope, increased length would have minor effect on runoff velocity, and the greater depths of accumulated runoff water would cushion the raindrop impact. An exponent of 0.2 for gradients of less than 1 percent is compatible with the scarce data available for such slopes and was used to derive figure 4 and table 3.

Distribution of Length Effect

LS values from figure 4 or table 3 predict the *average* erosion over the entire slope. But this erosion is not evenly distributed over the entire length. The rate of soil loss per unit of area increases as the **m**th power of the distance from the top of the slope, where **m** is the length exponent in the preceding equation.

An equation by Foster and Wischmeier (*12*) estimates the relative amounts of soil loss from successive segments of a slope under conditions where there is no deposition by overland flow. When the gradient is essentially uniform and the segments are of equal length, the procedure can be shortened (*55*). Table 4, derived by this procedure, shows the proportionate amounts of soil detachment from successive equal-length segments of a uniform slope.

Table 4 is entered with the total number of equal-length segments, and the fraction of the soil loss for each segment is read beneath the applicable value of **m.** For example, three equal-length segments of a uniform 6-percent slope would be expected to produce 19, 35, and 46 percent, respectively, of the loss from the entire slope.

TABLE 4.—*Estimated relative soil losses from successive equal-length segments of a uniform slope*[1]

Number of segments	Sequence number of segment	Fraction of soil loss		
		m = 0.5	m = 0.4	m = 0.3
2	1	0.35	0.38	0.41
	2	.65	.62	.59
3	1	.19	.22	.24
	2	.35	.35	.35
	3	.46	.43	.41
4	1	.12	.14	.17
	2	.23	.24	.24
	3	.30	.29	.28
	4	.35	.33	.31
5	1	.09	.11	.12
	2	.16	.17	.18
	3	.21	.21	.21
	4	.25	.24	.23
	5	.28	.27	.25

[1] Derived by the formula:

$$\text{Soil loss fraction} = \frac{j^{m+1} - (j-1)^{m+1}}{N^{m+1}}$$

where **j** = segment sequence number; **m** = slope-length exponent (0.5 for slopes ≥ 5 percent, 0.4 for 4 percent slopes, and 0.3 for 3 percent or less); and **N** = number of equal-length segments into which the slope was divided.

Four segments would produce 12, 23, 30, and 35 percent, respectively. Segment No. 1 is always at the top of the slope.

Percent Slope

Runoff from cropland generally increases with increased slope gradient, but the relationship is influenced by such factors as type of crop, surface roughness, and profile saturation. In the natural rain slope-effect studies, the logarithm of runoff from row crops was linearly and directly proportional to percent slope. With good meadow sod and with smooth bare surfaces, the relationship was insignificant. The effect of slope on runoff decreased in extremely wet periods.

Soil loss increases much more rapidly than runoff as slopes steepen. The slope-steepness factor, **S,** in the soil loss equation is evaluated by the equation

$$S = 65.41 \sin^2 \theta + 4.56 \sin \theta + 0.065 \qquad (5)$$

where θ is the angle of slope.

This equation was used to develop the slope-effect chart. The values reflect the average effect of slope steepness on soil loss in the plot studies. The relation of percent slope to soil loss is believed to be influenced by interactions with soil properties and surface conditions, but the interaction effects have not been quantified by research data. Neither are data available to define the limits on the equation's applicability.

This equation can be derived from the formerly published equation for **S.** Expressing the factor as a function of the sine of the angle of slope rather than the tangent is more accurate because raindrop-impact forces along the surface and runoff shear stress are functions of the sine. Substituting 100 sin θ for percent slope, which is 100 tan θ, does not significantly affect the initial statistical derivation or the equation's solutions for slopes of less than 20 percent. But as slopes become steeper, the difference between the sine and the tangent becomes appreciable and projections far beyond the range of the plot data become more realistic. The numerator was divided by the constant denominator for simplification.

Irregular Slopes

Soil loss is also affected by the shape of a slope. Many field slopes either steepen toward the lower end (convex slope) or flatten toward the lower end (concave slope). Use of the average gradient to enter figure 4 or table 3 would underestimate soil movement to the foot of a convex slope and would overestimate it for concave slopes. Irregular slopes can usually be divided into segments that have nearly uniform gradient, but the segments cannot be evaluated as independent slopes when runoff flows from one segment to the next.

However, where two simplifying assumptions can be accepted, **LS** for irregular slopes can be routinely derived by combining selected values from the slope-effect chart and table 4 (*55*). The assumptions are that (1) the changes in gradient are not sufficient to cause upslope deposition, and (2) the irregular slope can be divided into a small number of equal-length segments in such a manner that the gradient within each segment for practical purposes can be considered uniform.

After dividing the convex, concave, or complex slope into equal-length segments as defined earlier, the procedure is as follows: List the segment gradients in the order in which they occur on the slope, beginning at the upper end. Enter the slope-effect chart with the total slope length and read **LS** for each of the listed gradients. Multiply these by the corrresponding factors from table 4 and add the products to obtain **LS** for the entire slope. The following tabulation illustrates the procedure for a 400-ft convex slope on which the upper third has a gradient of 5 percent; the middle third, 10 percent; and the lower third, 15 percent:

Segment	*Percent slope*	*Table 3*	*Table 4*	*Product*
1	5	1.07	0.19	0.203
2	10	2.74	.35	.959
3	15	5.12	.46	2.355
				LS = 3.517

For the concave slope of the same length, with the segment gradients in reverse order, the values in the third column would be listed in reverse order. The products would then be 0.973, 0.959, and 0.492, giving a sum of 2.42 for **LS.**

Research has not defined just how much gradient change is needed under various conditions for deposition of soil particles of various sizes to begin, but depositional areas can be determined by observation. When the slope breaks are sharp enough to cause deposition, the procedure can be used to estimate **LS** for slope segments above and below the depositional area. However, it will not predict the total sediment moved from such an interrupted slope because it does not predict the amount of deposition.

Changes in Soil Type or Cover Along the Slope

The procedure for irregular slopes can include evaluation of changes in soil type within a slope length (*55*). The products of values selected from table 3 or figure 4 and table 4 to evaluate **LS** for irregular slopes are multiplied by the respective values of **K** before summing. To illustrate, assume the **K** values for the soils in the three segments of the convex slope in the preceding example were 0.27, 0.32, and 0.37, respectively. The average **KLS** for the slope would be obtained as follows:

Segment No.	*Table 3*	*Table 4*	K	*Product*
1	1.07	0.19	0.27	0.055
2	2.74	.35	.32	.307
3	5.12	.46	.37	.871
				KLS = 1.233

Within limits, the procedure can be further extended to account for changes in cover along the slope length by adding a column of segment **C** values. However, it is not applicable for situations where a practice change along the slope causes deposition. For example, a grass buffer strip across the foot of a slope on which substantial erosion is occurring induces deposition. The amount of this deposition is a function of transport relationships (*10*) and cannot be predicted by the USLE.

Equation for Soil Detachment on Successive Segments of a Slope

This procedure is founded on an equation (12) that can be applied also when the slope segments are not of equal length. Concepts underlying this equation include the following:

Sediment load at a location on a slope is controlled either by the transport capacity of the runoff and rainfall or by the amount of detached soil material available for transport. When the amount of detached material exceeds the transport capacity, deposition occurs and the sediment load is determined primarily by the transport capacity of the runoff at that location. Where upslope detachment has not equaled the transport capacity, sediment load at a given location is a function of erosion characteristics of the upslope area and can be computed by the USLE. Soil loss from a given segment of the slope can then be computed as the difference between the sediment loads at the lower and upper ends of the segment.

Foster and Wischmeier (12) present a procedure for using this equation to evaluate **LS** for irregular slopes and to account for the effects of the soil or coverage changes along a slope, so long as the changes do not cause deposition to occur.

COVER AND MANAGEMENT FACTOR (C)

Cover and management effects cannot be independently evaluated because their combined effect is influenced by many significant interrelations. Almost any crop can be grown continuously, or it can be grown in rotations. Crop sequence influences the length of time between successive crop canopies, and it also influences the benefits obtained from residual effects of crops and management. The erosion control effectiveness of meadow sod turned under before a row crop depends on the type and quality of the meadow and on the length of time elapsed since the sod was turned under. Seedbeds can be clean tilled, or they can be protected by prior crop residues. They can be left rough, with much available capacity for surface storage and reduction of runoff velocity, or they can be smoothed by secondary tillage.

Crop residues can be removed, left on the surface, incorporated near the surface, or plowed under. When left on the surface, they can be chopped or dragged down, or they can be allowed to remain as left by the harvesting operation. The effectiveness of crop residue management will depend on the amount of residue available. This, in turn, depends on the amount and distribution of rainfall, on the fertility level, and on the management decisions made by the farmer.

The canopy protection of crops not only depends on the type of vegetation, the stand, and the quality of growth, but it also varies greatly in different months or seasons. Therefore, the overall erosion-reducing effectiveness of a crop depends largely on how much of the erosive rain occurs during those periods when the crop and management practices provide the least protection.

Definition of Factor C

Factor **C** in the soil loss equation is the ratio of soil loss from land cropped under specified conditions to the corresponding loss from clean-tilled, continuous fallow. This factor measures the combined effect of all the interrelated cover and management variables.

The loss that would occur on a particular field if it were continuously in fallow condition is computed by the product of **RKLS** in the soil loss equation. Actual loss from the cropped field is usually much less than this amount. Just how much less depends on the particular combination of cover, crop sequence, and management practices. It also depends on the particular stage of growth and development of the vegetal cover at the time of the rain. **C** adjusts the soil loss estimate to suit these conditions.

The correspondence of periods of expected highly erosive rainfall with periods of poor or good plant cover differs between regions or locations. Therefore, the value of **C** for a particular cropping system will not be the same in all parts of the country. Deriving the appropriate **C** values for a given locality requires knowledge of how the erosive rainfall in that locality is likely to be distributed through the 12 months of the year and how much erosion control protection the growing plants, crop residues, and selected management practices will provide at the time when erosive rains are most likely to occur. A procedure is presented for deriving local values of **C** on the basis of available weather records and research data that reflect effects of crops and management in successive segments of a rotation cycle. The cropping and weather data needed for this purpose appear in reference form in the subsections entitled, **Soil Loss Ratios** and **Erosion Index Distribution Data.**

Cropstage Periods

The change in effectiveness of plant cover within the crop year is gradual. For practical purposes, the year is divided into a series of cropstage periods defined so that cover and management effects may be considered approximately uniform within each period.

Initially, five periods were used, with the seedling and establishment periods defined as the first and second months after crop seeding (*50*). Because of the existing ranges in soil fertility, row spacing, plant population, and general growing conditions, however, soil loss prediction accuracy is improved when the cropstage periods are defined according to percentage of canopy cover rather than for uniform time periods. The lengths of the respective periods will then vary with crop, climate, and management and will be determined by conditions in a particular geographic area.

The soil loss ratios presented in the next subsection for computation of **C** were evaluated for six cropstage periods defined as follows:

Period F (rough fallow)—Inversion plowing to secondary tillage.

Period SB (seedbed)—Secondary tillage for seedbed preparation until the crop has developed 10 percent canopy cover.

Period 1 (establishment)—End of *SB* until crop has developed a 50 percent canopy cover. (Exception: period 1 for cotton ends at 35 percent canopy cover.)

Period 2 (development)—End of period 1 until canopy cover reaches 75 percent. (60 percent for cotton.)

Period 3 (maturing crop)—End of period 2 until crop harvest. This period was evaluated for three levels of final crop canopy.

Period 4 (residue or stubble)—Harvest to plowing or new seeding.

Quantitative Evaluations of Crop and Management Effects

More than 10,000 plot-years of runoff and soil loss data from natural rain,[5] and additional data from a large number of erosion studies under simulated rainfall, were analyzed to obtain empirical measurements of the effects of cropping system and management on soil loss at successive stages of crop establishment and development. Soil losses measured on the cropped plots were compared with corresponding losses from clean-tilled, continuous fallow to determine the soil loss reductions ascribable to effects of the crop system and management. The reductions were then analyzed to identify and evaluate influential subfactors, interactions, and correlations. Mathematical relationships observed for one crop or geographic region were tested against data from other research sites for consistency. Those found compatible with all the relevant data were used to compute soil loss reductions to be expected from conditions not directly represented in the overall plot studies.

The value of **C** on a particular field is determined by many variables, one of which is weather. Major variables that can be influenced by management decisions include crop canopy, residue mulch, incorporated residues, tillage, land use residual, and their interactions. Each of these effects may be treated as a subfactor whose numerical value is the ratio of soil loss with the effect to corresponding loss without it (*57*). **C** is the product of all the pertinent subfactors.

Crop Canopy

Leaves and branches that do not directly contact the soil have little effect on amount and velocity of *runoff* from prolonged rains, but they reduce the effective rainfall energy by intercepting falling raindrops. Waterdrops falling from the canopy may regain appreciable velocity but usually less than the terminal velocities of free-falling

[5] See footnote 3, p. 2.

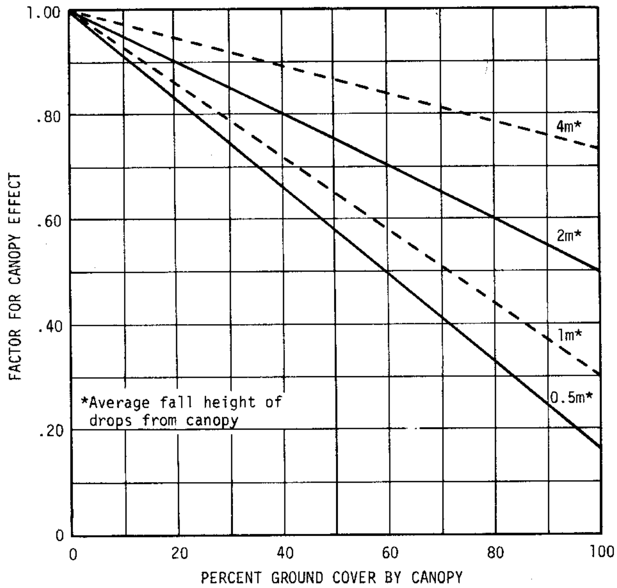

FIGURE 5.—Influence of vegetative canopy on effective EI values. Canopy factor is a subfactor of C.

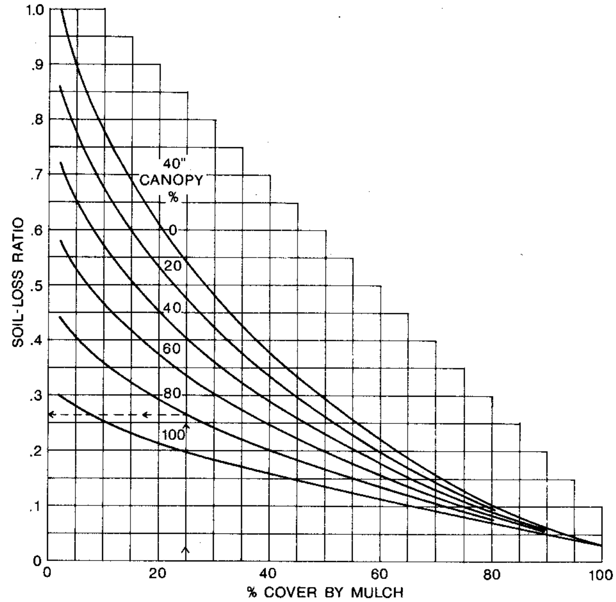

FIGURE 6.—Combined mulch and canopy effects when average fall distance of drops from canopy to the ground is about 40 inches (1 m).

raindrops. The amount by which energy expended at the soil surface is reduced depends on the height and density of the canopy. The subfactor for canopy effect can be estimated for specified conditions by reference to figure 5.

Residue Mulch

Residue mulches and stems from close-growing vegetation are more effective than equivalent percentages of canopy cover. Mulches intercept falling raindrops so near the surface that the drops regain no fall velocity, and they also obstruct runoff flow and thereby reduce its velocity and transport capacity. Measurements of the effectiveness of several types and rates of mulch have been published (*1, 2, 20, 27, 43*). Average subfactors for specific percentages of surface cover by plant materials at the soil surface are given by the upper curve of figure 6. Guides for estimating percent cover are given in the appendix.

If the cover includes both canopy and mulch, the two are not fully additive; the impact energy of drops striking the mulch is dissipated at that point regardless of whether canopy interception has reduced its velocity. The expected effects of mulch and canopy combinations have been computed and are given in figures 6 and 7. Figure 6 applies to corn, sorghum, and cotton in the maturing stage. Figure 7 applies to small grain, soybeans, potatoes, and the establishment period for taller row crops. Enter either figure 6 or 7 along the horizontal scale, move vertically to the appro-

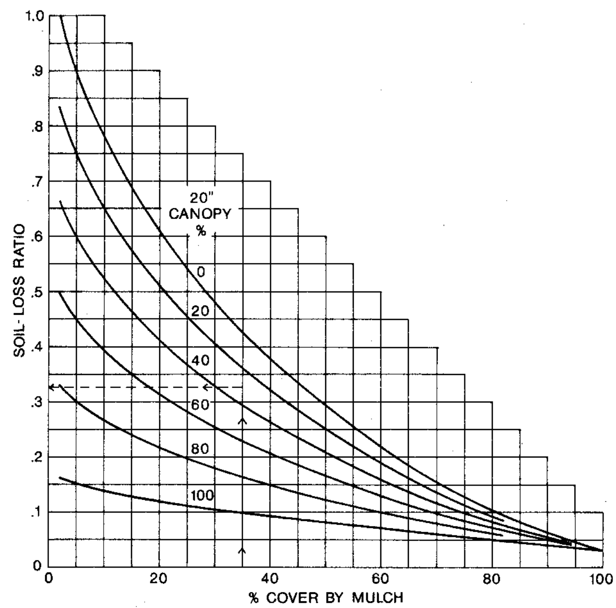

FIGURE 7.—Combined mulch and canopy effects when average fall distance of drops from canopy to the ground is about 20 inches (0.5 m).

priate percent-canopy curve, and read at the left the soil loss ratio from cover effect. This ratio is a subfactor that may be combined with other pertinent subfactors to account for the cropstage soil loss of table 5 or to estimate others.

Incorporated Residues

The plot data indicate that, at least during the seedbed and establishment periods, the erosion-reducing effectivensss of residues mixed into the upper few inches of soil by shallow tillage is appreciably greater than the residual effect of long-term annual incorporation with a moldboard plow. However, the incorporated residues are less effective than if left on the surface.

Tillage

The type, frequency, and timing of tillage operations influence porosity, roughness, cloddiness, compaction, and microtopography. These, in turn, affect water intake, surface storage, runoff velocity, and soil detachability, all of which are factors in potential erosion. These effects are highly correlated with cropland residual effects.

Land Use Residuals

These include effects of plant roots; long-term residue incorporation by plowing; changes in soil structure, detachability, density, organic matter content, and biological activity; and probably other factors. The residual effects are most apparent during seedbed and establishment periods.

Some residual effect will be apparent on nearly any cropland, but the magnitude of its erosion-reducing effectiveness will differ substantially with crops and practices. Tillage and land use residuals are influenced by so many factor interrelations that development of charts like those for canopy and mulch has not been feasible. However, apparent values of these subfactors for some situations were derived from the data and used for expansion of the soil loss ratio table to include conditions somewhat different from those directly represented in the plot studies.

Plowing residues down is far less effective than leaving them on the surface but better than burning them or removing them from the land. After several years of turning the crop residues under with a moldboard plow before row crop seeding in plot studies under natural rainfall, both runoff and soil loss from the row crops were much less than from similar plots from which cornstalks and grain straw were removed at harvesttimes (*52, 54, 59*).

Short periods of rough fallow in a rotation will usually lose much less soil than the basic, clean-tilled, continuous fallow conditions for which **C** = 1. This is largely because of residual effects and is also partly because of the roughness and cloddiness.

The most pronounced residual effect is that from long-term sod or forest. The effect of a grass-and-legume rotation meadow turned under diminishes gradually over about 2 years. In general, the erosion-reducing effectiveness of sod residual (from grass or grass-and-legume meadows) in the plot studies was directly proportional to hay yields. Site values of the subfactor for sod residuals in rotations can be obtained from soil loss ratio table 5-D. The effectiveness of virgin sod and of long periods of alfalfa in which grass became well established was longer lasting. Mixtures of grasses and legumes were more effective than legumes alone.

Residual effectiveness of winter cover crops plowed under in spring depends largely on the type and quality of the crop and its development stage at the time it is plowed under. The effectiveness of grass-and-legume catch crops turned under in spring was less and of shorter duration than that of full-year rotation meadows. Covers such as vetch and ryegrass seeded between corn or cotton rows before harvest and turned under in April were effective in reducing erosion during the winter and showed some residual effect in the following seedbed and establishment periods. Small grain seeded alone in corn or cotton residues showed no residual effect under the next crop. Small grain or vetch on fall-plowed seedbed and turned at spring planting time lost more soil than adjacent plots with undisturbed cotton residues on the surface.

Soil Loss Ratios

Factor **C** is usually given in terms of its average annual value for a particular combination of crop system, management, and rainfall pattern. To derive site values of **C**, soil loss ratios for the individual cropstage periods must be combined with erosion-index distribution data, as demonstrated later. Ratios of soil losses in each cropstage period of specified cropping and management systems to corresponding losses from the basic long-term fallow condition were derived from analysis of about a quarter million plot soil loss observations. The ratios are given in table 5 as percentages.

The observed soil loss ratios for given conditions often varied substantially from year to year because of influences of unpredictable random variables and experimental error. The percentages listed in table 5 are the best available averages for the specified conditions. To make the table inclusive enough for general field use, expected ratios had to be computed for cover, residue, and management combinations that were not directly represented in the plot data. This was done by using empirical relationships of soil losses to the subfactors and interactions discussed in the preceding subsection. The user should recognize that the tabulated percentages are subject to appreciable experimental error and could be improved through additional research. However, because of the large volume of data considered in developing the table, the listed values should be near enough to the true averages to provide highly valuable planning and monitoring guidelines. A ratio derived locally from 1-year rainfall simulator tests on a few plots would not necessarily represent the true average for that locality more accurately. Small samples are more subject to bias by random variables and experimental error than larger samples.

Table for Cropland

Table 5, with its supplements 5A, B, C, and D, replaces tables 2, 3, and 4 in the 1965 edition. The supplements had to be separated from the main table to accommodate changes in format requirements. The ratios are expressed as percentages in the tables to eliminate decimal points.

More than half the lines in table 5 are for conditions associated with conservation tillage practices (*65*), which were not included in the 1965 edition. Also, it provides a direct means of crediting effects of faster and more complete canopy development by improved fertility, closer row spacing, and greater plant population. Because the table includes several times as many specific conditions as the table in the 1965 edition and defines applicable field conditions more accurately, some simplicity has been sacrificed. However, it is not intended for direct use by each field technician or farmer.

Table 5 as presented here is designed to provide the details needed by a trained agronomist to develop simple handbook tables of **C** values for conditions in specific climatic areas. It is designed for use of the revised definitions of cropstage periods given in the preceding section. The agronomist will first determine, for the particular climatic area, the number of weeks normally required for the crop canopies to attain 10, 50, and 75 percent surface cover, respectively. The table will then be used as illustrated in the next major section. Linear interpolation between ratios listed in the table is recommended where appropriate.

Semiarid Regions

Water erosion is a serious problem also in subhumid and semiarid regions. Inadequate moisture and periodic droughts reduce the periods when growing plants provide good soil cover and limit the quantities of plant residue produced. Erosive rainstorms are not uncommon, and they are usually concentrated within the season when cropland is least protected. Because of the difficulty of establishing rotation meadows and the competition for available soil moisture, sod-based rotations are often impractical. One of the most important opportunities for a higher level of soil and moisture conservation is through proper management of available residues. The effects of mulch-tillage practices in these areas can be evaluated from lines 129 to 158 of table 5 and item 12 of 5-B.

Erosion Index Distribution Data

The rainfall factor, **R**, in the soil loss equation does not completely describe the effects of local differences in rainfall pattern on soil erosion. The erosion control effectiveness of a cropping system on a particular field depends, in part, on how the year's erosive rainfall is distributed among the six cropstage periods of each crop included in the system. Therefore, expected monthly distribution

TABLE 5.—*Ratio of soil loss from cropland to corresponding loss from continuous fallow*

Line No.	Cover, crop sequence, and management[1]	Spring residue[2]	Cover after plant[3]	Soil loss ratio[4] for cropstage period and canopy cover[5]							
				F	SB	1	2	3:80	90	96	4L[6]
		Lb	*Pct*	*Pct*	*Pct*	*Pct*	*Pct*	*Pct*	*Pct*	*Pct*	*Pct*
	CORN AFTER C, GS, G OR COT IN MEADOWLESS SYSTEMS										
	Moldboard plow, conv till:										
1	RdL, sprg TP	4,500	—	31	55	48	38	—	—	20	23
2		3,400	—	36	60	52	41	—	24	20	30
3		2,600	—	43	64	56	43	32	25	21	37
4		2,000	—	51	68	60	45	33	26	22	47
5	RdL, fall TP	HP[2]	—	44	65	53	38	—	—	20	—
6		GP	—	49	70	57	41	—	24	20	—
7		FP	—	57	74	61	43	32	25	21	—
8		LP	—	65	78	65	45	32	26	22	—
9	RdR, sprg TP	HP	—	66	74	65	47	—	—	22	[7]56
10		GP	—	67	75	66	47	—	27	23	62
11		FP	—	68	76	67	48	35	27	—	69
12		LP	—	69	77	68	49	35	—	—	74
13	RdR, fall TP	HP	—	76	82	70	49	—	—	22	—
14		GP	—	77	83	71	50	—	27	23	—
15		FP	—	78	85	72	51	35	27	—	—
16		LP	—	79	86	73	52	35	—	—	—
17	*Wheeltrack pl, RdL, TP*[8]	4,500	—	—	31	27	25	—	—	18	23
18		3,400	—	—	36	32	30	—	22	18	30
19		2,600	—	—	43	36	32	29	23	19	37
20		2,000	—	—	51	43	36	31	24	20	47
21	*Deep off-set disk or*	4,500	10	—	45	38	34	—	—	20	23
22	*disk plow*	3,400	10	—	52	43	37	—	24	20	30
23		2,600	5	—	57	48	40	32	25	21	37
24		2,000	—	—	61	51	42	33	26	22	47
25	*No-till plant in crop residue*[9]	6,000	95	—	2	2	2	—	—	2	14
26		6,000	90	—	3	3	3	—	—	3	14
27		4,500	80	—	5	5	5	—	—	5	15
28		3,400	70	—	8	8	8	—	8	6	19
29		3,400	60	—	12	12	12	12	9	8	23
30		3,400	50	—	15	15	14	14	11	9	27
31		2,600	40	—	21	20	18	17	13	11	30
32		2,600	30	—	26	24	22	21	17	14	36
	Chisel, shallow disk, or fld cult, as only tillage:										
33	On moderate slopes	6,000	70	—	8	8	7	—	—	7	17
34			60	—	10	9	8	—	—	8	17
35			50	—	13	11	10	—	—	9	18
36			40	—	15	13	11	—	—	10	19
37			30	—	18	15	13	—	—	12	20
38			20	—	23	20	18	—	—	16	21
39	Do.	4,500	70	—	9	8	7	—	—	7	18
40			60	—	12	10	9	—	—	8	18
41			50	—	14	13	11	—	—	9	19
42			40	—	17	15	13	—	—	10	20
43			30	—	21	18	15	—	—	13	21
44			20	—	25	22	19	—	—	16	22
	CORN AFTER WC OF RYEGRASS OR WHEAT SEEDED IN C STUBBLE										
	WC reaches stemming stage:										
79	No-till pl in killed WC	4,000	—	—	7	7	7	—	7	6	([13])
80		3,000	—	—	11	11	11	11	9	7	
81		2,000	—	—	15	15	14	14	11	9	
82		1,500	—	—	20	19	18	18	14	11	
	Strip till one-fourth row space										
83	Rows U/D slope	4,000	—	—	13	12	11	—	11	9	([13])
84		3,000	—	—	18	17	16	16	13	10	
85		2,000	—	—	23	22	20	19	15	12	
86		1,500	—	—	28	26	24	22	17	14	
87	Rows on contour[11]	4,000	—	—	10	10	10	—	10	8	([13])
88		3,000	—	—	15	15	15	15	12	9	
89		2,000	—	—	20	20	19	19	15	12	
90		1,500	—	—	25	24	23	22	17	14	
91	TP, conv seedbed	4,000	—	36	60	52	41	—	24	20	([13])
92		3,000	—	43	64	56	43	31	25	21	
93		2,000	—	51	68	60	45	33	26	22	
94		1,500	—	61	73	64	47	35	27	23	
	WC succulent blades only:										
95	No-till pl in killed WC	3,000	—	—	11	11	17	23	18	16	([13])
96		2,000	—	—	15	15	20	25	20	17	
97		1,500	—	—	20	20	23	26	21	18	
98		1,000	—	—	26	26	27	27	22	19	
99	Strip till one-fourth row space	3,000	—	—	18	18	21	25	20	17	([13])
100		2,000	—	—	23	23	25	27	21	18	
101		1,500	—	—	28	28	28	28	22	19	
102		1,000	—	—	33	33	31	29	23	20	
	CORN IN SOD-BASED SYSTEMS										
	No-till pl in killed sod:										
103	3 to 5 tons hay yld	—	—	—	1	1	1	—	1	1	1
104	1 to 2 tons hay yld	—	—	—	2	2	2	2	2	2	2
	Strip till, 3-5 ton M:										
105	50 percent cover, tilled strips	—	—	—	2	2	2	—	2	2	4
106	20 percent cover, tilled strips	—	—	—	3	3	3	—	3	3	5
	Strip till, 1-2 ton M:										
107	40 percent cover, tilled strips	—	—	—	4	4	4	4	4	4	6
108	20 percent cover, tilled strips	—	—	—	5	5	5	5	5	5	7
	Other tillage after sod:			([14])	([14])	([14])	([14])	([14])	([14])	([14])	([14])
	CORN AFTER SOYBEANS										
109	*Sprg TP, conv till*	HP	—	40	72	60	48	—	—	25	29
110		GP	—	47	78	65	51	—	30	25	37
111		FP	—	56	83	70	54	40	31	26	44
112	*Fall TP, conv till*	HP	—	47	75	60	48	—	—	25	—
113		GP	—	53	81	65	51	—	30	25	—
114		FP	—	62	86	70	54	40	31	26	—

45	Do.	3,400	60	—	13	11	10	—	10	8	20
46			50	—	16	13	12	—	12	9	24
47			40	—	19	17	16	—	14	11	25
48			30	—	23	21	19	—	17	14	26
49			20	—	29	25	23	—	21	16	27
50			10	—	36	32	29	—	24	20	30
51	Do.	2,600	50	—	17	16	15	15	13	10	29
52			40	—	21	20	19	19	15	12	30
53			30	—	25	23	22	22	18	14	32
54			20	—	32	29	28	27	22	17	34
55			10	—	41	36	34	32	25	21	37
56	Do.	2,000	40	—	23	21	20	20	15	12	37
57			30	—	27	25	24	23	19	15	39
58			20	—	35	32	30	28	22	18	42
59			10	—	46	42	38	33	26	22	47
	On slopes > 12 percent.										
60	Lines 33-59 times factor of:	—	—	—	1.3	1.3	1.1	1.0	1.0	1.0	1.0
	Disk or harrow after spring chisel or fld cult:										
	Lines 33-59 times factor of:										
61	On moderate slopes	—	—	—	1.1	1.1	1.1	1.0	1.0	1.0	1.0
62	On slopes > 12 percent	—	—	—	1.4	1.4	1.2	1.0	1.0	1.0	1.0
	Ridge plant:[10]										
	Lines 33-59 times factor of:										
63	Rows on contour[11]	—	—	—	.7	.7	.7	.7	.7	.7	.7
64	Rows U/D slope < 12 percent	—	—	—	.7	.7	1.0	1.0	1.0	1.0	1.0
65	Rows U/D slope > 12 percent	—	—	—	.9	.9	1.0	1.0	1.0	1.0	1.0
	Till plant:										
	Lines 33-59 times factor of:										
66	Rows on contour[11]	—	—	—	.7	.85	1.0	1.0	1.0	1.0	1.0
67	Rows U/D slope < 7 percent	—	—	—	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Strip till one-fourth of row spacing:										
68	Rows on contour[11]	4,500	[12]60	—	12	10	9	—	—	8	23
69		3,400	50	—	16	14	12	—	11	10	27
70		2,600	40	—	22	19	17	17	14	12	30
71		2,000	30	—	27	23	21	20	16	13	36
72	Rows U/D slope	4,500	[12]60	—	16	13	11	—	—	9	23
73		3,400	50	—	20	17	14	—	12	11	27
74		2,600	40	—	26	22	19	17	14	12	30
75		2,000	30	—	31	26	23	20	16	13	36
	Vari-till:										
76	Rows on contour[11]	3,400	40	—	13	12	11	—	—	11	22
77		3,400	30	—	16	15	14	14	13	12	26
78		2,600	20	—	21	19	19	19	16	14	34
115	*Fall & sprg chisel or cult*	HP	[15]30	—	40	35	29	—	—	23	29
116		GP	25	—	45	39	33	—	27	23	37
117		GP	20	—	51	44	39	34	27	23	37
118		FP	15	—	58	51	44	36	28	23	44
119		LP	10	—	67	59	48	36	28	23	54
120	*No-till pl in crop res'd*	HP	[15]40	—	25	20	19	—	14	11	26
121		GP	30	—	33	29	25	22	18	14	33
122		FP	20	—	44	38	32	27	23	18	40
	BEANS AFTER CORN										
123	*Sprg TP, RdL, conv till*	HP	—	33	60	52	38	—	20	17	([16])
124		GP	—	39	64	56	41	—	21	18	
125		FP	—	45	68	60	43	29	22	—	
126	*Fall TP, RdL, conv till*	HP	—	45	69	57	38	—	20	17	([16])
127		GP	—	52	73	61	41	—	21	18	
128		FP	—	59	77	65	43	29	22	—	
	Chisel or fld cult:			([17])	([17])	([17])	([17])	([17])	([17])	([17])	([18])
	BEANS AFTER BEANS			([18])	([18])	([18])	([18])	([18])	([18])	([18])	([16])
	GRAIN AFTER C, G, GS, COT[19]										
129	*In disked residues:*	4,500	70	—	12	12	11	7	4	2	([20])
130		3,400	60	—	16	14	12	7	4	2	
131			50	—	22	18	14	8	5	3	
132			40	—	27	21	16	9	5	3	
133			30	—	32	25	18	9	6	3	
134			20	—	38	30	21	10	6	3	
135	Do.	2,600	40	—	29	24	19	9	6	3	([20])
136			20	—	43	34	24	11	7	4	
137			10	—	52	39	27	12	7	4	
138	Do.	2,000	30	—	38	30	23	11	7	4	([20])
139			20	—	46	36	26	12	7	4	
140			10	—	56	43	30	13	8	5	
141	*In disked stubble, RdR*	—	—	—	79	62	42	17	11	6	([20])
142	*Winter G after fall TP, RdL*	HP	—	31	55	48	31	12	7	5	([20])
143		GP	—	36	60	52	33	13	8	5	
144		FP	—	43	64	56	36	14	9	5	
145		LP	—	53	68	60	38	15	10	6	
	GRAIN AFTER SUMMER FALLOW										
146	*With grain residues*	200	10	—	70	55	43	18	13	11	([21])
147		500	30	—	43	34	23	13	10	8	
148		750	40	—	34	27	18	10	7	7	
149		1,000	50	—	26	21	15	8	7	6	
150		1,500	60	—	20	16	12	7	5	5	
151		2,000	70	—	14	11	9	7	5	5	
152	*With row crop residues*	300	5	—	82	65	44	19	14	12	([21])
153		500	15	—	62	49	35	17	13	11	
154		750	23	—	50	40	29	14	11	9	
155		1,000	30	—	40	31	24	13	10	8	
156		1,500	45	—	31	24	18	10	8	7	
157		2,000	55	—	23	19	14	8	7	5	
158		2,500	65	—	17	14	12	7	5	4	
	POTATOES										
159	*Rows with slope*	—	—	43	64	56	36	26	19	16	
160	*Contoured rows, ridged when canopy cover is about 50 percent*[11]	—	—	43	64	56	18	13	10	8	

See footnotes, p. 24.

Footnotes for table 5.

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[1] Symbols: B, soybeans; C, corn; conv till, plow, disk and harrow for seedbed; cot, cotton; F, rough fallow; fld cult, field cultivator; G, small grain; GS, grain sorghum; M, grass and legume meadow, at least 1 full year; pl, plant; RdL, crop residues left on field; RdR, crop residues removed; SB, seedbed period; sprg, spring; TP, plowed with moldboard; WC, winter cover crop; —, insignificant or an unlikely combination of variables.

[2] Dry weight per acre after winter loss and reductions by grazing or partial removal: 4,500 lbs represents 100 to 125 bu corn; 3,400 lbs, 75 to 99 bu; 2,600 lbs, 60 to 74 bu; and 2,000 lbs, 40 to 59 bu; with normal 30-percent winter loss. For RdR or fall-plow practices, these four productivity levels are indicated by HP, GP, FP and LP, respectively (high, good, fair, and low productivity). In lines 79 to 102, this column indicates dry weight of the winter-cover crop.

[3] Percentage of soil surface covered by plant residue mulch *after* crop seeding. The difference between spring residue and that on the surface after crop seeding is reflected in the soil loss ratios as residues mixed with the topsoil.

[4] The soil loss ratios, given as percentages, assume that the indicated crop sequence and practices are followed consistently. One-year deviations from normal practices do not have the effect of a permanent change. Linear interpolation between lines is recommended when justified by field conditions.

[5] Cropstage periods are as defined on p. 18. The three columns for cropstage 3 are for 80, 90, and 96 to 100 percent canopy cover at maturity.

[6] Column 4L is for all residues left on field. Corn stalks partially standing as left by some mechanical pickers. If stalks are shredded and spread by picker, select ratio from table 5-C. When residues are reduced by grazing, take ratio from lower spring-residue line.

[7] Period 4 values in lines 9 to 12 are for corn stubble (stover removed).

[8] Inversion plowed, no secondary tillage. For this practice, residues must be left and incorporated.

[9] Soil surface and chopped residues of *matured* preceding crop undisturbed except in narrow slots in which seeds are planted.

[10] Top of old row ridge sliced off, throwing residues and some soil into furrow areas. Reridging assumed to occur near end of cropstage 1.

[11] Where lower soil loss ratios are listed for rows on the contour, this reduction is in addition to the standard field contouring credit. The *P* value for contouring is used with these reduced loss ratios.

[12] Field-average percent cover; probably about three-fourths of percent cover on undisturbed strips.

[13] If again seeded to WC crop in corn stubble, evaluate winter period as a winter grain seeding (lines 132 to 148). Otherwise, see table 5-C.

[14] Select the appropriate line for the crop, tillage, and productivity level and multiply the listed soil loss ratios by sod residual factors from table 5-D.

[15] Spring residue may include carryover from prior corn crop.

[16] See table 5-C.

[17] Use values from lines 33 to 62 with appropriate dates and lengths of cropstage periods for beans in the locality.

[18] Values in lines 109 to 122 are best available estimates, but planting dates and lengths of cropstages may differ.

[19] When meadow is seeded with the grain, its effect will be reflected through higher percentages of cover in cropstages 3 and 4.

[20] Ratio depends on percent cover. See table 5-C.

[21] See item 12, table 5-B.

TABLE 5-A.—*Approximate soil loss ratios for cotton*

Expected final canopy percent cover:	65	80	95
Estimated initial percent cover from defoliation + stalks down:	30	45	60
Practice Number — Tillage operation(s)	Soil loss ratio[1]		
COTTON ANNUALLY:		*Percent*	
1....*None:*			
Defoliation to Dec. 31	36	24	15
Jan. 1 to Feb. or Mar. tillage:			
Cot Rd only	52	41	32
Rd & 20 percent cover vol veg[2]	32	26	20
Rd & 30 percent cover vol veg	26	20	14
2....*Chisel plow soon after cot harvest:*			
Chiseling to Dec. 31	40	31	24
Jan. 1 to sprg tillage	56	47	40
3....*Fall disk after chisel:*			
Disking to Dec. 31	53	45	37
Jan. 1 to sprg tillage	62	54	47
4....*Chisel plow Feb-Mar, no prior tillage:*			
Cot Rd only	50	42	35
Rd & 20 percent vol veg	39	33	28
Rd & 30 percent vol veg	34	29	25
5....*Bed ("hip") Feb-Mar, no prior tillage:*			
Cot Rd only	100	84	70
Rd & 20 percent vol veg	78	66	56
Rd & 30 percent vol veg	68	58	50
Split ridges & plant after hip, or Disk & plant after chisel (SB):			
Cot Rd only	61	54	47
Rd & 20 percent vol veg	53	47	41
Rd & 30 percent vol veg	50	44	38
Cropstage 1:			
Cot Rd only	57	50	43
Rd & 20 percent vol veg	49	43	38
Rd & 30 percent vol veg	46	41	36
Cropstage 2	45	39	34
Cropstage 3	40	27	17
6....*Bed (hip) after 1 prior tillage:*			
Cot Rd only	110	96	84
Rd & 20 percent veg	94	82	72
Rd & 30 percent veg	90	78	68
Split ridges after hip (SB):			
Cot Rd only	66	61	52
Rd & 20 to 30 percent veg	61	55	49
Cropstage 1:			
Cot Rd only	60	56	49
Rd & 20 to 30 percent veg	56	51	46
Cropstage 2	47	44	38
Cropstage 3	42	30	19
7....*Hip after 2 prior tillages:*			
Cot Rd only	116	108	98
Rd & 20-30 percent veg	108	98	88
Split ridges after hip (SB)	67	62	57
8....*Hip after 3 or more tillages:*	120	110	102
Split ridges after hip (SB)	68	64	59
9....*Conventional moldboard plow and disk:*			
Fallow period	42	39	36
Seedbed period	68	64	59
Cropstage 1	63	59	55
Cropstage 2	49	46	43
Cropstage 3	44	32	22
Cropstage 4 (See practtices 1, 2, and 3)			

COTTON AFTER SOD CROP:

For the first or second crop after a grass or grass-and-legume meadow has been turnplowed, multiply values given in the last five lines above by sod residual factors from table 5-D.

COTTON AFTER SOYBEANS:

Select values from above and multiply by 1.25.

See footnotes at right.

of erosive rainfall at a particular location is an element in deriving the applicable value of cover and management, **C.**

Central and Eastern States

A location's erosion index is computed by summing **EI** values of individual rainstorms over periods from 20 to 25 years. Thus, the expected monthly distribution of the erosion index can be computed from the same data. For each rainfall record abstracted for development of the isoerodent map, the monthly **EI** values were computed and expressed as percentages of the location's average annual erosion index. When the monthly percentages are plotted cumulatively against time, they define **EI** distribution curves such as illustrated in figure 8 for three locations. The three contrasting curves are presented to demonstrate how drastically the normal **EI** distribution can differ among climatic regions.

On the basis of observed seasonal distributions of **EI**, the 37 States east of the Rocky Mountains were divided into the 33 geographic areas delineated in figure 9. The changes in distribution are usually gradual transitions from one area to the next, but the average distribution within any one of the areas may, for practical purposes, be considered applicable for the entire area. The **EI** distributions in the 33 areas, expressed as cumulative percentages of annual totals, are given in table 6. The area numbers in the table correspond to those in figure 9. The data in the table were

[1] *Alternate procedure for estimating the soil loss ratios:*

The ratios given above for cotton are based on estimates for reductions in percent cover through normal winter loss and by the successive tillage operations. Research is underway in Mississippi to obtain more accurate residue data in relation to tillage practices. This research should provide more accurate soil loss ratios for cotton within a few years.

Where the reductions in percent cover by winter loss and tillage operations are small, the following procedure may be used to compute soil loss ratios for the preplant and seedbed periods: Enter figure 6 with the percentage of the field surface covered by residue mulch, move vertically to the upper curve, and read the mulch factor on the scale at the left. Multiply this factor by a factor selected from the following tabulation to credit for effects of land-use residual, surface roughness and porosity.

Productivitty level	No tillage	Rough surface	Smoothed surface
High	0.66	0.50	0.56
Medium	.71	.54	.61
Poor	.75	.58	.65

Values for the bedded period on slopes of less than 1 percent should be estimated at twice the value computed above for rough surfaces.

[2] Rd, crop residue; vol veg, volunteer vegetation.

TABLE 5-B.—*Soil loss ratios for conditions not evaluated in table 5*

COTTON:
See table 5-A.
CROPSTAGE 4 FOR ROWCROPS:
Stalks broken and partially standing: Use col. 4L.
Stalks standing after hand picking: Col. 4L times 1.15.
Stalks shredded without soil tillage: See table 5-C.
Fall chisel: Select values from lines 33-62, seedbed column.
CROPSTAGE 4 FOR SMALL GRAIN:
See table 5-C.
DOUBLE CROPPING:
Derive annual C value by selecting from table 5 the soil loss percentages for the successive cropstage periods of each crop.
ESTABLISHED MEADOW, FULL-YEAR PERCENTAGES:

Grass and legume mix, 3 to 5 t hay	0.4
Do. 2 to 3 t hay	.6
Do. 1 t hay	1.0
Sericea, after second year	1.0
Red clover	1.5
Alfalfa, lespedeza, and second-year sericea	2.0
Sweetclover	2.5

MEADOW SEEDING WITHOUT NURSE CROP:
Determine appropriate lengths of cropstage periods SB, 1, and 2 and apply values given for small grain seeding.
PEANUTS:
Comparison with soybeans is suggested.
PINEAPPLES:
Direct data not available. Tentative values derived analytically are available from the SCS in Hawaii or the Western Technical Service Center at Portland, Oreg. (Reference 5).
SORGHUM:
Select values given for corn, on the basis of expected crop residues and canopy cover.
SUGARBEETS:
Direct data not available. Probably most nearly comparable to potatoes, without the ridging credit.
SUGARCANE:
Tentative values available from sources given for pineapples.
SUMMER FALLOW IN LOW-RAINFALL AREAS, USE GRAIN OR ROW CROP RESIDUES:
The approximate soil loss percentage after each successive tillage operation may be obtained from the following tabulation by estimating the percent surface cover after that tillage and selecting the column for the appropriate amount of initial residue. The given values credit benefits of the residue mulch, residues mixed with soil by tillage, and the crop system residual.

Percent cover by mulch	Initial residue (lbs/A) >4,000	3,000	2,000	1,500
90	4	—	—	—
80	8	[1]8	—	—
70	12	13	[1]14	—
60	16	17	[1]18	[1]19
50	20	22	24	[1]25
40	25	27	30	32
30	29	33	37	39
20	35	39	44	48
10	47	55	63	68

[1] For grain residue only.

WINTER COVER SEEDING IN ROW CROP STUBBLE OR RESIDUES:
Define cropstage periods based on the cover seeding date and apply values from lines 129 to 145.

TABLE 5-C.—*Soil loss ratios (percent) for cropstage 4 when stalks are chopped and distributed without soil tillage*

Mulch cover[1]	Corn or Sorghum: Tilled seedbed[2]	Corn or Sorghum: No-till	Soybeans: Tilled seedbed[2]	Soybeans: No-till in corn rd[3]	Grain Stubble[4]
20	48	34	60	42	48
30	37	26	46	32	37
40	30	21	38	26	30
50	22	15	28	19	22
60	17	12	21	16	17
70	12	8	15	10	12
80	7	5	9	6	7
90	4	3	—	—	4
95	3	2	—	—	3

[1] Part of a field surface directly covered by pieces of residue mulch.
[2] This column applies for all systems other than no-till.
[3] Cover after bean harvest may include an appreciable number of stalks carried over from the prior corn crop.
[4] For grain with meadow seeding, include meadow growth in percent cover and limit grain period 4 to 2 mo. Thereafter, classify as established meadow.

abstracted from the published EI distribution curves.

The percentage of the annual erosion index that is to be expected within each cropstage period may be obtained by reading from the appropriate line of table 6, the values for the last and first date of the period, and subtracting. Interpolate

TABLE 5-D.—*Factors to credit residual effects of turned sod*[1]

Crop	Hay yield	Factor for cropstage period: F	SB and 1	2	3	4
	Tons					
First year after mead:						
Row crop or grain ...	3-5	0.25	0.40	0.45	0.50	0.60
	2-3	.30	.45	.50	.55	.65
	1-2	.35	.50	.55	.60	.70
Second year after mead:						
Row crop	3.5	.70	.80	.85	.90	.95
	2-3	.75	.85	.90	.95	1.0
	1-2	.80	.90	.95	1.0	1.0
Spring grain	3-5	—	.75	.80	.85	.95
	2-3	—	.80	.85	.90	1.0
	1-2	—	.85	.90	.95	1.0
Winter grain	3-5	—	.60	.70	.85	.95
	2-3	—	.65	.75	.90	1.0
	1-2	—	.70	.85	.95	1.0

[1] These factors are to be multiplied by the appropriate soil loss percentages selected from table 5. They are directly applicable for sod-forming meadows of at least 1 full year duration, plowed not more than 1 month before final seedbed preparation.

When sod is fall plowed for spring planting, the listed values for all cropstage periods are increased by adding 0.02 for each additional month by which the plowing precedes spring seedbed preparation. For example, September plowing would precede May disking by 8 months and 0.02(8—1), or 0.14, would be added to each value in the table. For nonsod-forming meadows, like sweetclover or lespedeza, multiply the factors by 1.2. When the computed value is greater than 1.0, use as 1.0.

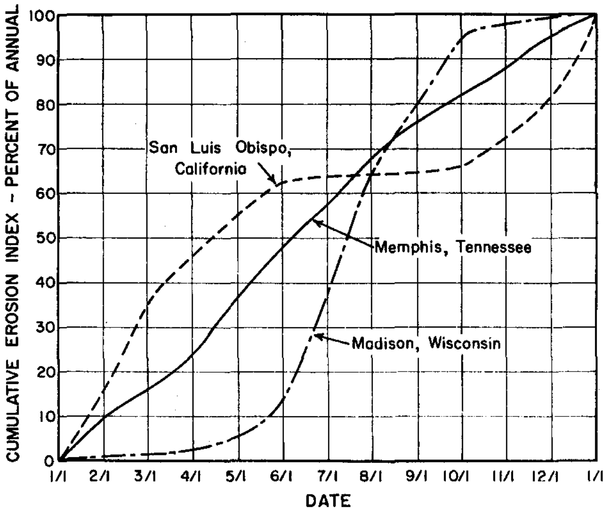

FIGURE 8.—Typical **EI**-distribution curves for three rainfall patterns.

between values in the selected line when the desired dates are not listed.

Western States, Hawaii, and Puerto Rico

Normal rainfall patterns in these mountainous States often change abruptly within a short distance. Figure 9 was not extended to include these States because long-term intensity data were not available for enough locations to delineate boundaries of homogeneous areas. However, **EI** distributions indicated by station records that were abstracted are given in table 7 for reference.

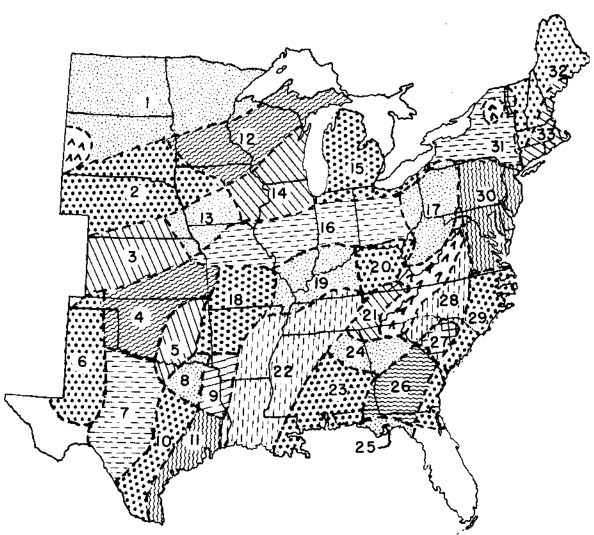

FIGURE 9.—Key map for selection of applicable **EI**-distribution data from table 6.

Winter Periods

Site **EI** values reflect only rain falling at erosive intensities. Where the winter precipitation comes as snow or light rain, **EI** distribution curves may show insignificant percentages for several winter months. Yet, snowmelt and low intensity rains on frozen soil may cause appreciable runoff that is erosive even though the associated maximum 30-minute rainfall intensity is extremely low or zero. The section on **Isoerodent Maps** pointed out that where this type of runoff is significant its erosive force must be reflected in an $\mathbf{R}_s$ value that is added to the **EI** value to obtain **R**. This additional erosive force must also be reflected in the *monthly distribution* of **R**. Otherwise, poor management during the winter period will not be reflected in the USLE estimate of annual soil loss because a zero cropstage **R** value would predict zero soil loss regardless of the relevant soil loss ratio.

Soil erosion by thaw runoff is most pronounced in the Northwest, where $\mathbf{R}_s$ values often exceed the average annual **EI**. However, it may also be significant in other Northern States. Probable amounts of thaw runoff were not available for inclusion in the calculations of the **EI** distributions given in tables 6 and 7, but the significance and probable time of occurrence of such runoff can be estimated by local people. The procedure for adjusting table 6 cumulative percentages to include this erosive potential will be illustrated.

Based on the previously described estimating procedure, $\mathbf{R}_s$ values in area No. 1, figure 9, appear to equal about 8 percent of the annual **EI**. Assuming that the thaw runoff in that area normally occurs between March 15 and April 15, the percentage in table 6 for April 1 is increased by 4, the April 15 and all subsequent readings are increased by 8, and all the adjusted readings are then divided by 1.08. This procedure corrects the data given in line 1, table 6, for dates April 1 to September 1 to the following cumulative percentages listed in chronological sequence: 5, 9, 10, 13, 18, 29, 41, 53, 66, 79, 91. The other values are unchanged. Such adjustments in monthly distribution of **R** where thaw runoff is significant will be particularly helpful when the USLE is used to estimate seasonal distribution of sediment from agricultural watersheds.

TABLE 6.—*Percentage of the average annual* **EI** *which normally occurs between January 1 and the indicated dates.*[1] *Computed for the geographic areas shown in figure 9*

Area No.	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15
1	0	0	0	0	0	0	1	2	3	6	11	23	36	49	63	77	90	95	98	99	100	100	100	100
2	0	0	0	0	1	1	2	3	6	10	17	29	43	55	67	77	85	91	96	98	99	100	100	100
3	0	0	0	0	1	1	2	3	6	13	23	37	51	61	69	78	85	91	94	96	98	99	99	100
4	0	0	1	1	2	3	4	7	12	18	27	38	48	55	62	69	76	83	90	94	97	98	99	100
5	0	1	2	3	4	6	8	13	21	29	37	46	54	60	65	69	74	81	87	92	95	97	98	99
6	0	0	0	0	1	1	1	2	6	16	29	39	46	53	60	67	74	81	88	95	99	99	100	100
7	0	1	1	2	3	4	6	8	13	25	40	49	56	62	67	72	76	80	85	91	97	98	99	99
8	0	1	3	5	7	10	14	20	28	37	48	56	61	64	68	72	77	81	86	89	92	95	98	99
9	0	2	4	6	9	12	17	23	30	37	43	49	54	58	62	66	70	74	78	82	86	90	94	97
10	0	1	2	4	6	8	10	15	21	29	38	47	53	57	61	65	70	76	83	88	91	94	96	98
11	0	1	3	5	7	9	11	14	18	27	35	41	46	51	57	62	68	73	79	84	89	93	96	98
12	0	0	0	0	1	1	2	3	5	9	15	27	38	50	62	74	84	91	95	97	98	99	99	100
13	0	0	0	1	1	2	3	5	7	12	19	33	48	57	65	74	82	88	93	96	98	99	100	100
14	0	0	0	1	2	3	4	6	9	14	20	28	39	52	63	72	80	87	91	94	97	98	99	100
15	0	0	1	2	3	4	6	8	11	15	22	31	40	49	59	69	78	85	91	94	96	98	99	100
16	0	1	2	3	4	6	8	10	14	18	25	34	45	56	64	72	79	84	89	92	95	97	98	99
17	0	1	2	3	4	5	6	8	11	15	20	28	41	54	65	74	82	87	92	94	96	97	98	99
18	0	1	2	4	6	8	10	13	19	26	34	42	50	58	63	68	74	79	84	89	93	95	97	99
19	0	1	3	6	9	12	16	21	26	31	37	43	50	57	64	71	77	81	85	88	91	93	95	97
20	0	2	3	5	7	10	13	16	19	23	27	34	44	54	63	72	80	85	89	91	93	95	96	98
21	0	3	6	10	13	16	19	23	26	29	33	39	47	58	68	75	80	83	86	88	90	92	95	97
22	0	3	6	9	13	17	21	27	33	38	44	49	55	61	67	71	75	78	81	84	86	90	94	97
23	0	3	5	7	10	14	18	23	27	31	35	39	45	53	60	67	74	80	84	86	88	90	93	95
24	0	3	6	9	12	16	20	24	28	33	38	43	50	59	69	75	80	84	87	90	92	94	96	98
25	0	1	3	5	7	10	13	17	21	24	27	33	40	46	53	61	69	78	89	92	94	95	97	98
26	0	2	4	6	8	12	16	20	25	30	35	41	47	56	67	75	81	85	87	89	91	93	95	97
27	0	1	2	3	5	7	10	14	18	22	27	32	37	46	58	69	80	89	93	94	95	96	97	99
28	0	1	3	5	7	9	12	15	18	21	25	29	36	45	56	68	77	83	88	91	93	95	97	99
29	0	1	2	3	4	5	7	9	11	14	17	22	31	42	54	65	74	83	89	92	95	97	98	99
30	0	1	2	3	4	5	6	8	10	14	19	26	34	45	56	66	76	82	86	90	93	95	97	99
31	0	0	0	1	2	3	4	5	7	12	17	24	33	42	55	67	76	83	89	92	94	96	98	99
32	0	1	2	3	4	5	6	8	10	13	17	22	31	42	52	60	68	75	80	85	89	92	96	98
33	0	1	2	4	6	8	11	13	15	18	21	26	32	38	46	55	64	71	77	81	85	89	93	97

[1] For dates not listed in the table, interpolate between adjacent values.

Procedure for Deriving Local C Values

Factor **C** in the USLE measures the combined effect of all the interrelated cover and management variables and is defined as the ratio of soil loss from land cropped under specified conditions to the corresponding loss from clean-tilled continuous fallow. It is usually expressed as an annual value for a particular cropping and management system. Soil loss ratios, as used in table 5, express a similar ratio for a short time interval within which cover and management effects are relatively uniform. The cropstage soil loss ratios must be combined in proportion to the applicable percentages of **EI** to derive annual **C** values.

To compute the value of **C** for any particular crop and management system on a given field, one needs first to determine the most likely seeding and harvest dates, rate of canopy development, and final canopy cover. Also, the system to be evaluated must be carefully defined with regard to crop and residue management details. Within the broad limits of tables 5 and 6, these tables then supply the research data needed to complete

TABLE 7.—*Monthly distribution of* **EI** *at selected raingage locations*

Location[1]	Average percentage of annual EI occurring from 1/1 to:											
	2/1	3/1	4/1	5/1	6/1	7/1	8/1	9/1	10/1	11/1	12/1	12/31
California												
Red Bluff (69)	18	36	47	55	62	64	65	65	67	72	82	100
San Luis Obispo (51)	19	39	54	63	65	65	65	65	65	67	83	100
Colorado												
Akron (91)	0	0	0	1	18	33	72	87	98	99	100	100
Pueblo (68)	0	0	0	5	14	23	40	82	84	100	100	100
Springfield (98)	0	0	1	4	26	36	60	94	96	99	100	100
Hawaii												
Hilo (770)	9	23	34	44	49	51	55	60	65	72	87	100
Honolulu (189)	19	33	43	51	54	55	56	57	58	62	81	100
Kahului (107)	14	32	49	62	67	68	69	70	71	76	86	100
Lihue (385)	19	29	36	41	44	45	48	51	56	64	80	100
Montana												
Billings (18)	0	0	1	6	22	49	86	88	96	100	100	100
Great Falls (17)	1	1	2	6	20	56	74	93	98	99	100	100
Miles City (28)	0	0	0	1	10	32	65	93	98	100	100	100
New Mexico												
Albuquerque (15) ..	1	1	2	4	10	21	52	67	89	98	99	100
Roswell (52)	0	0	2	7	20	34	55	71	92	99	99	100
Oregon												
Pendleton (6)	8	12	15	22	56	64	67	67	74	87	96	100
Portland (43)	15	27	35	37	40	45	46	47	54	65	81	100
Puerto Rico												
Mayaguez (600)	1	2	3	6	15	31	47	63	80	91	99	100
San Juan (345)	5	8	11	17	33	43	53	66	75	84	93	100
Washington												
Spokane (8)	5	9	11	15	25	56	61	76	84	90	94	100
Wyoming												
Casper (11)	0	0	1	6	32	44	70	90	96	100	100	100
Cheyenne (32)	0	1	2	5	17	42	73	90	97	99	100	100

[1] Numbers in parentheses are the observed average annual **EI**.

the computation of **C**. The procedure will be explained by an example that, for illustration purposes, was selected to include many changes in field conditions.

Problem. Evaluate **C** for a 4-year rotation of wheat-meadow-corn-corn on moderately sloping land in Central Illinois or Indiana, assuming the following management details and dates: Wheat is seeded October 15 in a 40-percent cover of disked corn residue, and a grass and legume meadow mix is seeded with the wheat. The wheat would normally develop a 10-percent cover by November 1, 50 percent by December 1, 75 percent by April 15, and nearly 100 percent in the maturing stage. It is harvested July 15, leaving an 80-percent surface cover of straw and small grass. The sod developed under 1 full year of meadow, yielding more than 3 t of hay, is turned under in April. The field is disked May 5 and is harrowed and planted to corn May 10. The first-year corn, harvested October 15, is followed by fall chiseling about November 15 and spring disking for second-year corn. Residue cover is 50 percent after fall chiseling and 30 percent after corn planting on May 10. Fertility, row spacing, and plant population for both corn years are such that 10, 50, and 75 percent canopy covers will be developed in 20, 40, and 60 days, respectively, from planting, and final canopy cover is more than 95 percent.

Procedure. Set up a working table similar to the one illustrated in table 8, obtaining the needed information as follows:

Column 1. List in chronological sequence all the land-cover changes that begin new cropstage periods, as previously defined.

Column 2. List the date on which each cropstage period begins.

Column 3. Select the applicable area number

TABLE 8.—*Sample working table for derivation of a rotation* **C** *value*

(1) Event	(2) Date	(3) Table 6, area 16	(4) Cropstage period	(5) EI in period	(6) Soil loss ratio[1]	(7) Sod Factor	(8) Cropstage C value	(9) Crop year
Pl W[2]	10/15	92	SB	0.03	0.27(132)	0.95	0.0077	
10 percent c	11/1	95	1	.03	.21	.95	.0060	
50 percent c	12/1	98	2	.12	.16	1.0	.0192	
75 percent c	4/15	10	3	.46	.03		.0138	
Hv W	7/15	56	4	.28	.07(5C)		.0196	0.066
Meadow	9/15	84		1.26	.004(5B)	1.0	.0050	.005
TP	4/15	10	F	.05	.36(2)	.25	.0045	
Disk	5/5	15	SB	.10	.60	.40	.0240	
Pl C	5/10	—						
10 percent c	6/1	25	1	.13	.52	.40	.0270	
50 percent c	6/20	38	2	.14	.41	.45	.0258	
75 percent c	7/10	52	3	.40	.20	.50	.0400	
Hv C	10/15	92	4L	.05	.30	.60	.0090	.130
Chisel	11/15	97	4c	.17	.16(46)	.60	.0163	
Disk	5/1	14	SB	.11	.25(48 & 61)	.80	.0220	
Pl C	5/10	—						
10 percent c	6/1	25	1	.13	.23	.80	.0239	
50 percent c	6/20	38	2	.14	.21	.85	.0250	
75 percent c	7/10	52	3	.40	.14(48)	.90	.0504	.138
Hv C & pl W	10/15	92						
Rotation totals				4.0			0.3392	
Average annual C value for rotation							.085	

[1] Numbers in parentheses are line numbers in table 5.

[2] Abbreviations: c, canopy cover; C, corn; hv, harvest; pl, plant; TP, moldboard plow; W, wheat.

from figure 9, and from the line in table 6 having the corresponding area number (in this case, 16), read the cumulative percentage of **EI** for each date in column 2. Values for the corn planting dates were omitted in table 8 because the seedbed periods had begun with the spring diskings. The **EI** percentage for May 5 was obtained by interpolating between readings from May 1 and 15.

Column 4. Identify the cropstage periods.

Column 5. Subtract the number in column 3 from the number in the next lower line. If the cropstage period includes a year end, subtract from 100 and add the number in the next lower line. The differences are percentages and may be pointed off as hundredths.

Column 6. Obtain from table 5. Enter the table with crop and management, pounds of spring residue or production level, and percent mulch cover after planting, in that sequence. The data in the selected line are percentages and are used as hundredths in the computation of **C**. For cropstage 3, use the column whose heading corresponds with expected final canopy. For conditions not listed in the primary table, consult supplements 5-A to D. Lines used for the examples are given in parentheses in column 6.

Column 7. From table 5-D.

Column 8. The product of values in columns 5, 6 and 7. The sum of these products is the value of **C** for the entire rotation. Because **C** is usually desired as an average annual value, this sum is divided by the number of years in the rotation.

Column 9. The subtotals in this column are **C** values for the individual crop-years. They also show the relative contributions of the four crops to the rotation **C** value.

Changes in geographic area or in planting dates would affect the **C** value by changing columns 3 and 5. Changes in amount or disposition of residues, tillage practices, or canopy development would change column 6. Thus **C** can vary substantially for a given crop system.

Values of **C** for one-crop systems are derived by the same procedure but would require only a few lines. Also, column 7 is omitted for meadowless systems.

C-Value Tables for Cropland

It will rarely, if ever, be necessary for a field technician or farmer to compute values of **C**. Persons experienced in the procedures outlined above have prepared **C** value tables for specific geographic areas. Such a table will list all the one-crop and multicrop systems likely to be found within the designated area and will list the **C** values for each system for each of the combinations of management practices that may be associated with it. They are usually listed in ascending or descending order of magnitude of the **C** values. The user can then quickly determine all the potential combinations of cropping and management that have **C** values smaller than any given threshold value. Persons in need of **C** values for a particular locality can usually obtain a copy of the applicable table from the nearest SCS state office.

C Values for Construction Areas

Site preparations that remove all vegetation and also the root zone of the soil not only leave the surface completely without protection but also remove the residual effects of prior vegetation. This condition is comparable to the previously defined continuous fallow condition, and **C** = 1. Roots and residual effects of prior vegetation, and partial covers of mulch or vegetation, substantially reduce soil erosion. These reductions are reflected in the soil loss prediction by **C** values of less than 1.0.

Applied mulches immediately restore protective cover on denuded areas and drastically reduce **C** (*1, 2, 20, 27, 43*). Soil loss ratios for various percentages of mulch cover on field slopes are given by the upper curve of figure 6. Where residual effects are insignificant, these ratios equal **C**. The percentage of surface cover provided by a given rate of uniformly spread straw mulch may be estimated from figure 10 (appendix).

Straw or hay mulches applied on steep construction slopes and not tied to the soil by anchoring and tacking equipment may be less effective than equivalent mulch rates on cropland. In Indiana tests on a 20 percent slope of scalped subsoil, a 2.3-t rate of unanchored straw mulch allowed soil loss of 12 t/A when 5 in of simulated rain was applied at 2.5 in/h on a 35-ft plot (*61*). There was evidence of erosion from flow beneath the straw. Mulches of crushed stone at 135 or more t/A, or wood chips at 7 or more t/A, were more effective. (Broadcast seedings of grass after the tests gave good stands on the plots mulched with 135 or 240 t crushed stone, 70 t road gravel, 12 t wood chips, or 2.3 t straw. Stands were poor on the no-mulch and the 15-t rate of crushed stone mulch.)

Table 9 presents approximate **C** values for straw, crushed stone, and woodchip mulches on construction slopes where no canopy cover exists, and also shows the maximum slope lengths on which these values may be assumed applicable.

Soil loss ratios for many conditions on construc-

TABLE 9.—*Mulch factors and length limits for construction slopes*[1]

Type of mulch	Mulch Rate	Land Slope	Factor C	Length limit[2]
	Tons per acre	*Percent*		*Feet*
None	0	all	1.0	—
Straw or hay,	1.0	1-5	0.20	200
tied down by	1.0	6-10	.20	100
anchoring and				
tacking	1.5	1-5	.12	300
equipment[3]	1.5	6-10	.12	150
Do.	2.0	1-5	.06	400
	2.0	6-10	.06	200
	2.0	11-15	.07	150
	2.0	16-20	.11	100
	2.0	21-25	.14	75
	2.0	26-33	.17	50
	2.0	34-50	.20	35
Crushed stone,	135	<16	.05	200
¼ to 1½ in	135	16-20	.05	150
	135	21-33	.05	100
	135	34-50	.05	75
Do.	240	<21	.02	300
	240	21-33	.02	200
	240	34-50	.02	150
Wood chips	7	<16	.08	75
	7	16-20	.08	50
Do.	12	<16	.05	150
	12	16-20	.05	100
	12	21-33	.05	75
Do.	25	<16	.02	200
	25	16-20	.02	150
	25	21-33	.02	100
	25	34-50	.02	75

[1] From Meyer and Ports (*24*). Developed by an interagency workshop group on the basis of field experience and limited research data.

[2] Maximum slope length for which the specified mulch rate is considered effective. When this limit is exceeded, either a higher application rate or mechanical shortening of the effective slope length is required.

[3] When the straw or hay mulch is not anchored to the soil, **C** values on moderate or steep slopes of soils having K values greater than 0.30 should be taken at double the values given in this table.

tion and developmental areas can be obtained from table 5 if good judgment is exercised in comparing the surface conditions with those of agricultural conditions specified in lines of the table. Time intervals analogous to cropstage periods will be defined to begin and end with successive construction or management activities that appreciably change the surface conditions. The procedure is then similar to that described for cropland.

Establishing vegetation on the denuded areas as quickly as possible is highly important. A good sod has a **C** value of 0.01 or less (table 5-B), but such a low **C** value can be obtained quickly only by laying sod on the area, at a substantial cost. When grass or small grain is started from seed, the probable soil loss for the period while cover is developing can be computed by the procedure outlined for estimating cropstage-period soil losses. If the seeding is on topsoil, without a mulch, the soil loss ratios given in line 141 of table 5 are appropriate for cropstage **C** values. If the seeding is on a desurfaced area, where residual effects of prior vegetation are no longer significant, the ratios for periods SB, 1 and 2 are 1.0, 0.75 and 0.50, respectively, and line 141 applies for cropstage 3. When the seedbed is protected by a mulch, the pertinent mulch factor from the upper curve of figure 6 or table 9 is applicable until good canopy cover is attained. The combined effects of vegetative mulch and low-growing canopy are given in figure 7. When grass is established in small grain, it can usually be evaluated as established meadow about 2 mo after the grain is cut.

C Values for Pasture, Range, and Idle Land

Factor **C** for a specific combination of cover conditions on these types of land may be obtained from table 10 (57). The cover characteristics that must be appraised before consulting this table are defined in the table and its footnotes. Cropstage periods and **EI** monthly distribution data are generally not necessary where perennial vegetation has become established and there is no mechanical disturbance of the soil.

Available soil loss data from undisturbed land were not sufficient to derive table 10 by direct comparison of measured soil loss rates, as was done for development of table 5. However, analyses of the assembled erosion data showed that the research information on values of **C** can be extended to completely different situations by combining subfactors that evaluate three separate and distinct, but interrelated, zones of influence: (a) vegetative cover in direct contact with the soil surface, (b) canopy cover, and (c) residual and tillage effects.

Subfactors for various percentages of surface cover by mulch are given by the upper curve of

TABLE 10.—*Factor* **C** *for permanent pasture, range, and idle land*[1]

Vegetative canopy		Cover that contacts the soil surface						
			Percent ground cover					
Type and height[2]	Percent cover[3]	Type[4]	0	20	40	60	80	95+
No appreciable canopy		G	0.45	0.20	0.10	0.042	0.013	0.003
		W	.45	.24	.15	.091	.043	.011
Tall weeds or short brush with average drop fall height of 20 in	25	G	.36	.17	.09	.038	.013	.003
		W	.36	.20	.13	.083	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.076	.039	.011
	75	G	.17	.10	.06	.032	.011	.003
		W	.17	.12	.09	.068	.038	.011
Appreciable brush or bushes, with average drop fall height of 6½ ft	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.087	.042	.011
	50	G	.34	.16	.08	.038	.012	.003
		W	.34	.19	.13	.082	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.078	.040	.011
Trees, but no appreciable low brush. Average drop fall height of 13 ft	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.089	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.087	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.084	.041	.011

[1] The listed **C** values assume that the vegetation and mulch are randomly distributed over the entire area.

[2] Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height and is negligible if fall height exceeds 33 ft.

[3] Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

[4] G: cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 in deep.

W: cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface) or undecayed residues or both.

TABLE 11.—*Factor* **C** *for undisturbed forest land*[1]

Percent of area covered by canopy of trees and undergrowth	Percent of area covered by duff at least 2 in deep	Factor C[2]
100-75	100-90	.0001-.001
70-45	85-75	.002-.004
40-20	70-40	.003-.009

[1] Where effective litter cover is less than 40 percent or canopy cover is less than 20 percent, use table 6. Also use table 6 where woodlands are being grazed, harvested, or burned.

[2] The ranges in listed **C** values are caused by the ranges in the specified forest litter and canopy covers and by variations in effective canopy heights.

figure 6. Subfactors for various heights and densities of canopy cover are given in figure 5. The subfactor for residual effects of permanent pasture, range, idle land, or grazed or harvested woodland has been estimated to vary from 0.45 to 0.10 (57). Major influences on this subfactor are plant roots, organic matter buildup in the topsoil, reduced soil compaction, and surface stabilization after long periods without soil disturbance. The **C** values given in table 10 were derived by combining subfactors for specified combinations of type, height, and density of canopy cover; type and density of cover at the soil surface; and probable residual effects of longtime existence of the specified cover on the land. They are compatible with the rather scarce existing soil loss data from undisturbed land areas.

C Values for Woodland

Three categories of woodland are considered separately: (1) undisturbed forest land; (2) woodland that is grazed, burned, or selectively harvested; and (3) forest lands which have had site preparation treatments for re-establishment after harvest.

In undisturbed forests, infiltration rates and organic matter content of the soil are high, and much or all of the surface is usually covered by a layer of compacted decaying forest duff or litter several inches thick. Such layers of duff shield the soil from the erosive forces of runoff and of drop impact and are extremely effective against soil erosion. Where cover by trees and litter is incomplete, the spots with little or no litter cover are partially protected by undergrowth canopy. Factor **C** for undisturbed forest land may be obtained from table 11. These estimated **C** values are supported by the quite limited existing data and also by the subfactor-evaluation procedure discussed in the preceding subsection.

Woodland that is grazed or burned, or has been recently harvested, does not merit the extremely low **C** values of table 11. For these conditions, **C** is obtained from table 10. However, the buildup of organic matter in the topsoil under permanent woodland conditions is an added factor that should be accounted for by a reduction in the **C** value read from table 10. An earlier publication (57) recommended a factor of 0.7 for this purpose.

Site preparation treatments for re-establishing trees on harvested forest land usually alter the erosion factors substantially. Canopy effect is initially greatly reduced or lost entirely, and its restoration is gradual. Some of the forest litter is incorporated in the soil, and it may be entirely removed from portions of the area. A surface roughness factor is introduced. Windrowed debris, if across slope, may function as terraces by reducing effective slope length and inducing deposition above and in the windrows. The amount of residual effect retained depends on the amount and depth of surface scalping. Some of the changes are analogous to cropland situations. Some of the relationships available from tables 5 and 10 can be used to evaluate **C** for these conditions, but neither table is directly applicable.

Table 12 presents **C** values computed for Southern Pine Forests that have had site preparation treatments after harvesting. This table was jointly developed (in 1977) by representatives of SEA, SCS, and Forest Service, using factor relationships from tables 5, 10, and 11 as basic guides. Its application on forest lands in other climatic regions may require some modifications of factor values. Research designed to refine and improve tables 10, 11, and 12 is underway.

Tree plantings on converted cropland should, in the initial years, be evaluated similarly to cropland because the forest residual effect which underlies tables 10 to 12 will not be applicable. The subfactor for residual effects may be estimated by selecting from lines 1 to 16 of table 5 the line that most nearly describes the condition of the converted cropland and assuming a residual subfactor equal to the seedbed-period value given in that line. If the cropland has most recently been in

TABLE 12.—*Factor* **C** *for mechanically prepared woodland sites*

Site preparation	Mulch cover[1]	Soil condition[2] and weed cover[3]							
		Excellent		Good		Fair		Poor	
		NC	WC	NC	WC	NC	WC	NC	WC
	Percent								
Disked, raked, or bedded[4]	None	0.52	0.20	0.72	0.27	0.85	0.32	0.94	0.36
	10	.33	.15	.46	.20	.54	.24	.60	.26
	20	.24	.12	.34	.17	.40	.20	.44	.22
	40	.17	.11	.23	.14	.27	.17	.30	.19
	60	.11	.08	.15	.11	.18	.14	.20	.15
	80	.05	.04	.07	.06	.09	.08	.10	.09
Burned[5]	None	.25	.10	.26	.10	.31	.12	.45	.17
	10	.23	.10	.24	.10	.26	.11	.36	.16
	20	.19	.10	.19	.10	.21	.11	.27	.14
	40	.14	.09	.14	.09	.15	.09	.17	.11
	60	.08	.06	.09	.07	.10	.08	.11	.08
	80	.04	.04	.05	.04	.05	.04	.06	.05
Drum chopped[5]	None	.16	.07	.17	.07	.20	.08	.29	.11
	10	.15	.07	.16	.07	.17	.08	.23	.10
	20	.12	.06	.12	.06	.14	.07	.18	.09
	40	.09	.06	.09	.06	.10	.06	.11	.07
	60	.06	.05	.06	.05	.07	.05	.07	.05
	80	.03	.03	.03	.03	.03	.03	.04	.04

[1] Percentage of surface covered by residue in contact with the soil.

[2] *Excellent* soil condition—Highly stable soil aggregates in topsoil with fine tree roots and litter mixed in.

Good—Moderately stable soil aggregates in topsoil or highly stable aggregates in subsoil (topsoil removed during raking), only traces of litter mixed in.

Fair—Highly unstable soil aggregates in topsoil or moderately stable aggregates in subsoil, no litter mixed in.

Poor—No topsoil, highly erodible soil aggregates in subsoil, no litter mixed in.

[3] NC—No live vegetation.

WC—75 percent cover of grass and weeds having an average drop fall height of 20 in. For intermediate percentages of cover, interpolate between columns.

[4] Modify the listed **C** values as follows to account for effects of surface roughness and aging:

First year after treatment: multiply listed **C** values by 0.40 for rough surface (depressions >6 in); by 0.65 for moderately rough; and by 0.90 for smooth (depressions <2 in).

For 1 to 4 years after treatment: multiply listed factors by 0.7.

For 4+ to 8 years: use table 6.

More than 8 years: use table 7.

[5] For first 3 years: use **C** values as listed.

For 3+ to 8 years after treatment: use table 6.

More than 8 years after treatment: use table 7.

meadow, the selected seedbed soil loss ratio is multiplied by a factor from table 5-D. If mulch is applied, a subfactor read from the upper curve of figure 6 is multiplied by the residual subfactor to obtain **C**. When canopy develops, a canopy subfactor from figure 5 is also included.

SUPPORT PRACTICE FACTOR (P)

In general, whenever sloping soil is to be cultivated and exposed to erosive rains, the protection offered by sod or close-growing crops in the system needs to be supported by practices that will slow the runoff water and thus reduce the amount of soil it can carry. The most important of these supporting cropland practices are contour tillage, stripcropping on the contour, and terrace systems. Stabilized waterways for the disposal of excess rainfall are a necessary part of each of these practices.

By definition, factor **P** in the USLE is the ratio of soil loss with a specific support practice to the corresponding loss with up-and-down-slope culture. Improved tillage practices, sod-based rotations, fertility treatments, and greater quantities of crop residues left on the field contribute materially to erosion control and frequently provide the major control in a farmer's field. However, these are considered conservation cropping and management practices, and the benefits derived from them are included in **C**.

Contouring

The practice of tillage and planting on the contour, in general, has been effective in reducing erosion. In limited field studies, the practice provided almost complete protection against erosion from storms of moderate to low intensity, but it provided little or no protection against the occasional severe storms that caused extensive breakovers of the contoured rows. Contouring appears to be the most effective on slopes in the 3- to 8-percent range. As land slope decreases, it approaches equality with contour row slope, and the soil loss ratio approaches 1.0. As slope increases, contour row capacity decreases and the soil loss ratio again approaches 1.0.

Effectiveness of contouring is also influenced by the slope length. When rainfall exceeds infiltration and surface detention in large storms, breakovers of contour rows often result in concentrations of runoff that tend to become progressively greater with increases in slope length. Therefore, on slopes exceeding some critical length the amount of soil moved from a contoured field may approach or exceed that from a field on which each row carries its own runoff water down the slope. At what slope length this could be expected to occur would depend to some extent on gradient, soil properties, management, and storm characteristics.

P Values for Contouring

A joint SEA and SCS workshop group, meeting at Purdue University in 1956, adopted a series of contour **P** values that varied with percent slope. The **P** values were based on available data and field observations supplemented by group judgment. Subsequent experience indicated only a few minor changes. Current recommendations are given in table 13. They are average values for the factor on the specified slopes. Specific-site values may vary with soil texture, type of vegetation, residue management, and rainfall pattern, but data have not become available to make the deviations from averages numerically predictable.

Full contouring benefits are obtained only on fields relatively free from gullies and depressions other than grassed waterways. Effectiveness of this practice is reduced if a field contains numerous small gullies and rills that are not obliterated by normal tillage operations. In such instances, land smoothing should be considered before contouring. Otherwise, a judgment value greater than shown in table 13 should be used when computing the benefits for contouring.

TABLE 13.—**P** *values and slope-length limits for contouring*

Land slope percent	P value	Maximum length[1]
		Feet
1 to 2	0.60	400
3 to 5	.50	300
6 to 8	.50	200
9 to 12	.60	120
13 to 16	.70	80
17 to 20	.80	60
21 to 25	.90	50

[1] Limit may be increased by 25 percent if residue cover after crop seedlings will regularly exceed 50 percent.

Slope-Length Limits

After the 1956 workshop, the SCS prepared reference tables for use with the Corn Belt slope-practice procedure. They included guides for slope-length limits for effective contouring, based largely on judgment. These limits, as modified with later data and observations (*16, 42*), are also given in table 13. Data to establish the precise limits for specific conditions are still not available. However, the **P** values given in table 13 assume slopes short enough for full effectiveness of the practice. Their use for estimating soil loss on unterraced slopes that are longer than the table limits specified is speculative.

Contour Listing

Contour listing, with corn planted in the furrows, has been more effective than surface planting on the contour (*29*). However, the additional effectiveness of the lister ridges applies only from the date of listing until the ridges have been largely obliterated by two corn cultivations. Therefore, it can be more easily credited through **C** than through **P**. This is done by a 50-percent reduction in the soil loss ratios (table 5) that apply to the time interval during which the ridges are intact. The standard **P** value for contouring is applicable in addition to the **C** value reduction.

Potato rows on the contour present a comparable condition from lay-by time until harvest. However, this ridging effect has been already credited in table 5, line 160, and should not be duplicated.

Controlled-Row Grade Ridge Planting

A method of precise contouring has been developed that provides effective conservation on farm fields where the land slope is nearly uniform, either naturally or by land smoothing, and runoff from outside the field can be diverted. The practice uses ridge planting with undiminished channel capacity to carry water maintained throughout the year. It is being studied in Texas (*36*), Arkansas, Mississippi (*8*), and Iowa (*30*). In Texas, the channel cross section, with 40-in row spacing, was nearly 0.5 ft^2, and row grades varied from nearly zero at the upper end to 1 percent at the lower end of a 1,000-ft length. Measured soil loss compared favorably with that from an adjacent terraced watershed. Soil loss measurements in Mississippi and Iowa showed similar effectiveness during the test periods.

Because each furrow functions as an individual terrace, **P** values similar to those for terracing seem appropriate. Slope-length limits for contouring would then not apply, but the length limits would be applicable if the channel capacity were only sufficient for a 2-year design storm.

Contoured-Residue Strips

Contoured strips of heavy crop-residue mulch, resembling contour stripcropping without the sod, may be expected to provide more soil loss reduction than contouring alone. **P** values equal to about 80 percent of those for contouring are recommended if fairly heavy mulch strips remain throughout the year. If the strips are maintained only from harvest until the next seedbed preparation, the credit should be applied to the soil loss ratio for cropstage 4 rather than the **P** value.

Contour Stripcropping

Stripcropping, a practice in which contoured strips of sod are alternated with equal-width strips of row crops or small grain, is more effective than contouring alone. Alternate strips of grain and meadow year after year are possible with a 4-year rotation of corn-wheat with meadow seeding-meadow-meadow. This system has the added advantage of a low rotation **C** value. A stripcropped rotation of corn-corn-wheat-meadow is less effective. Alternate strips of winter grain and row crop were effective on flat slopes in Texas (*14*), but alternate strips of spring-seed grain and corn on moderate to steep slopes have not provided better erosion control than contouring alone.

Observations from stripcrop studies showed that much of the soil eroded from a cultivated strip was filtered out of the runoff as it was slowed and spread within the first several feet of the adjacent sod strip. Thus the stripcrop factor, derived from soil loss measurements at the foot of the slope, accounts for off-the-field soil movement but not for all movement within the field.

P Values, Strip Widths, and Length Limits

Recommended **P** values for contour stripcropping are given in table 14. The system to which each column of factors applies is identified in the table footnotes. The strip widths given in column 5 are essentially those recommended by the 1956 slope-practice workshop and are to be considered approximate maximums. Reasonable adjustments to accommodate the row spacing and row multiple of the planting and harvesting equipment are permissible. Slope-length limit is generally not a critical factor with contour stripcropping except on extremely long or steep slopes. The lengths given in column 6 are judgment values based on field experience and are suggested as guides.

Buffer Stripcropping

This practice consists of narrow protective strips alternated with wide cultivated strips. The location of the protective strips is determined by the width and arrangement of adjoining strips to be cropped in the rotation and by the location of steep, severely eroded areas on slopes. Buffer strips usually occupy the correction areas on sloping land and are seeded to perennial grasses and legumes. This type of stripcropping is not as effective as contour stripcropping (*4*).

TABLE 14.—**P** *values, maximum strip widths, and slope-length limits for contour stripcropping*

Land slope percent	P values[1]			Strip width[2]	Maximum length
	A	B	C		
				Feet	*Feet*
1 to 2	0.30	0.45	0.60	130	800
3 to 5	.25	.38	.50	100	600
6 to 8	.25	.38	.50	100	400
9 to 12	.30	.45	.60	80	240
13 to 16	.35	.52	.70	80	160
17 to 20	.40	.60	.80	60	120
21 to 25	.45	.68	.90	50	100

[1] **P** values:

A For 4-year rotation of row crop, small grain with meadow seeding, and 2 years of meadow. A second row crop can replace the small grain if meadow is established in it.

B For 4-year rotation of 2 years row crop, winter grain with meadow seeding, and 1-year meadow.

C For alternate strips of row crop and small grain.

[2] Adjust strip-width limit, generally downward, to accommodate widths of farm equipment.

Terracing

The most common type of terrace on gently sloping land is the broadbase, with the channel and ridge cropped the same as the interterrace area. The steep backslope terrace is most common on steeper land. Difficulty in farming point rows associated with contoured terraces led to developing parallel terracing techniques (*16*). Underground outlets, landforming, and variable channel grades help establish parallel terraces. The underground outlets are in the low areas along the terrace line. The ridge is constructed across these areas. Another type of terrace, using a level and broad channel with either open or closed ends, was developed to conserve moisture in dryland farming areas.

Terraces with underground outlets, frequently called impoundment terraces, are highly effective for erosion control. Four-year losses from four such terrace systems in Iowa (*17*) averaged less than 0.4 t/A/year, which was less than 5 percent of the calculated soil movement to the channel. Comparable losses were measured from installations in Nebraska.

Terracing combined with contour farming and other conservation practices is more effective than those practices without the terraces because it positively divides the slope into segments equal to the horizontal terrace interval. The horizontal terrace interval for broadbase terraces is the distance from the center of the ridge to the center of the channel for the terrace below. For steep backslope terraces with the backslope in sod, it is the distance from the point where cultivation begins at the base of the ridge to the base of the frontslope of the terrace below (*44*). With terracing, the slope length is this terrace interval; with stripcropping or contouring alone, it is the entire field slope length.

P Values

Values of **P** for contour farming terraced fields are given in table 15. These values apply to contour farmed broadbase, steep backslope, and level terraces. However, recognize that the erosion control benefits of terraces are much greater than indicated by the **P** values. As pointed out earlier, soil loss per unit area on slopes of 5 percent or steeper is approximately proportional to the square root of slope length. Therefore, dividing a field slope into **n** approximately equal horizontal terrace intervals divides the average soil loss per unit area by the square root of **n**. This important erosion control benefit of terracing is not included in **P** because it is brought into the USLE computation through a reduced **LS** factor obtained by using the horizontal terrace interval as the slope length when entering figure 4 or table 3.

Erosion control between terraces depends on the crop system and other management practices evaluated by **C**. The total soil movement within a contour-farmed terrace interval may be assumed equal to that from the same length of an identical slope that is contoured only. Therefore, if a control level is desired that will maintain soil movement between the terraces within the soil loss tolerance limit, the **P** value for a contour-farmed terraced field should equal the contour factor (col. 2, table 15), and use of these values for farm planning purposes is generally recommended.

With contour stripcropping, the soil deposited in the grass strips is not considered lost because it remains on the field slope. With terraces, most of the deposition occurs in the terrace channels, but research measurements have shown that this deposition may equal 80 percent of the soil moved from the contour-farmed slopes between the terraces (*67*). Use of the contour factor as the **P** value for terracing assumes that all of the eroded soil deposited in the terrace channels is lost from the productive areas of the field. With broadbase terraces, the channels and ridges are cropped the same as

TABLE 15.—**P** *values for contour-farmed terraced fields*[1]

Land slope (percent)	Farm planning		Computing sediment yield[3]	
	Contour factor[2]	Stripcrop factor	Graded channels sod outlets	Steep backslope underground outlets
1 to 2	0.60	0.30	0.12	0.05
3 to 8	.50	.25	.10	.05
9 to 12	.60	.30	.12	.05
13 to 16	.70	.35	.14	.05
17 to 20	.80	.40	.16	.06
21 to 25	.90	.45	.18	.06

[1] Slope length is the horizontal terrace interval. The listed values are for contour farming. No additional contouring factor is used in the computation.

[2] Use these values for control of interterrace erosion within specified soil loss tolerances.

[3] These values include entrapment efficiency and are used for control of offsite sediment within limits and for estimating the field's contribution to watershed sediment yield.

the interterrace slopes, and some of the material deposited in the channels is moved to the ridges in terrace maintenance. The 1956 slope-practice group felt that some of the deposition should be credited as soil saved and recommended use of a terracing practice factor equal to the stripcrop factor (*64*). However, the more conservative values given in column 2 are now commonly used in conservation planning.

When the USLE is used to compute a terraced field's contribution to offsite sediment or watershed gross erosion, the substantial channel deposition must be credited as remaining on the field area. For this purpose, the **P** values given in the last two columns of table 15 are recommended unless an overland flow deposition equation based on transport relationships is used with the USLE.

With widespread use of large multirow equipment, farming with field boundaries across nonparallel terraces is not uncommon in some regions. When terraces are not maintained and overtopping is frequent, **P** $= 1$ and the slope length is the field slope length. However, if the terraces are periodically maintained so that overtopping occurs only during the most severe storms, **LS** is based on the horizontal terrace interval. If farming across terraces is at an angle that approximates contour farming, **P** values less than 1.0 but greater than the contour factors would be appropriate.

Soil Loss Terrace Spacing

Traditionally, terrace spacing has been based on slope gradient; however, some recent spacing guides have included modifying factors for severity of rainfall and for favorable soil and tillage combinations. A major objective of cropland conservation planning is to hold the productive topsoil in place. Extending this objective to terrace system design suggests limiting slope lengths between terraces sufficiently so that specified erosion tolerances will not be exceeded. Using the USLE in developing spacing guides will make this possible.

The USLE may be written as $\mathbf{LS} = \mathbf{T/RKCP}$, where **T** is the tolerance limit. If $\mathbf{T/RKP} = \mathbf{Z}$, then $\mathbf{LS} = \mathbf{Z/C}$, and $\mathbf{C} = \mathbf{Z/LS}$. The values **T**, **R**, **K** and **P** are constant for a given location and can be obtained from handbook tables and charts as illustrated in the section **Predicting Cropland Soil Losses.** Factor **C** can be selected as the **C** value of the most erosion-vulnerable crop system that a farmer is likely to use on the terraced field. **LS** can be computed by solving the equation as written above and, with the percent slope known, the maximum allowable length can be read from the slope-effect chart, figure 4.

To illustrate the procedure, assume a 6-percent slope at a location where $\mathbf{R} = 175$, $\mathbf{K} = 0.32$, $\mathbf{T} = 5$, $\mathbf{P} = 0.5$, and the most erodible crop expected to occur on the field has a **C** value of 0.24. (An assumption that the field will always be in a sod based rotation or that the operator will always make the best possible use of the crop residues would be too speculative to serve as a guide for terrace spacing.) With these assumptions, $\mathbf{Z} = 5/175(0.32)(0.5) = 0.179$ and $\mathbf{LS} = 0.179/0.24$, or 0.744. Enter the slope-effect chart, figure 4, on the **LS** scale with a value of 0.744, move horizontally to intersect the 6 percent-slope line and read the corresponding slope length, 120 ft, on the horizontal scale. Add to this value the width of the terrace frontslope and compute the vertical interval: $\left(\frac{120 + 12}{100}\right)6 = 7.9$ ft. However, the horizontal interval should not exceed the slope-length limit for effectiveness of contouring. From table 13 the length limit for contouring on a 6-percent slope is 200 ft, so the computed terrace interval is satisfactory. A small modification in spacing may be made to adjust to an even multiple of machinery width.

The maximum **C** value that will allow a horizontal terrace spacing equal to the length limit for effective contouring on the given slope can also be determined by using figure 4 and table 13. For the conditions in the illustration above, $\mathbf{C} = 0.179/\mathbf{LS}$. The maximum acceptable length for contouring is 200 ft. From figure 4, the **LS** value for a 200-ft length of 6-percent slope is 0.95. Therefore, the maximum allowable $\mathbf{C} = 0.179/0.95$, which is 0.188. With terraces spaced at 200-ft intervals, any cropping and management system with a **C** value of less than 0.188 should provide the level of conservation prescribed by the assumed soil loss tolerance limit of 5 t/A/year.

One additional consideration is important. For a terrace to function satisfactorily, the channel capacity must be sufficient to carry the runoff safely to a stabilized outlet without excessive channel scour or overtopping of the ridge. SCS engineering practice standards specify a capacity sufficient to control the runoff from a 10-year-frequency, 24-hour storm without overtopping. Some SCS practice standards may require a shorter terrace interval than would be indicated by the foregoing procedure.

The discussion of the topographic factor pointed out that the erosion rate increases as slope length increases. Table 4 lists the relative soil losses for successive equal-length increments of a uniform slope divided into 2, 3, 4, or 5 segments. The third column of table 4 shows that if a uniform 6-percent slope were controlled at a tolerance of 5 t average soil loss, the average loss per unit area from the lower third of the slope would exceed the tolerance by about 38 percent. Soil loss from the upper third would be 43 percent less than the tolerance limit. To have an average rate of 5 t from the lower third, the **T** values used in the spacing calculation would need to be 1/1.38 times the 5-t tolerance, or 3.6 t. This is an approach that can be used to calculate terrace spacings for a higher level of conservation.

Effect of Terraces on Amount and Composition of Offsite Sediment

By reducing runoff velocity and inducing deposition of sediment in the channels, terraces have a profound effect on the amount and composition of offsite sediments from cultivated fields. The type of terrace, the channel grade, and the type of outlet influence the magnitude of the effect.

The greatest reduction in sediment is attained with the impoundment type terrace systems that use underground outlets. With the outlets in the lower areas of the field and terrace ridges built across these areas, temporary ponds are created around the risers of the outlet tile. The outlets are designed to drain the impounded runoff in 1 to 2 days. Thus, the ponds provide a maximum stilling effect, and only the smallest and lightest soil particles are carried off the field in the runoff water. The increased time for infiltration also reduces runoff.

Sediments collected from four impoundment terrace systems over 4 years in Iowa (*17*) showed the following percentages of fine materials:

Soil type	< 0.002 mm	< 0.008 mm
	Percent	*Percent*
Fayette silt loam	78	91
Sharpsburg silty clay loam	68	96
Floyd loam	31	82
Clarion loam	35	78

Sediment concentrations in the runoff ranged from about 1,300 p/m on the Fayette soil to 6,300 p/m on the Clarion. Average annual sediment from the outlets was less than 800 lb/A for all four systems.

Farm chemical losses in runoff vary with type and formulation, amount, placement, and time of rainfall in relation to time of application, as well as with the usual runoff and erosion factors. Principal chemicals are the fertilizers, insecticides, fungicides, and herbicides. Losses are by solution and by suspension of chemical granules or adsorption on soil particles suspended in the runoff water.

Terracing exerts its greatest influence in reducing offsite pollution from those chemicals that are adsorbed on soil particles. Examples of these are the phosphates, organic nitrogen, and persistent organochlorine insecticides. Reductions in offsite *sediment* by terrace systems with contouring are estimated to range from 82 to 95 percent. However, the reductions in chemical transport are generally not proportional to reductions in soil loss because of an enrichment process that applies to the suspensions. The nutrient content of sediments is often 50 percent greater than that of the soil. Offsite delivery of sediment is also affected by watershed characteristics, particularly size of the drainage area. This reduction is measured by a "delivery ratio" that ranges from 0.33 for an area of one-half square mile to 0.08 for a 200-mi^2 area (*45*).

Terracing has the least effect on offsite pollution from those chemicals transported primarily in solution. Annual runoff reductions by terracing and contour farming, at 21 locations throughout the United States, have been estimated to vary only from 9 to 37 percent (*42*). Examples of farm chemicals transported primarily in solution are the nitrates and some herbicides such as 2,4-D ((2,4-dichlorophenoxy) acetic acid). The predominate transport modes for an extensive list of pesticides are listed in volumes 1 and 2 of "Control of Water Pollution From Cropland" (*42*).

APPLYING THE SOIL LOSS EQUATION

The major purpose of the soil loss prediction procedure is to supply specific and reliable guides for selecting adequate erosion control practices for farm fields and construction areas. The procedure is also useful for computing the upland erosion phase of sediment yield as a step in predicting rates of reservoir sedimentation or stream loading, but the USLE factors are more difficult to evaluate for large mixed watersheds. Specific applications of the soil loss equation are discussed and illustrated below.

Predicting Cropland Soil Losses

The USLE is designed to predict longtime-average soil losses for specified conditions. This may be the average for a rotation or for a particular crop year or cropstage period in the rotation. Where the term "average loss" is used below, it denotes the average for a sufficient number of similar events or time intervals to cancel out the plus and minus effects of short-time fluctuations in uncontrolled variables.

Rotation Averages

To compute the average annual soil loss from a particular field area, the first step is to refer to the charts and tables discussed in the preceding sections and select the values of **R, K, LS, C,** and **P** that apply to the specific conditions on that field. For example, assume a field on Russell silt loam soil in Fountain County, Ind. The dominant slope is about 8 percent with a length of 200 ft. Fertility and crop management on this field are such that crop yields are rarely less than 85 bu corn, 40 bu wheat, or 4 t alfalfa-brome hay. The probability of meadow failure is slight.

Factor **R** is taken from the isoerodent map (fig. 1). Fountain County, in west-central Indiana, lies between isoerodents of 175 and 200. By linear interpolation, **R** = 185. **K** is taken from a table of **K** values that were derived either by direct research measurement or by use of the soil erodibility nomograph (fig. 3). For the Russell silt loam soil, **K** = 0.37. The slope-effect chart, figure 4, shows that an 8 percent slope 200 ft long has an **LS** of 1.41. If the field were continuously in clean-tilled fallow, the average annual soil loss from the dominant slope would equal the product **RKLS**; that is, 185(0.37)(1.41) = 96.5 t/A.

Next, we need to know the effect of the cropping and management system and support practices existing on the field. This effect is represented by factors **C** and **P**. The **C** value for the field may either be derived by the procedure previously presented, using data from tables 5 and 6, or it may be obtained from a centrally prepared **C** value table available from the SCS. For convenience, assume the same crop system and management as were assumed for the problem illustrating the derivation of locality **C** values. From table 8, **C** then equals 0.085. If rows and tillage are in the direction of the land slope, factor **P** = 1.0. The computed average soil loss is then 96.5(0.085)(1.0) = 8.2 t/A/year.

From table 13, contour farming on 8 percent slopes not exceeding 200 ft in length has a **P** value of 0.5. Therefore, if farming were on the contour, the computed average soil loss for the field would be 96.5(0.085)(0.5) = 4.1 t. If the length of 8-percent slope was appreciably greater than 200 ft, the effectiveness of contouring could not be assumed, and the **P** value of 0.5 would not be applied unless the slope length was broken by terraces or diversions. Any change in either the crop sequence or the management practices would likely increase or decrease soil loss. This would be reflected in the USLE solution through a change in the **C** value.

When **C** is used at its average annual value for a rotation that includes a sod crop, as was done in the example given in table 8, the heavier losses experienced during row crop years are diluted by trivial losses in the meadow year(s). For holding longtime-average soil losses below some prescribed tolerance limit, this dilution poses no problem. But from the viewpoint of offsite water quality, it may not be desirable. The USLE may also be used to compute the average soil loss for each crop in the rotation or for a particular cropstage period.

Crop-Year Averages

The subtotals in column 9 of table 8 show that with the assumed management system, **C** for the first-year corn would be 0.130 and for the second-year, 0.138. For the second-year corn, without contouring, the expected average soil loss would equal 185(0.37)(1.41)(0.138), or 13.3 t. If, in the same crop system, the corn residues were plowed down in fall, the **C** value for second-year corn would be 0.29, and the soil loss would average 28 t. On the other hand, no-till planting the second-year corn in a 70-percent cover of shredded cornstalks would reduce the **C** value for this crop to 0.08 and the soil loss to about 8 t. This would also reduce the rotation average for straight row farming to 7 t. Killing the meadow instead of turning it under, and no-till planting, would reduce the **C** value for the first-year corn to 0.01 and the soil loss to less than 1 t. Thus, crop-year **C** values can be helpful for sediment control planning.

Cropstage Averages

Additional information can be obtained by computing the average annual soil loss for each cropstage period. First, the computed cropstage soil losses will show in which portions of the crop year (or rotation cycle) improved management practices would be most beneficial. Second, they provide information on the probable seasonal distribution of sediment yields from the field. When a tabulation like table 8 has been prepared, the values in column 8 will be directly proportional to the cropstage soil losses. They can be converted to tons per acre for a specific field by multiplying them by the product of factors **R, K, LS,** and **P.**

To estimate the average soil loss for a particular cropstage when such a table has not been prepared, the cropstage soil loss ratio from table 5 is used as **C.** The annual **EI** fraction that is applicable to the selected period is obtained from table 6 and is multiplied by the location's annual erosion index value (fig. 1) to obtain the relevant **R** value. **K, LS,** and **P** will usually be assumed to have the same values as for computation of average annual soil losses.

Suppose, for example, that one wishes to predict the average soil loss for the seedbed and establishment periods of corn that is conventionally planted about May 15 on spring plowed soybean land in southwestern Iowa (area No. 13, fig. 9). Suppose also that the corn is on a field for which the combined value of factors **K, LS,** and **P** is 0.67 and the fertility and crop management are such that corn planted by May 15 usually develops a 10 percent canopy cover by June 5, 50 percent by June 25, and a final canopy cover of more than 95 percent. Interpolating between values in line 13 of table 6 shows cumulative **EI** percentages of 12, 23, and 43 for these three dates. Therefore, on the average, 11 percent of the annual **EI** would occur in the seedbed period, and 20 percent would occur in the establishment period. From line 109 of table 5, the soil loss ratios for these two cropstage periods under the assumed management are 0.72 and 0.60. From figure 1, the average annual **EI** is 175. The soil loss would be expected to average $0.11(175)(0.72)(0.67) = 9.3$ t/A in the seedbed period and $0.20(175)(0.60)(0.67) = 14$ t in the establishment period. The cropping assumed for this example represents an extremely erodible condition. For second-year corn with good residue management, the applicable soil loss ratios and the predicted soil losses would be much lower.

Individual Storm Soil Losses

The USLE factors derived from tables and charts presented herein compute longtime-average soil losses for specified cover and management on a given field. The USLE is not recommended for prediction of specific soil loss events.

If it is applied to a specific rainstorm, using the storm **EI** for **R** and the relevant cropstage soil loss ratio for **C,** it will estimate the *average* soil loss for a large number of storms of this size occurring on that field and in that cropstage period. However, the soil loss from any one of these events may differ widely from this average because of interactions with variables whose values fluctuate randomly over time (*56*).

When rain falls on relatively dry, freshly tilled soil, most of the water may infiltrate before runoff begins, resulting in a low-average soil loss per unit of **EI** for that storm. When rain falls on presaturated soil, runoff begins quickly, and most of the rain becomes runoff. Such rains usually produce above-average soil loss per **EI** unit. Some rains are accompanied by high winds that increase the impact energy of raindrops; others occur in a fairly calm atmosphere. Some storms begin with a high intensity and seal the surface quickly so that trailing lower intensities encounter a low infiltration rate. In other storms the moderate intensities precede the high ones. In some seasons the soil is cultivated when wet and remains cloddy; in other seasons it is cultivated when soil moisture is ideal for fine pulverization. A claypan or fragipan subsoil may substantially influence permeability in early spring or in a wet growing season and yet have no significant effect on infiltration rates during intense thunderstorms on dry soil.

The soil loss ratios of table 5 are averages for cropstage periods that cover several weeks to several months. Early in a cropstage period, the ratio will usually be higher than the average because the development of cover is gradual. Later in the period it will be lower than average. In a poor growing season the ratio will be above average because cover and water use by transpiration are below normal. In a favorable growing season, the ratio will be below average. Cover effect in a specific year may be substantially influenced by abnormal rainfall. A crop canopy or conservation tillage practice may delay the start of runoff long enough to be 100 percent effective for moderate storms on a given field and yet allow substantial erosion by prolonged runoff periods.

The irregular fluctuations in these and other variables can greatly influence specific-storm soil losses. However, they do not invalidate the USLE for predicting long-term-average soil losses for specific land areas and management conditions. Their positive and negative effects tend to balance over a longtime period, and their average effects are reflected in the factor-evaluation tables and charts.

Two recent research reports are recommended references for those who find it necessary to estimate specific-storm soil losses (*34, 10*). The authors present modifications of **R** and **LS** that are designed to account for some random effects discussed.

Specific-Year Soil Losses

In any given year, both the annual **EI** and its monthly distribution may differ substantially from the location averages. Therefore, **R** values from figure 1 and **EI** distribution data from table 6 will not correctly reflect specific-year values of these variables. The most accurate procedure is to compute the **EI** value for each storm from a recording-rain gage record for the location and year by the method given in the appendix. The storm values are summed for each cropstage period, and the subtotals are combined with soil loss ratios from table 5 to estimate the soil loss for each cropstage period. The sum of the cropstage soil losses then reflects the effects of possible abnormal **EI** distribution, as well as the corrected **R** value for the specific year. However, the irregular fluctuations in variables discussed in the preceding subsection are often related to abnormalities in rainfall. The plus and minus effects on soil loss may not average out within 1 year but may appreciably bias specific-year soil losses. These biases will not be evaluated by the USLE. Therefore, specific-year estimates of soil loss will be less accurate than USLE estimates of long-term, crop-year averages.

Soil Loss Probabilities

Soil loss probabilities are a function of the combination of the probabilities for annual **EI**, seasonal distribution of the erosive rains, abnormal antecedent soil moisture conditions, favorable or unfavorable conditions for soil tillage and crop development, and other factors. The section on the **Rainfall Erosion Index** pointed out that a location's annual and maximum storm **EI** values tend to follow log-normal frequency distributions and that specific probability values are listed in tables 17 and 18 for 181 key locations. When these probabilities of **EI** are used for **R** in the USLE, the equation will estimate the soil loss that would occur if all the other factors were at their normal levels. However, the seasonal distribution of erosive rains, and the surface conditions in the field, may also be abnormal in years of rainfall extremes. Deriving probable relationships of these variables to extremes in annual **EI** would require longer records than were available.

Stochastic modeling techniques (*66*) are available that could be used to generate synthetic data having the same statistical properties as historical data. Such data could be used to estimate the probable range in specific-year soil losses in a particular rainfall area.

Determining Alternative Land Use and Treatment Combinations

The soil loss prediction procedure supplies the practicing conservationist with concise reference tables from which he can ascertain, for each particular situation encountered, which specific land use and management combinations will provide the desired level of erosion control. A number of possible alternatives are usually indicated. From these, the farmer will be able to make a choice in line with his desires and financial resources.

Management decisions generally influence erosion losses by affecting the factor **C** or **P** in the erosion equation. **L** is modified only by constructing terraces, diversions, or contour furrows with sufficient capacity throughout the year to carry the runoff water from the furrow area above. **R, K,** and **S** are essentially fixed as far as a particular field is concerned.

When erosion is to be limited within a predetermined tolerance, **T,** the term **A** in the equation is replaced by **T,** and the equation is rewritten in the form **CP** = **T/RKLS.** Substituting the site values of the fixed factors in this equation and solving for **CP** give the maximum value that the product **CP** may assume under the specified field conditions. With no supporting practices, **P** = 1, and the most intensive cropping plan that can be safely used on the field is one for which **C** just equals this value. When a supporting practice like contouring or stripcropping is added, the computed value of **T/RKLS** is divided by the practice factor, **P,** to obtain the maximum permissible cover and management factor value. Terracing increases the value of **T/RKLS** by decreasing the value **L.**

A special USLE calculator, originally designed in Tennessee (*41*) and recently updated, enables rapid and systematic calculation of either average annual soil loss or **T/RKLS** for any specific situation.

Many practicing conservationists prefer to use handbook tables. **C**-value tables for specific geographic areas (fig. 9) are centrally prepared by persons who are experienced in the procedures outlined in a preceding section and who obtain the needed data from tables 5 and 6. Values of **T/RKLS** are also centrally computed and arranged in two-way classification as illustrated in table 16 for **R** = 180, **K** = 0.32, and **T** = 5. Similar tables are prepared for other combinations of **R, K,** and **T.**

A conservationist working in the field usually carries a pocket-sized handbook which includes the **R** value(s), **T** and **K** soil values, applicable tables of **T/RKLS** values, and a table of **C** values for the area. These items will provide all the information needed to use this procedure as a guide

TABLE 16.—*Maximum permissible* **C** *values* (**T/RKLS**) *for* **R** = *180,* **K** = *0.32 and* **T** = *5*

Gradient percent	Values for slope lengths (feet) 50	75	100	150	200	250	300	400
	STRAIGHT ROW							
2 ..	0.53	0.47	0.43	0.38	0.35	0.33	0.31	0.28
4 ..	.29	.24	.22	.18	.16	.15	.14	.12
6 ..	.18	.15	.13	.11	.091	.082	.074	.064
8 ..	.12	.10	.087	.072	.062	.055	.050	.044
10 ..	.090	.073	.063	.052	.045	.040	.037	.032
12 ..	.068	.056	.048	.039	.034	.030	.028	.024
14 ..	.054	.044	.038	.031	.027	.024	.022	.019
16 ..	.043	.035	.030	.025	.022	.019	.018	.015
	CONTOURED[1]							
2 ..	0.89	0.78	0.72	0.64	0.58	0.55	0.52	0.47
4 ..	.57	.49	.43	.37	.33	.30	.28	.25
6 ..	.36	.30	.26	.21	.18	.16	([2])	—
8 ..	.25	.20	.17	.14	.12	.11	—	—
10 ..	.15	.12	.11	.086	([2])	—	—	—
12 ..	.11	.093	.080	.065	—	—	—	—
14 ..	.077	.062	.054	([2])	—	—	—	—
16 ..	.062	.050	.044	—	—	—	—	—

[1] The values for contour farming are **T/RKLSP**, where **P** is dependent on percent slope (see table 13).

[2] Omission of values indicates that the slope-lengths exceed the limits for effectiveness of contouring. Use corresponding values from upper half of table.

for selecting conservation practices in each field. Solving the equation or performing field computations rarely will be necessary.

Example. The first step is to ascertain the soil type, percent slope, and slope length for the field being planned. From his handbook data, the conservationist can then obtain the values of **R, K,** and **T.** To complete the illustration, assume that **R** = 180, **K** = 0.32, **T** = 5, and the field slope is 400 ft long with a nearly uniform gradient of 6 percent. For this combination, the **T/RKLS** table shows a value of 0.064 for straight-row farming with the land slope (table 16). This is the maximum **C** value that will hold the average annual soil loss from that field within the 5-t tolerance limit, if no supporting practices are used. Consulting the **C** value table will show that a **C** as low as 0.064 can be attained only with well-managed, sod-based crop systems, or with no-till planting in residue covers of at least 70 percent.

A logical improvement is to add contouring. Table 13 shows a slope-length limit of 200 ft (250 ft if residue cover after seeding exceeds 50 percent) for contouring on 6-percent slope. Therefore, the **P** value of 0.5 for contouring will not be applicable on the 400-ft slope without terracing. Construction of three, equally spaced terraces across the slope would divide it into four 100-ft slope lengths. Shortening the slope lengths to 100 ft will assure contour effectiveness and will also reduce the site value of **L.** For a 100-ft length of 6-percent slope farmed on the contour, table 16 shows a **T/RKLSP** value of 0.26. Any combination of cropping and management practices having a **C** value less than 0.26 will now be acceptable. Consulting the table of **C** values will show that with the terraces and contouring, the conservationist can recommend a range of possibilities for land use and management. If a system with a **C** value appreciably less than 0.26 is selected, a higher level of conservation will be attained than required by the 5-t tolerance limit.

Had the slope length in the example been only 200 ft, the contour **P** value of 0.5 (table 13) would have been applicable without the terraces. Table 16 shows that this combination would have permitted use of any system having a **C** value less than 0.18.

Thus, by this procedure a conservationist can list all the alternative crop system and management combinations that would control erosion on a field at an acceptable level. Study of this list will show how an erosion control program can be improved and still increase crop yields or decrease labor and fuel costs. In making a selection from this list, practices needed for control of nutrient and pesticide losses in the runoff (*42*) should also be considered.

Construction Sites

Procedures and data have been presented for predicting erosion losses from specific cropland areas and logically determining alternative ways in which the losses from each field may be held below given tolerance limits. These procedures and data can also be adapted to conditions on highway, residential, and commercial developing areas. The USLE will show under which development plan the area will produce the least sediment, and it will also show about how much sediment the developer will need to trap in sediment basins (*46*) during construction to prevent excessive soil movement to streams or reservoirs.

Evaluating the erosion factors for construction site conditions is discussed below. However, those primarily concerned with this particular phase of sediment control should also read the preceding discussions of the USLE factors and the procedures for predicting cropland soil losses.

Factor R. For a construction project extending over several years, the average annual **R** value for the site is obtained directly from figure 1. Probabilities of **EI** values greater than average are given in table 17. Using **EI** probabilities for **R** was discussed in the subsection **Soil Loss Probabilities.**

For construction periods of less than 1 year, the procedure outlined for predicting cropland soil losses for specific cropstage periods is appropriate. The portion of the annual **R** value that is applicable to the construction period is obtained from table 6 as illustrated on p. 41 for cropstage averages.

Factor K. Because the soil surface is often unprotected during construction, this factor assumes even greater importance than for cropland. The soil erodibility nomograph (fig. 3) can be especially helpful for sediment prediction and erosion control planning on construction sites because it can predict the changes in erodibility when various subsoil horizons are exposed in the reshaping process. Some subsoils are substantially more erodible than the original topsoil, and others are less erodible. The planner can usually obtain a detailed description of the successive horizons of his soil from published soil survey data. By using the data for each soil horizon separately to follow the steps of the nomograph solution, the **K** value can be determined after various depths of desurfacing. Soil losses from the successive soil horizons, if exposed on similar slopes, would be directly proportional to the horizon **K** values. Information on the subsoil **K** values not only shows the depths of cut that would result in the most or the least soil erosion but also indicates whether return of stockpiled topsoil on the exposed subsoil would be profitable on the particular site.

When a chemical soil additive is used that stabilizes the soil and makes it less erodible, the **K** value is the nomograph solution times a factor for the effectiveness of the chemical additive.

Factor LS. Within limits, the **LS** value for a given length and steepness of uniform slope can be obtained directly from figure 4 or table 3. When the slope is concave or convex, the figure 4 value needs to be adjusted by the procedure outlined for irregular slopes in the section on **The Topographic Factor.**

Development planning may include measures designed to reduce sediment yield by lowering **LS.** The effect of shortening slope lengths by diversions or stabilized drainageways is credited by entering figure 4 with the reduced slope length. A slope graded to flatten toward the bottom (concave) will lose less soil than an equivalent uniform slope whereas one that steepens toward the bottom (convex) will lose more. Reduction or increase in soil loss can be predicted by the procedure illustrated in the subsection **Irregular Slopes.**

Data are not available to evaluate **LS** on very steep slopes, like 2:1 and 3:1 roadbank slopes, in relation to soil and rainstorm characteristics. The best presently available estimates of **LS** for these slopes can be obtained by the **LS** equation presented earlier. However, values projected by this equation for steep slopes are speculative because the equation was derived from data obtained on slopes of less than 20 percent.

Factor C. Procedures for selecting **C** values for construction sites were given in the **Cover and Management Factor** section.

Factor P. This factor as used for soil conservation planning on cropland would rarely have a counterpart during construction on development areas, and **P** will usually equal 1.0. Erosion-reducing effects of shortening slopes or reducing slope gradients are accounted for through the **LS** factor.

If the lower part of a grass or woodland slope on a development area can be left undisturbed while the upper part is being developed, the procedure outlined for computing the value of **LSC** on irregular slopes is applicable, and sediment deposition on the undisturbed strip must be accounted for separately. For prolonged construction periods, buffer strips of grass, small grain, or high rates of anchored mulch may also be feasible to induce deposition within the area. Such deposition is important for water quality or offsite sediment control, but it should be evaluated from soil-transport factors rather than by a **P** factor.

Alternative plans. When appropriate numerical values of the six erosion factors are combined, their product is the soil loss estimate for the particular area in tons per acre and for the time interval for which **R** was evaluated. With the information supplied by the tables and charts in this handbook, the six factor values can be derived for each feasible alternative plan. Successive solutions of the equation will then provide comparative soil loss estimates to help guide decisions by the developer.

Estimating Upslope Contributions to Watershed Sediment Yield

The importance of predicting watershed sediment yields and identifying the major sediment sources was increased by the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500. Sources, causes, and potentials of sediment, nutrient, and pesticide losses from cropland, and measures that may be necessary to control these pollutants, are dealt with in depth in a two-volume manual developed by SEA and the Environmental Protection Agency (EPA) (*42*). Volume II, "An Overview," also includes an extensive list of other relevant publications. Only sediment yield prediction will be considered here.

Estimates show that about one-fourth of the amount of sediment moved by flowing water in the United States annually reaches major streams (*42*). The USLE can be used to compute average sheet and rill erosion in the various parts of a watershed, but deposition and channel-type erosion must be estimated by other means. A fully tested equation for sediment transport to use on agricultural land is not now available. One presented by Neibling and Foster (*32*) is perhaps the best now available for use with the USLE. It estimates transport capacity for sand and large silt-sized particles and does not consider the transport of clay particles.

Of the several methods now used for estimating sediment yield, the Gross Erosion-Sediment Delivery Method uses the USLE. A brief description of this method follows. More details are available from the SCS National Engineering Handbook (*45*). The equation is

$$\mathbf{Y} = \mathbf{E}(\mathbf{DR})/\mathbf{W_s} \qquad (6)$$

where **Y** is sediment yield per unit area,
E is the gross erosion,
DR is the sediment delivery ratio, and
$\mathbf{W_s}$ is the area of the watershed above the point for which the sediment yield is being computed.

Gross Erosion

Gross erosion is the summation of erosion from all sources within the watershed. It includes sheet and rill erosion from tilled cropland, meadows, pastures, woodlands, construction sites, abandoned acreages, and surface-mined areas; gully erosion from all sources; and erosion from streambeds and streambanks. The relative importance of each of these sources of gross erosion will vary between watersheds.

The USLE can be used to estimate the sediment generated by sheet and rill erosion that is usually, but not always, the major portion of a watershed's gross erosion. Sediment from gully, streambank and streambed erosion, and from uncontrolled roadsides must be added to the USLE estimates. Methods for estimating sediment yields from these sources are discussed in Section 3 of the SCS National Engineering Handbook (*45*).

For small areas like farm fields or construction sites, the six USLE factors can usually be evaluated directly from the information presented in this handbook. For a large heterogeneous watershed, the factors are more difficult to define. Several methods of computing the average slope length and gradient for a large drainage area are available. Using **LS** values based on such averages, together with estimated watershed-average soil and cover factors, simplifies the computing procedure, but the saving in time is at the expense of substantial loss in accuracy. Erosion hazards are highly site specific. The parameters that determine the USLE factor values vary within a large watershed, and the variations are often not interrelated. Combining overall averages in the equation does not reflect the particular way in which the factors are actually combined in different parts of the watershed. Neither does it show which portions of the drainage area are contributing most of the sediment.

A more accurate procedure is to divide the heterogeneous drainage area into subareas for which representative soil type, slope length, gradient, cover, and erosion-control practice factors can be defined. The USLE is then used to compute the sheet and rill erosion on each subarea. For this purpose, eroded soil that is entrapped within the field area by terrace systems is not soil loss. An estimate of the entrapped sediment can be excluded from the USLE soil loss estimates by using values from the last two columns of table 15 as the **P** values. An alternate procedure is to estimate the channel deposition by sediment-transport relationships and subtract this amount from the soil loss computed by using the standard terracing factor (col. 2, table 15) in the USLE. By this procedure, the subarea soil loss computations identify the portions of the drainage area that contribute most of the sediment and also show how much of the sediment derives from tracts that receive heavy applications of agricultural chemicals.

Procedures for computing soil losses from cropped, idle, pasture, range, or wooded areas and from construction or development areas were outlined in the preceding sections. Factor values derived by the prescribed procedures are assumed applicable also for surface-mined areas. However, the effect of mining processes on soil erodibility, **K**, has not been determined. Length and percent slope and deposition within the area also are hard to determine for rugged strip mine spoils. Sometimes nearly all the sediment may be trapped within the bounds of the area. The USLE can be quite useful for predicting the effectiveness of each feasible reclamation plan for such areas.

Sediment Delivery Ratio

Eroded soil materials often move only short distances before a decrease in runoff velocity causes their deposition. They may remain in the fields where they originated or may be deposited on more level slopes that are remote from the stream system. The ratio of sediment delivered at a given location in the stream system to the gross erosion from the drainage area above that location is the sediment delivery ratio for that drainage area. A general equation for computing watershed delivery ratios is not yet available, but the ratios for some specific drainage areas have been computed directly from local data. Helpful guides for estimating this factor for other drainage areas were published by SCS in Section 3 of their National Engineering Handbook (*45*), and most of these guides were also included in a publication by SEA and EPA (*42*). Therefore, the relationships involved will be only briefly summarized here.

Available watershed data indicate that the delivery ratio varies approximately as the 0.2 power of drainage-area size, with representative values of about 0.33 for 0.5 mi^2; 0.18 for 10 mi^2; and 0.10 for 100 mi^2. There were indications that the exponent in this relationship may be as small as 0.1 for very large areas. But the ratio may vary substantially for any given size of drainage area. Other important factors include soil texture, relief, type of erosion, sediment transport system, and areas of deposition within the watershed. Fine soil texture, high channel density, and high stream gradients generally indicate delivery ratios that are above average for the drainage-area size.

A substantial reduction in sediment delivered to a stream may sometimes result in a compensatory increase in channel erosion. Channel erosion produces sediment that is immediately available to the transport system and that may remain in motion as bedload and suspended sediment. The composition of sediment derived from channel erosion will usually differ substantially from that derived from cropland erosion. This is particularly important from the viewpoint of transported chemical pollutants.

With reference to a field-sized area, the delivery ratio can closely approach 1.0 if the runoff drains directly into a lake or stream system with no intervening obstructions or flattening of the land slope. On the other hand, a substantial width of forest litter or dense vegetation below the eroding area may cause deposition of essentially all the sediment except colloidal material. Anything that reduces runoff velocity (such as reduction in gradient, physical obstructions, vegetation, and ponded water) reduces its capacity to transport sediment. When the sediment load exceeds the transport capacity of the runoff, deposition occurs.

From analysis of runoff and soil loss data from small single-cropped watersheds, Williams (*48*) concluded that the need for a sediment delivery ratio could be eliminated by using the watershed runoff times peak rate as the storm **R** value in the USLE.

Accuracy of USLE Predictions

Soil losses computed with the USLE are best available estimates, not absolutes. They will generally be most accurate for medium-textured soils, slope lengths of less than 400 ft, gradients of 3 to 18 percent, and consistent cropping and management systems that have been represented in the erosion plot studies. The farther these limits are exceeded, the greater will be the probability of significant extrapolation error.

An indication of the accuracy of the equation, tables, and charts presented herein was obtained by using them to compute longtime average soil losses for plots in past erosion studies and comparing these with the actually measured losses on each plot. About 53 percent of the differences were less than 1 t/A, 84 percent were less than 2 t, and 5 percent were as much as 4.6 t (*53*). The mean annual soil loss for this 2,300 plot-year sample was 11.3 t. Of those differences that exceeded 1 t/A, 67 percent were from comparisons with plot records whose duration was less than half of a normal 22-year rainfall cycle (*33*). Such short records are subject to bias by cyclical effects and random fluctuations in uncontrolled variables whose effects are averaged in the USLE factor values (*56*). Testing the complete equation against the assembled plot data was statistically valid because the equation for each factor, as a function of several parameters, was independently derived from only selected portions of the data.

The accuracy of a predicted soil loss will depend on how accurately the physical and management conditions on the particular piece of land are described by the parameter values used to enter the factor-evaluation tables and charts. An error in the selection of a factor value will produce an equivalent percentage error in the soil loss estimate. Large-scale averaging of parameter values on mixed drainage areas will usually also reduce accuracy. For reasons previously pointed out and discussed in depth in another publication (*56*), specific-storm or specific-year soil losses and short-term averages may differ substantially from the longtime average predicted by the USLE for the specified physical and management conditions.

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APPENDIX

Estimating Percentages of Canopy and Mulch Covers

"Percent canopy cover" is the percentage of the field area that could not be hit by vertically falling raindrops because of canopy interception. It is the portion of the soil surface that would be covered by shadows if the sun were directly overhead. Because the blades from adjacent rows intertwine does not necessarily indicate 100 percent canopy cover.

"Percent mulch cover" is the percentage of the field area that is covered by pieces of mulch lying on the surface. Researchers in Indiana attempted to relate percent cover to mulch rate by photographing numerous small, equal-sized areas in harvested corn fields. The residues on the photographed areas were carefully picked up, dried, and weighed to measure mulch rates, and the photographs were projected on grids to determine percent cover. The indicated average relation of percent cover to dry weight of well-distributed corn stover mulch is shown by the solid-line curve in figure 10. However, observed differences between samples were appreciable. The average relation of percent cover to dry weight of straw mulch uniformly distributed over research plots is shown by the broken-line curve.

A simple method of estimating percent mulch cover on a field is with a cord, preferably not shorter than 50 ft, that has 100 equally spaced knots or other readily visible markings. The cord is stretched diagonally across several rows, and the knots that contact a piece of mulch are counted. This procedure is repeated at randomly selected spots on the field, and the data are averaged to obtain a representative value for the field.

Probability Values of EI in the United States

The annual and maximum-storm values of **EI** at any given location differ substantially from year to year. The observed ranges and 50 percent, 20 percent and 5 percent probabilities of annual **EI** values from 22-year precipitation records at 181 locations in 44 States are listed in table 17. Other probabilities can be derived by plotting the 50 percent and 5 percent values on log-probability paper and joining the two points by a straight line. Annual maxima storm probabilities for the same locations are given in table 18.

Computing the Erosion Index from Recording-Rain Gage Records

Soil loss prediction by the method presented in this handbook does not require computation of **EI** values by application personnel, but the procedure is included here for the benefit of those who may wish to do so.

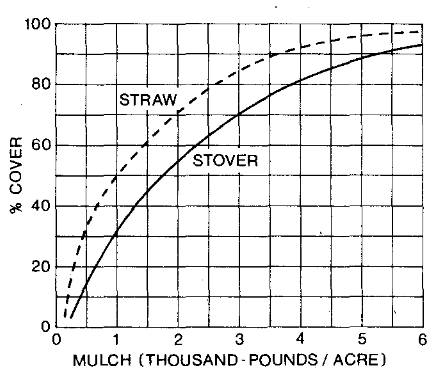

FIGURE 10.—Relation of percent cover to dry weight of uniformly distributed residue mulch.

The kinetic energy of a given amount of rain depends on the sizes and terminal velocities of the raindrops, and these are related to rainfall intensity. The computed energy per inch of rain at each intensity is shown in table 19. The energy of a given storm depends on all the intensities at which the rain occurred and the amount that occurred at each intensity. A recording-rain gage record of the storm will provide this information. Clock time and rain depth are read from the chart at each point where the slope of the pen line changes and are tabulated as shown in the first two columns of the sample computation below. Clock times (col. 1) are subtracted to obtain the time intervals given in column 3, and the depths (col. 2) are subtracted to obtain the incremental amounts tabulated in column 4. The intensity for each increment (col. 5) is the incremental amount times 60, divided by column 3.

Chart readings		For each increment			Energy	
Time	Depth (inch)	Duration (minute)	Amount (inch)	Intensity (in/hr)	Per inch	Total
4:00	0					
:20	0.05	20	0.05	0.15	643	32
:27	.12	7	.07	.60	843	59
:36	.35	9	.23	1.53	977	225
:50	1.05	14	.70	3.00	1074	752
:57	1.20	7	.15	1.29	953	143
5:05	1.25	8	.05	.38	777	39
:15	1.25	20	0	0	0	0
:30	1.30	15	.05	.20	685	34
Totals		90	1.30			1,284

Kinetic energy of the storm $= 1{,}284(10^{-2}) = 12.84$

The energy per inch of rain in each interval (col. 6) is obtained by entering table 19 with the intensity given in column 5. The incremented energy amounts (col. 7) are products of columns 4 and 6. The total energy for this 90-minute rain is 1,284 foot-tons per acre. This is multiplied by a constant factor of 10^{-2} to convert the storm energy to the dimensions in which **EI** values are expressed.

The maximum amount of rain falling within 30 consecutive minutes was 1.08 in, from 4:27 to 4:57. $\mathbf{I}_{30}$ is twice 1.08, or 2.16 in/h. The storm **EI** value is $12.84(2.16) = 27.7$. When the duration of a storm is less than 30 minutes, $\mathbf{I}_{30}$ is twice the amount of the rain.

The **EI** for a specified time is the sum of the computed values for all significant rain periods within that time. The average annual erosion index for a specific locality, as given in figures 1 and 2, is the sum of all the significant storm **EI** values over 20 to 25 years, divided by the number of years. For erosion index calculations, 6 h or more with less than 0.5 in of precipitation was defined as a break between storms. Rains of less than 0.5 in, separated from other showers by 6 h or more, were omitted as insignificant unless the maximum 15-min intensity exceeded 0.95 in/h.

Recent studies showed that the median dropsize of rain does not continue to increase for intensities greater than about 2.5 to 3 in/h (*7, 15*). Therefore, energy per unit of rainfall also does not continue to increase, as was assumed in the derivation of the energy-intensity table published in 1958 (*62*). The value given in table 19 for rain at 3 in/h (7.6 cm/h in table 20) should be used for all greater intensities. Also, analysis of the limited soil loss data available for occasional storms with 30-min intensities greater than 2.5 in/h showed that placing a limit of 2.5 in (6.35 cm)/h on the $\mathbf{I}_{30}$ component of **EI** improved prediction accuracy for these storms. Both of these limits were applied in the development of figure 1. They slightly lowered previously computed erosion index values in the Southeast, but average-annual **EI** values for the U.S. mainland other than the Southeast were not significantly affected by the limits because they are rarely exceeded.

Conversion to Metric System

Metric equivalents were not included in the procedures and tables presented in this handbook because direct conversion of each English unit would produce numbers that would be awkward and undesirable. Converting the USLE as a whole is more appropriate. Metric units can then be selected so that each of the interdependent factors will have a metric counterpart whose values will be expressed in numbers that are easy to visualize and to combine in computations.

A convenient unit for measuring cropland soil losses is metric tons per hectare per year. **EI** values of convenient magnitude can be obtained by expressing rainfall energy in metric ton-meters per hectare, expressing intensities in centimeters per hour, and retaining the constant factor of 10^{-2} that has been used consistently for **EI** calculations in English units. Factor **K** will then be in metric tons per hectare per metric **EI** unit. If 22 meters is taken as the basic slope length and 9 percent is retained as the basic slope gradient, the **LS** factor will not be significantly affected. Using these units is recommended and is assumed in the following paragraphs.

The USLE factors will normally be derived directly in these units by procedures outlined below. However, the following conversion factors will facilitate comparisons of the metric factor values with the English values published in this handbook. Factors expressed in the recommended metric units are identified by the subscript, **m**.

Text continues on page 56.

TABLE 17.—*Observed range and 50-, 20-, and 5- percent probability values of erosion index at each of 181 key locations*

Location	Values of erosion index (*EI*)			
	Observed 22-year range	50-percent probability	20-percent probability	5-percent probability
Alabama:				
Birmingham	179-601	354	461	592
Mobile	279-925	673	799	940
Montgomery	164-780	359	482	638
Arkansas:				
Fort Smith	116-818	254	400	614
Little Rock	103-625	308	422	569
Mountain Home	98-441	206	301	432
Texarkana	137-664	325	445	600
California:				
Red Bluff	11-240	54	98	171
San Luis Obispo	5-147	43	70	113
Colorado:				
Akron	8-247	72	129	225
Pueblo	5-291	44	93	189
Springfield	4-246	79	138	233
Connecticut:				
Hartford	65-355	133	188	263
New Haven	66-373	157	222	310
District of Columbia	84-334	183	250	336
Florida:				
Apalachicola	271-944	529	663	820
Jacksonville	283-900	540	693	875
Miami	197-1225	529	784	1136
Georgia:				
Atlanta	116-549	286	377	488
Augusta	148-476	229	308	408
Columbus	215-514	336	400	473
Macon	117-493	282	357	447
Savannah	197-886	412	571	780
Watkinsville[1]	182-544	278	352	441
Illinois:				
Cairo	126-575	231	349	518
Chicago	50-379	140	212	315
Dixon Springs[1]	89-581	225	326	465
Moline	80-369	158	221	303
Rantoul	73-286	152	201	263
Springfield	38-315	154	210	283
Indiana:				
Evansville	104-417	188	263	362
Fort Wayne	60-275	127	183	259
Indianapolis	60-349	166	225	302
South Bend	43-374	137	204	298
Terre Haute	81-413	190	273	389
Iowa:				
Burlington	65-286	162	216	284
Charles City	39-308	140	205	295
Clarinda[1]	75-376	162	220	295
Des Moines	30-319	136	198	284
Dubuque	54-389	175	251	356
Sioux City	56-336	135	205	308
Rockwell City	40-391	137	216	335
Kansas:				
Burlingame	57-447	176	267	398
Coffeyville	66-546	234	339	483
Concordia	38-569	131	241	427
Dodge City	16-421	98	175	303
Goodland	10-166	76	115	171
Hays[1]	66-373	116	182	279
Wichita	42-440	188	292	445
Kentucky:				
Lexington	54-396	178	248	340
Louisville	84-296	168	221	286
Middlesboro	107-301	154	197	248
Louisiana:				
Lake Charles	200-1019	572	786	1063
New Orleans	273-1366	721	1007	1384
Shreveport	143-707	321	445	609
Maine:				
Caribou	26-120	58	79	106
Portland	36-241	91	131	186
Skowhegan	39-149	78	108	148
Maryland:				
Baltimore	50-388	178	263	381
Massachusetts:				
Boston	39-366	99	159	252
Washington	65-229	116	153	198
Michigan:				
Alpena	14-124	57	85	124
Detroit	56-179	100	134	177
East Lansing	35-161	86	121	166
Grand Rapids	33-203	84	123	178
Minnesota:				
Alexandria	33-301	88	147	240
Duluth	7-227	84	127	189
Fosston	22-205	62	108	184
Minneapolis	19-173	94	135	190
Rochester	46-338	142	207	297
Springfield	37-290	96	154	243
Mississippi:				
Meridian	216-820	416	557	737
Oxford	131-570	310	413	543
Vicksburg	165-786	365	493	658
Missouri:				
Columbia	98-419	214	297	406
Kansas City	28-361	170	248	356
McCredie[1]	64-410	189	271	383
Rolla	105-415	209	287	387
Springfield	97-333	199	266	352
St. Joseph	50-359	178	257	366
St. Louis	59-737	168	290	488
Montana:				
Billings	2-82	12	26	50
Great Falls	3-62	13	24	44
Miles City	1-101	21	40	72
Nebraska				
Antioch	18-131	60	86	120
Lincoln	44-289	133	201	299
Lynch	34-217	96	142	205
North Platte	14-236	81	136	224
Scribner	69-312	154	205	269
Valentine	4-169	64	100	153

See footnote at end of table.

TABLE 17.—*Observed range and 50-, 20-, and 5- percent probability values of erosion index at each of 181 key locations*—Continued

Location	Values of erosion index (*EI*)			
	Observed 22-year range	50-percent probability	20-percent probability	5-percent probability
New Hampshire:				
Concord	52-212	91	131	187
New Jersey:				
Atlantic City	71-318	166	229	311
Marlboro[1]	58-331	186	254	343
Trenton	37-382	149	216	308
New Mexico:				
Albuquerque	0-46	10	19	35
Roswell	5-159	41	73	128
New York:				
Albany	40-172	81	114	159
Binghamton	20-151	76	106	146
Buffalo	20-148	66	96	139
Geneva[1]	33-180	73	106	152
Marcellus[1]	24-241	74	112	167
Rochester	22-180	66	101	151
Salamanca	31-202	70	106	157
Syracuse	8-219	83	129	197
North Carolina:				
Asheville	76-238	135	175	223
Charlotte	113-526	229	322	443
Greensboro	102-357	184	244	320
Raleigh	152-569	280	379	506
Wilmington	196-701	358	497	677
North Dakota:				
Bismarck	9-189	43	73	120
Devils Lake	21-171	56	90	142
Fargo	5-213	62	113	200
Williston	4-71	30	45	67
Ohio:				
Cincinnati	66-352	146	211	299
Cleveland	21-186	93	132	185
Columbiana	29-188	96	129	173
Columbus	45-228	113	158	216
Coshocton[1]	72-426	158	235	343
Dayton	56-245	125	175	240
Toledo	32-189	83	120	170
Oklahoma:				
Ardmore	100-678	263	395	582
Cherokee[1]	49-320	167	242	345
Guthrie[1]	69-441	210	316	467
McAlester	105-741	272	411	609
Tulsa	19-584	247	347	478
Oregon:				
Pendleton	2-28	4	8	16
Portland	16-80	40	56	77
Pennsylvania:				
Erie	11-534	96	181	331
Franklin	50-228	97	135	184
Harrisburg	48-232	105	146	199
Philadelphia	72-361	156	210	282
See footnote at end of table.				
Pittsburgh	43-201	111	148	194
Reading	84-308	144	204	285
Scranton	52-198	104	140	188
Puerto Rico:				
San Juan	203-577	345	445	565
Rhode Island:				
Providence	53-225	119	167	232
South Carolina:				
Charleston	174-1037	387	559	795
Clemson[1]	138-624	280	384	519
Columbia	81-461	213	298	410
Greenville	130-589	249	350	487
South Dakota:				
Aberdeen	19-295	74	129	219
Huron	18-145	60	91	136
Isabel	16-141	48	78	125
Rapid City	10-140	37	64	108
Tennessee:				
Chattanooga	163-468	269	348	445
Knoxville	64-370	173	239	325
Memphis	139-595	272	384	536
Nashville	116-381	198	262	339
Texas:				
Abilene	27-554	146	253	427
Amarillo	33-340	110	184	299
Austin	59-669	270	414	624
Brownsville	46-552	267	386	549
Corpus Christi	124-559	237	330	451
Dallas	93-630	263	396	586
Del Rio	19-405	121	216	374
El Paso	4-85	18	36	67
Houston	176-1171	444	674	1003
Lubbock	17-415	82	158	295
Midland	35-260	82	139	228
Nacogdoches	153-769	401	571	801
San Antonio	77-635	220	353	556
Temple[1]	81-644	261	379	542
Victoria	108-609	265	385	551
Wichita Falls	79-558	196	298	447
Vermont:				
Burlington	33-270	72	114	178
Virginia:				
Blacksburg[1]	81-245	126	168	221
Lynchburg	64-366	164	232	324
Richmond	102-373	208	275	361
Roanoke	78-283	129	176	237
Washington:				
Pullman[1]	1-30	6	12	21
Spokane	1-19	7	11	17
West Virginia:				
Elkins	43-223	118	158	209
Huntington	56-228	127	173	233
Parkersburg	69-303	120	165	226
Wisconsin:				
Green Bay	17-148	77	107	147
LaCrosse[1]	61-385	153	228	331
Madison	38-251	118	171	245
Milwaukee	31-193	93	139	202
Rice Lake	24-334	122	202	327
Wyoming:				
Casper	1-24	9	15	26
Cheyenne	8-66	28	43	66

[1] Computations based on SEA rainfall records. All others are based on Weather Bureau records.

TABLE 18.—*Expected magnitudes of single-storm erosion index values*

Location	Index values normally exceeded once in—				
	year 1	years 2	years 5	years 10	years 20
Alabama:					
Birmingham	54	77	110	140	170
Mobile	97	122	151	172	194
Montgomery	62	86	118	145	172
Arkansas:					
Fort Smith	43	65	101	132	167
Little Rock	41	69	115	158	211
Mountain Home	33	46	68	87	105
Texarkana	51	73	105	132	163
California:					
Red Bluff	13	21	36	49	65
San Luis Obispo	11	15	22	28	34
Colorado:					
Akron	22	36	63	87	118
Pueblo	17	31	60	88	127
Springfield	31	51	84	112	152
Connecticut:					
Hartford	23	33	50	64	79
New Haven	31	47	73	96	122
District of Columbia	39	57	86	108	136
Florida:					
Apalachicola	87	124	180	224	272
Jacksonville	92	123	166	201	236
Miami	93	134	200	253	308
Georgia:					
Atlanta	49	67	92	112	134
Augusta	34	50	74	94	118
Columbus	61	81	108	131	152
Macon	53	72	99	122	146
Savannah	82	128	203	272	358
Watkinsville	52	71	98	120	142
Illinois:					
Cairo	39	63	101	135	173
Chicago	33	49	77	101	129
Dixon Springs	39	56	82	105	130
Moline	39	50	89	116	145
Rantoul	27	39	56	69	82
Springfield	36	52	75	94	117
Indiana:					
Evansville	26	38	56	71	86
Fort Wayne	24	33	45	56	65
Indianapolis	29	41	60	75	90
South Bend	26	41	65	86	111
Terre Haute	42	57	78	96	113
Iowa:					
Burlington	37	48	62	72	81
Charles City	33	47	68	85	103
Clarinda	35	48	66	79	94
Des Moines	31	45	67	86	105
Dubuque	43	63	91	114	140
Rockwell City	31	49	76	101	129
Sioux City	40	58	84	105	131
Kansas:					
Burlingame	37	51	69	83	100
Coffeyville	47	69	101	128	159
Concordia	33	53	86	116	154
Dodge City	31	47	76	97	124
Goodland	26	37	53	67	80
Hays	35	51	76	97	121
Wichita	41	61	93	121	150
Kentucky:					
Lexington	28	46	80	114	151
Louisville	31	43	59	72	85
Middlesboro	28	38	52	63	73
Louisiana:					
New Orleans	104	149	214	270	330
Shreveport	55	73	99	121	141
Maine:					
Caribou	14	20	28	36	44
Portland	16	27	48	66	88
Skowhegan	18	27	40	51	63
Maryland:					
Baltimore	41	59	86	109	133
Massachusetts:					
Boston	17	27	43	57	73
Washington	29	35	41	45	50
Michigan:					
Alpena	14	21	32	41	50
Detroit	21	31	45	56	68
East Lansing	19	26	36	43	51
Grand Rapids	24	28	34	38	42
Minnesota:					
Duluth	21	34	53	72	93
Fosston	17	26	39	51	63
Minneapolis	25	35	51	65	78
Rochester	41	58	85	105	129
Springfield	24	37	60	80	102
Mississippi:					
Meridian	69	92	125	151	176
Oxford	48	64	86	103	120
Vicksburg	57	78	111	136	161
Missouri:					
Columbia	43	58	77	93	107
Kansas City	30	43	63	78	93
McCredie	35	55	89	117	151
Rolla	43	63	91	115	140
Springfield	37	51	70	87	102
St. Joseph	45	62	86	106	126
Montana:					
Great Falls	4	8	14	20	26
Miles City	7	12	21	29	38
Nebraska:					
Antioch	19	26	36	45	52
Lincoln	36	51	74	92	112
Lynch	26	37	54	67	82
North Platte	25	38	59	78	99
Scribner	38	53	76	96	116
Valentine	18	28	45	61	77

TABLE 18.—*Expected magnitudes of single-storm erosion index values*—Continued

Location	Index values normally exceeded once in—				
	year 1	years 2	years 5	years 10	years 20
New Hampshire:					
Concord	18	27	45	62	79
New Jersey:					
Atlantic City	39	55	77	97	117
Marlboro	39	57	85	111	136
Trenton	29	48	76	102	131
New Mexico:					
Albuquerque	4	6	11	15	21
Roswell	10	21	34	45	53
New York:					
Albany	18	26	38	47	56
Binghamton	16	24	36	47	58
Buffalo	15	23	36	49	61
Marcellus	16	24	38	49	62
Rochester	13	22	38	54	75
Salamanca	15	21	32	40	49
Syracuse	15	24	38	51	65
North Carolina:					
Asheville	28	40	58	72	87
Charlottte	41	63	100	131	164
Greensboro	37	51	74	92	113
Raleigh	53	77	110	137	168
Wilmington	59	87	129	167	206
North Dakota:					
Devils Lake	19	27	39	49	59
Fargo	20	31	54	77	103
Williston	11	16	25	33	41
Ohio:					
Cincinnati	27	36	48	59	69
Cleveland	22	35	53	71	86
Columbiana	20	26	35	41	48
Columbus	27	40	60	77	94
Coshocton	27	45	77	108	143
Dayton	21	30	44	57	70
Toledo	16	26	42	57	74
Oklahoma:					
Ardmore	46	71	107	141	179
Cherokee	44	59	80	97	113
Guthrie	47	70	105	134	163
McAlester	54	82	127	165	209
Tulsa	47	69	100	127	154
Oregon:					
Portland	6	9	13	15	18
Pennsylvania:					
Franklin	17	24	35	45	54
Harrisburg	19	25	35	43	51
Philadelphia	28	39	55	69	81
Pittsburgh	23	32	45	57	67
Reading	28	39	55	68	81
Scranton	23	32	44	53	63
Puerto Rico:					
San Juan	57	87	131	169	216
Rhode Island:					
Providence	23	34	52	68	83
South Carolina:					
Charleston	74	106	154	196	240
Clemson	51	73	106	133	163
Columbia	41	59	85	106	132
Greenville	44	65	96	124	153
South Dakota:					
Aberdeen	23	35	55	73	92
Huron	19	27	40	50	61
Isabel	15	24	38	52	67
Rapid City	12	20	34	48	64
Tennessee:					
Chattanooga	34	49	72	93	114
Knoxville	25	41	68	93	122
Memphis	43	55	70	82	91
Nashville	35	49	68	83	99
Texas:					
Abilene	31	49	79	103	138
Amarillo	27	47	80	112	150
Austin	51	80	125	169	218
Brownsville	73	113	181	245	312
Corpus Christi	57	79	114	146	171
Dallas	53	82	126	166	213
Del Rio	44	67	108	144	182
El Paso	6	9	15	19	24
Houston	82	127	208	275	359
Lubbock	17	29	53	77	103
Midland	23	35	52	69	85
Nacogdoches	77	103	138	164	194
San Antonio	57	82	122	155	193
Temple	53	78	123	162	206
Victoria	59	83	116	146	178
Wichita Falls	47	63	86	106	123
Vermont:					
Burlington	15	22	35	47	58
Virginia:					
Blacksburg	23	31	41	48	56
Lynchburg	31	45	66	83	103
Richmond	46	63	86	102	125
Roanoke	23	33	48	61	73
Washington:					
Spokane	3	4	7	8	11
West Virginia:					
Elkins	23	31	42	51	60
Huntington	18	29	49	69	89
Parkersburg	20	31	46	61	76
Wisconsin:					
Green Bay	18	26	38	49	59
LaCrosse	46	67	99	125	154
Madison	29	42	61	77	95
Milwaukee	25	35	50	62	74
Rice Lake	29	45	70	92	119
Wyoming:					
Casper	4	7	9	11	14
Cheyenne	9	14	21	27	34

Note: These conversions are incorrect. Refer to the supplement for corrections.

$$\begin{aligned} 1 \text{ t/ha} &= 2.242 \text{ tons per acre} \\ 1 \text{ t-m/ha/cm} &= 0.269 \text{ ft-tons per acre per inch} \\ 1\ E_m &= 0.683\ E \\ 1\ I_{30m} &= 2.54\ I_{30} \\ 1\ (EI)_m &= 1.735\ EI \\ 1\ K_m &= 1.292\ K \end{aligned} \tag{7}$$

Factor R. The procedure for computing $(\mathbf{EI})_m$ for a given rain period is similar to that described in the preceding section for computation of **EI**, but the input data will be in different units. If the rain gage chart used for the preceding example had been calibrated in millimeters, the computation would have been as follows:

Chart readings		Storm increments			Energy	
Time	Depth (mm)	Duration (min)	Amount (cm)	Intensity (cm/h)	Per cm	For increment
4:00	0					
:20	1.2	20	0.12	0.36	175	21
:27	3.0	7	.18	1.54	226	41
:36	8.8	9	.58	3.87	263	153
:50	26.6	14	1.78	7.68	289	514
:57	30.4	7	.38	3.26	256	97
5:05	31.7	8	.13	.98	220	29
:15	31.7	10	0	0	0	0
:30	33.0	15	.13	.52	184	24
Totals		90	3.30			879

Kinetic energy of the storm = $879(10^{-2}) = 8.79$

TABLE 19.—*Kinetic energy of rainfall expressed in foot-tons per acre per inch of rain*[1]

Intensity inch per hour	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0	—	254	354	412	453	485	512	534	553	570
0.1	585	599	611	623	633	643	653	661	669	677
.2	685	692	698	705	711	717	722	728	733	738
.3	743	748	752	757	761	765	769	773	777	781
.4	784	788	791	795	798	801	804	807	810	814
.5	816	819	822	825	827	830	833	835	838	840
.6	843	845	847	850	852	854	856	858	861	863
.7	865	867	869	871	873	875	877	878	880	882
.8	884	886	887	889	891	893	894	896	898	899
.9	901	902	904	906	907	909	910	912	913	915
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1	916	930	942	954	964	974	984	992	1000	1008
2	1016	1023	1029	1036	1042	1048	1053	1059	1064	1069
3	[2]1074									

[1] Computed by the equation, $E = 916 + 331 \log_{10} I$, where E = kinetic energy in foot-tons per acre per inch of rain, and I = rainfall intensity in inches per hour.

[2] The 1074 value also applies for all intensities greater than 3 in/h (see text).

TABLE 20.—*Kinetic energy of rainfall expressed in metric ton-meters per hectare per centimeter of rain*[1]

Intensity cm/h	.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0 ..	0	121	148	163	175	184	191	197	202	206
1 ..	210	214	217	220	223	226	228	231	233	235
2 ..	237	239	241	242	244	246	247	249	250	251
3 ..	253	254	255	256	258	259	260	261	262	263
4 ..	264	265	266	267	268	268	269	270	271	272
5 ..	273	273	274	275	275	276	277	278	278	279
6 ..	280	280	281	281	282	283	283	284	284	285
7 ..	286	286	287	287	288	288	[2]289			

[1] Computed by the equation $E = 210 + 89 \log_{10} I$,
where E = kinetic energy in metric-ton meters per hectare per centimeter of rain, and
I = rainfall intensity in centimeters per hour.

[2] The 289 value also applies for all intensities greater than 7.6 cm/h.

Values for column 6 are obtained by entering table 20 with the intensities listed in column 5, and their sum, 879, is the kinetic energy ($\mathbf{E}_m$) of the 3.30 cm of rain expressed in metric ton-meters per hectare. The constant factor of 10^{-2} used for the English system should be applied here also so that storm $(\mathbf{EI})_m$ values will usually not exceed 100. The maximum amount of rain in any 30-minute period was 2.74 cm, from 4:27 to 4:57. Therefore $\mathbf{I}_{30m} = 2(2.74 = 5.48$ cm/h. $(\mathbf{EI})_m = 8.79(5.48) = 48.17$

The procedure for combining storm **EI** values for local erosion index values was fully described in the preceding section. For predicting average annual soil losses from rainfall and its associated runoff, **R** equals the erosion index. Where runoff from thaw, snowmelt, or irrigation is significant, an $\mathbf{R}_s$ factor must be added to the **EI** value as previously discussed.

Where adequate rainfall intensity data are not available, the erosion index cannot be estimated solely from annual precipitation data. It is a function of the sizes and intensities of the individual rainstorms, and these are not closely related to annual precipitation. Therefore a given annual rainfall will indicate only a broad range of possible values of the local erosion index. However, the United States data indicate that the range of likely values can be somewhat narrowed by knowledge of the general climatic conditions in the particular geographic area.

In the U.S. Northern and Northeastern States, the winter precipitation generally comes as snow and low-intensity rains, but erosive intensities occur during the spring and summer. There, the local erosion index values, $(\mathbf{EI})_m$, have ranged from 2P-52 to 2.6**P**, where **P** is the average annual precipitation expressed in centimeters. In several Northwestern States, where rain intensities rarely exceed 2.5 cm/h, the annual $(\mathbf{EI})_m$ is generally less than **P**, but $\mathbf{R}_s$ values are high. Near the Gulf of Mexico and along the southern half of the Atlantic Coast, the rainfall characteristics are substantially influenced by coastal storms, 24-h rainfall exceeds 10 cm at least once in 2 years, on the average, and erosive rains occur in nearly every month of the year. There, erosion index values range between 4.2**P** and 6.7**P**. Values computed from the few long-term, recording-raingage records available for the islands of Hawaii and Puerto Rico were also within this range. In the large region between the northern and southern extremes mentioned above, the annual $(\mathbf{EI})_m$ values range from 2.5**P** to 4.5**P**. Brief, high-intensity thunderstorms are common in this region during the summer months, but general rains of longer duration also occur.

Where data are adequate to determine 2-year probabilities of 6-hour rainfall, these probabilities may provide more specific estimates of the local erosion index values. In the U.S. data, local erosion index values were approximately equal to the quantity 27.38 $\mathbf{P}^{2.17}$, where $\mathbf{P} =$ the 2-year, 6-hour precipitation in inches. Converted to the recommended metric units, $(\mathbf{EI})_m$ equals approximately 6.28$\mathbf{P}^{2.17}$, where **P** is expressed in centimeters. However, this estimating procedure should not be substituted for the standard erosion index calculation procedure where adequate intensity data are available.

Factor K. This factor is the average soil loss in metric tons per hectare per unit of $(\mathbf{EI})_m$, measured on unit plots of the given soil. A unit plot is a 22-m length of uniform 9 percent slope that has been in clean fallow for more than 2 years and is tilled to prevent vegetative growth and surface crusting during the period of soil loss measurement. If a gradient other than 9 percent must be used, the data are adjusted by an **LS** factor available from figure 11. If the soil-erodibility nomograph (fig. 3) is used to evaluate $\mathbf{K}_m$, the **K** value read from the nomograph is multiplied by a conversion factor of 1.292.

The most accurate direct measurement of **K** for a given soil is obtained by measuring soil losses from unit plots under natural rain for at least 5 years, beginning 2 years after the clean-fallow condition was established. This permits averaging the interactions of soil erodibility with antecedent soil moisture, storm size, and other randomly distributed variables. The fallow plots receive the same annual tillage as conventionally tilled row crops.

Using rainfall simulators to evaluate **K** is quicker and less costly, but it requires caution. A one-time simulator test, even though replicated on several plots, measures soil loss from only one storm size and rain intensity, on one set of antecedent conditions, and these may or may not represent natural rainfall patterns. When simulated rainfall is used to evaluate **K**, measuring the soil losses for four or five successive 30-minute periods is helpful so that the segmented data can be rearranged to represent small, intermediate, and large storms beginning at various antecedent soil moisture levels. These can be weighted according to their probability of occurrence in natural rainfall (*58*).

Factor LS. Selecting 22 m as the basic slope length and retaining 9 percent as the basic slope gradient leaves the **LS** values essentially unchanged from those used in the English system of units. For uniform slopes, **LS** may be obtained by entering figure 11 with the field slope length expressed in meters. For concave or convex slopes, the value read from figure 11 should be modified by the procedure given in the subsection **Irregular Slopes.**

Factors C and P. Soil loss ratios (table 5) and **P** values (tables 13, 14, 15) are not affected by the units selected for the other factors. However, in countries where crops and farming techniques are different from those reflected in table 5, measurements of soil loss reductions attainable with feasible changes in crop system, tillage methods, and residue management may merit priority over establishing **EI** and **K** values.

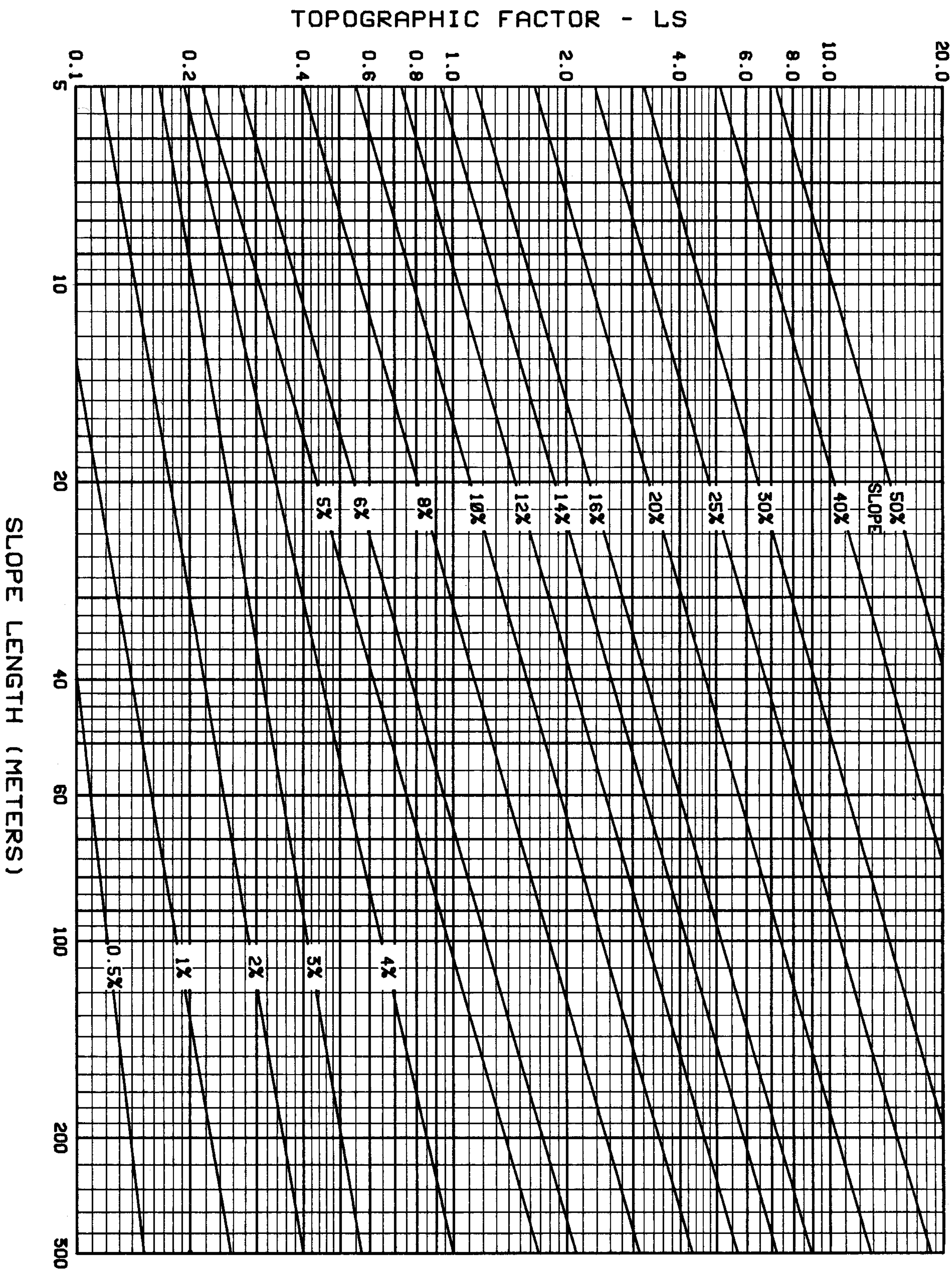

FIGURE 11.—Slope-effect chart for metric system.

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*note: **ERRATA** Jan. 1981

The following corrections and minor additions should be made with pen and ink in existing desk copies of AH-537. Corrected words or numbers have been identified by underlining. Additional footnotes that were added to clarify original content can be inserted in the lower margins of the indicated pages.

Page

4 Insert footnote symbol [4] after the definitions of **R** and **K** in column 1 and add footnote:

[4] The erosion index values in figures 1 and 2 and the EI values used in the text have the dimension 100 (foot-ton inch)/(acre hour). K values in tables 1 and 2 and figure 3 are in tons per acre per EI unit and have the dimensions 0.01 (ton acre hour)/(acre foot-ton inch).

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5 Equation (2) $e = 916 + 331 \log_{10} i$,

where e is kinetic energy in foot-tons per acre-inch and i is intensity in in/h (62). A limit of 3 in/h is imposed on i . . .

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9 column 2. Change footnote number from [4] to [5].

---

18 column 1. Change footnote number from [5] to [6].

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19 column 1, last sentence. Insert footnote symbol [7] after "The expected effects of mulch and canopy combinations" and add footnote in lower margin:

[7] Figures 6 and 7 and table 5 assume that slope-length limits for full effectiveness of residue mulches at the stated rates are not exceeded. Beyond these limits, the subfactor for mulch effect approaches 1.0. The length limits vary inversely with mulch rate, runoff depth and velocity, but have not been precisely defined by research.

FIGURE 6 and 7. Change the ordinate labels from "SOIL-LOSS RATIO" to SUBFACTOR FOR EFFECT OF COVER.

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23 TABLE 5, line 160. Change 50 percent to 10 percent and reduce the ratio for cropstage 1 from 56 to 28.

---

24 Add to footnote [4]: *See also* footnote [7], page 19.

Change footnote 13 to: Divide the winter-cover period into cropstages for the seeded cover and use lines 132-145.

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32 TABLE 10. Corrected title: *Factor* **C** *for permanent pasture, range, idle land, or grazed woodland*[1]

Change second category of vegetative canopy to: Tall grass, weeds or bushes with average drop fall height of less than 3 ft.[5]

Footnote [1]: The listed C values assume that the vegetation and mulch are randomly distributed over the entire area.

For grazed woodland with high buildup of organic matter in the topsoil under permanent forest conditions, multiply the table values by 0.7.

For areas that have been mechanically disturbed by root plowing, implement traffic or other means, use table 5 or 12.

Footnote [4], G: cover at surface is grass, grasslike plants, or decaying compacted duff. (Delete "or litter at least 2 in deep")

Add footnote [5]: [5] The portion of a grass or weed cover that contacts the soil surface during a rainstorm and interferes with water flow over the soil surface is included in "cover at the surface." The remainder is included in canopy cover. Use table 5-B for nearly complete grass covers.

TABLE 11. 33

Second column heading: Delete "at least 2 in deep."

Footnote [1]: The references to table 6 should be to table 10, and the following may be added: For sites that are mechanically treated following harvest, use table 12.

TABLE 12, footnotes [4] and [5]. The references to tables 6 and 7 should be to tables 10 and 11, respectively. 34

TABLE 13, footnote [1]. Change the word "seedlings" to plantings. 35

TABLE 14, footnote [1]. C For alternate strips of row crop and winter grain. 36

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column 2, line 6. 0.5 should be 0.05 in of precipitation . . . 51

centered heading. Insert footnote symbol [8] after **Conversion to Metric System** and add footnote in lower margin:

[8] See supplement for a recommended metrication of the USLE in the International System of Units (SI), which may be substituted for this section.

TABLES 19 and 20, footnotes. Change E to e and I to i in the energy equations. 56

Below the footnotes for table 20, insert the note: The table values multiplied by 9.81 would equal kilojoules of energy in the SI system.

UNITED STATES DEPARTMENT OF AGRICULTURE

AGRICULTURE HANDBOOK NUMBER 537

PREPARED BY SCIENCE AND EDUCATION ADMINISTRATION

Washington, D.C.

PREDICTING RAINFALL EROSION LOSSES—
A GUIDE TO CONSERVATION PLANNING

(Co/42.)

U.S.D.A.

Supplement to Agriculture Handbook No. 537

METRICATION OF THE USLE IN THE INTERNATIONAL SYSTEM OF UNITS (SI)

The metric conversion originally presented in this handbook and in prior publications (*53, 60*) is not completely in the International System of Units (SI), which is expected to gain widespread usage. This supplement presents an alternative conversion in which all the Universal Soil Loss Equation (USLE) factors are expressed in standard SI units or approved multiples thereof, and the order of magnitude of each new unit is similar to the old.

Both conversion systems are authentic, and conservationists who have adopted the originally recommended metric units would not improve their USLE accuracy by changing to the new units. For future conversions, however, the revised procedure, which is fully outlined below, is recommended because its use will facilitate standardization of units.

The USLE terms **A**, **LS**, **C**, and **P** need no change from the recommendations in the preceding section. Strictly, the **SI** units for mass and area are kilograms and square meters. Because of common use, however, metric ton (a special name for megagram) and hectare (a special name for square hectometer) will be used. Soil loss (**A**) wil be expressed in metric tons per hectare, and factor **K** in metric tons per hectare per metric **EI** unit. Factors **LS**, **C**, and **P** are dimensionless. **L** is expressed relative to slope lengths measured in meters, but selecting 22 m as the basic slope length and retaining 9 percent as the basic slope gradient leaves the **LS** values essentially unchanged. **C** and **P** are not affected by the units selected for the other factors.

Factor **R** will be in different units than previously recommended. In the **SI** system, energy is measured in joules and rainfall in millimeters. The use of "centi" as a multiple is minimized. Metric **EI** values can be obtained in standard **SI** units by expressing rainfall energy in megajoules (**MJ**) per hectare and maximum 30-minute intensity (I_{30}) in mm/h, but use of cm/h to express I_{30} is more expedient for the following reasons: With I_{30} expressed in mm/h, the metric **EI** values would be 17 times the magnitude of **EI** in U.S. customary units. Annual erosion index values would be in four- or five-digit numbers, which are harder to visualize and compare mentally than the present smaller numbers. Of greater importance, the large metric **EI** values would result in extremely small metric **K** values, ranging downward from a maximum of about 0.09. Absolute differences between **K** values would be so small that many casual users of the USLE would tend to neglect important soil differences as insignificant.

Reducing the magnitude of I_{30} by a factor of 10 alleviates these disadvantages and does not preclude the use of mm as the unit for rainfall amounts and incremental intensities in energy computations. The energy equation or table will also be expressed in MJ/ha per mm of rain. Only I_{30} will be converted to cm as a matter of expedience. This is directly comparable to the U.S. customary procedure of computing energy in ft-tons/acre and dividing by 100 to obtain more convenient magnitudes. The metric **EI** will then equal storm energy in MJ/ha times I_{30} in cm/h.

Assuming use of the metric units specified above, a comparison of U.S. customary and **SI** dimensions for the terms in the USLE is as follows:

Term	*US customary dimensions*	*SI dimensions*	*Symbol*
A	ton/acre	metric ton/hectare	t/ha
R	$\frac{\text{100 foot-ton inch}}{\text{acre hour}}$	$\frac{\text{megajoule centimeter}}{\text{hectare hour}}$	$\frac{\text{MJ cm}}{\text{ha h}}$
K	$\frac{\text{.01 ton acre hour}}{\text{acre foot-ton inch}}$	$\frac{\text{metric ton hectare hour}}{\text{hectare megajoule centimeter}}$	$\frac{\text{t ha h}}{\text{ha MJ cm}}$
L,S,C,P	dimensionless	dimensionless	

The USLE terms will usually be derived directly in the **SI** units by procedures outlined below. However, the following conversion factors will facilitate comparisons of the metric factor values with the U.S. customary values published in this handbook. Terms expressed in metric units are identified by the subscript $_m$.

To convert from:	*multiply by:*	*to obtain:*
A in tons/acre	2.242	A_m in t/ha
E in 100 ft-tons/acre	0.670	E_m in MJ/ha
I_{30} in in/h	2.540	I_{30m} in cm/h
EI in $\frac{\text{100 ft-ton in}}{\text{acre h}}$	1.702	$(EI)_m$ in $\frac{\text{MJ cm}}{\text{ha h}}$
K in $\frac{\text{.01 ton acre h}}{\text{acre ft-ton in}}$	1.313	K_m in $\frac{\text{t ha h}}{\text{MJ ha cm}}$

page 56 revised

Factor R. The procedure for computing $(EI)_m$ for a given rain period is similar to that described in the preceding section for computing **EI**, but the input data will be in different units. If the raingage chart used for the example on page 51 had been calibrated in millimeters, the computation would have been as follows:

Chart readings		*Storm increments*			*Energy*	
Time	Depth (mm)	Duration (min)	Amount (mm)	Intensity (mm/h)	Per mm of rain (MJ/ha mm)	Increment total (MJ/ha)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
4:00	0					
:20	1	20	1	3	0.161	0.161
:27	3	7	2	17	.226	.452
:36	9	9	6	40	.259	1.554
:50	27	14	18	77	.283	5.094
:57	30	7	3	26	.242	.726
5:05	32	8	2	15	.222	.444
:15	32	10	0	0	0	0
:30	33	15	1	4	.172	.172
Totals		90	33			8.603

Kinetic energy of the storm: 8.60 MJ/ha

Values for column 6 are obtained by entering the revised table 20 with the intensities listed in column 5. The sum of the products of corresponding values from columns 4 and 6 (8.60) is the kinetic energy, E_m, of the 33 mm of rain expressed in megajoules per hectare. The maximum amount of rain in any 30-minute period was 27 mm, from 4:27 to 4:57. Therefore the maximum 30-minute intensity was 2×27, or 54, mm/h, and $I_{30m} = 54/10 = 5.4$ cm/h. $(EI)_m = 8.60 \times 5.4 = 46.4$ (MJ cm)/(ha h).

For the **EI** computations, the rain occurring between two successive periods of 6 hours or more with less than 1.3 mm (0.05 in) of precipitation is considered one storm. Rain showers of less than 12 mm are omitted as insignificant unless they include a 15-minute intensity of at least 25 mm/h. The erosion index at a given location, as mapped in figures 1 and 2, is the average annual total of storm **EI** values over 20 to 25 years. For predicting average annual soil losses from rainfall and its associated runoff, **R** equals the erosion index. Where runoff from thaw, snowmelt, or irrigation is significant, **R** equals the **EI** plus an R_s value as discussed on page 7.

The erosion index cannot be reliably estimated from annual-rainfall data alone. It is a function of the sizes and intensities of the individual rainstorms, and these have no common relationship to annual rainfall totals. However, later analyses of the U.S. annual erosion index values that had been derived by the above procedure indicated that they were roughly equal to the quantity $27.38\ P^{2.17}$, where P = the 2-year, 6-hour rainfall expressed in inches. By direct conversion, the average annual $(EI)_m$ would be roughly estimated by $0.0416\ P^{2.17}$, where **P** is expressed in mm. This estimating formula is appreciably less accurate than the standard erosion index calculation procedure and should not be substituted for it where intensity data are available.

Factor K. The soil-erodibility factor K is the average soil loss in metric tons per hectare per unit of metric **EI**, measured on unit plots of the given soil. A unit plot (see p. 8) is a 22-m length of uniform 9 percent slope that has been in clean fallow for more than 2 years and is tilled to prevent vegetative growth and surface crusting during the period of soil loss measurement. If a gradient other than 9 percent must be used, the data are adjusted by the appropriate **LS** factor. If the soil-erodibility nomograph (fig. 3) is used to evaluate K_m, the K value read from the nomograph must be multiplied by a conversion factor of 1.313.

The basic slope length used for K and **L** in this handbook is 72.6 ft, which equals 22.134 m. For experimental evaluation of factor **K** in metric units, rounding this to 22.0 m is more convenient and introduces no error when 22.0 m is also used as the basic length for **L**, as in figure 11. The slight reduction in basic length increases factor **L** by 0.3 of 1 percent and decreases factor **K** by the same percentage, so the product of **K** and **L** is unchanged. For conversion of the U.S. customary K values in this handbook to metric K values based on a 22.0 m length, the relatively insignificant potential error is avoided by including an **L**-value of 0.997 in the conversion factor. The **K**-conversion factor of 1.313 given above has been so adjusted.

Factor LS. The preceding paragraph applies here, also. For uniform slopes, **LS** may be obtained by entering figure 11 with the field slope length expressed in meters or it may be computed by the equation

$$LS = (\lambda/22)^m\ (65.41\ \sin^2\theta + 4.56\ \sin\theta + 0.065)$$

where λ = slope length in m; θ = angle of slope; and m = 0.5 if the percent slope is 5 or more, 0.4 on slopes of 3.5 to 4.5 percent, 0.3 on slopes of 1 to 3 percent, and 0.2 on uniform gradients of less than 1 percent. For concave, convex, or mixed-gradient slopes, the value so computed or read from figure 11 should be modified by the procedure outlined on page 16.

Factor C and P. Soil loss ratios (table 5) and **P** values (tables 13, 14, 15) are not affected by the units selected for the other factors and therefore need no conversion.

TABLE 20. (revised).—*Kinetic energy of rainfall at specified intensities, expressed in megajoules per hectare per millimeter of rain*[1]

Intensity (mm/h)	0	1	2	3	4	5	6	7	8	9
0 ..	0	0.119	0.145	0.161	0.172	0.180	0.187	0.193	0.198	0.202
10 ..	.206	.210	.213	.216	.219	.222	.224	.226	.229	.231
20 ..	.233	.234	.236	.238	.240	.241	.242	.244	.245	.247
30 ..	.248	.249	.250	.252	.253	.254	.255	.256	.257	.258
40 ..	.259	.260	.261	.262	.262	.263	.264	.265	.266	.267
50 ..	.267	.268	.269	.270	.270	.271	.272	.272	.273	.274
60 ..	.274	.275	.276	.276	.277	.277	.278	.278	.279	.280
70 ..	.280	.281	.281	.282	.282	.283	.283[2]			

[1] Computed by the equation $e = 0.119 - 0.0873 \log_{10} i$, where e = kinetic energy in megajoules/(hectare millimeter) and i = rainfall intensity in mm/h.

[2] The value of 0.283 also applies for all intensities greater than 76 mm/h.

ESTIMATING FACTOR C FOR AN UNUSUAL CONDITION OR CROP THAT IS NOT LISTED IN TABLES 5 through 5-D of Ag. Handbook No. 537.

W. H. Wischmeier, 11-13-79

Soil-loss ratios can sometimes be closely estimated by comparing characteristic conditions in each cropstage period with conditions associated with a crop and management that is listed in the table. The cropstage ratios may need to be selected from several lines rather than following one line across the table.

Another possible procedure is to multiply-together a number of subfactor values obtained from field observations, guided by the following information.

Benchmark values throughout table 5 were obtained from direct soil-loss measurements under conditions involving various combinations of the subfactors. However, study of the ratios obtained by this method suggested a number of underlying subfactor relationships that can help guide estimation of appropriate ratios for untested conditions or crops. Before using this procedure, please read carefully the background material on pages 18-21 of AH-537.

For each cropstage period, estimate the percentage of surface cover by canopy and the percentage of cover by mulch, using the definitions given on pages 18 & 19 and evaluating the two separately. Include expected volunteer vegetation in the estimates of cover if significant. Then, use the following guides to estimate a subfactor value for each of the listed sub-parameters:

1. Canopy without mulch. Enter Fig. 5 with percent canopy cover, move vertically to drop fall height, and read the subfactor value at the left.

2. Mulch without canopy. Enter Fig. 6 with the percent cover by mulch, move vertically to the line for zero percent canopy (upper curve), and read subfactor value at left.

3. Combination of canopy and mulch. Use the other curves of Fig. 6 or 7, interpolating between the lines.

4. Land-use residual. The greatest residual effect is from sod crops or longterm woodland. Obtain residual sod-effect subfactor from table 5-D. Virgin sod or woodland would be even more effective.

Some residual effect will be apparent on nearly any cropland. For continuous corn with residues removed annually before turnplowing, the residual factor seems to be about 0.82 to 0.86, depending on productivity level. (These are the values given for the SB period in lines 13-16 of table 5.) This is a good starting point from which to move with judgment. This subfactor is in addition to subfactors for residues incorporated or sod-effect when those are also applicable.

(continued, p.2)

5. Residues plowed-down annually by inversion plowing. Credit for this may be approximated by multiplying the number of tons of residue per acre plowed down annually by: 0.12 for periods F, SB and 1; by 0.09 for period 2; and by 0.06 for periods 3 and 4. The residue-incorporated subfactor is 1.0 minus this amount.

6. Residues incorporated in the upper few inches of soil by shallow non-inversion tillage. Estimate effect by multiplying tons of residue so incorporated annually by: 0.20 for periods SB and 1; 0.16 for period 2; 0.12 for period 3; and 0.06 for period 4. Subtract product from 1.0 to obtain subfactor.

7. Random surface roughness. The condition left by inversion plowing and several diskings (with residues removed) has a roughness factor of 1.0. Freshly plowed land would rate a roughness subfactor of from 0.8 to 0.5, depending on amount of residue, soil-moisture at time of plowing, and other conditions. Chiseled or disked land would fall between these extremes.

In all cases, the subfactor becomes larger for each successive cropstage period because of rainfall and tillage effects. It reaches a value of 1.0 no later than the end of cropstage 3 and in some cases appreciably sooner.

8. Detachability. Soil that receives no tillage or traffic gradually becomes less detachable by rainfall. No-till systems with crop residues on the surface seem to merit a detachability subfactor of about 0.7. This is in addition to the mulch factor and may vary with soil texture.

9. Orientation of residues. The mulch-effect curves of figures 6 and 7 are based on fairly uniform, random distribution of the mulch over the field. When residues are concentrated in strips by the harvester, the percent-cover is reduced. However, when the strips are across the slope, they are more effective than the reduced percent-cover would indicate. When the strips are across-slope, they can probably be evaluated as equivalent to the percent cover that they would have provided if they had been fairly uniformly distributed. See figure 10, page 50. However, this does not apply if the strips are up and down slope.

10. High population of close-growing stems (like wheat). More effective than canopy from spreading plants like corn or bushes.

When these guides have been used to estimate the listed subfactors for each cropstage period, the subfactors are multiplied together to compute the soil-loss ratios.

This procedure should not be used for conditions covered by table 5 and its supplements. The relationships given above are only approximate and will provide less accuracy than direct measurements such as used to develop the table.

Slope-length limits for effectiveness of moderate mulch rates and random roughness are of course also applicable with this procedure.

EXHIBIT 4

DEPARTMENT OF ENVIRONMENTAL QUALITY

OFFICE OF WASTE MANAGEMENT AND RADIOLOGICAL PROTECTION

SOLID WASTE MANAGEMENT

(By authority conferred on the director of the department of environmental quality by sections 11538, 11539, and 11540 of Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, MCL 324.11538 to 324.11540)

PART 1. GENERAL PROVISIONS

R 299.4101 Definitions; A, B.

Rule 101. As used in these rules:

(a) "AASHTO" means American association of state highway and transportation officials.

(b) "Act" means 1994 PA 451, MCL 324.101 to 324.90106, and known as the natural resources and environmental protection act.

(c) "Act 299" means 1980 PA 299, MCL 339.101 to 339.2919, and known as the occupational code.

(d) "Act 399" means 1976 PA 399, MCL 325.1001 to 325.1023, and known as the safe drinking water act.

(e) "Active life" means the period of operation beginning with the initial receipt of solid waste and ending with the completion of closure activities in accordance with the act and these rules.

(f) "Active portion" means that part of a facility or unit that has received or is *receiving wastes and that has not been partially or finally closed in accordance with* these rules. The active portion does not include areas that have interim cover which complies with R 299.4429(7) or a constructed unit or portion of a unit that has not received waste.

(g) "Active work area" means the area which is or will be used for the storage, transport, or disposal of solid waste, methane gas, or leachate or in which heavy equipment is or will be used as part of the landfill operation. The active work area includes all of the following:

(i) The active portion.

(ii) Leachate collection and storage systems, exclusive of any of the following:

(A) Forcemains.

(B) Sewers.

(C) Enclosed manholes.

(D) Sewer hookups.

(iii) Gas collection and handling systems, exclusive of any of the following:

(A) Enclosed flares.

Editor's Note: An obvious error in R 299.4424 was corrected at the request of the promulgating agency, pursuant to Section 56 of 1969 PA 306, as amended by 2000 PA 262, MCL 24.256. The rule containing the error was published in *Annual Administrative Code Supplement,1999*. The memorandum requesting the correction was published in *Michigan Register,* 2012 MR 18.

R 299.4425 Type II landfill design standards; final cover.

Rule 425. (1) The owner or operator of a type II landfill unit shall install a final cover system which is designed to minimize infiltration and erosion and which is comprised of an erosion layer underlain by an infiltration layer, as specified in this rule.

(2) Except as provided for existing or preexisting units in subrules (3) and (4) of this rule, the owner or operator of a type II landfill shall install a final cover system that is comprised of all of the following components:

(a) An infiltration layer that is comprised of a composite liner. The lower soil component of such a composite liner shall consist of either of the following:

(i) A minimum of 18 inches of earthen material that has a permeability which is less than or equal to 1.0 x 10-5 cm/sec, as determined by test methods specified in R 299.4920.

(ii) A bentonite geocomposite liner which is in compliance with R 299.4914 and which is underlain by not less than 18 inches of earthen material to protect the liner from waste and minimize the effect of settlement.

(b) An erosion layer that consists of both of the following:

(i) A soil layer which is not less than 2 feet thick, which is immediately above the composite cover liner, and which is designed to do all of the following:

(A) Provide for the lateral drainage of precipitation off the cover of the landfill. The owner or operator may use permeable soil, geosynthetic drainage material, an alternative equivalent material approved by the director, or a combination to provide the lateral drainage.

(B) Minimize frost penetration into the infiltration layer.

(C) Protect the flexible membrane liner from root penetration, ultraviolet light, and other deleterious effects.

(ii) A minimum of 6 inches of earthen material capable of sustaining native plant growth.

(3) The owner or operator of an existing or preexisting type II landfill unit that does not contain a flexible membrane liner in all or portions of the bottom liner system may install a final cover system previously approved by the director over those portions if the final cover system contains both of the following:

(a) An infiltration layer that is comprised of a minimum of 2 feet of earthen material which has a hydraulic conductivity that is less than or equal to 1.0 x 10-7 cm/sec, as determined by test methods specified in R 299.4920. The earthen material shall meet standards for soil liners specified in R 299.4913.

(b) An erosion layer that consists of a minimum of 6 inches of earthen material which is capable of sustaining native plant growth.

(4) The owner or operator of an existing or preexisting type II landfill unit that does not contain a flexible membrane liner in the bottom liner system may enhance the final cover specified in subrule (3) of this rule by adding a flexible membrane liner if

the erosion layer specified in subrule (2)(b) of this rule is provided. The addition of the layer shall not constitute a vertical expansion.

(5) The director shall approve an alternative final cover design if the owner or operator of the landfill units demonstrates that the cover design includes both of the following components:

(a) An infiltration layer that achieves an equivalent reduction in infiltration as the infiltration layer specified in subrule (2) or (3) of this rule.

(b) An erosion layer that provides equivalent protection from wind and water erosion as the erosion layer specified in subrules (2) and (3) of this rule.

(6) The final cover of a type II landfill shall have either of the following to meet the gas control requirements of R 299.4433:

(a) A permeable soil layer which is not less than 1 foot thick and which is located directly below the infiltration layer that vents landfill gas to gas risers.

(b) Other means of assuring that gases cannot travel laterally from the site or accumulate in structures.

(7) To prevent the ponding of water on completed fill surfaces, the grading contours shall be sufficient to prevent the development of local depressions due to postconstruction settlement. Slopes of the final cover shall not be less than 4% at any location.

(8) Slopes of the final cover shall not exceed those necessary to prevent erosion and maintain slope stability. The final slope shall not be more than 1 vertical to 4 horizontal at any location, except where necessary to install berms for erosion control. If the final slope is more than 15%, then the slope shall include controls that the applicant demonstrates are sufficient to maintain slope stability, prevent erosion, and allow access. The controls shall be sufficient to limit erosion to not more than 2 tons per acre per year after vegetation is established based on the universal soil loss equation or other method approved by the director. The following ground cover estimates may be used in calculating erosion loss:

(a) Up to 95%, if the closure and postclosure plan provides for all of the following:

(i) Topsoil that has an organic matter content of more than 2.5%.

(ii) Fertilization consistent with the natural resources conservation service critical area planting guide.

(iii) Mowing twice annually until the required coverage is achieved.

(b) Up to 90%, if the closure and postclosure plan for the unit provides for both of the following:

(i) Topsoil that has an organic matter content of more than 1.25%.

(ii) Mowing annually until the required coverage is achieved.

(c) Up to 80%, if the organic content or mowing schedule is not specified.

(d) Other estimates approved by the director, if the estimates are supported by measures to establish vegetation specified in the closure and postclosure plan.

(9) All final covered areas shall be stabilized using appropriate shallow-rooted vegetation for the soil type, slope, and moisture conditions present. Seed and mulch rates shall, at a minimum, be consistent with recommendations contained in the United States department of agriculture document entitled "Natural Resources Conservation Service Critical Area Planting Guide." The natural resources conservation service critical area planting guide is adopted by reference in R 299.4141.

EXHIBIT 5

Electronic Filing: Received, Clerk's Office 2/22/2018

ILLINOIS POLLUTION CONTROL BOARD
August 31, 2017

SIERRA CLUB, ENVIRONMENTAL)
LAW & POLICY CENTER,)
PRAIRIE RIVERS NETWORK AND)
CITIZENS AGAINST RUINING)
THE ENVIRONMENT,) No. PCB 13-15
)
Complainants,)
)
vs)
)
MIDWEST GENERATION, LLC,)
)
Respondent.)

REPORT OF THE PROCEEDINGS had at the hearing on a motion of the above-entitled cause before the Honorable BRADLEY HALLORAN, Hearing Officer of said Court, Room 9-040, The Thompson Center, Chicago, Illinois, on the 1st day of February, 2018, at the hour of 9:00 a.m.

Electronic Filing: Received, Clerk's Office 2/22/2021

the sand cushion or the crushed stone and they don't have a ramp.

Q. So without a ramp, you can't get in?

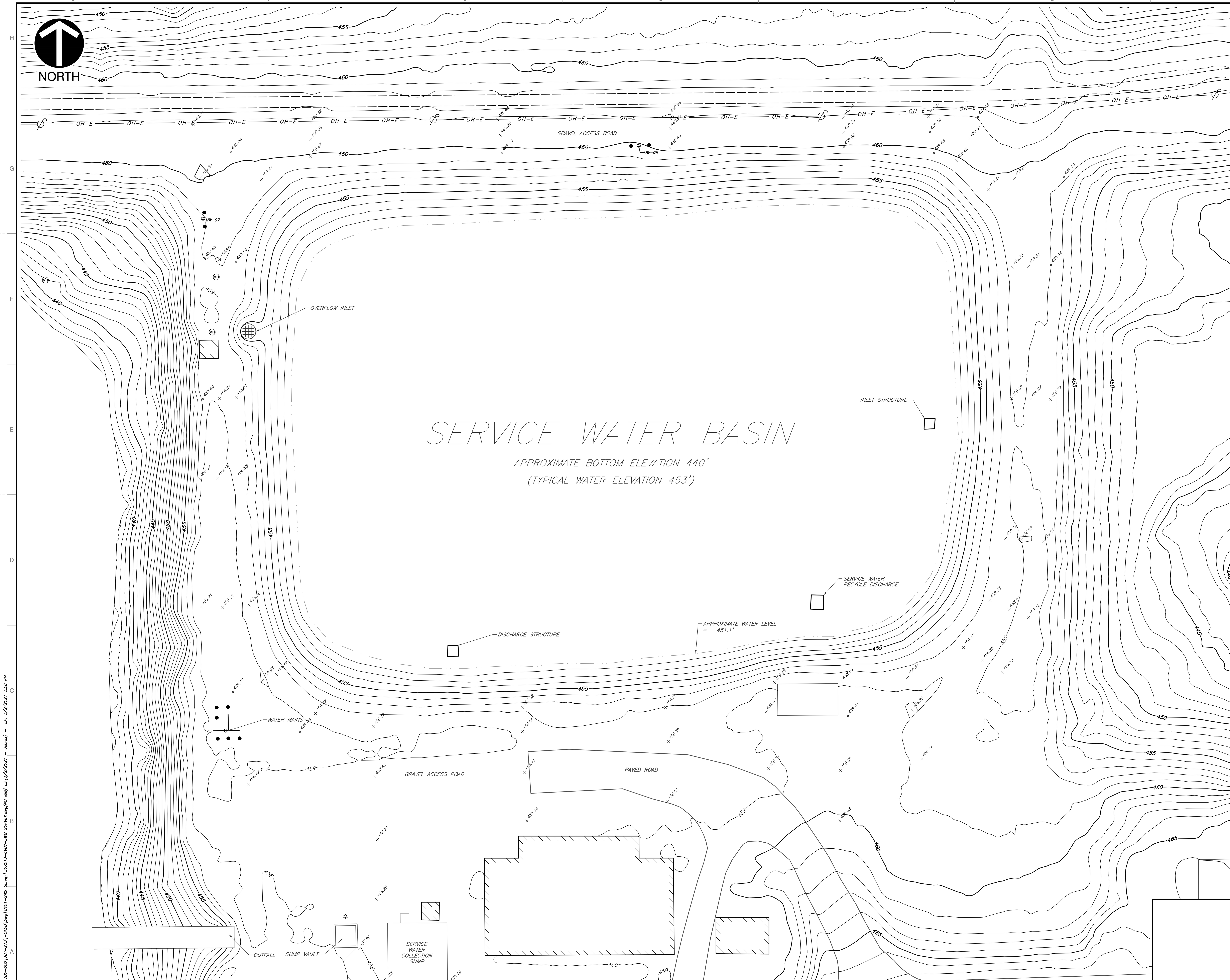
A. You're not going in and out if you don't have a ramp. So it's not designed to be cleaned out. As Mark Kelly indicated, they -- they -- when they went to clean it out, it had never been cleaned out before and they found some soft material in the bottom and in my professional experience on erosion that kind of soft material comes from the atmosphere.

We design for soil loss for landfills to have no more than two tons per acre per year soil loss. That comes from the old US soil conservation service. It's because the atmosphere deposits dust at about that rate. So you know that you're going to get dust in the pond. So what they found was not ash, but probably just soil, dust in the ponds.

Q. Now, we heard a lot of testimony that there have been some tears in the liners from time to time.

How is your opinion of the reliability of liners in this case impacted by the

EXHIBIT 6



REVISION RECORD

NO	DATE	DESCRIPTION

SUBMITTAL RECORD

NO	DATE	DESCRIPTION

LEGEND

- EXISTING RAIL LINE
- OH-E EXISTING OVERHEAD ELECTRIC
- EXISTING CONCRETE PAD
- EXISTING ROAD
- 455 EXISITING INDEX CONTOUR
- WATER LEVEL IN SERVICE WATER BASIN
- EXISTING BUILDING
- INLET
- WATER VALVE
- MANHOLE
- POWER POLE
- BOLLARD
- MONITORING WELL
- ×455.00 GROUND SHOT

NOTES

1. GROUND WAS PARTLY COVERED WITH SNOW AT THE TIME OF THE SURVEY.

REFERENCE

1. TOPOGRAPHIC INFORMATION BASED UPON AERIAL AND GROUND SURVEY CONDUCTED BY CIVIL & ENVIRONMENTAL CONSULTANTS, INC. ON FEBRUARY 23, 2021.
2. ALL ELEVATIONS ARE REFERENCED TO THE VRS NETWORK NAVD 88 VERTICAL DATUM ILLINOIS STATE PLANE WEST ZONE.
3. THE STRUCTURE LOCATIONS, WITHIN THE SERVICE WATER BASIN, WERE BASED UPON NATIONAL RESOURCE TECHNOLOGY'S DRAWING PRECONSTRUCTION CONDITIONS DATED 6/27/14.

SCALE IN FEET

0 20 40

CEC
Civil & Environmental Consultants, Inc.
1230 East Diehl Road, Suite 200 - Naperville, IL 60563
Ph: 630.963.6026 · 877.963.6026 · Fax: 630.963.6027
www.cecinc.com

MIDWEST GENERATION, LLC
SERVICE WATER BASIN SURVEY
POWERTON GENERATING STATION
PEKIN, ILLINOIS

DRAWN BY:	DJD	CHECKED BY:	MDJ	APPROVED BY:	MDJ
DATE:	2/25/2021	DWG SCALE:	1"=20'	PROJECT NO:	307-213

SERVICE WATER BASIN

DRAWING NO.: 1

SHEET 1 OF 1

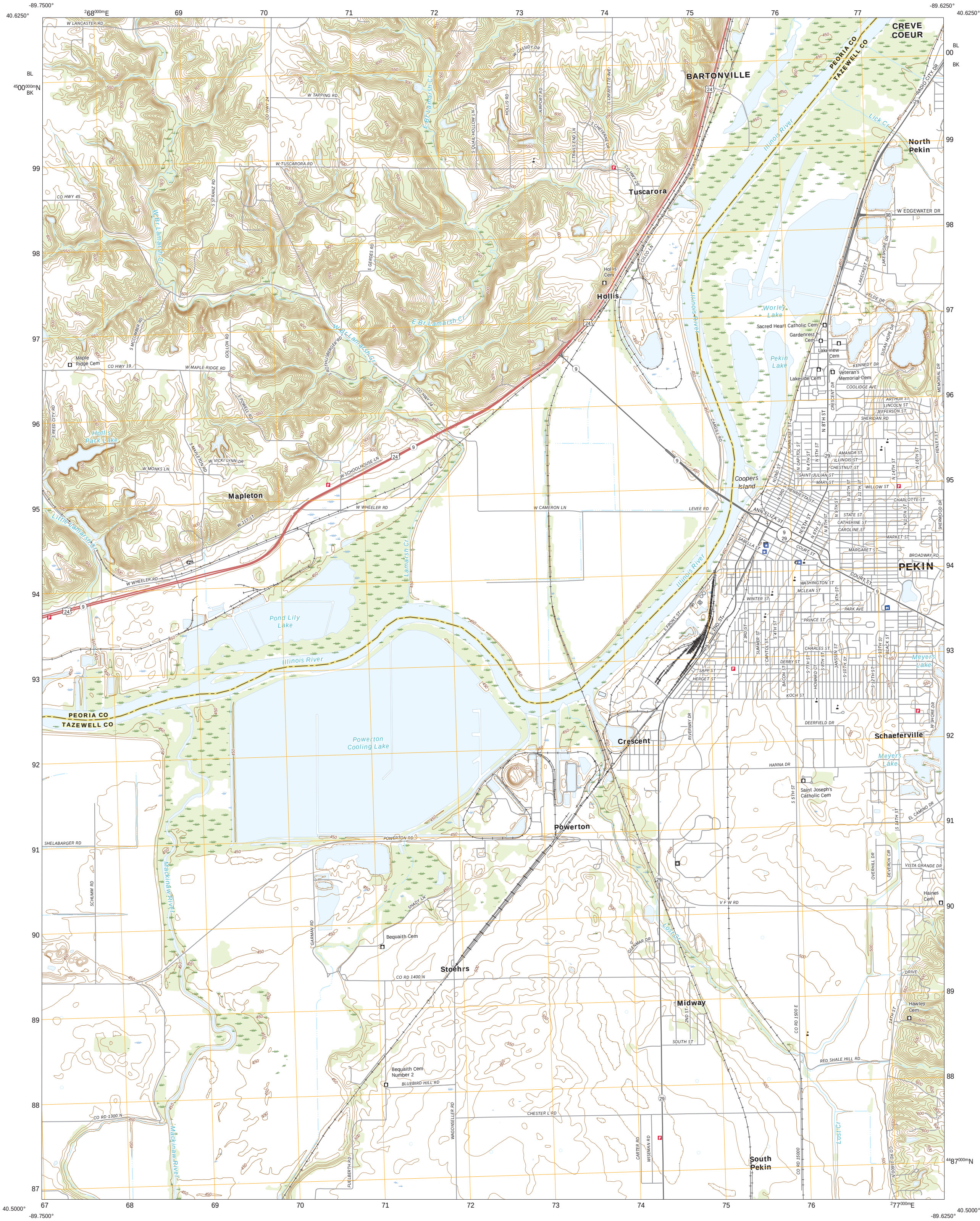
EXHIBIT 7

USGS science for a changing world

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

The National Map US Topo

PEKIN QUADRANGLE
ILLINOIS
7.5-MINUTE SERIES



Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and
1 000-meter grid:Universal Transverse Mercator, Zone 16T

This map is not a legal document. Boundaries may be generalized for this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands.

Imagery........NAIP, August 2015 - October 2015
Roads........U.S. Census Bureau, 2017
Names........GNIS, 1980 - 2017
Hydrography........National Hydrography Dataset, 2006 - 2015
Contours........National Elevation Dataset, 2012
Boundaries........Multiple sources; see metadata file 2014 - 2016
Public Land Survey System........BLM, 2017
Wetlands........FWS National Wetlands Inventory 1983 - 1986

MN
GN
2°6´
37 MILS
1°45´
31 MILS

UTM GRID AND 2017 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

U.S. National Grid
100,000 - m Square ID
BL
BK
Grid Zone Designation
16T

SCALE 1:24 000

KILOMETERS
METERS
MILES
FEET

CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This map was produced to conform with the
National Geospatial Program US Topo Product Standard, 2011.
A metadata file associated with this product is draft version 0.6.18

ILLINOIS
QUADRANGLE LOCATION

1	2	3
4		5
6	7	8

ADJOINING QUADRANGLES

1 Hanna City
2 Peoria West
3 Peoria East
4 Glasford
5 Marquette Heights
6 Manito
7 South Pekin
8 Delavan North

ROAD CLASSIFICATION
Expressway
Secondary Hwy
Ramp
Local Connector
Local Road
4WD
Interstate Route
US Route
State Route

PEKIN, IL
2018

NSN. 7643016365651
NGA REF NO. USGSX24K34638

EXHIBIT 8

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ILLINOIS POLLUTION CONTROL BOARD
August 31, 2017

SIERRA CLUB, ENVIRONMENTAL LAW & POLICY CENTER, PRAIRIE RIVERS NETWORK AND CITIZENS AGAINST RUINING THE ENVIRONMENT,	)	No. PCB 13-15
Complainants,	)	
vs	)	
MIDWEST GENERATION, LLC,	)	
Respondent.	)	

REPORT OF THE PROCEEDINGS had at the hearing on a motion of the above-entitled cause before the Honorable BRADLEY HALLORAN, Hearing Officer of said Court, Room 9-040, The Thompson Center, Chicago, Illinois, on the 31st day of January, 2018, at the hour of 9:00 a.m.

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Illinois River or we have pumps there that can pump the water back to our cooling pond for recycle.

Q. When you say it receives water from the ash surge basin, does it receive ash?

A. No.

Q. No. How do you know it receives no ash or little ash?

MR. WANNIER: Objection. Misstates the witness's testimony. He said that it received no ash.

HEARING OFFICER HALLORAN: Rephrase, please. Sustained.

MS. GALE: Okay.

BY MS. GALE:

Q. How do you know it receives no ash?

A. Before we were to clean that basin out in 2013 -- well, before that that basin had never, to my knowledge, and I have been there before that, it had never been cleaned out and before we went to reline that basin I had engineers from Natural Resource Technology and we pumped that basin all the way down so they could look to see how much material was in there and there was less than a foot of material and it really wasn't ash. It was more like -- like a muddy material. It was more soupy. It really wasn't ash at all.

Q. I have stipulation 22. "Since before 1999, the secondary ash settling basin had a Hypalon liner." And I have stipulation 24.

Mr. Kelly, you said that it had -- for the past 35 years, in your knowledge it had been operating, it had never been dredged, do you know why it had never been dredged?

A. There was never a need for it. I mean, there was never a need to go in there, there was never any indication that we had to go in and clean that -- clean that out.

Q. Stipulation 24. "In 2013, Midwest Generation relined the secondary ash settling basin with a 60 mil HDPE liner."

Mr. Kelly, if the secondary ash settling basin had never been dredged, why did it need a new liner?

A. That was part of the -- I believe it was part of the CCA agreement we had with the state that it would be relined with the ash surge

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that.

Q. Okay. So we can move onto the secondary basin now, which -- let me turn to my -- give me one moment to turn to my notes in the secondary basin.

Now, you said that it was relined with HDPE in 2013, right?

A. The -- I'm sorry?

Q. I'm sorry. The secondary basin was relined?

A. The secondary ash basin, yes.

Q. And you also I believe testified, and you can correct me if I'm remembering that wrong, that -- that it had never been cleaned before the relining in 2013?

A. Correct.

Q. Okay. And what did you find when you relined it at the bottom of this pond again?

A. When I was there to witness -- when they pumped the water down?

Q. Yeah.

A. There was -- there was -- like I said, there was material less than a foot thick, but it really wasn't similar to this. It was more

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muddy, soupy material. It was -- it was -- the technical term could be muck.

Q. Understood. Could it have been bottom ash, though?

A. I don't believe so. It did not look like this at all.

Q. Okay. And, again, you gave the testimony in this proceeding. So I'm going to ask you again to turn to your deposition testimony and specifically you can turn to page 27. And you can turn to line 6 on page 27.

A. Okay.

Q. And do you see where Mr. Russ asked, "Was there bottom ash in the basin?" We can confirm. Let me -- we can turn further back. So we can confirm this is the Bates number. So this is -- do you see on page 26 line 15 where Mr. Russ says "Okay. That could be called the secondary ash settling basin."

A. Okay.

Q. And you said -- you can read your response.

A. I said "Yes."

Q. Okay. And on the next page when you

EXHIBIT 9

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BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

In the Matter of:	)	
	)	
SIERRA CLUB, ENVIRONMENTAL LAW AND POLICY CENTER, PRAIRIE RIVERS NETWORK, and CITIZENS AGAINST RUINING THE ENVIRONMENT,	)	
	)	
Complainants,	)	
	)	
-vs-	)	PCB No. 2013-015
	)	
MIDWEST GENERATION, LLC,	)	
	)	
Respondent.	)	

REPORT OF PROCEEDINGS, at the Hearing of the above-entitled matter held at the James R. Thompson Center, 100 West Randolph Street, Suite 9-040, Chicago, Illinois, on the 29th day of January, 2018, commencing at the hour of 9:00 a.m.

HEARING OFFICER:

Mr. Bradley P. Halloran
Illinois Pollution Control Board
James R. Thompson Center, Suite 11-500
Chicago, Illinois 60601
(312) 814-8917
brad.halloran@illinois.gov

Reported by: Pamela L. Cosentino, CSR
License No.: 084-003601

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was removed from pond three at the Joliet 29 generating station in 2013.

Ms. Race, was pond three ever dredged before it was relined in 2013?

A. My understanding is that it didn't need to be.

Q. Why not?

A. Because there weren't any solids in the bottom.

Q. So nothing needed to be dredged because it wasn't there?

A. Correct.

Q. Was there ever any dredging of pond three after it was relined in 2013?

A. No.

Q. Now, turning back to ponds one and two, how frequently were they used by the station?

A. Very infrequently. Very rarely. They were only used when the landfill was not operating. So when the sluice lines that would go across the river to our existing landfill at that site where the sluice lines were not operating, taken out of service for maintenance, for example, then the water would be sluiced to either ash pond one or ash pond two.

Exhibit

N

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	AS 2021-002
Petition of Midwest Generation	)	
for an Adjusted Standard from 845.740(a)	)	
and Finding of Inapplicability of Part 845	)	(Adjusted Standard)
(Powerton Station)	)	

AFFIDAVIT OF GABRIEL NEIBERGALL

I, Gabriel Neibergall, certify under penalty of perjury pursuant to Section 1-109 of the Illinois Code of Civil Procedure, 735 ILCS 5/1-109, that the statements set forth in this affidavit are true and correct, and further state that if called upon to testify in this matter, I would competently testify as follows:

1. I serve as an Assistant Counsel (Technical Advisor III) in the enforcement unit of the Division of Legal Counsel for the Bureau of Water at the Illinois Environmental Protection Agency (the "Illinois EPA"), and I am located in Springfield, Illinois. Cumulatively, I have worked Division of Legal Counsel for the Illinois EPA for approximately three years and nine months.

2. As Assistant Counsel for the Bureau of Water, my duties include, but are not limited to, working with the Compliance Assurance Section, Field Operations Section, Permits Section, and other technical staff employed in the Division of Water Pollution Control and Division of Public Water Supplies in matters of non-compliance with the Illinois Environmental Protection Act ("Act") and associated Board regulations.

3. As part of my duties, I issued a Notice of Intent to Pursue Legal Action ("NIPLA") to Midwest Generation, LLC ("MWG" or "Petitioner") regarding Violation Notice W-2020-00042 ("VN"), attached to the Recommendation as Exhibit C ("Rec. Ex. C"), and handled communications between Illinois EPA staff and MWG regarding the VN and NIPLA.

4. I have reviewed the Petition for an Adjusted Standard from Section 845.740(a) and Finding of Inapplicability of Part 845 for the Powerton Station ("Petition") filed by Midwest Generation, LLC.

5. I have also reviewed Illinois EPA's Recommendation to the Board as to Petitioner's request for a finding that Part 845 does not apply to the Service Water Basin located at the Powerton Station, along with the Recommendation's attached exhibits.

6. Attached to the Recommendation as Exhibit D ("Rec. Ex. D") is a KPRG Memorandum re: Evaluation of Sediment in Powerton Generating Station's Service Water Basin, dated July 27, 2021. I received this memorandum on July 27, 2021, via email from Petitioner's counsel. This memorandum is kept by the Illinois EPA in the regular course of business, and it is the regular course of business of the Illinois EPA to transmit the information thereof to be included in this record. The July 27, 2021 KPRG Memorandum, attached to the Recommendation as Exhibit D, is an exact duplicate of the original submitted to me and maintained in Illinois EPA records.

7. Attached to the Recommendation as Exhibit F ("Rec. Ex. F") is an August 18, 2021 MWG letter to Illinois EPA. I received this letter on August 18, 2021, via email from Petitioner's counsel. The August 18, 2021 letter is kept by the Illinois EPA in the regular course of business, and it is the regular course of business of the Illinois EPA to transmit the information thereof to be included in this record. The August 18, 2021 letter, attached to the Recommendation as Exhibit F, is an exact duplicate of the original submitted to me and maintained in Illinois EPA records.

8. Attached to the Recommendation as Exhibit H ("Rec. Ex. H) is KPRG Memorandum re: Sampling Location Discussion as part of Evaluation of Sediment Quantities in Joliet Generating Station's Pond 1 and Pond 3 and Powerton Generating Station's Service Water Basin, dated February 26, 2021. I received this memorandum on February 26, 2021, via email

from Petitioner's counsel. This memorandum is kept by the Illinois EPA in the regular course of business, and it is the regular course of business of the Illinois EPA to transmit the information thereof to be included in this record. The February 26, 2021 KPRG Memorandum, attached to the Recommendation as Exhibit H, is an exact duplicate of the original submitted to me and maintained in Illinois EPA records.

9. Attached to the Recommendation as Exhibit I ("Rec. Ex. I) is a KRPG Memorandum re: Additional Sampling Location Discussion for Powerton Generating Station's Service Water Basin, dated May 12, 2021. I received this memorandum on May 12, 2021, via email from Petitioner's counsel. This memorandum is kept by the Illinois EPA in the regular course of business, and it is the regular course of business of the Illinois EPA to transmit the information thereof to be included in this record. The May 12, 2021 KPRG memorandum, attached to the Recommendation as Exhibit I, is an exact duplicate of the original submitted to me and maintained in Illinois EPA records.

10. Attached to the Recommendation as Exhibit J ("Rec. Ex. J") is a Revised Exhibit 1: Table 3, submitted to Illinois EPA as an amendment to the July 27, 2021 KPRG Memorandum (Rec. Ex. D). I received this document on August 6, 2021, via email from Petitioner's counsel. This document is kept by the Illinois EPA in the regular course of business, and it is the regular course of business of the Illinois EPA to transmit the information thereof to be included in this record. The Revised Exhibit 1: Table 3, attached to the Recommendation as Exhibit J, is an exact duplicate of the original submitted to me and maintained in Illinois EPA records.

11. Attached to the Recommendation as Exhibit K ("Rec. Ex. K") is a Midland Standard Engineering, Inc. Geotechnical Laboratory Report, dated July 26, 2021. I received this document on August 6, 2021, via email from Petitioner's counsel. This document is kept by the

Illinois EPA in the regular course of business, and it was the regular course of business of the Illinois EPA to transmit the information thereof to be included in this record. The July 26, 2021 report, attached to the Recommendation as Exhibit K, is an exact duplicate of the original submitted to me and maintained in Illinois EPA records.

FURTHER AFFIANT SAYETH NOT

GABRIEL NEIBERGALL

09/21/2021
DATE

State of Illinois
County of Sangamon

Subscribed and Sworn to before
me this 21st day of September 2021.

Notary Public

OFFICIAL SEAL
DAWN A. HOLLIS
NOTARY PUBLIC, STATE OF ILLINOIS
MY COMMISSION EXPIRES 03-21-2025